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Inspiration for Action

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BOOK OF ABSTRACTS

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Table of Contents

Parallel Sessions

AGR1 - Intercropping – exploitation of biodiversity benefits in arable fields

537 RAPID TRANSGENERATIONAL ADAPTATION IN RESPONSE TO INTERCROPPING BENEFITS YIELD

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By capitalising on positive biodiversity-productivity relationships, intercropping provides opportunities to improve agricultural sustainability. However, intercropping is generally implemented using commercial seeds that were bred for maximal productivity in monocultures, which might limit the yield benefits of crop diversity. Plants can adapt over generations to the level of surrounding plant diversity, notably through increases in niche differentiation. However, this adaptation potential has not been explored in annual crop systems. Here we investigated whether plant–plant interactions among annual crops could adapt over several generations in response to their surrounding diversity. We showed that after three years, plant-plant interactions shifted towards increased facilitation and reduced competition when the plants' coexistence history matched their current diversity setting. This led to increasing yield benefits in mixtures composed of mixture-adapted individuals. We further showed that this adaptation effect was unexpectedly linked to a convergence of above-ground plant functional traits. This study provides the first empirical evidence for the importance of parental diversity affecting plant–plant interactions and ecosystem functioning of the following generations in annual cropping systems, with important implications regarding specific breeding for mixtures.

440 PERFORMANCE OF THE PIGEON PEA-COWPEA INTERCROPPING SYSTEM IN MALAWI

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A pilot study of the pigeon pea-cowpea intercropping system was established in the 2019/2020 at Kasinthula, Chitala and Bvumbwe agricultural research stations; and in the 2020/2021 cropping season on two farmers' fields in Lunzu Extension Planning Area (EPA) of Blantyre district in southern Malawi. The experiment was laid out in a Randomised Complete Block Design (RCBD) with 4 treatments replicated 3 times namely 1. Pigeon pea 2. Cowpea 3. Pigeon pea + Cowpea (biomass incorporated to the soil at harvest time) 4. Pigeon pea + Cowpea (biomass not incorporated to the soil at harvest time). The Land Equivalent Ratio (LER) was used to evaluate the productivity of the intercrop against the monocultures. Agronomic data were analyzed in Genstat Discovery Edition 4 and subjected to analysis of variance at 95% level of confidence. Means of yields were separated using the least significant difference (LSD0.05). Overall cowpea grain yield was significantly higher in the monoculture (up to 4,609 kg ha-1) above the intercrop (up to 3,616 kg ha-1). Generally there were no significant differences in the

pigeon pea grain yield in the monoculture (up to 1,543 kg ha-1) and the intercrop (up to 1,485 kg ha-1). A similar pattern was observed on farmers' fields in Lunzu EPA. However, evaluation of the productivity of the intercrop against the monocultures both on-station and on-farm showed yield advantage (total LER >1.0) for the intercrop compared to the monocultures on equivalent hectarage.

237 COMBINING THEORY AND PRAGMATISM TO IMPROVE THE MIXING OF CROP VARIETIES

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Crop variety mixtures can provide many benefits, such as pathogen suppression or increases in yield and yield stability. However, such mixture benefits are not necessarily guaranteed for any given mixture, or they may not outweigh disadvantages that come with increased crop heterogeneity. At the same time, traditional heuristic methods to find optimal mixtures are typically very costly and labor-intense. In our work, we have examined a variety of approaches to predict mixture benefits from components. Here, I will show that the inspiration for such predictive methods may come from various disciplines, such as genetics, ecology or engineering. I will present cases where mixture benefits can be increased by surprisingly simple means, and highlight synergies between breeding for monocultures and mixtures that could act as a lever for increasing within-crop diversity.

333 AN APPROACH TO STUDY BIODIVERSITY AND PEST CONTROL IN COFFEE AGROFORESTS

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Coffee agroforests harbor substantial biodiversity which in turn provides important ecosystem services to the agroecosystem. One of those ecosystem services is pest control. But due to the high diversity of potential natural enemies present and the complex interactions that emerge among them, the comprehensive study of how biodiversity contributes to pest control can be an overwhelming task. Here we suggest that the systematic construction of a community, may be done in such a way that individual processes can be seen as coming together naturally as components are added, creating large, apparently complex, structures. However, ultimately, such a constructive process generates the need to deconstruct, or scale back. We move from the epistemological context of asking “what else is there?”, to the necessity of asking “what can be ignore?” This approach combines natural history with complex systems theory applied to a concrete example from our field work in coffee agroforestry systems in Mexico and Puerto Rico.

501 CURRENT TRENDS IN BREEDING AND INTERCROPPING OF PULSES IN SWITZERLAND

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The cultivation of pulses in mixture with cereals and other field crops has been a common form of arable farming in Europe. The general decline in grain legume production until recently and the predominance of cultivation in pure stand have led to a loss of

genotypes with essential plant physiological traits necessary for intercropping. In addition, pulses have been grown mainly as animal feed over the last century, which is why selection methods for traits required for processing as food are lacking. Getreidezuchtung Peter Kunz, a non-profit breeding organisation in Switzerland, focuses on developing varieties of field pea (Pisum sativum) for cultivation in mixture and as food. The presentation will outline the current methods used for genotype selection for intercropping and the obstacles to reintroducing the cultivation of pulses in mixed cropping in Switzerland. In particular, challenges arising from the current structures of the seed systems and marketing and processing chains will be addressed.

454 NUTRITIONAL QUALITY AND PROCESSING OF LEGUMES AND OTHER INTERCROPPED SPECIES

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Intercropping leads to a vibrant exchange of interactions between soil, diversified crops, and the environment in which they are grown. Importantly, it can optimise the use of natural resources and deliver locally grown, diversified foods, which can reduce the environmental footprint of the current agri-food systems. However, intercropped species must be integrated in successful dynamic value chains to allow farmers to have a sustainable, equitable, fair, and resilient farming operation. On a market level, there is a need for less normalised market strategies, more diversified, small-scale processing methods and different market pulls to deliver the most effective business plans and models. Strategic thinking is needed when selecting the best crops for different intercropping goals, and here legume crops maybe a versatile option. In this talk I will discuss the benefits of intercropping on the nutritional composition of intercropped species, on the delivery of a multitude of traditional or novel foods (e.g. drinks, breads, meat replacers, snacks, flours), and on the global role of intercropping as a holistic strategy to improve soil health, deliver multiple ecosystem services, but also a range of nutritious, healthy and sustainable foods that can feed worthy value chains for all actors of the system.

499 INTERCROPPING SYSTEMS IN SUB-SAHARAN AFRICA: LESSON LEARNED

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Different intercropping systems have been traditionally used in Sub-Saharan Countries (SSA), but have due to agricultural intensification become less prevalent. Nevertheless, intercropping is still been done and now there is renewed interest in them and a need to further optimize them due to the generally low productivity of the systems within the SSA context. In my talk, I will discuss some of the traditional intercropping systems of SSA (cassava-maize, maize-legumes, faidherbia-maize, etc.) with their advantages and disadvantages from an agronomic perspective, with a focus on nutrient cycling and soil fertility effects within these systems. Furthermore, I will focus on the trade-offs presented by intercropping and potential innovations for further optimization. Wherever possible, a link will be made to temperate systems to exemplify how (traditional) knowledge about tropical systems can enhance the development of intercropping systems in temperate regions.

136 HOW TO INTERCROP IN A LARGE-SCALE GRAIN PRODUCTION SYSTEM

L. Shaw[1]
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Mixed grain intercropping is a developing and exciting practice that is taking hold at a commercially relevant scale in the northern prairies of Canada and the United States. I will discuss the potential for intercropping to intensify broadacre agriculture while also increasing biodiversity and lowering use of pesticides. Intercropping chickpea with flax has reduced disease severity and improved quality of chickpea in Saskatchewan, which has led to uptake of this practice on commercial acres in that province and into the United States. This talk will also cover small-plot and field-scale trial results from other crop combinations like pea-oat, pea-mustard, and pea-canola. Intercropping presents many challenges for mechanization, which will be discussed in a practical level for large-scale grain farmers.

ARC1-a - Arctic biodiversity under global change – from documenting changes to identifying pathways toward sustainable development

121 DETECTING INDUSTRIAL DEVELOPMENT IN THE ARCTIC VIA NIGHTTIME LIGHTS

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Change in land and sea use has been identified as one of the main drivers of the worldwide biodiversity loss. In the Arctic, oil, gas, and mineral exploitation is one of the main stressors for habitat degradation, which can have negative effects on the Arctic biodiversity through fragmentation of landscapes to thawing of permafrost. Possible collapse of infrastructure built on the permafrost, such as the Norilsk oil spill in 2020, is another threat to biodiversity. Although extractive industries play a major role in the habitat degradation in the Arctic, their cumulative effects, especially on land use change, are not quantified at pan-Arctic scale. In this study, we utilize Nighttime Lights (NTL) data from 1992 - 2020 to analyse industrial development in the terrestrial Arctic. We present an Arctic NTL Trend Map that highlights where industrial activity has increased or decreased and a Cumulative NTL development map based on yearly NTL data as a proxy for the total area that has been affected by the spatially shifting industrial activity. We found that due to extraction industries, the NTL change throughout years is very dynamic, i.e. while some of the oil and gas fields are depleted and abandoned, new ones are developed. Our results indicate that land use change by oil & gas field development in the Arctic is significant to calculate economic externalities sourced by the oil & gas industry.

437 INCREASED ARCTIC TEMPERATURE EXTREMES UNDER GEOENGINEERING RADIATION MANAGEMENT

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Radiative forcing geoengineering (RFG) methods are proposed to control global temperatures to reach the Paris Agreement goals, as anthropogenic greenhouse gas emissions might not be reduced in time. Earth system model simulations suggest that while these methods succeed at keeping the global mean temperature increase below 2°C compared to pre-industrial levels, they might lead to responses in other climate variables, such as extreme temperatures. However, the response of extreme temperatures has not been investigated before, also not for the Arctic with its rapid warming.
In this study we used the output of the Nor-ESM1 model to analyse how extreme temperatures will be affected by three different RFG methods: Cirrus Cloud Thinning (CCT), Marine Sky Brightening (MSB) and Stratospheric Aerosol Injection (SAI). Our results indicate that while these geoengineering methods seem to succeed in keeping global mean temperature increase below 2°C, the Arctic region will still warm by 5°C. CCT and MSB show a stronger trend for maximum temperature especially in the Arctic, compared to the RCP8.5 scenario, shifting the system into temperature conditions where wildfires are more frequent. SAI shows a stronger trend for minimum temperature compared to the RCP8.5 scenario, leading to permafrost thawing.
This study helps to better understand the consequences of implementing RFGs and highlights their risks to Arctic ecosystems, like increased maximum temperature and wildfire frequency.

168 SYNTHESIS OF ARCTIC FRESHWATER BIODIVERSITY: SPATIAL TRENDS, DRIVERS, PREDICTIONS

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- Warming and subsequent landscape transformations result in rapid biodiversity change in Arctic lakes and rivers. Here we synthesize analyses of alpha and beta diversity in Arctic freshwaters gained from regional and circum-Arctic assessments for diatoms, plankton, macrophytes, macroinvertebrates, and fish, and summarize the major drivers of change.
- Alpha diversity was lowest at high latitudes and constrained primarily by temperature and spatial connectivity. Data standardized across organism groups indicated low overall diversity in cold regions and highlighted the role of dispersal barriers.
- Beta diversity showed high variability among ecoregions for most organism groups, ranging from 0 to 1. The high degree of dissimilarity illustrates the

uniqueness of Arctic freshwater communities. Turnover generally contributed more than nestedness to beta diversity, but nestedness was higher for organisms at higher trophic levels.
- Range expansion of freshwater taxa into Arctic regions may lead to large changes in ecosystem state, to increased competition for cold-stenothermic and cold-adapted species, and ultimately to the irreversible extinction of unique species.
- Societal responses to predicted impacts include (1) actions to improve detection of changes (e.g., harmonized monitoring, remote sensing), and engagement with Arctic residents and Indigenous Peoples, and (2) those that aim at reducing the impact of unwanted changes (e.g., CO_2-emissions, invasive species).

ARC1-b - Arctic biodiversity under global change – from documenting changes to identifying pathways toward sustainable development

261 PATTERNS AND DRIVERS OF MACROINVERTEBRATE DIVERSITY IN ARCTIC FRESHWATERS

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Arctic warming is predicted to change freshwater biodiversity through loss of taxa and northward range expansion of lower latitude taxa. Benthic macroinvertebrate diversity, a metric of good water quality, was examined using a circumpolar dataset of 1,500 lake and river sites. We assessed alpha diversity within catchments along latitude and temperature gradients, and regional community composition of beta diversity and its components. Alpha diversity of lakes and rivers declined with increasing latitude, although more strongly across mainland regions than islands. Diversity was strongly related to long-term air temperature, with the lowest diversity in the coldest catchments. Regional dissimilarity was highest when mainland regions were compared with islands suggesting that connectivity limits diversity through dispersal constraints. High Arctic

rivers and lakes were predominately occupied by midges and worms, whereas mayfly, stonefly and caddisfly taxa were more abundant at lower latitudes. Temperature was a primary driver of community composition, although geology and precipitation were also important. The strong association with temperature supports the prediction that warming will increase Arctic macroinvertebrate diversity, however, low diversity on islands suggests biogeographical constraints will limit this increase. Long-term, harmonized monitoring across the Arctic is necessary to detect such changes to diversity and inform the water quality management.

197 MULTITROPHIC BIODIVERSITY PATTERNS OF SUB-ARCTIC LAKES IN NORTHERN EUROPE

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The sub-Arctic lakes are increasingly threatened by climate change. We analyzed spatial biodiversity patterns of 74 sub-Arctic lakes in northern Europe with monitoring data for at least three focal ecosystem components (FECs) – macrophytes, phytoplankton, littoral benthic macroinvertebrates (BMI), zooplankton, and fish – that cover multiple trophic levels. We calculated the richness$_{rel}$ (taxon richness in the lake divided by the total richness in all 74 lakes) and biodiversity metrics (taxon richness, diversity, and evenness) for each FEC, and assessed whether they were correlated with lake abiotic and geospatial variables. We predicted that (i) individual FECs are more diverse in a warmer and wetter climate, and in hydrobasins with greater forest cover; and (ii) FEC responses are coupled among trophic levels. Redundancy analyses showed higher richness$_{rel}$ of phytoplankton, macrophytes and fish, but lower richness$_{rel}$ of the intermediate trophic levels (BMI and zooplankton) at higher latitudes and/or elevations. Fish richness$_{rel}$ and diversity increased with increasing temporal variation in temperature and/or precipitation, lake nutrient concentrations, and woody vegetation in hydrobasins, while taxon richness of BMI and zooplankton decreased with increasing temporal variation in climate. Overall, the spatial biodiversity patterns were trophic-level specific. An integrated food-web perspective is needed for better understanding and monitoring of biodiversity in sub-Arctic lakes.

552 CLIMATE CHANGE AND BREEDING RANGE DYNAMICS OF SONGBIRDS IN NORTH-EAST RUSSIA

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Climate changes impacts ecosystems globally, but the impact is most prominent in the Arctic. With remote sensing methods, researchers identified two main changes of tundra and northern boreal forests associated with climate change: the so-called "greening": increase of cover, height, and thickness of shrub vegetation and "browning": the degradation of woody vegetation. A substantial proportion of Arctic and Subarctic passerines rely on shrub vegetation for breeding and should benefit from changes in the land cover due to shrubification. They are responding fast to habitat changes by colonizing new areas, or in some cases disappearing locally.
In 2019-2021 we collected data on the distribution, abundance, and species composition of passerines at seven sites around Chukotka. In all the sites a number of species appeared, that had not been recorded there before, several of which were rather abundant. Species that shifted furthers from their previous distribution range were: dusky warbler, fieldfare, redwing, Siberian rubythroat, common rosefinch, dusky thrush. At the same time in in the southeast of the Chukchi Peninsula, despite the pronounced development of shrubs, the species composition of passerines did not change even compared to the 1930s. Thus, it is necessary to clarify the distribution range of the dispersing species, as well as determine the limitations they could be facing during this process.

485 BIODIVERSITY OF THE RUSSIAN HIGH ARCTIC ISLANDS

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Polar deserts on the Russian High Arctic Islands were exposed to the highest climate warming rates in the Arctic in recent decades. However, they are severely understudied, with some islands never or only briefly visited by botanists. The Arctic Century Expedition organized by SPI, GEOMAR and AARI in 2021 provided a unique opportunity to conduct geobotanical field work on Vize, Graham Bell, Komsomolets, Pioneer, October Revolution, Bolshevik and Uedineniya islands. We aimed at documenting the biodiversity and analyzing its structure and functioning across the islands.
The classical biogeography theory of island biodiversity built on tropical regions fails to explain the floristic diversity of the Arctic islands. Factors such as island area, sea current exposure, distance from main land or archipelago affiliation seem to be less important. Our new data show that floristic biodiversity is mainly explained by soil texture. The most diverse plant communities were documented on loamy soils, sandy soils appeared to be almost bare and not able to provide habitats even for lichen and algae crusts.
Vegetation is very sparse in polar deserts, not providing the insulation function for permafrost of denser vegetation canopies in tundra regions. The active layer measured on the islands was often much thicker than expected according to latitude. Permafrost degradation might lead to rapid changes in plant community structure and species richness of the pristine polar desert ecosystems.

603 ABUNDANCE AND DIVERSITY TRENDS AND CLIMATE CHANGE RESPONSES IN ARCTIC ARTHROPODS

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Time series data on arthropod populations are critical for understanding the magnitude, direction, and drivers of change. However, most arthropod monitoring programs are short-lived and restricted in taxonomic resolution. Monitoring data from the Arctic are especially underrepresented, yet critical to uncovering and understanding some of the earliest biological responses to rapid environmental change. Clear imprints of climate on the behavior and life history of some Arctic arthropods have been demonstrated, but a synthesis of population-level abundance changes across taxa is lacking. We utilized long-term data from Zackenberg in High-Arctic Greenland to assess trends in abundance and diversity and identify potential climatic drivers of abundance changes. Total arthropod abundance gradually declining during 1996 to 2014, followed by a sharp increase. Family-level diversity showed the opposite pattern, suggesting increasing dominance of a small number of taxa. Total abundance masked more complicated trajectories of family-level abundance, which also frequently varied among habitats. Together, these data highlight the complexity of characterizing climate change responses even in relatively simple Arctic food webs. Our results underscore the need for data reporting beyond overall trends in biomass or abundance and for including basic research on life history and ecology to achieve a more nuanced understanding of the sensitivity of Arctic and other arthropods to global changes.

202 CLIMATE-DRIVEN CHANGES IN BIODIVERSITY PATTERNS IN THE SIBERIAN SHELF SEAS

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Observed and projected climatic shifts and their pronounced impacts on marine ecosystems and the composition, diversity and function of pelagic and benthic biotas have been investigated in Arctic Siberian Shelf Seas (SSS) by the German-Russian TRANSDRIFT collaborative research project, which also involved a series of cruises between 2014 and 2021. Pelagic communities in shallow waters (20–50 m), which are characterized by naturally high seasonal and inter-annual variability, showed little climate-related changes in species composition and biomass during summer and fall, despite the observed shift of spring bloom timing due to earlier ice melt. In contrast, clear impacts on macrozooplankton were detected at greater depths over the continental slope, within the direct influence of Atlantic water masses. For instance, breeding krill Thysanoëssa raschii and adult Meganyctiphanes norvegica (Euphausiacea) were recorded as far east as in East Siberian Sea in 2018 and 2019 (but interestingly not in 2021). Macrobenthic species distribution patterns were shown to be structured on three different spatial scale, driven by a unique set of environmental drivers (broad (≥ 400 km): apparent oxygen utilization and phosphate; meso (100–400 km): distance-to-shoreline and water temperature; small (≤ 100 km): organic carbon flux and distance-to-shoreline). Based on environmental conditions prevailing in the SSS, potential "hot-spot" and "cold-spot" areas of biodiversity change were identified.

BEF1 - Scaling diversity-functioning relationships from plot-scale experiments to real-world landscapes: emergent mechanisms

591 EFFECTS OF HABITAT LOSS ON BIODIVERSITY AND ECOSYSTEM FUNCTIONING

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Habitat loss is the primary direct driver of biodiversity loss in terrestrial ecosystems. In a new landscape-scale grassland habitat loss experiment, I am testing theoretical predictions for extinction debts and biodiversity-dependent ecosystem service debts. The experiment crosses habitat area treatments (100, 50, 5, or 1%) with seed addition treatments (none or diverse mix) to test whether seed additions can alleviate dispersal limitation induced by habitat fragmentation, thereby preventing or reducing extinction debts. The experiment is located adjacent to two of the world's longest-running biodiversity experiments, which manipulate local grassland plant species richness and measure a wide range of ecosystem functions. Remote sensing over these biodiversity and habitat loss experiments allows estimation and validation of the effects of plant diversity on ecosystem functioning, while also experimentally testing how habitat loss and seed additions alter these relationships, at multiple scales. The edges of the habitat fragments are responding first. These spatially-explicit and scale-dependent responses are revealing early warning indicators that could inform future monitoring efforts.

194 EVIDENCE OF EMERGENT DIVERSITY EFFECTS AT THE LANDSCAPE-SCALE

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In biodiversity-ecosystem functioning (BEF) experiments, local species richness is manipulated to study effects on local ecosystem functioning. Insights from such experiments are difficult to translate to real-world landscapes and ecosystem services. A key reason is that complex landscapes contain multiple ecosystem types that may interact through the exchange of organisms and different forms of matter (e.g. carbon, nutrients, water) and energy (e.g heat). Hence, such landscapes show diversity at levels of organization not present, and thus impossible to study, in relatively homogeneous plots of BEF-experiments.
Here, we used satellite-remote sensing to study landscape-wide productivity in North America. We found significant increases in productivity with the number of ecosystem types present in a landscape, similar to how local ecosystem functioning increases with species richness in BEF experiments. Signatures of ongoing global change such as positive decadal trends in productivity were more pronounced in more ecosystem-diverse landscapes. These effects were independent of variation in α-species diversity.
We develop an extended framework of diversity effects in which effects at different levels of organization (e.g. species in communities, ecosystems in a landscape) jointly shape landscape-level functioning. Such an extended perspective on real-world systems allows integrating human-dominated systems and processes not addressable by focusing on species diversity alone.

449 DIFFERENTIAL EFFECTS OF SOIL FOOD WEBS ON DECOMPOSITION IN MOUNTAIN ECOSYSTEMS

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Soil food webs are crucial for biogeochemical cycles and in particular for decomposition. However, few studies have quantified how microbial decomposition activity is influenced by both the composition of bacterial and fungal communities and their respective consumers, conditionally on environmental variation. Here, we measured and compared these effects between forests and open habitats, using several altitude gradients in the French Alps.
We found that while the response of microbial decomposition activity to abiotic conditions varied little between the two habitats, it was determined by the composition of fungal communities in forests, and by the composition of bacterial communities in open habitats. We also identified indirect effects of consumer communities that suggest the existence of trophic regulation of microbial decomposition activity. The effect of trophic regulation differed between habitats: minor in forests, it was however strong in open habitats.
The hierarchical integration of the environment and the soil food web to quantify indirect and direct pathways effects on decomposition highlights the need to better assess the importance of trophic regulation to predict ecosystem functioning.

55 LANDSCAPE DIVERSITY-FUNCTIONING RELATIONSHIPS: EVIDENCE FROM REMOTE SENSING

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Biodiversity experiments have shown that ecosystem functioning generally increases with species richness. Anthropogenic change, in addition to driving global losses of species, as well resulted in landscapes with complex mosaics of different land-uses and covers. Yet, the functional importance of the diversity of such larger scale ecological entities, land units, is still unclear.
Here, we used a set of over 20,000 systematically selected plots, 500-1,000 meters in extent, to study such effects in North America. Combining time-series of satellite imagery and land-cover maps, we detected a positive relationship between land-cover-type diversity and primary productivity, measured as NDVI. Applying the additive partitioning method, we discovered that complementarity effects were more important than selection effects, similar to what has been found in species-diversity experiments.
Our findings suggest that landscape-wide productivity increases in more diverse landscape mosaics, but the specific mechanisms remain obscure. We hypothesize that this relationship emerges, at least in part, from mechanisms independent of local, within-ecosystem, species diversity. One example could be heat redistribution, which we currently analyze using thermal infrared data. Eventually, an increasing emphasis on landscape-level diversity–functioning relationships is suggested, as they base the provision of ecosystem services to humans.

BEF2-a - Functional diversity in space and time: measurements, models and experiments to advance trait-based ecology

483 INCORPORATING FUNCTIONAL DIVERSITY INDICES TO ENHANCE THE PERFORMANCE OF MMIS

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Worldwide, freshwater ecosystems are impacted by multiple stressors, causing ecological degradation and reducing biodiversity. Traditionally, biomonitoring of freshwater ecosystems is based on taxonomic indices of biotic communities, but incorporating functional diversity indices may help to inform on mechanisms underlying species-environment relationships. We developed multimetric indices (MMIs) combining taxonomic and functional diversity indices of macroinvertebrate communities in the Karun river basin, Iran. We sampled biotic and abiotic variables in 53 sites during four seasons and identified macroinvertebrates (mostly genus level) and assigned values for ten traits (respiration mode, aquatic stage, feeding habits, locomotion and substrate relation, dispersal strategy, propensity to drift, current velocity, maximum body size, life cycle duration, and a potential number of reproductive cycle per year). To account for trait plasticity, we used a fuzzy coding approach to score traits modalities. We calculated community-weighted mean trait values and functional diversity indices. Finally, we used standard metrics screening steps to identify metrics responsive to pressure gradients and develop MMIs. Taxonomic-based MMI showed acceptable discrimination ability between reference sites and impacted sites, but incorporating functional diversity indices increased the MMI discrimination ability and improved our understanding of the performance and ecological interpretation of MMIs.

251 THE NASA BIODIVERSITY SURVEY OF THE CAPE (BIOSCAPE)

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We provide an overview of the first-ever NASA Biodiversity campaign, to be flown in 2023. Incorporating airborne imaging spectroscopy, lidar, and field observations, the campaign will explore the structure, composition, function, and threats to biodiversity across South Africa's Greater Cape Floristic Region (GCFR), including freshwater, coastal and marine environments. The GCFR contains two Global Biodiversity Hotspots with the richest temperate flora and the third-highest marine endemism in the world. The field campaign includes the collection of new hyperspectral remote sensing data ranging from UV to thermal wavelengths acquired by PRISM, AVIRIS-NG, and HyTES imaging spectrometers combined with the LVIS laser altimeter (LiDAR) aboard the NASA GIII and GV aircraft. These remotely sensed data will be combined with existing and new field observations and spatial data to enable high-resolution mapping of biodiversity and functional traits, ecosystem processes and their threats, and environmental structure. The campaign is working with local research and conservation stakeholders to address locally and globally relevant questions organized around three major themes: 1) the

distribution and abundance of biodiversity, 2) the role of biodiversity in ecosystem function, and 3) the impacts of biodiversity change on ecosystem services.

336 CONTEMPLATING THE STRUCTURE AND FUNCTION OF A TROPHIC METAWEB FOR SWISS FAUNA

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Rather than being isolated entities, species in nature interact in complex and dynamic ecological networks. The functional role of a species in an ecosystem can be represented in a metaweb, a matrix encompassing all potential trophic interactions between species in a regional pool. Global changes impact on species can have cascading effects on the food web with consequences for the structure and function of entire ecosystem. Anticipating these consequences requires high resolution knowledge about the functional role of species within food webs across environmental gradients at large spatial scales, which can be recovered with remote sensing from satellite images. Studies of the variation in structure of tetrapods along environmental gradients should be broadened to the entire fauna to study whole ecosystem functioning. We aim to build a trophic metaweb of Swiss fauna by integrating metagenomics, literature and functional analyses. We will infer local networks from the metaweb using species range maps from species distribution modelling. We will investigate the structure and function of these local networks across climate and land-use intensity gradients in present and future scenarios using remote sensing data. Finally, we will build a new set of ecological indicators of ecosystem change that can be combined with existing biomonitoring programs. Remote sensing coupled with trophic information should allow a better understanding of ecosystem trajectories under global change.

326 FUSE (FUNCTIONAL UNIQUE, SPECIALISED AND ENDANGERED), A NEW CONSERVATION METRIC

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Reversing, or halting biodiversity loss under growing anthropogenic pressure is one of the greatest challenges in biodiversity conservation. Scientists have long focused on species diversity as a barometer for the success of conservation initiatives. However, conserving not just species, but ecological functions is critical for ensuring ecosystem stability and resilience. Despite this, the functional role of threatened species has rarely been considered in conservation actions. To tackle this issue, we proposed a framework that consists of characterising per-clade functional diversity based on species traits, and applying our novel index (FUSE: Functionally Unique, Specialised and Endangered), which allows ranking species according to their contribution to functional diversity and extinction risk. We have applied this framework to threatened marine and terrestrial organisms, from marine megafauna to palms, and identified species and areas of highest priority for the preservation of ecological functionality. We expect our approach to be applied across different taxonomic groups, realms and spatial scales, ultimately allowing ecological functionality to move from theory to mainstream conservation practice.

607 AQUATIC PLANT TRAIT SYNDROMES WITH IMAGING SPECTROSCOPY

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Global change drivers re-distribute organisms leading to the emergence of novel trait syndromes that affect ecosystem functioning. However, mismatches in scales of data collection have hindered our understanding of trait syndrome dynamics. Imaging spectroscopy (IS) has shown many options to measure, map and monitor plant traits enabling unprecedented understanding of trait syndromes dynamics. Here we examine trait syndrome change over time for the Sacramento-San Joaquin river delta in California. We use IS data collected over two time series in 2004-2008 and again 2014-2019 to compute 88 vegetation indices, as well as estimating traits with single and multitrait models for emergent aquatic and riparian plant communities. We found that trait syndromes emerge for both emergent aquatic and riparian plant communities, which include traits related to pigments, leaf morphology and biochemistry, water, lignin, and cellulose content and salinity. We find consistent decreases in trait values between the two decades: Chlorophyll and pigments decrease for emergent and increase for riparian, LAI decreases for both, while water stress, water thickness and salinity increase for both. Emergent plants show stronger changes of trait syndromes between the two periods of time in comparison to riparian, suggesting stronger effects on ecosystem functioning. Our proposed framework could a better understanding of conditions under which trait syndromes vary and be expandable to other ecosystems.

BEF2-b - Functional diversity in space and time: measurements, models and experiments to advance trait-based ecology

445 MAPPING FUNCTIONAL DIVERSITY OF FORESTS USING SENTINEL-2 AND GEDI DATA

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Ecosystem functions are strongly linked to plant functional traits (morphological, physiological or phenological features of organisms) and corresponding functional diversity. Previous studies based on airborne LiDAR and imaging spectroscopy have illustrated the capacity to map functional traits and diversity at individual-tree or pixel level in forest. However, acquiring airborne data over larger space and time scales is often too costly. With high spatiotemporal resolution, Sentinel-2 satellite imagery has shown great potential to estimate functional traits and upscale functional diversity from site to regional or global scale. In this study, we retrieved physiological traits related to forest growth, drought stress and productivity from Sentinel-2 spectral data based on vegetation indices, partial least square regression and the PROSAIL radiative transfer model in a species-rich subtropical forest in China. We assessed the performance of different models by comparison with in-situ plot-level data. We also explored the use of NASA's global ecosystem dynamics investigation (GEDI) spaceborne LiDAR data, combined with Sentinel-2 optical imagery and machine-learning algorithms for mapping morphological traits continuously across large areas. Finally, we calculated commonly-used functional richness and divergence indices to assess functional diversity based on

spaceborne per-pixel functional trait values, and compared these to airborne-based assessments of functional diversity.

239 LAND-USE CHANGE EFFECTS ON FUNCTIONAL DIVERSITY USING MECHANISTIC SIMULATIONS

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Land-use change remains the main driver of biodiversity loss, with fragmentation and habitat loss expected to exacerbate population declines and biodiversity loss. We apply a R package for a spatially-explicit mechanistic simulation model (RangeShiftR), which incorporates habitat suitability, demographic as well as dispersal processes to understand temporal effects of land-use change (land-use harmonization scenarios for the 1850-2100 period) on abundance and richness of functional groups of mammalian species in South-Asia. Preliminary results suggest a drop in species abundance particularly throughout the 20th century when rangelands and crop area considerably increased throughout South-Asia, reducing primary habitats. Our approach is innovative in assessing how land-use scenarios can influence animal populations through underlying ecological processes.

441 MULTI-TEMPORAL IMAGING SPECTROSCOPY DATA PROCESSING CHAIN FOR ESTIMATING BIOMASS

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Ecosystem monitoring requires high-spectral, spatial and temporal resolution remote sensing data and analyses to provide reproducible and reliable estimates of change. Explicitly, biodiversity state changes measured in plant functional traits can lead to a better interpretation of ecosystem processes on a multi-temporal scale. Nevertheless, few studies have so far benefitted from high temporal resolution imaging spectroscopy (IS) data. Acquired spectral measurements at different times across years are potentially subject to inter-seasonal variations. Therefore, there is a need for a consistent multi-temporal IS data processing chain across years.
The study aims to assess a chain of data processing to minimize multi-annual IS data quality disturbances caused by instrument, acquisition and data processing-related factors, including radiometric, atmospheric, and geometric compensations in a high Alpine ecosystem. Having no human intervention, the Swiss National Park (SNP) bears the potential to analyse biodiversity dynamics in space and time. Results show that the effects of the multi-temporal IS data corrections are relatively well resolved for the SNP. We find that the statistical model well predicts inter-annual aboveground biomass explained by the number of growing degree days and location of the alpine grasslands. Results already show that IS data in the multi-temporal domain enable estimating important traits to expand our understanding of ecosystem dynamics.

520 FOREST FUNCTIONAL DIVERSITY FROM PRISMA IMAGES WITH A TRAIT-BASED APPROACH

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Remote sensing data have been used with different degrees of success to monitor changes in functional diversity during the last few decades. Here, we investigate the potential of hyperspectral data collected by the PRISMA satellite of the Italian Space Agency in providing information on functional diversity of mixed forest ecosystems. In particular, we exploited PRISMA data to develop a hybrid retrieval workflow to map forest trait and to analyse the spatial patterns of plant functional diversity. The hybrid retrieval scheme combined physically based radiative transfer models with machine learning regression algorithms to learn the relationships between the simulated spectra and the input variables. A combination of leaf and canopy traits were then used to compute information theory metrics to characterise forest functional biodiversity. The patterns in the functional diversity maps were discussed in relation to several factors, expected to drive biodiversity changes in the study areas.
The results obtained in this study demonstrate that the retrieval of a broad set of leaf and canopy traits from space using hybrid retrieval schemes is feasible, paving the way for future operational algorithms for the routine mapping of vegetation traits from spaceborne sensors. Also, we showed that the use of hyperspectral reflectance can improve our ability in biodiversity mapping compared to state-of-the-art measures based on broad band vegetation indices available from current platforms.

306 FUNCTIONAL DIVERSITY AT LANDSCAPE SCALES USING SENTINEL-2 IMAGERY

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The increasing need for continuous global information on the biodiversity of Earth's forests calls for new approaches using satellite data. As an important dimension of biodiversity, advancing our scientific understanding of functional diversity of forest traits on regional to global scales contributes to assessing the impact of environmental change on ecosystems. How to link functional diversity maps derived from satellite imagery to in-situ measurements of biodiversity remains unclear.
We present an approach to upscale, map, and quantify functional diversity from physiological traits derived from Sentinel-2 data in temperate forest ecosystems of Canton Aargau (around 500 km2 of forests) in Switzerland. Based on physiological forest traits related to forest health, stress, and potential productivity, we derive a cantonal map of forest functional diversity working towards the direct comparison of forest patches throughout the landscape and providing the base for analysis of the changes over time. Comparing biodiversity monitoring data from in-situ measurements to functional diversity maps from Sentinel-2 data will provide answers to the question of how in-situ measures of biodiversity link to functional diversity measures derived from space. Our results will provide important information about the method's potential and open up new possibilities for large-scale interpretation.

91 HOW FUNCTIONAL DIVERSITY HELPS EUROPEAN NATURAL FORESTS TO RESIST CLIMATE CHANGE

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Functional diversity can increase stability and ecosystem functions in plant ecosystems via trait complementarity. Being mostly observed in grasslands[1], respective knowledge for forest ecosystems is still anecdotal. Yet, functional diversity also affects plant competition in resource-limited ecosystems leading to competitive exclusion which might increase in the face of climate change[2].
Despite years of biodiversity-stability research in forest ecosystems, understanding how climate change would affect connections between functional diversity and stability is largely unclear.
We combine state-of-the-art vegetation modelling and machine learning to analyse the importance of functional diversity in temperate natural forests to resist climate change. More specifically, we investigate what helps trees to survive in the 21th century in a flexible trait-based dynamic vegetation model. We show how the importance of trait diversity changes depending on the tree layer.
Our results demonstrate that functionally diverse understoreys are important for natural forests to resist climate change, emphasizing the role of competition and environmental filtering for the best adapted trees to emerge.
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BEF2-c - Functional diversity in space and time: measurements, models and experiments to advance trait-based ecology

77 VISION TRANSFORMERS AS A NEW PARADIGM FOR PLANKTON CLASSIFICATION

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Plankton are found in aquatic ecosystems worldwide, and play a key role in maintaining ecosystem processes and the functioning of natural food webs. Because of their critical role, a high-frequency assessment of their community composition and abundance would be a major step forward. Besides its utility for water quality monitoring, this would allow us, for example, to address endeavours such as understanding the interactions between species in complex dynamic systems, and forecasting of harmful algal blooms which have significant impact on aquatic ecosystem services. To perform high-frequency monitoring we can use underwater imaging systems. However, since the high throughput of images makes manual annotation intractable, we resort to deep learning to identify the taxa captured by the camera. Until the present date, the state of the art was obtained through convolutional neural networks (CNNs). Here, we first show that by using more recent CNN architectures, with transfer learning and ensembling, we are able to slightly improve the performances with respect to previous work. Then, we show that by using a novel kind of architecture, vision transformers (VTs), we are able to outperform any previous attempts at plankton classification by a large margin. We find that the strong improvement obtained by VTs is consistent across all the datasets we study, and provide an intuition on why VTs perform better.

549 GLOBAL COMPARISON OF TAXONOMIC AND TRAIT-BASED COMPONENTS OF PLANKTON DIVERSITY

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Several terrestrial studies have suggested that gradients of functional and phylogenetic diversity are closely related, while those of functional and taxonomic diversity often diverge. In marine phytoplankton, however, different biodiversity components have rarely been compared across global space. Here, we consider the size-class richness of phytoplankton as a major component of trait-based marine biodiversity, as it influences the ocean's ability to sequester carbon and may promote the size based biodiversity of other taxa up the food chain. We found, on the basis of ecological niche models of 350 species, that global correlations between the size-class richness and taxonomic richness of phytoplankton range from 0.91 to 0.99
(Pearson's r) across key groups. Overall, the highest size-class richness emerged in tropical to subtropical areas, with certain groups showing maxima in the subtropics—known hotspots in the taxonomic diversity of higher trophic organisms. In sum, this suggests that size-based and taxonomic richness serve as surrogates in the phytoplankton at broad scales. To what extent such relationships are modified by competition and selection in turbulent ocean regimes and whether the size-based composition of multiple phytoplankton groups promotes higher trophic biodiversity awaits demonstration.

193 THE ROLE OF FUNCTIONAL DIVERSITY IN ECOSYSTEM REGIME SHIFTS

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Biodiversity can increase the resilience of ecosystems facing environmental change. However, we have limited understanding if this holds true for ecosystems that respond to gradual environmental change with abrupt regime shifts. Here we investigated if functional diversity can delay the collapse and accelerate the recovery of ecosystems that abruptly transition between alternative ecosystem states. As a case study, we used a mathematical model developed by Bush et al. (2017) which describes anoxic-oxic regime shifts of aquatic ecosystems mediated by cyanobacteria and sulphur bacteria. We extended this model so as to include functional diversity in either cyanobacteria, sulphur bacteria, or both. Specifically, we manipulated the amount of variation in environmental tolerance and in maximum growth rate, and explored how trait variation influenced anoxic-oxic regime shifts along a gradient of oxygen influx. We found that greater diversity with a functional group delayed its collapse but did not necessarily accelerate its recovery. Our results also illustrate that the effect of functional diversity on resilience can become smaller or even negative when both rather than only one of the functional groups vary in traits. Collectively, our findings highlight the importance of considering multiple interacting functional groups when predicting the effect of functional diversity on ecosystem resilience.

510 ECOLOGICAL EFFECTS OF MARINE EXTINCTIONS: FROM THE PLIOCENE TO THE ANTHROPOCENE

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The fossil record of the marine megafauna, the largest animals in the oceans, has revealed that in the Pliocene (~3Ma), habitat loss caused the extinction of one third of their genera, along with nearly one fifth of their functional diversity. Such a level of ecological loss contrasts with the almost negligible changes after the (mass) extinction of benthic invertebrates around the same time. Unlike the marine megafauna, small invertebrates can share similar ecological traits and thus be highly redundant and ecologically resilient in the face of extinction. The much larger marine megafauna, on the other hand, tends to be functionally unique and therefore highly vulnerable. Given that the Pliocene extinction left the marine megafauna functionally depleted, how will they respond to the current extinction crisis? Forty percent of marine megafaunal species are currently threatened. Simulated extinction scenarios forecast this could result in the loss of up to half of their ecological functions. Sharks, in particular, show greater-than-expected losses of functional diversity. Biogeographic analyses further indicate that megafauna functional richness is globally greatest along the tropical continental shelf and oceanic island environments. Meanwhile, high latitudes harbour the most functionally unique species. The protection of these areas could therefore help safeguard the key ecological functions these organisms play in marine ecosystems.

399 MACHINE LEARNING-ASSISTED MONITORING OF AN AQUARIUM IN KARLSRUHE, GERMANY

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Coral reef restoration projects play a critical role in maintaining and re-establishing marine biodiversity and ecosystem functioning. However, the reliable, seamless, and cost-effective assessment of the efficacy of restoration efforts remains challenging. In July 2016 an artificial reef was inaugurated in the State Museum of Natural History Karlsruhe, Germany. To assess the evolution and effect of the submerged structure and to broadcast live footage, the Museum installed one low-cost Spot X Underwater Vision camera that continuously streams high-resolution video of the aquarium. The Nature Counts Foundation extracted images from the video feed and developed a fish species detector (convolutional neural network) based on 8 of the 34 species in the aquarium. The detector was able to reliably detect all of the species richness in the test set and almost half of the aquarium's fish functional diversity. This preliminary analysis can be used to demonstrate 1) the capabilities of machine learning-driven computer vision for biodiversity monitoring, and 2) the potential of high frequency, long-term monitoring for reliable conservation and restoration assessment. Our vision is to deploy similar low-cost, cutting-edge monitoring systems and open source software to equip scientists, conservation and restoration practitioners, and stakeholders with powerful tools for monitoring, analysis, and decision making that will ultimately benefit the world’s reefs and oceans.

65 PATTERNS AND DRIVERS OF ZOOPLANKTON FUNCTIONAL DIVERSITY IN THE GLOBAL OCEAN

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Terrestrial functional diversity patterns have been extensively studied over the last decade whereas marine clades other than coastal fishes have been understudied. Patterns of marine plankton functional diversity remain poorly documented although they form the basis of marine food webs. We aim to fill this gap by modelling the global

distribution of functional diversity for marine planktonic copepods. Five functional traits (body size, myelination, spawning mode, feeding mode, trophic group) of >300 copepod species were used to define functional groups. An ensemble of distribution models were used to estimate the species' monthly habitat suitability patterns and compute complementary functional diversity indices. Indices of functional dispersion (FDis and Rao's Q) increase from the poles to the equator and peak in tropical oligotrophic gyres whereas functional evenness (FEve) shows the opposite pattern. Our results show that copepod traits are more evenly distributed in cold and productive conditions whereas warm and oligotrophic ones favour the coexistence of very dissimilar functional groups. Richness-based indices (FRic and sesFRic) are lower than expected in the tropics, suggesting that tropical conditions filter out certain traits (e.g., larger body sizes and active feeding modes) that are favourable at high latitudes. Our study constitutes a key step towards a better understanding of biodiversity-ecosystem functioning relationships in the open ocean plankton.

BEF3 - Climate change impacts on biodiversity and ecosystem functioning: Lessons learned from climate change manipulation experiments

171 HEATHLAND ECOSYSTEM FUNCTIONING UNDER A GRADIENT OF CLIMATE CHANGE SCENARIOS

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Heathland ecosystems provides critical ecosystem services such as regulation of climate, purification of water and recreation. Climate change will impact on heathland ecosystems by affecting plant- and soil-associated communities, which, in turn, might impact on the functions and services provided by the ecosystem. Using an ecotron facility, we exposed 10-ton dry heathland macrocosms to six different levels of climate change, ranging from least to most severe. These six levels corresponded to local projections of climate models of the RCP8.5 scenario at different timepoints (1951-1955, 2009-2013, 2026-2030, 2042-2046, 2063-2067 and 2086-2090). The model projections included changes in air temperature, relative humidity, precipitation, wind speed and atmospheric CO_2 concentration. We then measured ecosystem response through net ecosystem exchange (NEE), evapotranspiration (ET), methane and N_20 balance, water quality, plant communities, plant phenology and structure and functioning of microbial communities. We will present the results of the first two years of the experiment.

293 DROUGHT ACCELERATES LOCAL EXTINCTION AND ERODES MOUNTAIN PLANT COM. STABILITY

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Warming of mountain regions is projected to be three times faster than the global average. Few studies have reported species loss in mountain plant communities, and even fewer have explored mechanisms facilitating the colonization by novel species. Despite this apparent high resistance to climate change, mountain communities are likely

generating an "extinction debt". Following five years of exposure to downslope climates, we track translocated plant-soil communities and their novel competitor interactions at the trailing range edge of mountain plant communities. We found increasing species turnover under two warming scenarios with time. Gradual extinction of native species was followed by the colonization by novel species after a severe drought year in the third year of exposure. Here, the mechanism facilitating novel species colonization in mountain communities was not competitive pressure but a direct environmental filter. We show a time lag between the extinction of native species and the colonization by novel species which can be explained by interacting climate stressors, here warming and drought, pushing communities to a certain threshold increasing their susceptibility to colonization. Destabilized and thinned communities provided a window of opportunity for novel species to enter. Our study provides experimental evidence of the payment of extinction debt in mountain plant communities revealing abrupt threshold dynamics in a long thought inert system.

87 SUSTAINABLE LAND USE MITIGATES THE BELOWGROUND CONSEQUENCES OF CLIMATE CHANGE

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Global environmental changes threaten biodiversity and the functioning of ecosystems. However, we know remarkably little about the effects of multiple, interacting global change drivers on soil biodiversity and functions. In this context, it is important to understand how our management decisions influence biodiversity and ecosystem services under future climate conditions. Although low-intensity land use and nature protection are expected to support higher levels of biodiversity and a more stable provision of ecosystem services, empirical evidence for soil biodiversity is scarce. Recent results from a large-scale climate change experiment in different land-use types suggest that low-intensity land-use in cropland and grassland may indeed benefit soil organisms and buffer detrimental climate effects in the long term. Moreover, meta-analyses show that the combined application of multiple pesticides is particularly harmful for soil biodiversity and that the consequences of biodiversity change are especially significant when human activities decrease soil biodiversity. At the same time, common nature protection actions may not be sufficient to support higher levels of soil biodiversity and functions. The new Soil BON initiative is an international soil monitoring program based on essential biodiversity variables that can act as a standardized warning system of how successful different nature conservation measures are in protecting soil biodiversity and ecosystem services.

146 LARGE-SCALE EXPERIMENTAL INFRASTRUCTURES FOR BIODIVERSITY RESEARCH: ANAEE

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Biodiversity is an ecosystem property governed by drivers and processes at large spatial and temporal scales, such as climate and land use change, dispersal, and succession. This challenges the inherent size and time limitations of controlled experiments, in particular when ecosystems need to be exposed to predicted future changes such as elevated CO_2, climate-warming or shifting precipitation to assess their impact. Moreover, such studies are conducted in a wide variety of experimental facilities, raising the

question how to harmonize their collaborative use in joint efforts targeting broad geographical coverage. This presentation explores these issues and presents a European research infrastructure for experiments on ecosystems, AnaEE (Analysis and Experimentation on Ecosystems), under the umbrella of the European Strategy Forum on Research Infrastructures (ESFRI). We discuss
(i) how individual open-air and enclosed AnaEE facilities have recently advanced research on the interaction between biodiversity and climate change,
(ii) where current technology and experimental approaches are still limiting for biodiversity studies, and
(iii) how multiple facilities spread across Europe could collaborate in coordinated distributed experiments that exploit both their differences and common features. Finally, we highlight the role that supranational service centres of international research infrastructures could play in advancing experimental biodiversity studies.

259 GRASSLAND RESILIENCE TO DROUGHT MODULATED BY BIODIVERSITY AND INVASIVE SPECIES

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Extreme weather events and the presence of invasive species can act as pressures threatening biodiversity, resilience and ecosystem services of semi-natural grasslands. On the other hand, biodiversity itself may buffer ecosystem functioning and services against change. Here, we summarize results of the BiodivERsA project 'SIGNAL', addressing the interaction of three major global changes: biodiversity, climate change, and invasive species. The project made use of coordinated experiments across Europe to increase the scope and relevance of the results, combined with a meta-analysis and literature review. We found that aboveground biomass production declined due to experimental drought, with species richness not affecting resistance but promoting recovery. However, invader presence turned the positive and stabilizing effects of diversity on native species recovery into a neutral relationship. Our broad literature review and meta-analysis revealed varying impacts of biodiversity on the stability of ecosystem functioning in the face of drought and extreme rainfall. Several explanations are put forward, from stress thresholds to biotic interactions and community assembly. In general, SIGNAL results suggest that promoting or protecting biodiversity can be beneficial in protecting grasslands from adverse climate extreme impacts, although tailored management is likely necessary to take into account the complexity of diversity effects.

444 PLANTS AND SOIL: THE FASTER LIFE OF ALPINE GRASSLANDS UNDER EXPERIMENTAL WARMING

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Increase in temperature, longer growing seasons, and earlier snowmelt change above and belowground life in mountain ecosystems. Transient responses of the different ecosystem components can serve as early warning signals of long-term impairments and cascading effects.
We simulated 3°C of warming in the French Alps by transplanting alpine grassland communities (2450m) with 20cm of their soil to subalpine conditions (1920m). We studied vegetation and soil functioning after four years of warming and compared them to alpine controls (warming effect) and subalpine controls (acclimation lag).
Our results show a functional shift from a conservative to a more exploitative strategy. While the strength of environmental filtering decreased, warmed plant communities became more productive and taller. In the soil, bacterial biomass increased and microorganisms invested more into carbon than nutrients. Yet, most studied ecosystem components were still far from subalpine controls showing acclimation lags. Thus, warmed communities are still prone to competitive exclusion when co-occurring with subalpines. Our recent analysis of the root-microbial associations will also reveal their response on the collaborative vs. do-it-yourself strategy gradient under warming.
Finally, we will examine how strongly the different ecosystem components are correlated with each other and if warming can break these linkages and thus, potentially impair the stability of the feedback systems.

267 CLIMATE AND NITROGEN EXPERIMENTS ON SENSITIVITY OF GLOBAL SHRUBLANDS

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Increasing climate change and nitrogen deposition are expected to alter vegetation structure and functioning globally, yet the experimental evidence of changes in species diversity, composition and functioning of global shrublands to these drivers are not systematically quantified.
We conducted a global meta-analysis on the sensitivity of vegetation structure (e.g species richness, plant cover, density, Shannon index) and functions of aboveground biomass and net primary productivity for 80 shrubland communities to experimental warming, precipitation shifts (e.g. drought and irrigation) and nitrogen addition.
We observed that both vegetation metrics relate to plant structure and functions are sensitive to climate and nitrogen addition, especially in warming and irrigation experiments. The sensitivity of AGB and ANPP are negatively correlated with the site mean annual precipitation (MAP) and aridity index (AI), with high sensitivity at the dry and/or arid sites. There is no clear correlation between for the sensitivity of vegetation structure metrics and habitat background climate. Moreover, there is no differences between short-term (1-4 years) and long-term (over 10 years) for the sensitivity of vegetation structure and function metrics.
There is high sensitivity to climate and nitrogen addition for the shrub communities in water-limited sites, and further work should focus on the ecological consequence by structure and functional changes.

235 SOIL FAUNA DRIVES VERTICAL REDISTRIBUTION OF SOIL ORGANIC CARBON UNDER DROUGHT

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Summer droughts strongly affect soil organic carbon (SOC) cycling, but net effects on SOC storage are unclear. Here, we explored the overlooked role of soil fauna on SOC storage in forests, hypothesizing that soil fauna is particularly drought-sensitive, thereby reducing litter incorporation into the mineral soil and, eventually, long-term SOC storage. In a drought-prone pine forest (Switzerland), we performed a large-scale irrigation experiment for 17 years and assessed its impact on vertical SOC distribution and composition. We also examined litter decomposition of dominant tree species and determined soil fauna abundance and community composition.
Long-term irrigation resulted in a C loss in the organic layers and a comparable C gain in the mineral soil and thus did not affect total SOC stocks. Irrigation increased the litter mass loss more strongly when meso- and macrofauna were included (+215%) compared to excluded (+44%). The enhanced faunal-mediated litter decomposition was paralleled by a many-fold increase in the abundance of meso- and macrofauna. Moreover, irrigation led to a shift in Acari and Collembola community composition.
Our study shows that soil fauna is highly sensitive to natural drought, reducing the incorporation of C from organic layers to the mineral soil. In the longer term, this potentially impacts SOC storage, decreasing the C stored in mineral soil, and therefore, soil fauna plays a key role in shaping SOC responses to drought.

CIT1-a - Towards Blue Green Cities: nature-based solutions for enhancing urban ecology

100 CONTRIBUTION OF SCIENTIFIC CONNECTIVITY ASSESSMENTS TO GREEN INFRASTRUCTURE (GI)

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Green infrastructure (GI) provides functional networks of habitats and ecosystems to maintain biodiversity long-term, while at the same time optimizing ecosystem functions and services to meet human needs. Scientific connectivity studies are informed by movement ecology with species-specific attributes of the type and timing of movement (e.g., dispersal, foraging, mating) and movement distances, while spatial environmental data help delineate movement pathways across landscapes. To date, a range of methods and approaches are available that are relevant across any organism and movement type independent of time and space scales and are ready-to-use as standalone freeware or custom GIS implementation. However, to enhance the robustness of connectivity assessments and ensure that current trends in connectivity modeling contribute to GI with their full potential, common denominators on which to ground planning and design strategies are required. Likewise, comparable, repeatable connectivity assessments will be needed to put results of these scientific tools into practice for multi-functional GI plans and implementation. I discuss use and limitations of employed data, tools and methods used in scientific connectivity assessments contributing to GI.

44 HOW WILD BEES FIND A WAY IN EUROPEAN CITIES

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Urban ecosystems habour sometimes diverse wild bee assemblages, partly because of their rich and diverse floral resources, composed of both native and exotic species. However, how wild bees use the existing urban resources is still little studied. A better understanding of the urban bee diet, particularly at the larval stage, is necessary to improve the management and planning of urban floral resources in order to promote wildbees. We investigated the larval diet and distribution patterns of four solitary wild bee species with different diet specialization along urban intensity gradients in five European cities (Antwerp, Paris, Poznan, Tartu and Zurich) using two complementary analyses: Using trap-nests and pollen metabarcoding techniques, we characterized the species' larval diet, assessed diet consistency across cities. In addition, we modeled the distribution of wild bees using species distribution models (SDMs). Our results demonstrate that urban wild bees display different successful strategies to exploit existing urban floral resources including broad generalism, intermediate generalism and specialism. Furthermore, SDMs showed that wild bee distribution ranges inside urban ecosystems ultimately depend on their degree of specialization.

294 "FROM GREY TO GREEN" – HOW BGI INCREASES BIODIVERSITY, A CASE STUDY!

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Heavy rain events, heat stress, periods of drought or the loss of species, just to name a few topics, are on everyone's mind at the moment. These are not trending words; rather all these problems and developments are related to climate change. This has a strong influence on the design of our landscape, especially in urban areas. What will the cityscapes of the future look like?
In order to make our cities climate-resilient, we need a landscape that can be more than just beautiful! Through the use of Blue Green Infrastructure (BGI), so-called "sponge cities" are developed creating a more natural water balance, as well as positive influences on biodiversity, heat islands and the quality of life for people.
A pilot project in Singapore, called Kallang River, shows how river restoration can help to redevelop a conventional drainage system into a meandering naturalized river. This river is designed to have a positive impact on climate change and ecology. The revitalization of Kallang River in Bishan – Ang Mo Kio Park shows the positive effect of BGI on ecology, society and especially on the biodiversity.
I will share my experience as the Project Director for Kallang River along Bishan – Ang Mo Kio Park. Over 10 years in Singapore I was able to develop the project from the first workshops to the opening. Further, I had the opportunity to observe the use of the park by the residents and visitors in the following years.

131 LET´S GET TOUCHED –HUMAN-NATURE RESONANCE FOR A FLOURISHING LIFE IN CITIES

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Despite increasing efforts by research and policy to approach sustainability, human impact on nature is intensifying the current social-ecological crisis. To foster sustainability transformation, there is the need to re-think qualities of responsive and reciprocal human-nature relations, in particular in cities where the physical and mental distance between human and nonhuman nature is resulting in mute human-nature connections. By introducing the concept of human-nature resonance, the presentation will debate on the importance of and capacities for responsive human-nature relations, which foster a human-nature partnership in cities and beyond. The concept of human-nature resonance emphasizes the significance of external and internal affections by the social-ecological crisis to foster responses for sustainability transformation and global justice. Under the light of human-nature resonance, it needs then in particular internal relational capacities (e.g., empathy, compassion, solidarity, self-reflection) to bridge the often external (i.e., material and experiential) distance between an urban Western lifeworld and its lacking local implications of the global social-ecological crisis. In the end, the presentation will discuss potential affect-laden sustainability interventions for individual and collective urban actors. A special focus will be laid on interventions that can strengthen nature´s unavailability by acknowledging her intrinsic value, sentience and intelligence.

531 IMPLEMENTING THE ECOLOGICAL INFRASTRUCTURE SUPPORTED BY DATA-BASED METHODS

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The development of the ecological infrastructure is a central concern of the Swiss Biodiversity Strategy, which is based on the Strategic Plan for Biological Diversity of the United Nations, in particular the Aichi Targets of the Nagoya Conference (2010). Competition from a wide variety of use demands is very high, given the limited space in Switzerland. The Canton of Aargau, located near the urban centers of Zurich, Basel and Bern, is characterized by peri-urban and rural areas, with a population density that is twice the Swiss average. Consequently, it is very challenging to realize the new areas of high ecological value that are required to create a functioning ecological infrastructure. We present here our systematic procedure for the planning and implementation of the ecological infrastructure in the Canton of Aargau. The planning is done supported by data-based methods, especially GIS and remote sensing and supplemented with expert-based approaches. Spatial planning instruments play a central role in the implementation. We address the conflict and synergy potentials in peri-urban areas, show possible solutions and compare them with the possibilities in rural areas.

530 ASSESSING THE POTENTIAL OF URBAN ECOSYSTEMS TO PROMOTE NATIVE WILD PLANTS

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The global decline in biodiversity also affects Switzerland with its high species diversity of about 2700 vascular plants, over 1000 mosses and the associated diversity of fungi, lichens and animals. Almost half of all vascular plants in Switzerland – 44% – are either potentially endangered, threatened or even extinct. Under a "business-as-usual" scenario, there is a high probability that this negative development will continue. To halt and reverse this continuing loss of biodiversity, new measures are therefore required that include the urban landscape. Urban areas with their high diversity of (replacement)

habitats offer an opportunity to promote wild plant species and their ecosystem services. An urban structure that has a high level of biodiversity also guarantees high resilience to the challenges of climate change and offers health and economic benefits for the population. While specific biodiversity targets and implementation priorities exist at national level for rare species, rare and priority habitats and for biodiversity in agricultural areas and forests, there is still no list of target habitats and species in urban areas under current and future climate conditions. With this project we would like to close this gap. In addition to rare and endangered species, it therefore seems sensible to consider species in urban areas that can be efficiently managed, provide important ecosystem services and have a high aesthetic potential.

192 BLUE-GREEN INFRASTRUCTURE TO ENHANCE BIODIVERSITY IN HUMAN DOMINATED LANDSCAPES

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Increasing urbanization degrades quantity, quality, and the functionality of spatial cohesion of natural areas essential to biodiversity and ecosystem functioning worldwide. The movability of wildlife is especially challenged in fragmented and artificial landscapes due to the uncontrolled pace of building activity and erosion of blue-green spaces. Local scale measures, such as nature inspired engineered instruments, referred to as Blue-Green Infrastructures (BGIs) are emerging mitigation solutions. Initially planned to promote adaptation to climate change and improve human livability in cities, such instruments offer increasingly interesting synergies for biodiversity. BGIs are especially appealing for globally declining amphibians, a rich and diverse vertebrate assemblage sensitive to urbanization. We sought to combine biological and highly resolved urban-rural land-cover data, ensemble models of habitat suitability, and connectivity models based on circuit theory to improve multiscale and multispecies protection of core habitats and ecological corridors in the Swiss lowlands. Our results indicate that cities can also make a substantial contribution to wider landscape habitat connectivity for multiple species. It is important to plan BGIs at strategic locations in urban and peri-urban areas to increase the permeability and availability of 'stepping stone' habitats in densely populated landscapes to promote habitat connectivity and enhance broad landscape biodiversity.

CIT1-b - Towards Blue Green Cities: nature-based solutions for enhancing urban ecology

248 URBAN ENVIRONMENTAL ACUPUNCTURE (UEA) SUPPORTING SUSTAINABLE BGI IN URBAN AREAS?

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Urban blue-green infrastructure (BGI), like parks, gardens, forests, fields and greenways provide important services for urban residents. However, for many European cities, because of the need for housing and economic growth, it is a challenge to allocate large land areas as green space. In contrast, smaller areas such as courtyards, wastelands, roofs and roadsides are often available.
One approach for the improvement of urban BGI could be the concept of urban environmental acupuncture (UEA). Behind this concept lies the idea of triggering major effects on the development of cities through small targeted interventions in their structure. Aiming on improving the function of cities, the concept of UEA has already been used in various parts of the world. The advocates of this approach try to identify the "acupuncture points" (i.e. certain sensitive places) that are important for the city organism in order to apply the "needles" (specific measures) that are necessary to solve the respective problems.
The "SALUTE4CE" project, funded by the European Union (2019-2022), examines the extent to which this approach could be applied to urban BGI by developing small green spaces (ca. 0.2 ha) in four European cities using the UEA-concept.
In the lecture the UEA-concept will be critically discussed as a possible approach to transformation pathways towards more sustainable BGI in urban areas. Some examples for implemented UEA action plans in cities will be shown.

317 SOCIAL-ECOLOGICAL NETWORKS TO UNDERSTAND THE MANAGEMENT OF URBAN GREEN SPACES

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Among the greatest challenges of the Anthropocene are unprecedented high rates of urbanization with impact on biodiversity and related consequences for safety and quality of life. The growing concern about the global loss of biodiversity clearly requires a more active role of cities to facilitate and ensure the long-term persistence of biodiversity. Recently, urban green areas (UGA) have been attributed a key role in urban biodiversity management. UGA encompass short-term vacant lots, vegetated rooftops, highly managed and persistent parks and cemeteries, or new habitat such as vertical green walls. The combination of different types of UGA can be considered a spatially dynamic habitat network with different types of interactions among them (species movement, pollination, etc.). Networks or UGA thus potentially provide functional green infrastructure supporting both, ecological habitat and human needs for safe, resilient and sustainable cities. Social-ecological networks (SEN) have been suggested to help disentangle and analyze such complex social-ecological systems. SEN combine the ecological networks with social networks among stakeholders relevant to the management and governance of ecological issues, such as biodiversity. The capacity of addressing UGA and related biodiversity in cities thus depends on the different structures and functions of social, ecological, and social-ecological interactions.

416 A SOCIO-ECOLOGICAL STUDY OF BLUE-GREEN BIODIVERSITY AT THE URBAN-RURAL INTERFACE

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Blue-Green Infrastructures (BGIs) provide multiple benefits to cities and their inhabitants –human and non-human. The potential of these measures to address issues such as flooding, extreme heat, air and water quality, and well-being, received growing recognition in recent years. Their potential to support biodiversity has received less attention. While urban areas often lead to the degradation and fragmentation of natural habitats, interventions such as multifunctional BGIs can be spatially planned and designed to enhance both local and broader landscape biodiversity. For such interventions to be effective, it is crucial to identify optimal implementation spaces based on ecological approaches. Yet, they also require supportive governance arrangements that span across the urban area and beyond, integrating actors across multiple sectors and levels. Little is known on the interactions between the social and ecological dimensions of BGIs, especially when these are spanning across heterogenous landscapes. Focusing on case studies across a rural-urban gradient, we use social-ecological network approaches to examine the governance implications of planning, designing, and implementing BGIs for biodiversity enhancement, and how actors and actor interactions shape these interventions. Through surveys, interviews and stakeholder workshops, we explore challenges and identify transformation pathways for more sustainable ecosystem governance at the urban-rural interface.

389 ENGINEERING BLUE-GREEN SYSTEMS TO IMPROVE BIODIVERSITY: A PERSPECTIVE AND REVIEW

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More than ever, cities are called upon to help mitigate the biodiversity crisis and tackle the consequences of global changes, including climate change. From an ecology perspective, urban green and blue spaces, such as parks, gardens, green roofs, streams and ponds, are key to providing suitable living conditions for functionally diverse biodiversity. From an engineering context, these same spaces, referred to as "blue-green infrastructure", are crucial to managing multiple urban challenges, which primarily include stormwater management and urban heat mitigation. These Blue-Green Systems (BGS) can provide multiple benefits; however, this information is often fragmented throughout the literature, especially between biodiversity enhancements of "green" versus "blue" systems. Integrated solutions can arise from collaborations between different stakeholders and experts, such as environmental engineers and ecologists. However, we still lack a common, interdisciplinary language and understanding to enable these unified blue-green solutions. Environmental DNA (eDNA) is novel way to study biodiversity, which might help to link blue and green compartments and enhance collaboration between stakeholders. Here we propose a review about the potential of BGS to harbor species diversity. We focus on three objectives:
1) the importance of biodiversity in cities,
2) how BGS can help conservation efforts, and
3) how eDNA can be used to quantify urban biodiversity.

466 FOSTERING URBAN BIODIVERSITY VIA MEDIA-TECHNOLOGICAL DESIGN INTERVENTIONS

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This contribution will present an interdisciplinary approach to fostering biodiversity in peri-urban contexts via intermediate results of the ongoing (2020-2024) SNF-funded design research project "Mitwelten. Media-ecological Infrastructures for Biodiversity" (https://www.mitwelten.org/). Its goal is to develop and test media-technological infrastructures, design interventions and participatory strategies in close collaboration with practitioners in three field studies involving ecology, cultural studies, landscape architecture and engineering. The second field study in Basel-Klybeck's (former) harbor area will be the focus of this presentation. It investigates how the local network of blue-green infrastructures can be fostered while creating new experiences engaging humans in nature conservation. The analysis of the interplay of ecological and social entanglements of urban structures and elements with interactive GIS data includes an exploration of the internal connectivity of the BGI network as well as its external connectivity within city and region. Strategically placed sensor arrays and a citizen science project are evaluated as permanent elements of biodiversity monitoring. Exemplary interventions utilizing a sensor-actuator network include a multifunctional bus stop, a set of outdoor furniture which combines habitecture with educational media and a guidance system to coordinate interspecies encounters and mobility.

52 INTEGRATION OF LANDSCAPE ECOLOGY AND URBAN MODELS FOR BIODIVERSITY ENHANCEMENT

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Urban sprawl is a major driver of habitat degradation and fragmentation, resulting in declines in biodiversity worldwide. Blue-green infrastructures (BGI) can be highly relevant for maintaining a backbone of connected habitats. However, they are generally planned for other functions. This is partly because urban models (i.e. UrbanBEATS), which rely on spatial networks of dataset blocks representing local neighborhoods, lack ecological information; while landscape connectivity models, which are generally based on high-resolution raster grids and computationally intense operations, do not adequately represent urban space. As part of the Swiss Blue-Green Biodiversity Research Initiative, this study addresses the need to integrate the merits of landscape ecology with detailed urban planning, including a case study in the cantons of Zürich and Aargau and focusing on four ecologically distinct amphibian species. First, we assess the performance of different spatial representations and resolutions to model circuit theory-based connectivity and simplify the model setup. Then, we apply spatial network analysis methods to identify minimum spanning trees and critical nodes for connectivity support. The results are illustrated in a BGI opportunity map for biodiversity preservation. Our findings will guide the development of a biodiversity module in UrbanBEATS and aim to provide practitioners with an optimized methodological framework for strategical BGI implementation in urban settings.

378 SOCIAL RESILIENCE AND COMMUNITY GARDENING DURING THE COVID-19 PANDEMIC

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Urban green spaces like community gardens received increased attention during the COVID-19 pandemic. Drawing from an ethnographic study on participating in community garden activities in Edmonton, Canada and inputs from 194 gardeners and 20 garden coordinators, this paper captures the experiences of creating community during a pandemic. Garden coordinators had to rethink and rework their operating styles in keeping participants physically apart but socially connected. Participants confirmed that garden activities provided respite from the pandemic restrictions. Findings also indicate that some participants missed group activities like work bees and potlucks while others were able to re-create community in digital spaces and in chanced and informal interactions. This study draws from and subsequently contributes to the existing literature on social resilience provided by community gardens during and after a crisis event. It also provides policy recommendations on how the city administration can help facilitate garden activities during times of disruptions.

593 BLUE-GREEN INFRASTRUCTURES AND URBAN ECOLOGY IN SUPPORT OF CO-HABITATION DESIGN

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Blue-green infrastructures (BGI) are nature-based solutions ranging from engineered technologies to strategic spatial planning. With climate change and urbanization threatening global biodiversity, human health and the sustainability of cities, many have recognised the potential of BGI as climate-adaptive solutions, providing multi-functionality in integrated spaces. The architectural design of urban spaces to accommodate both human-dominated activities and natural habitats is an emerging paradigm that has been gaining traction in parallel with BGI, a concept referred to as co-habitation or co-existence. However, how co-habitation can be realised through effective urban design remains underexplored and often with little backing from emerging knowledge and tools in scientific disciplines, which are progressively helping us to understand the complex interactions of urban and regional ecologies. This study reflects upon an interdisciplinary collaboration between engineering, ecology and architecture and explores how BGI knowledge, integrated assessment tools, (e.g., geospatial modelling, ecological and landscape connectivity modelling) were used to guide architectural design ideas for an area in the city of Bern, Switzerland. We will discuss how the investigation of spatial relationships and regional ecologies helped inform site planning, BGI solutions and test radical design ideas in an attempt to provide a sustainable, ecological, and liveable new urban environment.

CIT3 - Urban Biodiversity – European best practice examples for a better future

628 URBAN BIODIVERSITY COUPLING STRATEGIES, PRIVATE DEVELOPMENT ACTIONS IN HUNGARY

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Environmental, anthropogenic as well as cultural and socioeconomic drivers vary at different densities which influence patterns of urban biodiversity. Biodiversity on the city level is closely linked to climate adaptation and resilience. The shape and quality of urban biodiversity is driven by top-down and bottom-up motivations. The top-down processes are analysed by Hungarian cities' Sustainable Energy and Climate Action Plans, the actions what Hungarian regions, cities and settlements are committed to in relationship to city-scale biodiversity indicators. A comparison is shown how priorities change as urban density grows. The bottom-up initiatives are shown by survey results of the Hungary Green Building Council's real estate and construction sector's members' priorities in sustainability and climate change. Although the private sector weighs more mitigation in their actions, local regulations and green building certifications require biodiversity considerations. The highest valued options of private real estate developments are discussed according to building scale indicators. The challenge is to find the synergy between the public and private actions. The city-scale targets and decisions and building-scale motivations are discussed to show the best interrelationships, the win-win situations and the most critical ones. Some good examples of coupling in Hungary will be presented.

249 MUNICIPAL BIODIVERSITY STRATEGIES – SOLUTIONS FOR HARMONIZED URBAN NATURE

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In cities diverse habitats and a high diversity of animals and plants can be found, being an important base for ecosystem services and the quality of urban life of residents (e. g. climate adaptation, food production, recreation, social interaction, nature experience, culture, health care, social relationships). It has become increasingly clear that quality of life, well-being of citizens and sustainable living depend on nature and biodiversity, but at the same time, the high density of uses and the dynamics of settlement are a threat to biodiversity. Which urban development and solutions have succeeded to tackle this conflicts?
Municipalities have a great responsibility for the protection and development of biodiversity on their territory. This challenge must be addressed systematically with suitable planning strategies and instruments. Even though there are planning and implementation approaches to promote biodiversity in many cities, there is often a lack of overarching strategies and integrated planning that take into account a city-wide approach in particular and also consider inner urban areas and the urban stock.
Hence, in this presentation, potentials and limits of municipal biodiversity strategies will be discussed. In this context, the following questions will be examined: How to develop

and manage urban biodiversity best? Who are the decision makers/stakeholders and how to include them in the process? How to implement the necessary changes in terms of policy?

627 BIODIVERSITY POLICY IN THE CITY - EXAMPLES FROM BRUSSELS-CAPITAL REGION

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Brussel's regional minister for Climate and Environment, Mr Alain Maron, will present the region's strategy to protect and develop urban biodiversity. With a population of 1.2 million, the Brussels-Capital Region covers 162 km2, and counts about 80 km2 of green spaces that are very unevenly distributed on the territory. Considering the unique territorial structure of the region and the socio-economic challenges of the population, the Minister aims at developing a public policy in which the city protects nature and the nature helps the city. He will illustrate this vision by presenting four projects : the greening of schoolyards, the reopening of the Senne river, the construction of floating island on the Brussels' canal, the purchase of a wilderness (Marais Wiels). Through these examples, he will show that an environmental policy can have a strong social objective, that the shape of the city is not irreversible, that industrial infrastructures can be a real asset when it comes to developing biodiversity.

629 A FRAMEWORK FOR PARTICIPATION FOR COLLABORATIVE INFRASTRUCTURES FOR URBAN DESIGN

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A particular framework was developed as part of a PhD research and tested in two cities: Budapest and Beirut. It aimed at facilitating deeper levels of participation (based on Arnstein's participatory ladder, 1969) of multiple stakeholders (e.g. municipality, NGOs, charities) and amongst them, people as key users of public spaces. The approach addresses notions around novel ways to redefine what is 'value' in a place-based manner, facilitate inclusion and diversity and alternative ways of knowledge co-creation, addressing the right to the city and right for environmental justice. The framework includes gamification as methodology and valuable tool to facilitate those notions. Furthermore, empirical knowledge around nature-based solutions (NbS) that are small-scale, low-cost, off-grid and build-it-yourself in order to enable communities to employ these in the future. The approach also facilitates bringing together multiple stakeholders and developing solutions that address the place-based co-defined values of particular communities, thus providing better chance for long-term sustainability and maintenance. In an article with Abunnasr (2021) we argued for the need for more real-world case studies that employ deeper levels of participation in urban planning and development focusing on NbS as a way to better develop and manage urban biodiversity and generate case studies that can inform policymaking and changes that need to happen to deconstruct existing barriers.

626 URBAN BIODIVERSITY – EUROPEAN BEST PRACTICE EXAMPLES FOR A BETTER FUTURE

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This session was developed by stakeholders who typically do not meet and/ or cooperate as they stem from separate sectors such as academia, civil society and cooperative planning. Bridging these supposedly different spheres, we approach the broad topic of urban biodiversity from a spectrum of different starting points: ranging from a purely scientific-ecological view to expertise and action around cooperative urban development. By this, we also include the socio-cultural diversity of cities and want to be pinpoint to various common challenges. We believe that a connected conceptualization of these starting points enable a valuable discussion for a more sustainable urban development in Europe.

630 CITIZEN SCIENCE 2.0: (~~BIG~~) QUALITY DATA AND (~~ARTIFICIAL~~) COLLECTIVE INTELLIGENCE

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Today, over half the world's population lives in cities. Cities are therefore places where urban population can create a link to biodiversity in their daily lives. Furthermore, well-being of citizens and sustainable living depend on sufficient amount of nature and biodiversity. Existing literature globally tends to show that participation in Citizen Science (CS) projects promotes knowledge about biodiversity, pro-biodiversity behaviors, and interest towards biodiversity and conservation sciences. Citizen Science is therefore often seen as a win-win solution for promoting public engagement with scientists, but also for empowering the public and, in the process, improving scientific literacy.
Within CS, Mosaic is specialized in an original method of data production that we call CS 2.0. We contribute to the co-conception of the projects aiming at collecting structured data (based on protocols/guidelines). Such data are then shared among participants, and interactions such as comments, validation, complementation, are encouraged and organized. This leads on the one hand to high value data, often innovative compared to other form of data production, and on the other hand, to empowered participants that acquire knowledge and skills through their participation, as well than to structured communities.
In our input we will present how our method helps to gain knowledge on urban biodiversity through examples of projects we have conducted in particular on flowers, insects, hedgehog.

631 DEVELOPMENT OF FEASIBLE ACTION PLANS FOR EUROPE'S URBAN BIODIVERSITY LANDSCAPE

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From status quo to a new vision: Looking at urban biodiversity as a spectrum, there are many contextual overlaps, e.g. concerning the public and private sector. We aim to pick up on these and other overlaps in order to develop new visions and common positive pathways for urbanization.
Aiming for action: We will instigate how further approximation amongst stakeholders in

the field of urban biodiversity can be achieved, bridging the divides between different sectors and fostering cross-sectoral cooperation.
This closing input will summarize the key findings of the session and put them into perspective. We will sketch an interdisciplinary pathway how to go ahead together in the near future and develop *pioneering prototype products* to act in the field of urban biodiversity. More specifically, together with those interested, we will develop an inter- and trans-disciplinary study that includes a "must have" list of most-urgent research-demands and draft a roadmap for the development of feasible action plans for Europe's urban biodiversity landscape.

COM1 - Habitat loss and management Africa & Communicating biodiversity to engage and inspire people to act

535 EFFECTS OF CHARCOAL PRODUCTION ON CARBON CYCLING IN MAJOR AFRICAN BIOMES

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Increasing charcoal demand in Sub-Saharan Africa will likely affect carbon cycling. We parameterised the LPJ-GUESS dynamic global vegetation model to determine the effect of charcoal production on the magnitude and direction of carbon fluxes in six biomes. We find that Net Ecosystem Exchange (NEE) in all biomes under the traditional production rate of 7% per year varies more than the natural forest state except for moist savannahs, tropical rain forests, and montane forests, where initial charcoal extraction results in a peak carbon source before returning to natural biome carbon dynamics. As a result, all biomes except temperate grasslands lose vegetation carbon while tropical rain forests, montane forests, and moist savannah lose litter and soil carbon. There is a trend of switching from sink to source in all biomes under a 1% tree cut every 10 years. This trend disappears with 10% and 20% cuts every 10 years, where carbon fluxes increase up to two orders of magnitude higher than the natural fluctuations for most biomes. Our preliminary results suggest that while biome's carbon dynamics are variable, even low charcoal production result in large changes in the carbon balance, ranging from lower variation in semi-desert, dry savannah and temperate grasslands and stronger variation in tropical rain forest, montane forest and moist savannah. With the continued harvesting for charcoal, we may observe a switch from sink to source and much-amplified carbon cycle dynamics.

296 EFFECTIVE MANAGEMENT OF MANGROVES: REFLECTIONS FOR BIODIVERSITY CONSERVATION.

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Mangrove forests provide essential and unique services to coastal communities in particular and the environment in general, making their preservation and management vital. In addition, mangroves are nurseries for fish, shrimp, and crabs even though they are sensitive to the effects of climate change. They also provide services such as carbon sequestration, water filter, sustenance of coastal livelihoods. However, they undergo direct and indirect threats from increasing population, deforestation, rising urbanization and changes in land-use patterns resulting in the loss of natural habitats. Using a

systematic review, this study sought to examine the status of mangrove forests in Cameroon. The study also investigates the management of mangrove forests geared towards mitigating climate change while conserving biodiversity. Climate change mitigation, biodiversity conservation and sustainable livelihoods could be ensured if mangrove forests are effectively managed. The involvement of those who depend on it for their livelihoods for decision-making processes is imperative for sustainable outcomes.

310 FOREST POLITICS FROM BELOW: PROTESTING FOR FOREST AND BIODIVERSITY CONSERVATION

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I will introduce the concepts of forest politics from below and Eco-Solidarism by describing and analyzing environmental social movements and indigenous communities protecting forests. Forest protection movements in the Americas, South Asia, Southeast Asia, Africa and Europe protect old growth forests and forest biodiversity by mobilizing publics through non-institutionalized modes of contestation. By focusing on the movement´s policy goals, ideologies and tactics, with a specific attention towards the practice of forest occupations, the presentation will provide an overview of a specific group of actors relating themselves to forest biodiversity and environmental protection. Additionally, I will provide a deeper insight into the ideology, movement tactics and lifestyle politics of forest politicians from below in Germany. The focus on social movements that combine non-institutionalized modes of contestation with lifestyle politics targeting forest and biodiversity conservation provides insights into the sustainability innovations created through forest policy from below.

233 THE ROLE OF POLITICAL PARTIES IN FOREST NATURE CONSERVATION IN GERMANY

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In modern societies, the formation of organized interest groups is the most common way for societal interests to influence political decisions. Under the conditions of a multi-party system the different interest groups have an additional channel to influence government decision-makers. Liberal democracy theories, especially the partisan theory, see this as the heart of democratic decision-making. From the point of view of the theory of the state, the ministerial administration is obliged to maintain a neutrality that takes precedence over interests, so that there is a tension here between party democracy and the state's neutrality of interests.
The article works out the differences in the attitudes of the political parties to forest nature conservation in Germany. The differences are measured on the basis of election programs and the policies for which the respective ministers are responsible. Using a comparative approach, the 16 German federal states are examined over a period of around 20 years. Furthermore, the possibilities of action of the specialist administration in forest nature conservation, the possibilities of the government to control them, and the influence of interest groups are examined. The result shows the variety of partisan influences on forest nature conservation issues with regard to the different societal interests in Germany. This variety is discussed from the point of view of the pros and cons compared with a one-party system.

224 FOSTERING FOREST NATURE CONSERVATION IN CHINA BY STATE-ENGO PARTNERSHIP

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In nature conservation China's government-led governance system is facing challenges from rising private sector and civil society. The state responds by creating partnership projects with ENGOs Based on the political theory of public-private partnerships the paper formulates the hypothesis that such a partnership project is embedded into the power balance between state and actors of the civil society. A prominent case is the establishment and management of Old Creek Nature Reserve in 2012. Empirical evidence is collected by triangulated document analysis and expert interviews from 2017 to 2020. The paper shows that the power balance between governments and ENGO is based on a mix of the specific power elements coercion, incentive and dominant information. The government acquires the resources from the private sector while the NGOs get the legitimacy. We conclude that the specific embeddedness in the power balance of state and private actors decides whether a public-private partnership project is able to support forest nature conservation.

513 MAPPING BIODIVERSITY RISK AREAS FROM POTENTIAL COCOA EXPANSION IN CONGO BASIN

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The growing global demand for cocoa could lead to large-scale land-use changes and habitat loss in biodiversity rich-areas such as the tropics. Low productivity and climate change is projected to affect cocoa production in major parts of west Africa, which could drive expansion into central Africa. Additionally, Cameroon aims to double its cocoa production by 2030 which may only be possible through expansion. Little is known about potential expansion areas of cocoa in the Congo Basin and how this could impact biodiversity. We attempt to address this gap by answering these questions: (i) What are the available suitable areas to grow cocoa in the Congo Basin? (ii) What are the risks of potential cocoa expansion to biodiversity? (iii) Which areas need to be avoided for cocoa cultivation to minimize biodiversity impacts? We followed a spatial exclusionary approach to identify available suitable areas for cocoa within areas with moderate to high climatic suitability for cocoa. This was achieved by identifying and excluding land-use types which are unsuitable for cocoa expansion under different scenarios. We then identified areas of high risk within the available area for cocoa as those with high cocoa suitability and high biodiversity significance (i.e., rarity-weighted species richness). Based on our findings, we recommend areas in the Congo Basin where cocoa cultivation needs to be avoided and measures such as agroforestry which could minimize impacts on biodiversity.

117 LIVELIHOOD STRATEGIES AND POLICY PROCESS UNDER THE HUMAN-ELEPHANT CONFLICT

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Xishuangbanna is the main habitat for Asian wild elephant in China, where has seen a significant human-elephant conflict caused by the destroy of economic plants. This research focus on the diversity on banana planting strategies of rural households under the conflict between human and elephant. With the integrated governance perspective, we will conduct analysis on policy instruments (such as ecological compensation, agricultural insurance, etc) by three steps: actor analysis, institution analysis and policy discourse analysis, in order to explain how the relationship between policy instruments are shaped in livelihood strategies affected by the human-elephant conflict. A qualitative case study will be conducted in Mengla Nature reserve in this research. We will collect data through face-to-face, semi-structured interviews and related documents, while direct observations in the field will also be used in this research.

COM2 - Communicating biodiversity to engage and inspire people to act

191 COMMUNICATING BIODIVERSITY THROUGH SCHOOLS CONSERVATION EDUCATION PROGRAMMES

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Conservationist must be deliberate in growing environmental literacy to try and bring about the social and cultural changes required to reverse biodiversity collapse. . Participation in ecologically focused outdoor activities, including field courses, can also lead to the development of an empathic relationship with nature. Knowledge and experience alone do not always result in desirable behavior. They are, however, still important tools for laying the groundwork for students to appreciate and understand ecological concepts and our connection to nature. It takes time to develop a truly environmentally literate society, and conservationist plays a larger role outside of academia to help bring it to fruition. This paper discusses various ways in which several organisations have participated in various hands-on activities and programmes that have directly targeted school students and teachers who are key agents of change in society. These programmes are diverse in their way of implementation and they include; ecological field trips, Training of Trainers in Education for Sustainable Development (ESD), National Art and Essay Competitions, School Greening programmes and youth leaders workshops.
Keywords: Biodiversity, ecology, Conservation Knowledge, Habitat, Education for Sustainable Development,

622 EARTH JOURNALISM NETWORK ADVISES ON BIODIVERSITY COVERAGE

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The issue of biodiversity loss tends to receive less attention than climate change, even though some argue the impacts of the biodiversity crisis are even more serious. Part of the problem is that, although news and stories about wildlife and particular species tend to be popular in the media, the bigger story of how vital biodiversity is to the healthy functioning of our civilization and ecosystems is not told as often or explained as well.

This presentation will focus on ways to help the media provide improved coverage of biodiversity issues, to document the real impacts that media coverage has on public policies and debate, on the need for more investment in biodiversity coverage by the media, and how to help journalists, scientists and other stakeholders better engage with each other.

107 FOR PLEDGES THAT WORK: ADRESSING BIODIVERSITY LOSS REQUIRES MORE STRATEGIC DEPTH

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A few sectors of society are sounding the alarm, demanding that political leadership recognizes climatic and environmental changes as a global emergency. Decision-makers meanwhile diverge in their responses to the urgent need for action on the twin challenge of biodiversity loss and climate change. Action gaps are exacerbated by the perceived inability of decision-makers to respond efficiently to the mounting threats described by scientists. Surprisingly, with the growing evidence and the accumulation of firsthand experiences of the impacts of biodiversity loss, the gap is not only a problem of conflicting values or beliefs but also a problem of inefficient strategies. Bridging the gap and tackling the growing polarization within society calls for decision-makers to engage with the full complexity of the issues the world is facing. We define strategic depth as the layers of anticipation a decision maker has in his mental model of the other parties involved. We propose to use strategy games to increase the strategic depth in environmental decision making, improve the representation of agency in scenario development and create spaces for deliberation between different worldviews. Biodiversity pledges that work can be achieved through transparent democratic dialogues that identify, challenge, and support the human and social limitations inherent to shallow strategic thinking in current environmental decision-making.

178 PARTICIPATORY VIDEO TO ENGAGE LOCAL POPULATIONS AND DECISION-MAKERS

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Improving equity in the context of conservation cannot be achieved in situations where people have vastly different capabilities to participate. Participatory video has the potential to uncover hidden perspectives and worldviews, as well as build trustworthy, transparent and accountable relationships between marginalised communities and external agencies. In this presentation, we present on video-mediated dialogues between Indigenous peoples and decision-makers involved in the management of three protected areas in Guyana. Participatory films created by Indigenous researchers in their communities were screened and discussed with protected areas managers, and their responses were recorded and presented back to the communities. We show how the video-mediated process provided a rich and contextualised understanding of equity issues. It enabled recognition and respect for traditional knowledge, Indigenous values and peoples' lived experiences in the management of protected areas. For Indigenous peoples the participatory video process built confidence and critical reflection on their own activities and responsibilities while allowing them to challenge decision-makers on

issues of transparency, communication and accountability. We show that promoting equity in conservation must be a long-term process, to facilitate deeper understandings, greater representation, relationship building and a recognition of rights.

208 BEHAVIORAL INSIGHTS FOR SUCCESSFUL BIODIVERSITY COMMUNICATION

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Extinctions and loss of biodiversity are altering key processes of the ecosystem. Excessive greenhouse gas emissions result in climatic changes and extreme weather events. While the great majority of people are aware of this, too little is done to translate this knowledge into concrete sustainable action. Research in the social and behavioral sciences has identified psychological barriers that prevent people from acting towards the promotion of biodiversity: Knowledge barriers may keep people from understanding why biodiversity loss is problematic. Self-interest barriers may keep them from understanding why they are personally concerned and how they would benefit from promoting biodiversity. Moral barriers may prevent the experience of emotions that can fuel collective action. Action barriers may lead to disengagement when people don't know what they can do to improve the situation. Finally, cognitive barriers may keep people from acting, even though they have the intention to do so. I will give an overview of the different barriers and discuss how they can be addressed and overcome with behaviorally informed communication strategies.

122 HOW TO COMMUNICATE EFFECTIVELY - THE PROCESS TO AUDIENCE ENGAGEMENT

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Communication is key in passing information and in changing habits. However today the behavioral changes are happening too slowly in the field of biodiversity and even if a lot of content is posted, concrete mind switches are not happening as much as expected. How can I improve the impact of my message? How can I effectively communicate scientific facts, true news or relevant data? This presentation will show you what would be the process to follow and keep in mind before, during and after communicating. Even if the heart of the message is content, we will also talk about audience, format and tone. Through images, concrete examples of good and bad practices will be presented to illustrate what the best practices are.

CUL2 - Indigenous knowledge networks for biocultural conservation (by invitation only) & Convivial Constitutionality: historical-institutional perspectives on human-predator interrelations and conservation policies.

161 HOW TO ACHIEVE PERSISTENT CROP-LIVESTOCK INTEGRATION IN SOUTH SUDANIAN FARMS?

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Indigenous people also have specific knowledge about the social-ecological system they live in. They manage their ecosystems for a long time and succeed in promoting their resilience in face of global change. In this study, we assessed both the indigenous and scientific knowledge to anticipate dynamics of Sub-Saharan smallholder farm systems, and to improve their livelihood through investments in new assets. These investments and their effectiveness are constrained by current capital and management practices, thus requiring considering the combined effects of multiple management practices and the timing of investments and losses.
We modeled farm trajectories in southwestern Burkina Faso under 64 contrasted scenarios, on the basis of a discrete formalism based on if-then rules describing a wide range of economic and ecological events. Rules are built from a literature review, interviews with local experts and direct observations of indigenous people, for integrating knowledge on this complex social-ecological system. The model then computed all possible farm trajectories and correctly predicted all observed farm types and trajectories. It also highlighted potential socio-ecological tipping points and the crucial roles of livestock and agricultural equipment for small farmers to develop a persistent agropastoralism. Although qualitative, model predictions are consistent with available knowledge and provide economic and ecological explanations about farm trajectories.

551 HUMAN-PREDATOR INTERRELATIONS AND CONSERVATION POLICIES IN ECUADOR AND ROMANIA

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Ecuador and Romania have a long history of coexistence between humans and large carnivores (jaguar /wolf), which continues to this day despite numerous political and economic changes. While shamanic practices can be found in Ecuador in the context of the human-jaguar interrelation, Romania has a long-lasting agro-pastoral shepherd tradition. Current conservation strategies use large carnivores such as wolf and jaguar often as flagship species and thus indicate a functioning ecosystem that needs to be protected. In addition, historically grown, local practices and knowledge systems get forgotten and the fact that local people developed institutions and practices over centuries and maintained cultural landscape ecosystems in which a «con-vivre» between humans and large carnivores was possible. Rather, a dichotomization between the "natural" environment, which includes wolves and jaguars, and the human worlds is propagated. Using the examples of Romania and Ecuador, we want to discuss the extent to which political-economic processes and international conservation policies change everyday practices and the space shared by humans and large carnivores, and how this changes the human-wolf / jaguar relationship. We also want to discuss what influence international conservation policies have on indigenous land rights and raise the question of what role local ecological knowledge has in this debate.

383 INDIGENOUS KNOWLEDGE NETWORKS AND LANGUAGE EXTINCTION

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Indigenous communities depend to a large extent on their knowledge about surrounding plants for food, shelter, and medicinal services. Unlike the burning of the Library of Alexandria, however, the knowledge that non-literate societies have acquired may vanish in silence. Here, I will first introduce “indigenous knowledge networks” as a framework to quantify how knowledge about plant services is structured locally, how it varies

regionally, and how it is eroded by the loss of cultural and biological heritage. Because such indigenous knowledge is transmitted orally, I will next assess how it is distributed across the world's different languages. Specifically, I will explore how language extinction may affect the loss of indigenous medicinal knowledge, and how this risk compares to that posed by ecological extinction. Together, these examples illustrate that cultural and biological conservation are inextricably linked.

476 LIVING IN HARMONY WITH NATURE: THE KACHCHH CASE STUDY

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Kachchh is a very unique geo-ecological terrain of western India. It is surrounded by the gulf of kachchh and the Arabian sea to the southern west while the northern and eastern parts are surrounded by great and little ran (seasonal wetlands) of kachchh. The region is endowed with different ecological set ups and also it has to face the vagaries of different climate changing factors. The indigenous communities of this area have adapted themselves to the harsh climatic condition. Conservation of biological diversity has been the focal attention of the world since past few decades. The indigenous traditional knowledge of local people of kachchh has helped them to endure these various implications of Mother Nature in a very gentle and friendly way. As an example the kharai camels have been adapted by these maldharis (pastoralist community) in such a way that they can swim their way to the food that is the mangroves that are found there. With scattered and scanty rainfall the community has learnt to live with limited resources by making pastoralism a good way of producing food, compared to more rain dependent farming. Flora and fauna both are given equal importance by connecting them to the religious beliefs of communities in different parts of kachchh. Sacred grooves are classic example of this. Present paper deals with various indigenous mechanisms that people of kachchh have learnt to live in harmony with harsh climatic condition.

479 WHY LEGACY IS KEY TO MAINTAINING AND REBUILDING RESILIENT CO-WORLD INSTITUTIONS

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In a contested landscape where resources are fought over, land-rights and ownership hold a scarred legacy, spaces for different beings are reshaped and borders between them redrawn. This description although befitting many cases around the world is particularly noteworthy in a conservation case in northern Kenya that shall be exemplary for the forthcoming presentation. The story here begins a long time ago, in a foggy past, before the first British settlers set foot in the interior of east Africa and continues to the present day. Within this arc, that long gone past still exists, if not clearly in the memories of those still alive, then in the cultural practice and ontological understandings of a people, who have remained in touch with their institutional foundations even through the challenging upheaval brought with colonization and the struggles that followed independence. And these institutions are key to understanding how these people live in a diverse landscape that has shaped them as much as they have shaped it. I am not talking about some romantic past of a people who are one with some nature concept as born in the industrial West. I am talking about a different understanding of the world altogether, one that clashes with what the conservation and tourism industry in Kenya represent. In this context, we must be careful not to get blinded by the majestic elephants, giraffes, and rhino, lest we forget that a landscape depends on far more than what a game drive can offer.

377 CULTURAL KEYSTONE SPECIES FOR BIOCULTURAL CONSERVATION ACTION

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Cultural keystone species are plant, animal, or fungal species of **exceptional significance** to a specific ethnic or cultural group and often prevalent in language, cultural practices, traditions, diet, medicines, material items, and histories of a community. Integrating literature reviews and survey responses from academic experts, we compiled an extensive list of 418 cultural keystone species from more than 200 cultural groups. Although the list of documented cultural keystone species is geographically biased, we found that plants dominated in the list, most species being of local significance, i.e., exceptionally important only for a specific culture. Beyond supporting cultural identity, cultural keystone species provide many global (e.g., habitat regulation) and local (e.g., food provision) contributions to people. Despite being widespread, deeply entangled with local cultures, and constituting a ubiquitous source of nature's contributions to people, many cultural keystone species have high biocultural vulnerability (i.e., the species is endangered, the language of the cultural group reporting it is endangered, or both). Targeting cultural keystone species in conservation actions and global post-2020 frameworks could help to incorporate local priorities in strategies for biodiversity use and management.

305 PROTECTING THE SOCIO-ECOLOGICAL LOOP

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Broadly speaking indigenous knowledge represent a collection of local epistemologies, carved and maintained by the sustained interaction between people and the local ecosystem wherein they live. Key components of this interaction are the existence of a flux of energy and resources from the local ecosystem that affect demographic process, driving technical and social innovation, which feedback to the ecosystem and affect ecosystem fluxes, forming a socioecological loop. In this talk I will present this socioecological loop, discuss examples, and present a large-scale analysis on the role of global changes, and particularly deforestation, in affecting its integrity across the tropics and the Andes.

DAT1 - Integrating biodiversity and human well-being data

167 GLOBAL AND REGIONAL HEALTH AND FOOD SECURITY IN A HALF EARTH WORLD

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Global biodiversity is rapidly declining and goals to halt biodiversity loss, such as the Aichi Biodiversity Targets, have not been achieved. To avoid further biodiversity loss, area-based protection will form part of new biodiversity targets. Here I will present results from a state-of-the-art global land-use model, LandSyMM (www.landsymm.earth), showing how global and regional human health and food security outcomes could be affected if a 30% or 50% land protection is strictly enforced scenario. We find that future strict protection scenarios can cause additional human mortality due to diet- and weight-related changes. Low-income regions such as South Asia and Sub-Saharan Africa are expected to experience the highest levels of malnutrition mortality. In contrast, high-income regions are less affected by such protection measures. Our results highlight that radical measures to strictly protect areas of high biodiversity value may jeopardise food security and human health in the most vulnerable regions of the world. While area-based protection is of utmost importance for protecting biodiversity, our results highlight implementation of strict protection plans would need to be scrutinised to ensure other sustainable development goals are not compromised.

623 TOWARDS A MULTIDIMENSIONAL BIODIVERSITY INDEX FOR NATIONAL APPLICATION

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Biodiversity is highly complex. It is a multidimensional concept in the same way that poverty, sustainable development or human health are. Taking a multidimensional approach to biodiversity – to assess what we value, facilitate mainstreaming and support national decision-making – can help to make explicit the many linkages between biodiversity and society and make the biodiversity loss crisis a societal priority.
The Multidimensional Biodiversity Index framework (MBI) is a new policy-focused index that aims to measure and monitor biodiversity and its contributions to people with an eye towards greater conservation and connect biodiversity science to the political agenda.
The MBI Team proposes that national governments use a policy-focused MBI that incorporates ecological and human-centered perspectives on biodiversity following the success of indices in other sectors as tools to support policy analyses, advocacy and social awareness such as the Human Development Index. The MBI Team will present how this Index aims to bring a holistic measure that accounts for the diversity of values underpinning nature–human relationships by presenting ongoing case studies from Europe, Africa, Asia and Latin America. Co-authors: Andrea Baquero, Sam Hill, Mike Harfoot, Eva Sphen, Roger Baer, Andrew Skowno, Duong Khuu Thuy, Franz Mora.

240 MODELLING OF THE "LEARNING AND INSPIRATION" POTENTIAL OF THE SWISS LANDSCAPE

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Cultural ecosystem services (CES) are often overlooked in ecosystem services assessments for lack of relevant data or indicators. In the last decade, growing access to social media data has allowed to deepen the development of models to quantify CES. However, these models can fail to be an accurate representation of CES due to the quantity and quality of the data gathered, as well as disparities in use of social media

platforms across areas and through time. In this study, we propose a new methodology to spatially represent the distribution of the CES "Learning and inspiration" (as defined by IPBES) and apply it to Switzerland. Here, we used automatic image annotation on geo-referenced pictures from two social media platforms to automate data processing and to enhance the quality of the observations. Then, we built spatial distribution models using several algorithms and an extensive set of environmental, demographic, and topological covariates, creating a map of the probability of picture taking in the outdoors in Switzerland, at a 25-m resolution. Results highlight the discrepancies between our modelled map and more conventional methods used so far to map this CES potential supply, often based on overlay and weighting of landscape features layers. This study presents an innovative approach to map CES and allows to explore at a high resolution the drivers of outdoor recreation for learning and inspiration.

66 UNDERSTANDING THE POTENTIAL TO LINK SPECIES WITH NATURE'S CONTRIBUTION TO PEOPLE

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While conservation ecology was highlighted by the creation of the IUCN redlist in the 1960s, it was in the 1990s that conservationists and economists decided to integrate the services provided by nature to humans to increase motivations to conserve our environment, later renamed Nature's contributions to people (NCP). Yet, conservation planning has been largely focused so far on landscape units (e.g. landuse, landcover, specific habitats) for their valuations rather than looking at the species composing them. Here, we wanted to fill this gap by assessing how much we could highlight the relationship between Biodiversity - here species - and NCPs. With this prospect, we used literature and expert knowledge to build an innovative contingency table between more of two thousand species (1818 tracheophytes' species and 250 vertebrates observed into our study area Rechalp) and up to 17 NCPs (17 NCPs for tracheophytes and 9 NCPs for vertebrates' species), this way offering a key tool to express direct and indirect linkages between species and NCPs. Based on that, we can predict and map NCPs from species and this way fuel conservation planning with crucially missing ecological information.

412 NUTRITIONAL POTENTIAL OF SHALLOW-WATER REEF FISHES FOR HUMAN WELL-BEING

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The extraction of food from our oceans feeds billions of people but causes large impacts on marine ecosystems. In developing countries, a lack in nutrients leads to half of all deaths of children under 5 but small-scale fisheries on reefs could contribute to micronutrient intake (i.e., calcium, iron, vitamin A, zinc). Yet, the micronutrient potential of reef fishes is unknown at large spatial scale. Here, we mapped the global distribution and biomass of 2,320 reef fishes and estimated their nutrient concentration (average nutrient mass per 100g portion fish) and nutrient yield (total nutrient mass) per country. We find high heterogeneity in the distribution of micronutrients on reef ecosystems globally. Thus, we reveal an unappreciated biogeographic inequality in the availability for

people to receive health benefits from natural ecosystems. At present, catch tonnage is weakly related to nutrient content and availability, so an opportunity exists to re-orientate fishing effort for health and well-being targets. Identifying species contributing most to micronutrients on reefs uncovered benefits of targeting these nutrient 'super-contributors'. However, we also find trade-offs between micronutrients – whereby super-contributor species rarely contain a high level of multiple nutrients – which will reduce the benefit of re-orientating catches. We therefore present challenges and opportunities in achieving global health targets whilst simultaneously maintaining biodiversity.

DAT2 - Be FAIR and CARE; synergies, tradeoffs, and perspectives in biodiversity data for science, policy, and action

374 INDIGENOUS AND LOCAL KNOWLEDGE IN GLOBAL-SCALE IPBES BIODIVERSITY ASSESSMENTS

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Since its inception in 2012, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) has recognised the important contributions of indigenous and local knowledge (ILK) to understanding, managing and conserving ecosystems. There are however many challenges to effectively working with ILK in global scale biodiversity assessments, and to ensuring participation of indigenous peoples and local communities in the process. IPBES has therefore developed approaches to working with ILK and enhancing participation. Key approaches include a task force on ILK that oversees the development and implementation of methods, multidisciplinary author teams, dialogue workshops, calls for contributions, and expanded reviews of materials beyond academic literature, to include community reports, videos and artworks. Ensuring that indigenous peoples and local communities benefit from engaging with IPBES is also a key area of work. Free, prior and informed consent principles have also been developed in consultation with indigenous peoples. This talk will discuss progress, on-going challenges and future developments, including aspects relating to data management, reflecting on experiences from the IPBES global assessment, and the ongoing IPBES assessments on values of nature, sustainable use of wild species, and invasive alien species.

505 OPEN SCIENCE PRINCIPLES FOR ACHIEVING POSITIVE BIODIVERSITY OUTCOMES WORLDWIDE

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The Group on Earth Observations Biodiversity Observation Network (GEO BON) works is dedicated to improving the acquisition, coordination, and delivery of biodiversity observations and services to decision-makers and the scientific community around the world. Principles for open science and open data are key for the success of GEOBON and other global networks and must be included both in the structure of the network and in the products and projects it develops. We show how FAIR (Findable, Accessible, Interoperable, and Reuseable) principles are core to the production of Essential

Biodiversity Variables (EBV) and the operation of Biodiversity Observation Networks at different scales, from local to global. We show how EBVs have implemented FAIR principles for developing metadata and infrastructures for their delivery. We also show how other principles of open science such as Equality, Diversity, and Inclusivity and CARE principles for Indigenous data governance must be implemented in the structure of the network and in the projects developed so that genuine societal transformation of this knowledge is achieved. The aim is to close the gap between the global north and global south by increasing equity in data availability and capacity for using biodiversity information for decision making.

408 INTERNATIONAL POLICY FRAMEWORK FOR OPEN SCIENCE

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Recognizing Open Science as a true game-changer in addressing the pressing planetary and socio-economic challenges, UNESCO has led a global dialogue with the aim of developing the first international standard-setting instrument on Open Science in the form of a UNESCO Recommendation since 2019. The Recommendation adopted by all 193 UNESCO Member States in November 2021 defines shared values and principles for Open Science and identifies concrete measures on open access and open data, with proposals to bring society closer to science and commitments to facilitate the production and dissemination of scientific knowledge worldwide. In her presentation, Dr Ana Persic will introduce the Recommendation text and the key pillars of open science, among which is the "Open dialogue with other knowledge systems" recognizing CARE and FAIR principles for Data Governance. She will also describe the transparent and inclusive consultative process for developing the future UNESCO Recommendation on Open Science and will talk about UNESCO's vision of using Open Science to strengthen the links between science and society and to bring benefits to diverse knowledge systems.

457 IMPLEMENTING BE FAIR AND CARE FOR BIODIVERSITY DATA: POLICIES AND PRACTICES

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The current movement toward open data and open science does not fully engage with Indigenous Peoples rights and interests. The predominant FAIR principles (findable, accessible, interoperable, reusable) seek to make data machine actionable to facilitate increased data sharing while ignoring power differentials and historical contexts. The CARE Principles for Indigenous Data Governance (Collective benefit, Authority to control, Responsibility, Ethics) center people and purpose, reflecting the crucial role of data in advancing Indigenous innovation and self-determination. These application of CARE and FAIR together ensure Indigenous Peoples' rights and wellbeing are present at all stages of the data life cycle, increase Indigenous access to data, and foreground Indigenous leadership in data governance. Since the release of the CARE Principles in 2019, a number of institutions and researchers have begun to implement CARE within their policies and practices, including the IPBES Data and Knowledge Management policy. While implementation of the CARE Principles begun, as with the early stages of operationalizing the FAIR principles, clear indicators for assessment do not exist. This session will explore advances in creating criteria to assess implementation of the CARE Principles.

428 RECONCILING CARE AND FAIR IN AN OPEN DATA INFRASTRUCTURE AND COMMUNITY

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A recent community consultation through GBIF - the Global Biodiversity Information Facility - collected experiences in mobilizing biodiversity data relating to Indigenous and Local Knowledge, largely in the form of metadata, species occurrences and checklists of species names. This includes historic and current data from natural history collections, ethnobiological research, citizen science initiatives and community-based monitoring. GBIF is an international network and data infrastructure funded by the world's governments with over 20 years' experience in providing open access to data about all types of life on Earth. GBIF provides access to over 1.9 billion species occurrence records, published by over 1,700 institutions making use of community-developed data standards and open licenses, and with a cutting-edge mechanism for data citation and attribution. Capacity development - including community guidance materials - strengthens the global community of practice underpinning this work.
In 2021, GBIF adopted a values statement including assurance that "data sharing safeguards the rights of Indigenous Peoples and Local Communities". We share progress on guidance materials to support this, reflecting on how the CARE principles can be promoted alongside FAIR in the GBIF community. We invite collaboration on further steps to ensure the rights of Indigenous Peoples and Local Communities are safeguarded as we promote open biodiversity data.

211 BEYOND THE PRINT AND PDF PRISONS: DATA ABOUT BIODIVERSITY WANT TO BE FREE

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Most of what scientists discovered about biodiversity and published, totaling a corpus of an estimated 500 million printed pages stacked up in our libraries and more recently, in digital format, is not known. It is an amount of information that can not be processed by humans, but even machines can't cope with it because the publications are either not scanned, or are behind paywalls, or in formats that machines can't read at scale. It is a tragedy that in this digital age we can't make use of this data.
But it doesn't need to be like this. Scientific publications are structured, they use standard means to express the results. Arguments cite previous arguments building a network of knowledge. If represented digitally, this knowledge could be represented as a knowledge graph and analysed.
The data in publications can be made FAIR: Figures, blocks of texts such as the descriptions of species, or material citations; named entities such as person or taxonomic names can be annotated and linked to reference vocabularies. They can be cited and reused irrespective whether a publication is behind closed doors.
In an exemplary way this lecture will show the collaboration between the Biodiversity Literature Repository and the Global Biodiversity Information Facility that has made available data about 80,000 species known in GBIF only because they have been liberated from the publications, thereby enabling the sharing of this scientific knowledge with anybody, anywhere for any purpose.

321 ADD CARE TO FAIR - THE STORY BEHIND THE NEW IPBES DATA MANAGEMENT POLICY

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In January 2020 the first Data Management Policy of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) was approved (https://doi.org/10.5281/zenodo.3551079).
This milestone was presented at the last WBF in 2020 (https://doi.org/10.5281/zenodo.3669004).
But very soon after its approval, it was realised, that the policy does not tell the whole story: The policy lays a solid foundation for FAIR data management, but it does not adress specific requirements of the handling and usage of Indigenous and Local Knowledge (ILK), which is used extensively in IPBES and follows strict rules (see the Talk by Peter Bates in this session). The CARE Principles for Indigenous Data Governance do provide a framework which supplements the FAIR data management principles (see the talk by Stephanie Russo Carroll in this session for a discussion of FAIR and CARE).
The IPBES Task Force on Knowledge and Data therefore decided to develop a Data Management Policy v2.0 which incudes CARE as well as FAIR and which pays attention to the special role of Indigenous People and Local Communities (IPLCs).
In this talk, I will discuss the motivation behind this decision, the considerations during the process, and the problems and challenges faced. Please also see the e-poster by A. Niamir (https://doi.org/10.5281/zenodo.3551078) about the data and knowledge mangement policy (https://doi.org/10.5281/zenodo.3551078 after approval).

eDNA1 - Environmental eDNA and Spatial Ecology

268 MONITORING THE MICROBIOME WITH REMOTE SENSING

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Monitoring biodiversity at a fine scale (15-30 m) but with a synoptic overview at a global level requires new approaches to meet information needs of government, companies, as well as the global agendas including the UN Sustainable Development Goals SDG and Convention on Biodiversity post-2020 targets. In a ERC funded "BIOSPACE" project, we combine next-generation satellite images (hyperspectral imagery and LiDAR) with taxonomic groups profiled from environmental DNA. With an overall aim of monitoring biodiversity from space, we used hyperspectral remote sensing in combination with eDNA. Here we present results of mapping the relative abundance of bacterial family taxa in different ecosystems (boreal, tundra and savanna) using hyperspectral imagery. Further we explore the fundamental relationship between ecosystem function as determined by eDNA profiling and by hyperspectral imagery.

295 GLOBAL BIODIVERSITY MONITORING BY SAMPLING EDNA HOTSPOTS-A LAKE PERSPECTIVE

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The global loss and redistribution of biodiversity is a hallmark of the Anthropocene. Our challenge is to generate information about how altered biodiversity influences ecosystems and use this information to bring our societies into sustainable a future. Actions to restore and reverse negative impacts to ecosystems are underway all over the world. However, to know we are on a better trajectory, we need monitoring data on vast scales of space and at high temporal resolution. Basically, we need a paradigm shift in how we monitor a species' presence in a landscape. In this project, we are testing if lakes act as accumulators of environmental DNA (i.e., eDNA hotspots) in the landscape by receiving transported eDNA from rivers. We are investigating how chemical, physical, and biotic processes cause eDNA decay to understand its transport potential in the environment, how much eDNA from a lake's catchment is transported into a lake, and in a global set of lakes, asking whether eDNA measures seasonal turnover of biodiversity for catchment spatial scales. If lakes prove to be reliable eDNA hotspots that measure biodiversity turnover in time, then sampling water from lakes will provide the paradigm shift needed to vastly change the cost, speed, and geographic scale with which species can be monitored. Then hopefully data gathered from lakes can be put into the right hands at the right time to affect positive outcomes for people and nature.

569 UNTANGLING CALIFORNIA'S SEASONALITY FROM RESILIENCE AND CONVERSION WITH CALEDNA

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Mediterranean climates are biodiversity hotspots meaning they are rich with endemic, specialized species that are thought to be part of delicate communities. In California, high human impact, environmental modification, wildfire suppression and climate change threaten the persistence of such communities, but we are limited in ways to quantify community variation, risk, and resilience. To expand our biomonitoring toolkits, the CALeDNA program facilitates and connects grassroots projects that measure ecological communities with eDNA metabarcoding and Earth observations including remote sensing. In this presentation, we describe two such projects. The first is on wildfire in the Santa Monica Mountains where we use remote sensing data to calculate patch size and ask if patch size or burn intensity explain biodiversity patterns through space and time. The second is on the Los Angeles River, which flows from the mountains through highly urbanized concrete environments to the Pacific Ocean. We co-analyze remote sensing data, local features, and eDNA to identify which spatial ecology linkages persist over seasons. Our results show that remote sensing data help parse eDNA-based biodiversity into indicators of seasonality, resistance, resilience, and habitat conversion. We also argue that support is needed to develop co-analysis frameworks and models so that integrated eDNA and remote sensing data efforts can meet their potential to aid biodiversity conservation in hotspots.

375 SURVEYING THE WORLD'S BIODIVIERSITY WITH DNA, AUDIO AND IMAGE

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The ERC-synergy project LIFEPLAN surveys global biodiversity using DNA-, image-, and audio-based sampling technologies. The project is estimated to generate ca. 100 million camera-trap images, ca. one billion one-minute-duration audio segments, and 1ca. 0 billion DNA barcoding sequences. I describe the implementation of the globally

distributed sampling campaign and the preliminary results based on the first year of the sampling. In particular, I discuss the methodological challenges related to deriving ecological insights from LIFEPLAN data (and other big data acquired by DNA, audio, image and other sensors), including machine learning methods targeted for automated species classification as well as joint species distribution models targeted for deriving ecological inference from such data.

16 BIOCUBE: INTEGRATING REMOTE SENSING AND IN-SITU DIMENSIONS OF BIODIVERSITY

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As the need for biodiversity assessments increases in the face of accelerated global change, novel monitoring approaches that are rapid, repeatable, and scalable are critical. New methods to remotely-sense some dimensions of biodiversity including canopy spectral diversity, functional traits and their diversity, and 3-D structure and its diversity are very promising. Yet, we still don't know how these dimensions of biodiversity measured from space relate to each other, to ecosystem functioning, and to in-situ measures of biodiversity at large spatial scales. To address this key knowledge gap, we are constructing a data cube, built on an open-source analysis framework and a common spatiotemporal grid, with layers characterizing six major dimensions of biodiversity that can be measured from space (vegetation structure, physiology, phenology, function, composition, and environmental covariates). This 'BioCube' integrates these remote sensing observations with multiple types of in-situ biodiversity observations including species richness, endemism, and phylogenetic diversity from field surveys across California and animal occurrence and behavior data from the Snapshot Wisconsin camera trap and citizen science network. Here we present on the status of the BioCube initiative and some preliminary results relating remotely-sensed canopy structural/physiological diversity and in-situ measures of diversity from eDNA collected by citizen scientists across the state of California.

580 SPATIOTEMPORAL BIODIVERSITY PATTERNS AS INFERRED FROM ANCIENT ENVIRONMENTAL DNA

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Ancient environmental DNA promises to expand our understanding of the formation of, and drivers of change within, biological communities over multi-millennial timescales. Here, we showcase environmental DNA biodiversity data from cores that span thousands of years of sediment accumulation at the bottom of high altitude and high latitude lakes. We explore what these data can reveal about community responses to long-term changes in local climate and anthropogenic disturbances. We consider existing technological and statistical bottlenecks in analyses of ancient environmental DNA data, as well as future innovations that will increase the power of this approach.

EVO1 - Gene to ecosystem ecology for a changing world

431 LINKING GENES TO FOOD-WEB PERSISTENCE

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Genes encode information that determine an organism's fitness. Yet, we do not know the extent to which genes of one species determine the persistence of interacting species in an ecological community. Here we experimentally test the effect of three plant defense genes on the persistence of an insect food web. We found that a single allele at a single gene enhanced the structural stability of the food web by increasing plant growth rate, which in turn increased the intrinsic growth rates of species across multiple trophic levels. Our discovery of a keystone gene illustrates the need to bridge between biological scales, from genes to ecosystems, to understand community persistence. In particular, our results indicate that ongoing losses of genetic diversity may induce sudden changes in the persistence and functioning of ecosystems. These changes in the ecological community context, in turn, may feedback to modify the coevolution of constituent species.

436 EFFECTS OF WARMING AND RESOURCE LIMITATION PHYTOPLANKTON METABOLISM AND GROWTH

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Climate change may interact with other environmental gradients including resource availability, in driving the growth and metabolism of phytoplankton. This has the potential to alter competitive hierarchies and community assembly, particularly in lakes where increased thermal stratification may itself generate resource-limited surface waters. While temperature-resource interactions are documented, we lack a mechanistic understanding of their basis. We aim to explore the metabolic basis of interactive effects of temperature and resource-limitation on individual-level traits and population-level growth rates. We investigated the responses of three different functional groups of phytoplankton: diatoms, green algae and cyanobacteria, which have different optimum temperatures and nutrient requirements. We found that temperature and resource-availability have interactive effects on growth rates for all species, though the nature of the interaction varies depending on the species and resource. We used a newly developed methodology - direct-infusion high resolution mass spectrometry – to perform high throughput quantification of metabolomes. We explored key metabolic pathways in phytoplankton, including photosynthesis, respiration, starch, lipid and amino acid synthesis, and stress responses. We discuss how the temperature and resource-sensitivities of these various metabolic pathways scale up to individual and population-level responses.

435 GENE TO ECOSYSTEM ECOLOGY FOR A CHANGING WORLD

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I will introduce this session by first demonstrating how global change is reshaping biodiversity across scales—from the genetic makeup of populations to the composition of species in ecological communities. I will then discuss how these cross-scale changes unleash an array of indirect effects that make it difficult to predict ensuing ecological and evolutionary responses in complex ecosystems. I will then argue that to predict gene-to-ecosystem responses to global change, we need approaches that explicitly address the interconnected nature of biodiversity across scales. I'll end by briefly highlighting the integrated and complementary approaches that each speaker of this session takes in their work to advance our understanding of how biodiversity originates, is maintained, and will respond to global change.

504 THE EVOLUTIONARY ECOLOGY OF SPECIES COEXISTENCE

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Biodiversity is being redistributed across the globe, forcing interactions between populations and species that have historically been separated. What happens to invader and resident populations or species when these introductions occur, at different points in the invasion process? Will they evolve to coexist or will one exclude the other, and is coexistence or exclusion expected to enhance or erode diversity? What ecological and evolutionary mechanisms underlie different outcomes? I will use manipulative experiments in the greenhouse and field to test (1) how biogeography has shaped the (macro)evolution of coexistence mechanisms, in ways that can predict the success and failure of invading species, (2) how a history of interspecific competition has driven the (micro)evolution of competitive differences between species, to an invader's detriment, in underappreciated ways, and lastly, (3) how interaction strengths evolve in natural multispecies communities. I will show that interspecific interaction strengths can sometimes intensify as a consequence of adaptation, and reveal a richness of challenges populations face in nature: uneven abundances and a diffuseness of species interactions, non-linear density effects on fitness, and evidence of (mal)adaptation that is conditional on local conditions.

553 EXPERIMENTAL COEVOLUTION IN COMMUNITIES OF FRESHWATER INVERTEBRATES

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As Earth's living organisms continue to face a rapidly changing environment, it is important to consider whether and how species will evolve adaptations to cope with novel conditions. It is important to also consider how groups of organisms experience coevolution in response to selection pressures – organisms may develop distinct adaptive trajectories in the presence and absence of other species, or their ability to adaptively evolve may be inhibited with other species present. We present here the results of three-year experimental coevolution in communities of freshwater organisms, using outdoor mesocosms to determine the impacts of two selection pressures: oligotrophic (low nutrient) or eutrophic (high nutrient) conditions, and the presence of one or two top grazers (Daphnia magna and Daphnia pulex). We have monitored population sizes, community composition, and phenotypic changes in Daphnia and in the phytoplankton

community, and we will present our findings that both the environmental (nutrient level) and community context (presence of one or two top grazers) impact phenotypic, genetic, and community composition at multiple trophic levels. This has created eco-evolutionary dynamics in response to the combined selection pressures of eutrophication and competition.

EVO2 - Harnessing rapid evolution to conserve global biodiversity

417 CHANGES IN SPECIES' COMPETITIVE ABILITIES IN NATURAL COMMUNITIES UNDER SELECTION

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Competition for limiting resources is a major force structuring communities and their biodiversity. Species minimum resource requirements (R*s), measured in isolation, can predict the outcome of competition among species, and can evolve under selection in simple communities under controlled conditions. However, whether R*s predict competitive outcomes or demonstrate adaptive evolution in naturally-complex communities is unknown. We subjected natural phytoplankton communities to three different types of essential resource limitations (nitrogen, phosphorus and light) in outdoor mesocosms over 10 weeks. We quantified community composition weekly and isolated 21 strains of phytoplankton (7 species), from the start and end of the experiment, to quantify the natural variation and responses to selection of R* for these resources. We quantified the evolutionary change in R*s in the dominant species, Desmodesmus armatus. Overall, R*s were good predictors of species changes in relative abundance, though largely driven by the success of D. armatus. This species demonstrated evolutionary change in R*s under resource limitation, supporting the potential for adaptive trait change to modify competitive outcomes. As inland waters warm, they will tend to become nutrient-limited due to thermal stratification. Predicting which species will be successful and able to adapt to future low-resource conditions will be important for the conservation of freshwater biodiversity and ecosystem services.

498 SIMULATING THE PAST TO BETTER UNDERSTAND THE FUTURE OF BIODIVERSITY

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Biodiversity emerges and emerged from ecological and evolutionary forces interacting over an ever-changing world. This complexity of ecological, evolutionary, geological and climatological processes is mirrored in our current fragmented scientific landscape. Recent developments in computer modelling and past climatic reconstructions allow for virtually emergent biodiversity, supporting the formalization and testing of biodiversity theories. As science advances, eco-evolutionary models help us to better grasp how species and populations coped with past changes by connecting the knowledge from multiple fields. For example, present genetic structures and large scale biodiversity patterns were reproduced using past environmental reconstructions in tandem with eco-evolutionary rules. Ultimately, this knowledge can be used to predict how biodiversity might change under future scenarios. Nevertheless, main challenges remain, such as the need to better understand the links between genetic diversity and functions as well as how ecological and evolutionary feedbacks act at different temporal and spatial scales.

Forward-time eco-evolutionary simulations coupled with dynamic landscapes are promising tools to improve our numerical knowledge of biodiversity and therefore support concrete conservation action.

13 EVOLUTION CAN BOTH PREVENT ECOSYSTEM COLLAPSE AND DELAY ECOSYSTEM RECOVERY

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There is growing concern about the dire socio-ecological consequences of abrupt transitions between alternative ecosystem states in response to environmental changes. At the same time environmental change can trigger evolutionary responses that could stabilize or destabilize ecosystem dynamics. However, we know little about how coupled ecological and evolutionary processes affect the risk of transition between alternative ecosystem states. Using shallow lakes as a model ecosystem, we investigate how trait evolution of a key species affects ecosystem resilience under environmental stress. We find that adaptive evolution of macrophytes can increase ecosystem resilience by shifting the critical threshold, which marks the transition from a clear-water to a turbid-water state, to a higher level of environmental stress. However, following the transition, adaptation to the turbid-water state can delay the ecosystem recovery back to the clear-water state. This implies that restoration could be more effective when implemented early enough after a transition occurs and before organisms adapt to the alternative state. Our findings provide new insights into how to prevent and mitigate the occurrence of regime shifts in evolving ecosystems and highlight the need to understand ecosystem responses to environmental change in the context of coupled ecological and evolutionary processes.

588 THE NEED FOR A HOLISTIC PERSPECTIVE OF ADAPTATION TO HUMAN INDUCED CHANGE

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Human induced environmental changes expose natural populations simultaneously to multiple stressors, which can induce natural selection across the whole life-cycle. However, the majority of microevolutionary studies focus on only a select life-stage or single selective factors, whilst in conservation biology still little attention is paid to within species phenotypic and genetic diversity. Therefore our understanding of how natural populations respond to global change is limited, which may also compromise the way we protect biological diversity. In this talk, we use the moor frog (Rana arvalis) populations along an environmental acidification gradient as an example of multidimensional adaptation (from molecular to morphological and life-history trait variation across embryonic and juvenile to adult stages) to demonstrate the different pathways of natural selection in stressful environments. We argue that to conserve biological diversity, a more holistic perspective is needed to maintain within species phenotypic and genetic diversity in face of global change.

456 COMPETITIVE HISTORY SHAPES EVOLUTIONARY TRAJECTORY IN A CHANGING CLIMATE

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Eco-evolutionary dynamics will play a critical role in determining species' fates as the climate changes, but unfortunately we have little understanding of how rapid evolutionary responses to climate play out when species are embedded in the competitive communities that they inhabit in nature. We tested the effects of rapid evolution in response to interspecific competition on subsequent ecological and evolutionary trajectories in a seasonally changing climate using a field-based evolution experiment with Drosophila melanogaster. Populations of D. melanogaster were either exposed, or not exposed, to interspecific competition with an invasive competitor over the summer, and then we quantified these populations' ecological trajectories (abundances) and evolutionary trajectories (heritable phenotypic change) when exposed to a cooling fall climate. We found that competition with the invasive species in the summer funamentally altered the subsequent evolutionary trajectory of D. melanogaster populations in the fall, after all interspecific competition had ceased. This study demonstrates that competitive interactions can leave a legacy that shapes evolutionary responses to climate even after competition ends, and more broadly, that evolution in response to one agent of global change can fundamentally alter evolutionary responses to another.

186 AN ECO-EVO TOOLBOX FOR CONSERVATION IN THE 21ST CENTURY

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The multitude of threats that face biodiversity and ecosystems will require all the tools in the biologist's toolbox. Generally, conservation usually employs ecological tools firmly centered on enhancing or restoring ecological processes. Evolutionary tools, meanwhile, are more often neglected or missing completely from the standard toolbox. Here, I synthesize our understanding of evolutionary tools for conservation by examining when and where they might be best employed. Tools such as assisted gene flow, antagonistic selection, evolutionary dampening, and gene drive manipulations offer powerful tools under certain situations. Many of these approaches are easier and less costly to employ than existing practices. However, this same power also can create opportunities for adverse effects and ethical dilemmas, thus requiring greater care in application. Once started, evolutionary processes can be difficult to control. Given the magnitude of threats, I argue we should develop and use all the possible tools, including evolutionary ones, in the eco-evolutionary toolbox so that we can protect species and ecosystems through this threat-filled Century.

282 HOTSPOTS OF ECO-EVOLUTIONARY INTERACTIONS IN THE LANDSCAPE

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There is increasing evidence of rapid contemporaneous evolution and for significant impacts of evolution on ecological dynamics. Most studies on eco-evolutionary dynamics

are proof-of-principle studies under highly standardized conditions. While often designed in a very clever way and yielding highly inspiring results, it remains unclear to what extent evolutionary trait change impacts ecological dynamics in natural landscapes. Important open questions are whether there are eco-evolutionary hotspots in the landscape and, if so, what determines these hotspots. One prediction is that eco-evolutionary dynamics might have the highest impact in more extreme environments, where local adaptation is important for pivotal species in the community to persist. In this contribution I will (a) explore this idea and highlight approaches to study the landscape moasic of eco-evolutionary dynamics, (b) present and discuss the results of a transplant experiment in the field that points to the importance of landscape gradients in the importance of eco-evolutionary dynamics, and (c) discuss the implicatios for the role of eco-evolutionary dynamics in biodiversity conservation. One prediction is that eco-evolutionary dynamics may often be important in determining ecological dynamics in novel habitats and in habitats and areas that are strongly impacted by anthropogenic stress, such as urbanized areas, areas of intensive agriculture, and areas that are subject to nature conservation management.

426 THE ROLE OF FOOD-WEB COMPLEXITY IN SHAPING THE SPEED, TRAJECTORY, AND PREDICTABILITY OF EVOLUTIONARY CHANGE

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Species are embedded in complex networks of ecological interactions. Although we know that species interactions have played a central role in shaping the evolution of life on Earth, the evolutionary influence of multiple indirect effects that emerge in interaction networks has not been studied empirically. Here, we explore the role of network complexity in driving the speed, trajectory, and predictability of evolutionary change in an experimental food web. This experimental food web consists of a plant (Arabidopsis thaliana), three species of herbivorous aphids, two species of parasitoid wasps, and a hyperparasitoid wasp. We studied how evolution of a focal species (green peach aphid, Myzus persicae) changes as it is embedded in progressively more complex food webs (n = 12 configurations). Specifically, we allowed the aphid to either evolve by itself, with one other species, with two other species, or the entire food web. We tracked evolution by monitoring change in the frequency of red and green color morphs of the focal aphid as well as changes in the relative frequency of the 6 aphid genotypes in each founding population. We found that the composition of species in the food web played a central role in driving evolutionary change. For example, we found that the evolutionary trajectory of color morphs was less predictable in more complex food webs. We discuss the evolutionary implications of our results in the context of the biodiversity crisis.

FIN1-a - Transformative Change in Economic and Financial Systems

596 FAST TRACKING NATURE-BASED FINANCING

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For nearly 30 years, the Rio Conventions have set forth a plethora of financial mechanisms to address terrestrial biodiversity loss with limited scales and degrees of success. The United Nations Framework Convention on Climate Change (UNFCCC), and

its subsequent multilateral accords, namely the Kyoto Protocol and the Paris Agreement, have timidly unleashed several public financial instruments aspiring to halt forest ecosystem loss, particularly in the global south. However, the Glasgow Pact neglected to acknowledge the urgent need to scale up financing and multi-stakeholder coordinated efforts to implement an ambitious global financial architecture to cater for nature-based solutions in the context of the Warsaw International Framework for Reducing Emission from Deforestation and Degradation (REDD+) and the Paris Agreement. This paper outlines a proposed conceptual, institutional, and financial framework to assist the global south in meeting its terrestrial restorative commitments agreed under the Aichi Biodiversity Targets, the Paris Agreement, and the Sustainable Development Goals.

49 ´BIODIVERSITY IN GOOD COMPANY`: FROM PIONEER TO ROLE MODEL

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The 'Biodiversity in Good Company' Initiative was the first cross-sectoral business network worldwide that is specifically committed to the protection and sustainably use biodiversity. Initiative members are small-, medium- and large-scale companies based in Germany and operate globally. By signing the Initiative's Mission
Statement and Leadership Commitment they commit to report progressively on a biennial basis on their activities on biodiversity.
Today we look back on a wealth of over 10 years of practical experience in biodiversity mainstreaming. What works best? And what does not? We will share our most valuable lessons learned and leverage points for transformative change.
As one of our core activities, we have been providing concrete starting points and hands-on tools for companies on how to integrate biodiversity on their premises, in corporate volunteering programs and their value chains. Other activities range from the coordination of a dialogue platform for mutual exchange of expertise, sharing best practices to the organization of business awards. We actively build multi-stakeholder partnerships with businesses, industry associations, politics, environmental organizations and research institutions.
Having started as a pioneer, the approach has now become a role model. We want to pave the way forward for many more successful activities in the future. Our vision is a world where business engagement for biodiversity means success - for businesses, society and nature.

592 SUSTAINABLE BIODIVERSITY FINANCE INSTRUMENTS

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Sustainable Biodiversity Finance Instruments dynamics will be illustrated and discussed. A more active engagement in finding a biodiversity financial investment tool can provide an excellent opportunity that benefits the environment and offers an anti fragile asset for investors. This will optimize the resource allocation in the sustainable investment sector. Better practices and detailed information on companies and an active engagement approach through timely measurement of different ESG policies and their implementation with concret outputs would better help to capture so-called indirect impact through listed investment by companies that implement the best practices including stakeholders' rather than shareholders' benefit. In a such approach, both environmental and biodiversity will become active part of a successful Investment tool.

320 MODELLING AND ASSESSING PATHS TO A BIODIVERSE AND SUSTAINABLE AUSTRALIAN ECONOMY

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Human impact on the Australian environment is now so extensive that biodiversity and the basic operations of many ecosystems are threatened. Australia needs to rapidly reduce the consumption of its natural resources, reduce pollution, and provide greater space for 'natural' ecosystems. This research provides a detailed proposal of the policies and institutions needed to transform the current fossil fuel and iron ore dependent Australian economy to one that operates on a sustainable basis.
A macroeconomic model was developed incorporating the unique aspects of Australia's environment, society, financial systems and economy. This was used to model four policy suites representing four different pathways for the economy. These simulations provided the basis for a political economy analysis of key policies within each policy suite with predictions of possible inflection (crisis) points.
This presentation will first discuss the principles underlying the model, in particular the inclusion of social and environmental factors. The modelling results will then be examined, with some comments on the environmental impact of each pathway. Finally, the political economic analysis of the policy suites will be considered, including the policies most likely to lead to a successful transformation of the current Australian economy so it delivers a high standard of life for all Australians within environmental limits and preserves Australia's unique flora and fauna.

130 UPSCALING NATURE-BASED JOBS IN SWITZERLAND

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Enabling a nature-based economy will require inter- and transdisciplinary perspectives well beyond economics and entrepreneurship. Any economy is embedded in the worldviews, knowledge systems and social relationships that prevail in a society and in turn shapes power relationships among knowledge and value holders and decision-makers. I will explore based on applied research projects how in an affluent country many more people can economically sustain a decent life based on ecological practices. Ways have to be found to integrate different economic and social tools in order to use synergies and overcome systemic lock-in situations (legal regulations, taxes, re-directing subsidies and research and development (R&D), financial instruments, engaging in dialogues about valuing nature, fostering nature experiences and knowledge). The use of nature does not follow the rules of classical economics: efficiency, standardization, division of labor, primacy of capital over labor, and growth. Therefore a nature-based economy cannot be discussed independently of debates about changing economic paradigms, e.g. degrowth, strengthening of local economies, the value of informal and unpaid work, care economy or tools such as a universal basic income. There will be many co-benefits: nature-based jobs can be more fulfilling than many well-paid jobs with little societal value, and, if well done, a nature-based economy will reduce inequalities and increase diversity and inclusion.

141 BIODIVERSITY DAMAGING SUBSIDIES – TACKLING AICHI TARGET 3 IN SWITZERLAND

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Within the framework of the Convention on Biological Diversity, Switzerland has committed itself to abolishing, redirecting or reconfiguring subsidies that are harmful to biodiversity.
The Federal Council has included this goal in the Swiss Biodiversity Strategy 2012.
In 2020, Swiss Federal Institute for Forest, Snow and Landscape Research WSL and the Swiss Biodiversity Forum, SCANT published for the first time a broad compilation of biodiversity-damaging subsidies in Switzerland.
On the basis of the state of the most important habitats in Switzerland, we identified factors that damage biodiversity. These factors belong to eight economic sectors, which were then investigated to identify subsidies and incentive schemes: transport, agriculture, forestry, energy production and consumption, settlement development, tourism, wastewater disposal and flood protection.
The study, to be presented in the session, covers various types of subsidies. These subsidies reduce the costs of production or consumption and thereby damage biodiversity. Subsidies that damage biodiversity are not only ecologically problematic but they are also economically inefficient, because they charge different budgets in several ways.
While the results are directly relevant for Switzerland, public incentives to harm biodiversity are ubiquitous and the methodology for identifying these incentives can motivate similar investigations in other countries.

FIN1-b - Transformative Change in Economic and Financial Systems

524 ESG - CAN WE FUNDAMENTALLY GENERATE IMPACT WHEN INVESTING IN LIQUID MARKETS?

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The emergence of ESG products in the financial industry is quasi-exponential but are these products really generating an impact? Do they reflect what ESG initiators wanted to achieve? Or is it pure marketing? Examples in mutual funds and ETFs show that ESG product construction results mainly from data collections. The big winners of this ESG products growth are undoubtedly data providers. These data are often used to construct a basket of stocks in-line with the data measurements but the notions of purpose, impact objective, engagement are rarely embedded in the product management. How could we solve for this? How could we associate performance catalysts to impact objectives? Are these data used with the right purpose? Most of the data focus for liquid products is on environmental data. However, what about the S and the G? Probably the notion of engagement (G in ESG) is the future. Several studies have demonstrated that a good G drives a good E and a good S. However, G can easily be measured for its structure but what about its quality? This quality of G can hardly be scored in standard measures and requires profound reflection when constructing a product. In this context, investors should set some rules to ESG fund managers to make the financial industry more impactful. In this presentation we will discuss whether data add value, whether/how they could be used, and what measures should be taken by the financial industry to make ESG more Impactful.

560 RESOURCES FOR IMPLEMENTING THE NEW BIODIVERSITY FRAMEWORK IN THE NEXT DECADE

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To reduce biodiversity loss in the next decades, adequate resource mobilization is central to the new global biodiversity framework. An important determinant of biodiversity conservation is the amount of resources from all sources committed to finance biodiversity policies, programmes and projects. Higher levels of resources do not guarantee higher levels of conservation, but research has shown that, on average, a higher allocation of resources into biodiversity programmes and projects is associated with reduced biodiversity loss. All the works in the last couple of years broadly point in the same direction by indicating a need for financial resources to increase substantially from current levels in order to "bend the curve" on biodiversity loss. I will present all recent work on this area and key messages from the Report of Panel of Experts on Resource Mobilization for the new Biodiversity Framework.

500 ECONOMICS AND FINANCE: THE DANGERS OF THE MAINSTREAM SCHOOL OF THOUGHT

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The academic world is too often disconnected with the needs and realities of the economy and society. It has not sufficiently drawn lessons from the 2008 financial crisis, and repeatedly demonstrates great restraint when faced with financial scandals. Its responsibility is, however, to analyze these problems and to argue objectively.

595 ESG

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ESG data providers rate companies based on public data, hence supporting the hypothesis of a weak market form (mkt efficiency hypothesis) hence more an active investment should outperformance passive ETF approach.
Although ESG has both quantitative and qualitative characteristics, companies main mission is very different from impact investing per say. Therefore, measurement of so-called externality with all its positive and negative outputs matters the most. Consequently, these outputs are not concretely measurable on the public information but rather through inside one.
As the result, more active engagement should provide detailed information on companies ESG policies and ongoing implementation of those and ETFs are very limited as majority of them are factor-based maximizing the best ESG score/rating, hence large cap biased. Reversely, an active engagement approach through timely measurement of different ESG policies and their implementation with concret outputs would better help to capture so-called indirect impact through y listed investment by helping companies to implement the best practices including stakeholders' rather than shareholders' benefit. In a such approach, both environmental (i.e. biodiversity through clean of soil) and social (i.e. employees turnover, training program and new recruitment as well as salary increase) could be well measured by comparing the delta prior and after the engagement.

612 A FEMINIST ECOSYTEM: SHIFTING POWER TOWARDS A NEW RELATIONSHIP WITH THE EARTH

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An economy that is overly obsessed with power dominance and structures within a male and western prevailed culture are one of the root causes of environmental degradation. It is possible to speed up the health of our planet by going back to a more ancient way of connecting with the planet, by adapting more 'feminine' styles of caring and creating collaborative partnerships, and by having more power 'with' rather than power 'over' paradigms. This presentation targets ecofeminism and ecopsychology as a framework to explain what is present in society within an increasingly disconnected society. The main goal of this talk is to address how companies create equal opportunities for underrepresented groups and shift the power paradigms through putting their voice first.

FIN2 - Ecosystem Services in Sustainable Finance

181 THE ECONOMIC CASE FOR NATURE

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New research led by the World Bank, in collaboration with the University of Minnesota and Purdue University, sheds light on the macroeconomic risks associated with biodiversity and ecosystem services loss, as well as on the critical role of nature-smart policies in achieving win-win outcomes for nature and the global economy. Economies are embedded in nature and depend profoundly on the flow of goods and services it generates. Yet, conventional economic models do not account for the declining trends in ecosystem services and therefore provide overly optimistic scenarios of growth. To demonstrate the interlinkages between nature and economic development, a first-of-its-kind global modeling exercise presented in the Economic Case for Nature report integrates select ecosystem services into a computable general equilibrium model. When the "business-as-usual" loss of ecosystem services is factored into the model, projections of growth in global GDP drop in 2030. In a scenario where certain services - wild pollination, provision of food from marine fisheries and timber from native forests – collapse, the global GDP shows drops of $2.7 trillion in 2030; with low-income and lower-middle-income countries experiencing drops in 2030 GDP of more than 10 percent. Crucially, nature-smart policies, such as decoupling of subsidies to farmers, forest carbon payments, and investment in agricultural research and development, can reduce the risks of nature loss and generate economic growth.

430 ECOSYSTEMS, BIODIVERSITY AND SUSTAINABLE FINANCE: EU POLICY ACTION

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Improved understanding and better disclosure of both the impact and risk linkages between the financial sector as well as the real-economy and biodiversity loss and ecosystem degradation is urgently needed. It is important to identify and to shift investments and funding to environmental sustainable activities and business models, avoiding false claims and greenwashing. Equally important is the need for better

identification, assessment and management of financial sector risk exposures to ecosystem degradation.
The European Commission is taking action to support businesses and stakeholders with coherent and meaningful frameworks. This includes policy initiatives:

- To agree on robust classifications of environmental sustainable activities and financial products such as the EU Taxonomy and the related Delegated Acts, the EU Green bond Standard and the ecolabel for financial products;
- To improve disclosure and risk assessment, such as the EU's Corporate Sustainability Reporting directive and the Sustainable Finance Disclosure Regulation; and
- To ensure the European Green Deal principle of 'do no harm' is mainstreamed through more consistent criteria and tracking of EU end Member State funding programmes.

All this needs to be underpinned by coherent ecosystem and biodiversity risk and impact assessment methodologies and frameworks that link to robust natural accounting frameworks and data. This session will explore those links and EU policy actions in support of this.

617 TOWARDS A NEW NATURE-BASED ECONOMIC PARADIGM

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Humanity faces a dual threat to its existence: climate change and loss of natural capital. If either of these risks were to materialize the repercussions would be cataclysmic. The two risks, however, are intricately linked through human activity, and in particular an economic system that promotes growth at the expense of natural capital. This paper explores the interplay between the twin risks and exploits their interdependence to sketch out a new economic and financial framework that is centered around preserving nature. We argue that this new nature-based economic paradigm can help mitigate the dual risks, as well as bring sustained and shared prosperity. We show how markets can be developed around the protection and regeneration of nature and highlight the policy action that is needed to unleash the resources and innovation of markets to empower inclusive growth and economic development centered around nature.

307 PHYSICAL RISK ASSESSMENT BY THE DUTCH CENTRAL BANK

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Reduced availability of ecosystem services present a physical risk for financial institutions, like banks, investors and insurance companies. In their role as supervisors of financial markets, central banks need tools to assess whether loss of ecosystem services is a threat to national financial stability. Using the ENCORE database, we determined the extent to which the companies in the investment and loan portfolios of national financial institutes are dependent on ecosystem services. As a deep dive, we also examined how the financial sector is dependent on animal pollination. In order to obtain a comprehensive picture of these physical risks for the financial sector, exposure to ecosystem services should be analysed in more depth, with more geographical accuracy. To manage risks in an appropriate way, more insight is needed in the supply-chain dependencies of businesses in financial portfolios. Using integrated assessment models

for analysis of global change scenarios, forward looking stress testing can be done, and by including Input/Output models the general sectoral supply-chain dependencies can be taken into account as well. Financial institutes need to be able to refine these general sectoral analysis at a more concrete company level, to be able to assess and manage these risks appropriately. This translation is a crucial step in mobilizing the potential contribution of the financial sector to the targets of the CBD Global Biodiversity Framework.

493 EARTH ECONOMY MODELLING: EXTENDING THE ECONOMIC CASE FOR NATURE WITH GTAP-INVEST

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"The Economic Case for Nature," led by the World Bank, used a first-of-its-kind Earth Economy model to show that conventional economic models are overly optimistic because they exclude degradation of natural capital and ecosystem services. This talk discusses key research advances that enabled creation of this model and new research directions. The underlying model, GTAP-InVEST, linked the Global Trade Analysis Project's (GTAP) computable general equilibrium model to the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model from the Natural Capital Project. To make the linkage, however, several methodological advances were needed, including accurate downscaling of land-use change from global to local scales, incorporation of endogenously determined land-use expansion into natural land, and identifying how changes in ecosystem services can be represented as "shocks" to the economic model to assess their impacts. This talk will then discuss several forthcoming research directions that will increase the robustness and policy relevance of the GTAP-InVEST model. Specifically, these include: creation of country-specific versions of the model that increase the model's economic detail for the target country, solution of the economic portion of the model on millions of grid-cells rather than hundreds of countries, endogenous determination of climate damage pathways, and extension to a dynamic model to further explore risks of regime change and tipping points.

364 ECOSYSTEM SERVICES VULNERABILITY ACCOUNTS TO MAP RISK

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Ecosystem Services (ES) accounts, as framed and assessed in INCA (Integrated system for Natural Capital Accounting), are able to provide information on the interaction between ES Potential and ES demand. This interaction can generate a match, that represents the ES actual flow from ecosystems to economic units. This interaction can also generate mis-matches, that can be caused by:
(i) the overuse of ES that eventually lead to ecosystem degradation,
(ii) the absence of the needed ES that leave the ES D unsatisfied, and finally
(iii) the ES missed flow. Mismatches can be used to build ES vulnerability accounts that in turn enable to map risk. Because ES are allocated to economic units, ES vulnerability accounts can be directly "allocated" to the economic units that will eventually suffer from this increased ecological risk. This presentation is meant to provide examples for each of the mismatch categories that are collected by ES vulnerability accounts to explore how this information can be structured in map risk.

FRW1-a - Freshwater biodiversity crisis: horizon scanning of challenges and solutions

625 PARTICIPATORY APPROACHES TO ASSESS CHANGES IN YALA WETLAND, KENYA

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The Yala wetland (YW) in Kenya is an internationally designated key biodiversity area, supporting the livelihoods of a large local community. At national level it has attracted several large-scale agricultural projects over the past 50 years due to its richness in resources thus threatening its existence. This study adopted participatory approaches to explore how drivers of change will affect biodiversity and ecosystem service (ES) delivery in the wetland under diverse scenarios. We used the matrix model to determine key ES and rank their flow over Land-Use, Land-Cover types based on stakeholder preferences. We used participatory geographic information systems to map changes in historical ES flow and participatory scenario planning to develop qualitative scenarios storylines of the future of YW. Our results demonstrate that papyrus, trees, and shrubs provide a range of ES that are valuable to stakeholders in the wetland. Participatory GIS showed changes in ES delivery over the past 30 years. The major drivers of change were land-use, governance, environmental resource use and pollution. Scenario storylines developed revolved around changes in the former three drivers, identified as the most significant according to the community. Our findings demonstrate the value of participatory approaches in providing inclusive, locally relevant and demand-driven evidence to inform long term resilience while managing conflicting needs of biodiversity conservation and development within YW.

438 IDENTIFYING PRIORITY AREAS FOR THREATENED PERI-ALPINE FRESHWATER BIODIVERSITY

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The global biodiversity crisis is particularly dramatic in freshwater ecosystems which have suffered exceptionally high species loss. High local endemism in perialpine lakes and the number of imperilled species in the surrounding rivers make them sensitive to both climate change and habitat alterations. These pressures urgently demand conservation management to balance competing economic uses whilst supporting biodiversity, as well as the process of diversification, both now and into the future. Switzerland is warming at twice the global average and contains a range of habitats from natural to intensively modified, offering an excellent case study to design solutions to multifaceted conservation threats. Our interdisciplinary project involving scientists, governmental agencies, and NGOs will identify and implement data-driven conservation strategies

integrating both climate change and human impacts. National observations of fishes – including cryptic diversity and endemic species of high conservation priority – were combined with high resolution environmental data to model changes in species' distributions. Using spatial conservation planning at the watershed scale, we simulated priority areas that would benefit most from mitigation measures under different policy options. This information will help local and governmental authorities as a decision support tool for conservation of diversity and the process of diversification in the freshwaters of a warming world.

367 FRESHWATER AND CLIMATE - INTERLINKED CHALLENGES REQUIRING HOLISTIC SOLUTIONS

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Rivers are the arteries of the Earth, transporting the water and nutrients needed to support diverse forms of life and a third of global food production. They also act as zones of major carbon transfer from the atmosphere and continents to the oceans. Yet, the health of rivers is degrading rapidly and freshwater biodiversity is being lost at alarming rates; a crisis that is largely overlooked. A major driver of this is the obstruction of rivers by, inter alia, large hydropower dams. There are currently over 500 dams planned or under construction in protected areas alone, and large dams continue being hailed as a climate-friendly solution. Science from the last decades however tells another story: large dams constitute methane sources (notably in the tropics); are detrimental to freshwater biodiversity; and have permanently displaced up to 80 million people globally, especially affecting indigenous peoples. Addressing the climate crisis cannot come at the cost of freshwater ecosystems. One innovative tool to holistically protect rivers from being further fragmented is the Rights of Rivers framework, which is rapidly taken up by governments and communities across the globe. This presentation will present the contemporary set of recommendations on hydro energy best practices arising from IUCN WCC 2020 Res 134, as well as the potential of the Rights of Rivers movement, and what the world can gain from holistically addressing the freshwater biodiversity and climate crises.

144 SHEDDING LIGHT ON THE HIDDEN GROUNDWATER FAUNA — A CITIZEN SCIENCE APPROACH

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A large part of freshwater is hidden beneath the earth's surface as groundwater. It represents a main drinking water resource in many regions across the globe. But groundwater is also an ecosystem that harbors a broad and highly adapted biodiversity. This biodiversity has long been neglected in research, mainly due to difficulties in groundwater accessibility. In the light of human-caused environmental changes, for example through pollution, the incomplete knowledge on groundwater fauna is alarming. To overcome the challenges of accessibility, we established a citizen science method with the aim of integrating drinking water providers into the process of data collection. Hundreds of participants across Switzerland sampled their raw water from captured springs for macroinvertebrates. By implementing such a standardized, systematic, and countrywide approach, we built one of the most extensive datasets on groundwater macroinvertebrates in Central Europe including over 1500 samples. Focusing on the

order Amphipoda, we shed light on the diversity, distribution, and endemism in Switzerland. We found groundwater amphipods (genus Niphargus) in 25% of the springs sampled, belonging to 12 different species; several of these species are new to science or newly reported for this region. Overall, we conclude that the use of citizen science approaches can be helpful and efficient for hitherto largely underexplored aquatic ecosystems such as groundwater.

51 EBIOATLAS - MAPPING THE WORLD'S FRESHWATER BIODIVERSITY USING ENVIRONMENTAL DNA

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The World Economic Forum lists biodiversity loss as one of the biggest challenges facing humanity this decade. The situation in freshwater habitats is especially critical. Freshwater species populations have declined by 84% since the 1970s and, according to the IUCN Red List, almost a third are threatened with extinction. This rapid and global erosion of freshwater ecosystems is happening despite wide recognition that they are vital to our future. We have an urgent need to better understand where freshwater species are and how to conserve them to target actions and resources.
But biodiversity has a measurement problem. Conventional biodiversity survey techniques are expensive and slow, most often only giving data on a few species at a time requiring vast resources. We need big data rapidly not only to inform where to act but also to better understand the drivers of species and ecosystem declines, enable meaningful goals and targets to be set, and for measuring progress in meeting these targets.
Employing a globally standardized sampling and analysis protocol, eBioAtlas will provide 30,000 eDNA samples urgently required to underpin effective conservation, sustainable investment, environmental management, and ecological impact assessment. We are focused on global freshwater systems in regions' most at risk from climate change and those experiencing the fastest rate of biodiversity decline. These data will feed into and improve Knowledge Products such as IUCN's Red List.

405 BIOMONDO - EARTH OBSERVATION SUPPORTED MONITORING OF FRESHWATER BIODIVERSITY

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The European Space Agency (ESA) activity "Biodiversity+ Precursors" is a contribution to the joint EC-ESA Earth System Science Initiative to advance ESS and its response to the global challenges. The Precursor BIOMONDO is focused on biodiversity in freshwater ecosystems, such as lakes, wetlands and rivers. Based on analysis of relevant sources for scientific and policy priorities, the main knowledge gaps and challenges in biodiversity monitoring, and also requirements to understand drivers for change and for preserving ecosystem functions for favorable biodiversity conditions are compared to possibilities from Earth Observation (EO). These findings are the basis for the development of innovative integrated earth science solutions that integrate EO based products, biodiversity modelling (GLOBIO-Aquatic and Delft3D-ECO/ BLOOM) and in situ data using advanced data science and information technology, which will be implemented in the

BIOMONDO Biodiversity data cube. Time series of the cube'd data will be analysed using Machine Learning (ML) technique and integrated Thematic Ecosystem Change Indices (TECI), e.g. LCLU and its change in the riparian zone and catchment and water quality and lake water temperature evolution, will be deduced. The validation of the integrated products are key tasks within BIOMONDO and beyond, and interested biodiversity experts can get access to the novel EO products through the cube, and support the evaluation of impact and benefit of the developments.

255 A FRAMEWORK TO IDENTIFY FOREST-ASSOCIATED AQUATIC SPECIES OF THE UNITED STATES

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Freshwater ecosystems are fundamentally linked to the landscapes that they drain. In particular, forested landscapes are a significant portion of the conterminous United States, and are used for a variety of purposes from recreation to harvest. Multiple stressors on forests and freshwater environments are anticipated to increase in response to resource extraction, climate change, invasive species, and changes in land uses. These stressors directly affect habitats for aquatic biota through altered flow regimes and allochthonous inputs. A comprehensive assessment of aquatic biota associated with forested systems will facilitates comprehensive land management options as well as the identification of species vulnerable to changes in forest condition. We developed a procedure to identify and classify the levels of forest association or dependence by aquatic biota and mapped our results across the conterminous U.S.. Patterns of forest-associated biota varied across the country reflecting distribution patterns of forest communities, as well as variation in overall species biodiversity. The northern coasts and southeast regions of the U.S. are heavily forested and showed the largest numbers of forest-associated biota. The framework we developed defined associations between aquatic biota and levels of forest cover consistently across broad spatial extents, and is one of many types of data that managers will need to face the current and future threats to freshwater species.

FRW1-b - Freshwater biodiversity crisis: horizon scanning of challenges and solutions

183 PHYTOPLANKTON COMMUNITY STRUCTURE OF THE CASCADE DAMS ALONG UPPER YANGTZE RIVER

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Dams constitute spatially complex anthropogenic disturbances to riverine systems, altering habitat both upstream and downstream of dams within stream networks. Often alterations on habitat affects hydrology, stream temperature, channel morphology, water chemistry, and hydrologic connectivity, making isolation of individual mechanisms of habitat alteration difficult. The phytoplankton biodiversity study was conducted in the

Xiluodu and Xiangjiaba reservoirs - the cascade dams built along the Upper stream of Yangtze River were represented by 280 species belonging to five major algal classes with Bacillariophyceae (57.32% & 59.02%) followed by Chlorophyceae (31.21% & 29.51%) members. The dominant species were Melosira granulata var. angustissima , Cyclotella menenghiniana and Cyclotella ocellata in Xiluodu reservoir. The heterogeneity in both reservoirs were revealed by Shannon's diversity index, both reservoirs had a lower Shannon's diversity (1.344 & 1.349 respectively) which figures out an uncertainty and disorder of phytoplankton species distribution pattern. Phytoplankton biomass was highest in Xiangjiaba reservoir during summer season (271.571 mg/L) whereas it was lowest in Xiluodu reservoir (14.963 mg/L) during the autumn season. The results elucidated an uneven distribution of phytoplankton communities at each station and seasons. This study emphasised on implementing an adaptive management strategy to reduce the impact of cascade dams.

109 CAN DNA METABARCODING REPLACE TRADITIONAL METHODS FOR BIODIVERSITY ASSESSMENT?

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The global biodiversity crisis requires the development of a new generation of reliable, high-throughput and high-resolution techniques to measure and describe state and change of biodiversity. In recent years, DNA metabarcoding has emerged as a promising solution that could meet these criteria. However, several challenges still stand in the way of widespread adoption of environmental DNA to track biodiversity, one of the most important and urgent being the validation of DNA metabarcoding as an effective and sensitive approach to detect targeted species and the comparability between the results obtained by metabarcoding and those obtained by traditional methods. Here, we present a global meta-analysis of all the available studies reporting comparisons between metabarcoding and traditional methods to assess the richness and composition of biological communities in aquatic environments. We found that metabarcoding provides richness estimates that are globally consistent to those obtained using traditional methods. Metabarcoding also generates species inventories that are highly congruent with traditional methods for fish. Contrastingly, species inventories of microorganisms and macroinvertebrates obtained by metabarcoding showed pronounced differences to traditional methods. Based on these results we will highlight how DNA metabarcoding could be integrated with traditional approaches to provide a powerful solution to monitor freshwater diversity in a changing world.

68 INTEGRATED SOLUTIONS TO FRESHWATER CONSERVATION

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IUCN's World Conservation Congress in September 2021 included, for the first time ever, a theme specifically focused on fresh water. This theme identified priorities for achieving biodiversity conservation and sustainable management of freshwater ecosystems; in particular, the better representation of freshwater ecosystems in regional and global management and policies for protection. The highest priority is to include more adaptive mechanisms for achieving the protection and restoration of freshwater ecosystems, going beyond protected areas and using other effective conservation measures. Restoring and maintaining connectivity across the landscape, from freshwater sources to transitional estuarine environments and coastal habitats that are connected to them is a key prerequisite, and there is a need for marine and freshwater programmes to integrate better. Our most significant challenge is to reconnect our global consciousness to fresh water as an ecosystem rather than principally as a resource for our consumptive use. A guiding framework that identifies solutions for managing freshwater biodiversity both as a conservation and a development priority, whose proper management is directly relevant to the sustainable development agendas of the private and governmental sectors is needed. This contribution will exemplify how the Freshwater Conservation Committee of IUCN's Species Survival Commission can help attain those goals.

FRW2-a - Research and implementation to restore and protect Blue-Green biodiversity

583 QUANTIFYING THE ECOLOGICAL PERFORMANCE OF BLUE-GREEN INFRASTRUCTURE

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Urban space is scarce, expensive and, ideally, multi-functional. Blue-green infrastructure (BGI) promises to reconcile often conflicting social, ecological and engineering objectives such as mitigating hydrological and thermal stress while protecting biodiversity. The absence of metrics to quantify the ecological performance of BGI systems hinders a more systematic consideration of ecological objectives in BGI design choices. Here we first discuss the challenges and opportunities of developing an integrative modelling framework that allows identification, quantification and triage of potential synergies and trade-offs between engineering, ecological and social objectives. We then present a Bayesian species distribution model to examine how a distributed BGI system can enhance urban biodiversity while ensuring engineering objectives and stakeholder preferences are met. We focus on BGI-associated taxa (birds, amphibians, dragonflies and grasshoppers) in the city of Zurich, Switzerland. The model incorporates both engineering and ecological variables, as well as stakeholder preferences and expertise. It accounts for sampling biases and rigorously quantifies prediction uncertainties, which is paramount to informing engineering design decisions. Future extensions of the modelling framework are discussed, including the incorporation of novel survey data (eDNA) and projections of the ecological and engineering performance of distributed BGI systems under scenarios of climate change.

492 I'M IN FAVOUR OF BIODIVERSITY, BUT ….

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Reversing Biodiversity loss is a key challenge for the future. Despite the urgent need of action, changes in policy and politics are slow. The importance of better protection of biodiversity is acknowledged by many politicians in sermonizing Sunday speeches, but often ignored in workday decision-making.
In Switzerland's federal system, important decisions regarding the conservation of biodiversity are made at national, cantonal and communal level. These may concern the budget, the further development of laws or concrete projects. Usually, (negative) impacts on biodiversity are not considered in the decision-making process and changes in favour of biodiversity are regularly highly disputed. Many politicians consider biodiversity conservation as a luxury, as an obstacle of economic uses and an additional restriction of liberty.
So, what role can scientists play to improve the recognition of the biodiversity, its value and importance in politics? Which other stakeholders need to be involved? What processes can be used to ensure that scientific findings are incorporated into political decisions? In this presentation, I will discuss some experiences and observations from my experiences as member of the cantonal legislation, member of the municipal executive and national policy work.

548 SOIL NUTRIENT CONTENT DRIVES MANGROVE FOREST ABOVEGROUND BIOMASS ON ALDABRA ATOL

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Mangroves are vital for carbon capture and conservation of biodiversity. Yet, they are decreasing globally at a rate higher than most other tropical ecosystems. In addition to human drivers, local environmental factors influence the functioning of mangroves, but their importance is relatively unknown. Here, we investigate the drivers of mangrove functioning, approximated by mangrove aboveground biomass (AGB), in a protected lagoonal mangrove ecosystem on Aldabra Atoll, Seychelles. Based on a survey of the mangrove forest in 54 plots, we recorded six mangrove species and estimated that the mean mangrove forest AGB on Aldabra was 82 ± 13 Mg ha-1. The total AGB of the mangrove area (1720 ha) was equivalent to about 66 100 Mg of carbon stored in the standing biomass. To assess the direct and indirect effects of soil nutrient content, water level variation and soil salinity on mangrove AGB, we used a structural equation model. Our model explained 82% of the variation in mangrove AGB. Soil nutrient content had the greatest influence on the variation of mangrove AGB. Additionally, a high variation in water level increased mangrove AGB by increasing nutrient content levels. Our results show the important contribution of Aldabra's mangrove ecosystem to Seychelles' carbon storage. We suggest conservation managers worldwide use an ecosystem-level perspective for successful mangrove conservation, including the protection and maintenance of nutrient cycling and hydrological processes.

487 RIPARIAN VEGETATION AFFECTS MACROINVERTEBRATE COMMUNITIES AND LEAF BREAKDOWN

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Headwater streams harbour diverse macroinvertebrate communities and are hotspots for organic matter processing. As allochthonous leaf litter input is often the major carbon and nutrient source in headwater stream ecosystems, the surrounding vegetation can affect aquatic decomposers and potentially lead to cascading effects on leaf litter breakdown. Assessing the in-stream consequences of the presence or absence of riparian forests is therefore fundamental for effective stream conservation and restoration strategies. We investigated the structure of macroinvertebrate communities and leaf litter breakdown rates in experimental leaf litter bags in forested and non-forested sections of several streams in two regions of Switzerland. We focused our analyses on effects on May-, Stone- and Caddisflies (EPT) and on the functional feeding group of shredders. We expected these groups to be strongly affected by changes in the riparian vegetation because of their sensitivity and functional role in detritus-based food webs. We found that the abundance, diversity, and biomass of both EPT and shredders were often highest in the forested sections. There, the macroinvertebrate-mediated leaf litter breakdown rates were also higher. Our findings suggest that sensitive macroinvertebrate groups and important ecosystem processes can be affected by the riparian vegetation.

508 TOWARDS PREDICTING HUMAN IMPACTS ACROSS REALMS USING FUNDAMENTAL PROCESSES

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Human impacts such as habitat loss, biological invasions, and climate change are fundamentally altering biodiversity, with even greater effects projected in the future. However, there is growing evidence that human impacts on ecosystems may differ in

magnitude between aquatic and terrestrial ecosystems, hindering our ability to make general predictions about the trajectories of ecosystems. A potentially powerful tool to improve our understanding of global change impacts, and to facilitate predictions of these impacts across systems, is to focus on the fundamental processes that structure ecological communities. Here we attempt to provide a synthesis of how the relative importance of the four fundamental community ecology processes proposed by Vellend (2010, 2016): selection, drift, dispersal and speciation, may differ (or not) among terrestrial and aquatic realms. Based on knowledge of how these processes may change in importance across realms, we consider whether and how global change drivers can impact terrestrial and aquatic communities in different ways. In addition, we identify key knowledge gaps and outline future studies to fill them. We conclude that a higher number of quantitative cross-ecosystem studies are needed to improve our understanding of the impacts of global change across aquatic and terrestrial systems. Finally, due to the importance of cross-ecosystem flows of material, energy and organisms, it is also crucial to consider these linkages in future studies.

47 PERSISTENT CONSERVATION ACTION LEADS TO LANDSCAPE-SCALE RECOVERY OF AMPHIBIANS

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Conservation science should provide the tools to halt and reverse population declines. Habitat creation can benefit declining populations, but reports of positive conservation outcomes are few. We showcase an amphibian conservation success story from the canton of Aargau in Switzerland, where hundreds of new ponds have been built over the last decades. Fitting dynamic occupancy models for 12 amphibian species to 20 years of monitoring data, we show that persistent conservation action reversed negative population trends and lead to landscape-scale increases in metapopulation size of amphibian species. While there were regional and species-specific differences in the use of constructed ponds, in 77% of metapopulations, the colonization of new ponds stabilized or increased metapopulation size. Testing for effects of local and landscape-scale variables on colonization probability generated species-specific recommendations to improve pond creation. Higher connectivity increased colonization probability in some species, but large roads surrounding ponds could negate or reverse this effect. Importantly, we found that simple connectivity metrics such as Euclidian distance and pond density could substitute more complex metrics. We conclude that simple, but persistent conservation action through pond creation can lead to population recovery of threatened amphibian species at the landscape scale, and that easily implementable rules of thumb can help maximise conservation efficacy.

FRW2-b - Research and implementation to restore and protect Blue-Green biodiversity

339 WARMING-RELATED COMMUNITY TURNOVER IN FRESHWATER AND TERRESTRIAL ECOSYSTEMS

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It is a grand challenge facing humanity to determine how Earth's biodiversity will respond to global warming. Local communities are responding to rising temperatures with turnover towards warm-affinity species - a process called thermophilisation. Whether this response is widespread across realms remains unknown, as freshwater communities are usually not included in broad-scale assessments. To fill these gaps, we quantified thermophilisation for 13,292 terrestrial and freshwater communities for 8 taxonomic groups. We observed faster rates of thermophilisation for the terrestrial realm on average than for the freshwater realm. We observed positive rates of thermophilisation for most taxonomic groups studied, but not for phytoplankton and zooplankton. Faster warming was strongly associated with higher rates of thermophilisation in the terrestrial realm and less in the freshwater realm. Faster warming was associated with higher rates of thermophilisation in plants, birds and fish, but these effects depended on body size, thermal niche breadth and the species richness of the initial communities. Species that colonized communities tended to have higher warm-affinities than species that were lost over time, except in phytoplankton. Finally, species-rich communities were able to resist the impact of warming better than species-poor communities, suggesting that the interacting effects of climate change and biodiversity loss together may exacerbate rates of local community change.

368 HUMAN PRESSURES DRIVE MULTIFACETED HOMOGENIZATION OF BLUE-GREEN BIODIVERSITY

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Human activity is a leading driver of biodiversity loss. Changes in species diversity in local assemblages (α-diversity) owing to human pressures are well documented. However, the broader consequences of these changes in biodiversity for ecological resilience and ecosystem functioning remain unclear. To resolve these, assessments at larger spatial scales are needed to elucidate how gradients in human pressures shape patterns of biodiversity among multiple assemblages (β-diversity). Thereby, not only the constituent species (taxonomic β-diversity), but also species' traits (functional β-diversity) that modulate key ecological interactions need to be considered. We analysed >8,000 assemblages spanning terrestrial and freshwater systems, including >10,000 species of microorganisms, plants, invertebrates, and vertebrates. We show that human pressures account for substantial changes in both taxonomic and functional β-diversity, often driving negative effects on the replacement of species and traits, indicating

taxonomic as well as functional homogenization. The effect sizes exceed those of other environmental factors such as spatial distance and climate. Most responses are nonlinear; assemblages embedded within landscapes with high human pressures show disproportionate losses of species and traits. These impacts are most severe for terrestrial and freshwater invertebrates. We discuss the consequences of and ways to mitigate a pervasive homogenization of multifaceted biodiversity.

207 GLOBAL REMOTELY SENSED PHENOLOGY OF BLUE-GREEN ECOSYSTEMS

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Changing environmental conditions, such as a change in temperature, precipitation, or land use, have significantly altered the phenology, spatial distribution, and abundances of species in both 'green' (terrestrial) and 'blue' (freshwater) ecosystems. In this study, we used remote sensing data to extract phenology metrics (e.g. start of the growing season) from daily lake chlorophyll estimates and terrestrial vegetation indices of 4264 lakes and their surrounding watersheds across a wide range of biomes and a period of 10-20 years. We investigated whether changes in the phenology of lake phytoplankton and terrestrial vegetation growth have occurred during this period, how these changes correlate with changes in environmental conditions, and whether the observed rates of change are similar for lakes and their surrounding watersheds. Our results suggest that the phenology of lake phytoplankton is more sensitive to environmental change than the phenology of the vegetation on the watersheds. This has led to increasingly large mismatches between aquatic and terrestrial phenology across environmental gradients of which the direction and magnitude differ strongly between regions. A finding that is of particular importance because terrestrial vegetation and lake phytoplankton are, as 'primary producers', at the base of food webs, and because terrestrial and freshwater ecosystems are closely interlinked through biogeochemical cycles and species that inhabit both ecosystems.

221 STABILITY-DIVERSITY RELATIONSHIPS AND PATTERNS OF SYNCHRONY DIFFER ACROSS REALMS

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Community stability (or variability) is considered central for the conservation of biodiversity, especially given ongoing global changes. While these global changes vary considerably across terrestrial and aquatic realms their relative influence on stability has

yet to be systematically evaluated. Further, a major driver of stability, variation in synchrony, is generally characterized based on pairwise correlations across all species, ignoring dynamics when species are particularly common or rare. Here we evaluate if our ability to identify drivers of stability can be improved by considering such interspecific associations, i.e., synchrony when species are simultaneously rare (or common), in conjunction with usual drivers, i.e., richness and variance ratio. We consider the relationship between stability and its drivers using an extensive dataset of 2759 communities including both freshwater (716) and terrestrial (2043) assemblages across 7 taxa. We find that (i) an asymmetric pattern in pairwise species synchrony matters for stability irrespective of the realm-effect, and can even supercede the model performance based on classic predictors; and, (ii) it is important to consider a realm effect on stability because both stability and its drivers vary across realms. Linking synchrony patterns with stability in multiple realms offers new insights into the mechanistic pathway to explain variation in stability, and also highlights the varying conservation needs across the realm.

124 BLUE AND GREEN FOOD WEBS RESPOND DIFFERENTLY TO ELEVATION AND LAND USE

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While the structure of aquatic (blue) and terrestrial (green) food webs is well studied separately, it remains unclear whether they respond similarly to shared landscape-scaled environmental changes. We construct local blue and green food webs using empirical taxa occurrence data from hundreds of sites across Switzerland, in combination with a knowledge-driven trophic metaweb. We show that blue and green food webs have different structural and ecological properties along elevation and among various land types. Specifically, in green food webs elevation is positively related to their modular structure and negatively to the overlap of consumers' diet niche, while the opposite is observed in blue ones. Such blue-green differences are more pronounced in farmlands compared to forests within the same elevation range. Taking elevation gradient as a climate-change proxy, our findings indicate that anthropogenic habitat modification can moderate the climatic effects on food webs, but differently in blue vs. green ecosystems. These findings provide a comprehensive understanding of the current structure of blue and green communities across the landscape and their potential future change.

133 UNPACKING THE LAND-SEA BIODIVERSITY PARADOX USING A 307,328 SPECIES DATASET

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Why do some areas of the globe have more species than others? Providing an answer to this fundamental question is crucial to understand how Earth's biodiversity patterns are formed and to ensure the conservation of biodiversity into the future. Total geographic area is often invoked as a fundamental driver of species richness, yet while more than 70% of the Earth is covered by ocean, most species are found on land- the so-called land-sea biodiversity paradox. In an attempt to resolve this paradox, we compiled a dataset of 307,328 terrestrial, freshwater and marine species distributions- spanning plants, vertebrates and invertebrates- and combined it with data on major climatic axes of temperature and productivity. We find that while terrestrial and freshwater taxa occupy less geographic space, they span several times more environmental space than marine taxa. In addition, terrestrial taxa have smaller range sizes and higher assemblage turnover than marine taxa. Taken together, these results suggest that the total available climatic niche space, and the way this environmental space is packed by species, is more important for determining diversity than sheer geographic area. Our results provide a general understanding of global biodiversity accumulation and suggest new strategies to conserve biodiversity by protecting the environmental space occupied by species as opposed to the geographic space.

FRW3-a - The role of coordination and harmonization for detection of trends in freshwater biodiversity at a global scale

309 COORDINATING CIRCUMPOLAR ASSESSMENT OF ARCTIC FRESHWATER BIODIVERSITY

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To address the need for coordinated monitoring and assessment of freshwater biodiversity on a circumpolar scale, the Conservation of Arctic Flora and Fauna (CAFF) working group of the Arctic Council established the Circumpolar Biodiversity Monitoring Program (CBMP). The CBMP is an international network of scientists, government agencies, Indigenous organizations and conservation groups. The CBMP promotes coordination, harmonization, and collaboration in monitoring and assessment centered around four ecosystem themes (Freshwater, Terrestrial, Coastal, Marine). CBMP-Freshwater accomplishments since inception in 2010 include:
1) development and implementation of a circumpolar monitoring plan,
2) creation of an Arctic freshwater database with more than 9000 sites, and
3) use of the database to complete the first circumpolar state of Arctic freshwater biodiversity assessment. In this presentation, we provide an overview of the CBMP-Freshwater collaborative process, highlighting international cooperation efforts, the collection, harmonization, and management of circumpolar data, and the development of harmonized monitoring protocols. By identifying gaps in monitoring data across the circumpolar region and identifying best practices for monitoring and assessment, CBMP-Freshwater provides important resource information for researchers, policy makers, and Indigenous and local communities that can support future assessments of ecosystem change.

61 NEOTROPICAL MONITORING NETWORKS SURVEY: A CRITICAL STEP TOWARDS COLLABORATION

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There are many aquatic biodiversity monitoring initiatives around the Neotropical region, however they are not integrated. Here, we will present the results of the Neotropical in situ Aquatic Biodiversity Monitoring Networks Survey applied in 2021. The purpose of the Network is to create a catalog of monitoring initiatives to stimulate new uses of avaliable datasets and increase collaboration between institutions and networks. The Survey was elaborated by a team of Brazilian researchers and it was applied in collaboration with the Freshwater BON-Latin America team and the Brazilian Limnological Association. The study did not involve primary data, just metadata, such as monitored parameters, monitoring sites, start and last sampling dates, as well as information about the network itself. In this special session, we will share the planning process of the survey, the strategies to improve participation, the protocols, and the main results.

106 TOWARDS GLOBAL HARMONIZATION OF FRESHWATER MACROINVERTEBRATE SAMPLING PROTOCOLS

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A multitude of protocols for biodiversity monitoring and ecological assessment of freshwater ecosystems are in use regionally and globally. The use of different methods challenges large-scale assessments of biodiversity and ecosystem change, but may also reduce transparency in how results are obtained and the confidence in their reliability. While some regions have harmonized their protocols, such as the European Union and the United States, most countries and regions have yet to do so. Many of these same regions and countries do not have nationally accepted protocols in place for the monitoring and ecological assessment of freshwater habitats. In order to close the gap both in terms of knowledge and application, we established the IUCN/SSC Task Force on Global Freshwater Macroinvertebrate Sampling Protocols (GLOSAM) in 2021. The GLOSAM Task Force aims to: (a) support the application of biodiversity and bioassessment protocols based on benthic freshwater macroinvertebrates, (b) establish globally accepted, harmonized steps for sample collection and data treatment, both for bioassessment and species inventories, which also account for specific biogeographic requirements, and (c) ensure the collection of ecologically relevant data of known and acceptable quality and (d) support, promote, and facilitate regionally comparable bioassessment schemes (incl. tools and assessment systems).

50 MEASURING GLOBAL CHANGE IN FRESHWATER BIODIVERSITY

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Implementing the Global Biodiversity Framework (GBF) is contingent on having reliable biodiversity measurements. In 2017 the Freshwater Biodiversity Observation Network (FWBON) identified priorities for applying the Essential Biodiversity Variables (EBV) concept in freshwaters. FWBON has since been supporting national and multinational monitoring programs which align with these priorities. The Circumpolar Biodiversity Monitoring Program Freshwater Group (CBMP-F) has successfully tackled some of the challenges in implementing multinational freshwater biodiversity monitoring activities at very broad spatial scales based on in-situ measurements and inclusive of Indigenous and local knowledge.
We propose the following steps towards measuring global change in freshwater biodiversity:
1) develop other multinational programs similar to the CBMP-F in other biomes and especially across large transboundary river basins
2) use the learnings from these programs to arrive at globally applicable solutions to the major challenges facing global measurement of change in freshwater biodiversity;
3) refine the application of remote sensing techniques, especially those used for Ecosystem Structure and Community Composition EBVs, combining the established methods with new methods e.g. UAV; and
4) fill geographic gaps in EBV measurements using functional and statistical models based on Globally continuous maps of drivers of freshwater biodiversity.

360 GLOBAL COORDINATION AND HARMONIZATION OF FRESHWATER BIODIVERSITY OBSERVATIONS

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Initiatives to halt current freshwater biodiversity declines operate on different spatial scales and usually in a complex transdisciplinary context with various experts and stakeholders involved. To maximize their effectiveness, initiatives require approaches that are coordinated and harmonized on larger spatial and temporal scales and account for socio-economic and cultural diversity. If such larger-scale perspectives exist, individual (smaller) initiatives and projects can benefit from and support initiatives and projects with similar goals in other regions and focusing on other timescales. However, this requires coordination and harmonization of approaches and methods used for observation of freshwater biodiversity as well as of storage, mobilization, and communication of resulting data. The goals of the Freshwater Biodiversity Observation Network (FWBON, a part of GEOBON) include harmonization of different monitoring approaches and methods, and of data handling for all freshwater organism groups (including classical monitoring approaches, remote sensing, citizen science, etc.). These approaches are coordinated within the umbrella concept of Essential Biodiversity Variables (EBVs) developed by GEOBON. We present the status of FWBON and of its key

activities; and then introduce the contributions of the session and show how they link to efforts for coordination and harmonization of global freshwater biodiversity observation.

332 OPPORTUNITIES AND HARMONIZATION CHALLENGES OF UAV DATA FOR FRESHWATER EBVS

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Spatial resolution continues to be a major limiting factor in the application of remote sensing for essential biodiversity variables (EBV) mapping and monitoring, particularly for freshwater ecosystems. Innovations in unoccupied aerial vehicle (UAV) platforms and the miniaturization of sensors are opening new opportunities to expand remote sensing of EBVs to freshwater systems. UAVs enable data collection at higher spatial resolutions and on-demand temporal resolution with sophisticated instruments such as imaging spectrometers, LiDAR and thermal imaging to monitor community composition, species traits, ecosystem structure and function. With the expansion of UAV-enabled remote sensing of freshwater EBVs comes great opportunities, but also presents new challenges to global coordination and harmonization efforts. Unlike most satellites, the timing, frequency and extent of data collection is not systematic, and this is confounded by variable regulations and restrictions. Off-the-shelf sensors and data processing software vary tremendously, impacting data quality and provenance. A new era of high resolution datasets and accompanying data volumes will challenge our cyberinfrastructure and impact data preservation and access. Interoperability for EBV data products has become a focus for data and research infrastructures. Given the high value UAV data bring to freshwater EBVs, the challenges posed by UAVs must be included in emerging operational frameworks for global EBV monitoring.

FRW3-b - The role of coordination and harmonization for detection of trends in freshwater biodiversity at a global scale

335 ETHNOBIODIVERSITY: A FRAMEWORK FOR FRESHWATER BIOMONITORING IN MELANESIA

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Indigenous communities of Pacific Island countries are culturally connected to their environments, natural resources and biodiversity. Because of this, biomonitoring that builds upon commonly held knowledge and cultural values has the greatest opportunity for success. In Melanesia, the dragonflies and damselflies of the Order Odonata represent speciose endemic genera whose morphological and ecological diversity makes them suitable as sentinels for monitoring regional and local environmental trends of ecosystems. The Odonata are also recognized by indigenous communities as traditionally important. They are large colourful insects, easily seen. They can even be identified in flight. They can be found longitudinally distributed across all running and standing

waters. These features make Odonata well suited as focal organisms in Melanesia for freshwater conservation and biomonitoring that builds upon Traditional Ecological Knowledge.

518 THE POTENTIAL OF RANGERS TO MONITOR STREAM HEALTH IN UGANDA'S PROTECTED AREAS

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In situ biodiversity observations is fundamental in sustainable management of the world's freshwater resources. We trained protected area rangers from four protected areas located within the Albertine rift region of Uganda to carry out river health assessment using benthic macroinvertebrates and habitat assessment protocols. The trained rangers were able to successfully sample different streams in protected areas of their jurisdiction and identify benthic macroinvertebrates to family level for most taxa. With metrics such as family taxa richness and Ephemeroptera, Plecoptera, Trichoptera (EPT) scores the sites segregated along a land use gradient but also along a geographical gradient. Savanna national park sites were poor in benthic macroinvertebrate (BMI) and habitat scores while forested stream sites had the highest scores recorded, total habitat scores ranged from 96 to 178. Low habitat scores indicate less desirable habitat for BMI and low biodiversity overall. With minimal resources and training rangers have the potential to generate data on stream health and the status of freshwater biodiversity across the country. Using rangers and other protected area staff in monitoring is advantageous over using non-local professionals due to benefits of indigenous and local knowledge, improved engagement motivation and better connection between management actions and biodiversity state.

517 HYDROATLAS-A COMPREHENSIVE SPATIAL DATA BACKBONE FOR GLOBAL BIODIVERSITY MODELS

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Seamless, comprehensive and harmonised spatial data that is easily accessible and useable is essential as background information and covariates for global biodiversity models. We mapped ~250 attributes to the world's rivers, catchments and lakes. These attributes include hydrology; physiography; climate; land cover & use; soils & geology; and anthropogenic influences. Published in 2019, HydroATLAS comprised two companion datasets: BasinATLAS offered data for ~1.0 million sub-basins globally, and RiverATLAS offered data for ~8.5 million river reaches globally. LakeATLAS adds a third layer with equivalent data for lakes and reservoirs in a compatible structure. All three datasets can easily be linked by common identifiers, therefore providing a global data infrastructure for ecohydrological analysoi.The standardized format of HydroATLAS ensures easy applicability while the inherent topological information supports basic network functionality such as identifying up- and downstream connections. In this presentation, we will discuss the datasets but also present example applications, like a current program that models global nutrient inputs to lakes.

540 PLENARY DISCUSSION ON TOPICS AND CONTRIBUTIONS OF SESSION A6C

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*** Plenary discussion of 45 minutes at the end of the session***
This slot at the end of session A6c | The role of coordination and harmonization for detection of trends in freshwater biodiversity at a global scale will allow extended discussions in plenary on the main concepts raised and the examples presented during the session. If it helps discussions, the plenary will be split into groups with a reporting back and plenary discussion towards the end of the slot. The discussions will be moderated by the session conveners.

71 INDICATORS TO CONSIDER FOR GLOBAL BIODIVERSITY TARGETS OF FRESHWATER ECOSYSTEMS

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Indices for tracking changes in freshwater ecosystems are reported under the Aichi target 11, and the SDG 6 and 15. Using available spatial datasets reporting can be improved for freshwater ecosystems. The following improvements are proposed for these three targets:

1. Aichi target 11 aimed to '… (e)nsure the protection of at least 17% of the extent of inland waters, including rivers, by 2020'
    1. Changes in protection levels of free-flowing and/or flagship rivers;
2. SDG 6 target 6.6 states '… (b)y 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes'.
    1. Reporting of changes in the % extent of free-flowing or flagship rivers in a good ecological condition. This will require the selection and prioritization of free-flowing and/or flagship rivers for focused management, conservation and reporting by each country;
    2. Ecological condition of rivers and wetlands;
    3. Quantifying the changes in extents per wetland biome;
    4. Quantifying changes in the hydrological regime of lacustrine wetlands against natural climatic cycles;
    5. Quantifying changes in the extent of forested vs marsh palustrine wetlands;
3. Sustainable Development Goal 15 'Life on Land' and aimed to conserve and restore terrestrial and freshwater ecosystems and halt biodiversity losses:
    1. Changes in protection levels of free-flowing and/or flagship rivers; &
    2. Number of freshwater RLE.

The proposed indices are discussed with illustrations on the possible improvements.

FRW4 - Integrating perspectives on biodiversity and ecosystem functioning of aquatic and terrestrial ecosystems across river catchments & The importance of being small: biodiversity conservation in ponds and other small freshwater systems

464 DRIVERS OF POND BIODIVERSITY: THE INTERPLAY BETWEEN LOCAL AND REGIONAL FACTORS

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Small lentic freshwater bodies are important habitats for global biodiversity because they often host high levels of local biodiversity and have a strong contribution to regional biodiversity. A vast body of studies shows that pond biodiversity is largely determined by a combination of local and regional factors.
Using literature and empirical data, I will identify the key factors underpinning the structure and diversity of pond communities. I will first focus on major local biotic and abiotic conditions, and subsequently explore the relative importance of local environmental conditions and landscape structure on pond community characteristics at different spatial scales. My findings demonstrate that the ecological importance of ponds is not exclusively linked to the value of individual ponds, but rather related to a network of ponds at the landscape scale ('pondscape'). Such information is highly relevant for the design of policies for blue infrastructures at the national and European levels.

410 EUROPONDS FRESH PROJECT - ECOLOGICAL CONTRIBUTION OF PONDS TO THEIR LANDSCAPES

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Ponds, whilst being mostly neglected in management and protection plans, can constitute habitats with high α- and β-diversity, including many rare and endemic species. In heterogeneous landscapes, ponds can also contribute to habitat connectivity and enhance γ-diversity whilst delivering many ecosystem services. Semi-aquatic insects are one of the groups contributing most to aquatic faunal biomass in these ecosystems. Upon emerging from the water, they provide lipids and essential fatty acids to the adjacent terrestrial environments, and constitute an important nutritional subsidy for terrestrial and aerial consumers. Numerous studies have pointed out the relations between emerging aquatic insects and fitness benefits to terrestrial consumers. However, large-scale studies using common standardized methodology are needed to explore differences in dietary links from diverse pond types and different ecogeographical contexts.
In this project we quantify the seasonal and geographical variation in insect emergence in 55 ponds across Europe. In our dataset we compile data from unprecedented geographical gradients, and we include both near-natural and artificial systems. The project brings together the knowledge of early-career limnologists from all over Europe and therefore not only provides important insight into the aquatic-terrestrial linkages of ponds, but also offers an important exchange among the future generation of European limnologists.

111 LINKING BIRDS, INSECTS AND FUNCTIONS TO MODEL RIVER REWILDING POTENTIAL

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Canada is home to much of the world's freshwater, harbouring biodiversity and providing vital ecosystem functions and services, including vast carbon sinks. Despite this, many of our rivers are threatened by networks of dams that fracture connectivity, industrial and agricultural practices that extract water and introduce pollution, and climate change, which changes the timing, variability and seasonal availability of water and threatens cold water refugia. Many countries, including Canada, have pledged to conserve large tracks of land according to Aichi targets, but often conservation areas are chosen due to remoteness or cost rather than their value for biodiversity and ecosystem function. We present a framework for prioritizing conservation areas based on species diversity patterns and propose a new way of mitigation measures (rewilding) based on ecosystem function metrics as targets. This research combines 'green' (terrestrial) and 'blue' (aquatic) biodiversity by focusing on freshwater specific habitat variables and linking distribution of aquatic biota to terrestrial consumers. Including climate parameters also supports prediction of hotspots for future biodiversity loss and prioritization of future conservation measures. We showcase this model as a case study in the Wolastoq | Saint John River, a priority place identified by the Government of Canada due to its significant biodiversity, concentration of species at risk and opportunities to advance conservation efforts.

12 PATHWAYS FOR CROSS-BOUNDARY EFFECTS OF BIODIVERSITY ON ECOSYSTEM FUNCTIONING

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The biodiversity–ecosystem functioning concept states that properties of and processes in ecosystems are markedly influenced by species richness and other facets of biodiversity. However, biodiversity–ecosystem functioning studies have been largely restricted to single ecosystems, ignoring the importance of functional links—such as the exchange of matter, energy and organisms—between coupled systems. Here we outline

three different pathways of cross-boundary biodiversity effects on ecosystem processes, focusing on terrestrial-aquatic linkages to illustrate the case. Pathway 1 describes cases where biodiversity of 'donor' ecosystems directly affects the functioning of 'recipient' ecosystems. Pathway 2 illustrates cases where biodiversity of 'donor' communities affects the functioning of 'recipient' ecosystems indirectly, by influencing biodiversity of the 'recipient' communities. Pathway 3 describes cases where biodiversity of 'donor' ecosystems affects 'recipient'-ecosystem functioning indirectly through effects on 'donor'-ecosystem processes that propagate across system boundaries.
This cross-boundary perspective of biodiversity–ecosystem functioning relationships presents a promising frontier for biodiversity and ecosystem science, with repercussions for the conservation, restoration and management of biodiversity and ecosystems from local to landscape scales.

311 WITHIN-WETLAND PATCH DIVERSITY CRITICAL TO ECOSYSTEM FUNCTION AND RESTORATION

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Research on the role of freshwater wetlands in the global carbon cycle has typically focused on two divergent scales. One involves measurements or use of top-down models to estimate CO2 and CH4 exchange at landscape scales. The other involves measurement of soil carbon by collecting several sediment cores within one or more wetlands. Both largely ignore within-wetland heterogeneity in hydrology and plant cover. Yet, wetlands often vary in topographic relief that leads to within-wetland differences in hydroperiod and often are composed of functionally distinct plant communities, including emergent grasses, sedges, submerged and floating aquatic vegetation, and non-vegetated open water or mud flats. Thus, spatially-discrete patches characterize many wetlands. Our research suggests that these patches differ considerably in their soil biogeochemistry, gaseous emissions, and carbon stores. Given the increasing interest in restoration of freshwater wetlands to mitigate the impacts of climate change, it is critical that we increase our understanding of patch diversity in the context of wetland carbon dynamics. Since restoration actions typically involve manipulation of topographic relief to restore hydrology and they involve active plantings, can we better design restoration projects? Biodiversity matters -- not just in the plant species we use but the diversity of patch types we create in our efforts to ensure more sustainable futures.

300 CONNECTIVITY LOSS AS A DRIVER OF BIODIVERSITY LOSS IN PONDSCAPES

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Ponds usually form natural networks in the landscape where high biodiversity is sustained by sufficient dispersal between local habitats. Freshwater biodiversity is threatened by losing this vital connectance due to shrinking habitat networks worldwide. In my talk, I will combine empirical evidence and experimental work to show that biodiversity loss is clearly linked to the disruption of regional processes when individual ponds are lost from a habitat network. This emphasizes the importance of connectivity conservation for small waterbodies and the need for better recognition of their network structure and spatial connectance.

148 METAECOSYSTEM DYNAMICS DRIVE SPATIAL DISTRIBUTION OF FUNCTIONAL GROUPS IN RIVERS

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Spatial flow of material and resources is a central process structuring ecological communities. The meta-ecosystem concept provides a theoretical framework to study the interplay between local and regional flows of resources and their implications for ecosystem dynamics and functioning. Yet, meta-ecosystem theory has hitherto been applied to highly simplified systems, and the effects of meta-ecosystem dynamics in real-world landscapes, characterized by specific spatial structures, remain largely unexplored. Here, we develop a spatially explicit meta-ecosystem model for dendritic river networks based on a realistic landscape matrix. By formalizing the River Continuum Concept, a seminal principle in freshwater ecology, we show that the spatial distributions and regional biomass of major functional groups observed in stream communities are determined by specific rates of resource flows. Overall, high rates of resource flow have a negative effect on the regional biomass of all the functional groups studied and can lead to extinctions at the meta-ecosystem scale. Hence, we show that integrating spatially realistic landscapes into ecosystem studies will significantly increase our ability to predict the large-scale consequences of human-induced changes on biodiversity and ecosystem functioning.

GOV1 - The influence of environmental, social and governance (ESG) reporting on investors' decisions - is this an alternative, effective way to achieve biodiversity conservation goals? & Building back better in the post-COVID era: Locking in insights for sustainable ocean governance

73 OCEAN ACCOUNTS TO INTEGRATE ENVIRONMENTAL, SOCIAL AND ECONOMIC OCEAN INDICATORS

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The integration of environmental, social and economic information has become a critical aspect of informed ocean governance for ocean sustainable development. Ocean valuation processes have in the past been largely carried out as economic contribution (gross value add) of maritime industry sectors to national account metrics such as GDP. Such measures provide no information on ocean health, total ocean wealth including natural or non-produced capital, distribution of ocean economy benefits and costs in terms of inclusivity. Ocean accounts provide for the integration of social, environmental and economic data in standard and consistent manners using discrete accounting systems that are both accepted (for example the SNA and the SEEA) and novel accounting approaches (e.g. ocean risk and ocean governance). Integration across disciplines is achieved through links and flows between accounting systems. The compilation of accounts at regular intervals means that they result in benchmarked ocean indicators that underpin informed ocean decision-making processes and adaptive policy cycles. Marine ecosystem accounts as a component of ocean accounts measure ecosystem types, extents, condition, assets and can result in important biodiversity

indicator metrics to address strategic planning decisions, the promulgation of regulatory instruments, operational and management decisions, finance and investment decisions and progress reporting against agreed commitments.

401 THE CATALYTIC ROLE OF ESG INVESTMENT IN ECOSYSTEM-BASED FISHERIES MANAGEMENT

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We use a South African fishing sector as a case study to explore the role investors may be able to play in ensuring the implementation of ecosystem-based fisheries management (EBFM). Management oversight and regulation of fisheries usually falls within a countries' government structures. However, requirements of various stakeholders that include fishing industries as well as those impacted by fishing activities, can often be conflicting, leading to difficult decision-making processes for government. In some cases, much needed decisions and their implementation, within an EBFM framework, are delayed or watered down as a result of this conflict. With the threats and pressures that ocean ecosystems are currently under, these delayed or ineffective decisions can have disastrous ecological consequences for these systems. We disentangle some of the influential pathways between investors and successful implementation of EBFM in the South African small pelagic fishing sector within the context of Environmental and Social Governance (ESG) reporting. The concepts explored in our case study are pertinent to other fishing sectors in South Africa, and also in the international context. Finally, we consider how E SG may be useful in addressing broader priority linkages cross multiple sectors, pressures and ecosystem components, as identified during Integrated Ecosystem Assessments of a marine ecosystem.

550 ESG INVESTING – PERSPECTIVES FROM AN INVESTMENT COMPANY

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ESG investing as a requirement for custodians of client investments to demonstrably incorporate it in their investment process continues to gain traction worldwide. Pressure continues to build on companies in terms of their commercial behaviour and disclosure requirements regarding their environmental impacts. Economic growth is required, yet activities favouring short term gains are often supported despite negative environmental impacts. Advocacy against these activities may cause unintended consequences. Responsible industries with strict scrutiny/evaluation processes across operations and supply chains are required. If conditions make operating difficult, these industries may withdraw– eg in thermal coal and oil and gas extraction, opening the door for unscrupulous operators subject to no public scrutiny with dire environmental repercussions. We provide examples from an investment company actively pursuing ESG in the South African and global public markets. We highlight where our actions have promoted sound environmental practise. We discuss effective ESG implementation and how environmental organisations can contribute. ABAX is a partner owned Cape Town based fund management firm managing assets on behalf of South African and International institutional clients to the value of about $7bn employing an active investment style and where ESG has been embedded into the research process for many years, practised by a veteran team who have worked together for more than a decade.

474 TOWARDS NATURE-POSITIVE AGRICULTURE. A META-META ANALYSIS

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Biodiversity is declining worldwide, across a wide range of ecosystems and species. Agriculture is the main driver of terrestrial biodiversity loss, so reducing its overall impact will be crucial for asustainable future. Many agricultural commodities can be sourced from a range of agricultural land systems, which can have significantly different impacts on local biodiversity and hence the ecosystem's ability to make other (non-crop) contributions to people. To achieve a sustainable future, agricultural businesses must become more nature-positive. This goal can seem easily achievable at first glance, given the vast scientific literature on how various agricultural practices impact biodiversity. However, the sheer volume and range of information can sometimes hinder decision-making. To help companies make science-based changes towards more nature-positive ways of working, we are developing a synthesis – a 'meta-analysis of meta-analyses' – of how agricultural production systems affect local biodiversity. Although the work is still ongoing, we outline how different lines of evidence are combined, how current knowledge gaps are identified, and we present results for a subset of crops – the land-use systems involved in producing vegetable oils and fats.

562 URBAN FOREST ECOSYSTEM SERVICES AND STEWARDSHIP IN MEDELLÍN, COLOMBIA

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Urban forests provide ecosystem services that improve human health and well-being. Knowledge of the benefits or urban trees is important for the strategic management of this resource and the sustainability and resilience of cities. On the other hand, it is important to involve people in the conservation of green areas, for which the first thing we need is to identify the social groups that work for the environment, and know how they interact with each other. The main objective of our project was to integrate ecological and social variables into a useful indicator for environmental organizations in the decision-making process and policy formulation. We applied a simplified multicriteria analysis tool for urban forest management that estimates ecosystem services provided by public trees, and identifies stewardship organizations engaged in care for the local environment. We focus on Comuna 10 in Medellin, Colombia to demonstrate this process and discuss management options going forward. The tools used were i-Tree and STEW-MAP. We created online maps to show the ecosystem services of each public tree in the study site, the organization network, and the overlap of these two. We recommend that further work is needed to understand and map stewardship capacity in Latin American cities, to advance our understanding of civic environmental stewardship in various countries, as well as to enable improved decision-making about urban biodiversity.

467 COVID-19: THE NEXUS OF NATURAL RESOURCE DEGRADATION AND SUSTAINABILITY

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The COVID-19 pandemic has greatly influenced the global economy and the natural environment. Thus, natural resource-dependent communities have undermined their

capabilities to access and manage the resources that they depend on for their livelihoods and wellbeing. International aid organisations and national governments are taking measures to preserve and save lives while reviving their economies and creating employments even as the virus continues to spread across the globe. Such unfortunate events in the natural resource sector could impede efforts made to improve rural livelihoods. Furthermore, the effects of climate change continue to frustrate measures to improve the livelihoods and wellbeing of vulnerable communities, particularly rural women who depend on the natural environment for sustenance. Given that the Global South is one of the regions highly vulnerable to socio-economic and environmental shocks, it is imperative to examine ways to reinstate and ensure sustainable natural resources management. This study adopts a systematic review of academic literature to investigate how Covid-19 influences measure employed by international organisations and national governments to sustainably manage natural resources. This chapter argues that the Covid-19 pandemic provides an opportunity to enhance investments in effective natural resource management and comprehensive recovery.

MOD1-a - Spatiotemporal Scales and Novel Methods in Modelling Biodiversity at a Landscape Level

528 A MACHINE-LEARNING FRAMEWORK TO UNDERSTAND AND PREDICT SOIL BIODIVERSITY

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While soil biodiversity is of upmost importance for ecological processes, ecosystem functions and services, we are still unable to fully grasp the main drivers of its spatial structure and complexity. There are two reasons for this. First, spatially explicit data that cover the full range of soil organisms are still quite scarce. Second, statistical approaches that integrate small-scale landscape complexity are still not widely used. Here, we developed a large-scale monitoring program across the French Alps where soil biodiversity from environmental DNA was collected on 30 elevational gradients, totaling 185 sampling plots. By developing a soil ontology, knowledge graphs and feature extractions from literature, we built a meta-network of 65 soil trophofunctional groups. To understand their spatial structure and the compositional turnover of soil communities, we built machine learning models that account for fine-grained environmental variations. We were able to distinguish the influence of large-scale from fine-grained environmental gradients on the composition turnover of soil diversity, and then to predict the spatial structure of soil biodiversity across the French Alps at a 100m resolution. Finally, we quantified the effectiveness of the current protected area network in maintaining soil diversity and proposed expansion scenarios to meet the post-2020 CBD targets. Our work paves the way for a better integration of multitrophic soil diversity in conservation planning.

129 LANDSCAPE HETEROGENEITY AND BIOTIC INTERACTIONS SHAPE MULTI-TAXA BETA DIVERSITY

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Vast areas of tropical forests have been converted into monoculture plantations, resulting in dramatic losses in biodiversity and habitat homogenisation. As we enter the UN Decade on Ecosystem Restoration, whether and how biodiversity in human-modified landscapes can be restored is unknown. One promising approach to make tropical landscapes more biodiversity-friendly is the establishment of native tree islands inside monocultures. However, our knowledge about the effects of enriched tree islands on landscape-level multi-taxa diversity is limited. Here, we quantified the beta diversity of understory arthropods, soil biota, herbaceous plants, and trees across 52 experimental tree islands embedded in an oil palm plantation in Sumatra, Indonesia. We applied a network approach to reveal the interplay among vegetation structural complexity, biotic interactions, and soil conditions shaping multi-taxa beta diversity. Our results showed that changes in beta diversity across taxa resulted from species turnover, suggesting that experimental tree islands can foster unique species at the landscape level and increase gamma diversity. We also revealed the pivotal role of vegetation structural complexity and soil biota structuring the spatial structure of multi-taxa communities. Our results provide experimental evidence pointing towards a key role of landscape heterogeneity and the imprint of biotic interactions for ecological restoration of degraded tropical landscapes

386 CLIMATE CHANGE IMPACTS ON THE UNIQUE BIODIVERSITY OF DEEP PERIALPINE LAKES

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Freshwater ecosystems are disproportionately threatened by environmental change but are extraordinarily diverse, especially in isolated lake ecosystems. Climate change's effect on the diversity of taxa in perialpine lake ecosystems that have radiated rapidly since the glacial retreat 12,000 years ago is poorly understood. Many taxa have radiated into vacant ecological niches but may exhibit high spatial niche overlap that predisposes them to climate-induced changes in the frequency and intensity of species interactions,

including competition and hybridization. Monitoring of lake fish biodiversity from 2010 to 2017 – at more than 5,000 sites across 34 lakes – recorded over 110 species and recognized various 'evolutionary significant units' with unique genetic and ecological adaptations. We paired this sampling with physical lake models that provide depth-resolved temperatures at a daily resolution for three future climate change scenarios for each lake. We quantified the modified availability of thermal habitat for the entire lake fish assemblages, with a special focus on recovering fine-scale changes across depths and seasons. We used this information to investigate changes in habitat overlap of sympatric species with climate change, and the potential for extinction of little-known deep-water specialist fishes. This provides novel insights to climate change effects on adaptive radiations in dispersal- and habitat-limited systems.

159 SPATIO-TEMPORAL NETWORKS FOR WETLAND BIODIVERSITY CONSERVATION

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Socio-ecological systems analysis for biodiversity conservation often only considers the size and quality of habitats, but ignores their spatial connections and evolution over time. This can lead to results that are not mechanistically intuitive e.g. an increase in habitat area or quality does not correlate to biodiversity increase. The confounding factors here include oversight of patch connectivity indicators or an 'ecological debt' incurred by species due to a delayed response to past anthropogenic stress. In an effort to address this issue, this study proposes the use of spatio-temporal habitat networks to explain contemporary biodiversity patterns. Such networks allow for the quantification of unique indicators like rates of change in habitat topology or quality. They also help derive 'complexity' signatures over a range of spatial and temporal scales that distinguish different management styles, intensities and their impacts. We developed such spatio-temporal indicators for the highly fragmented wetlands of the Swiss Plateau to explain alpha and beta diversity in amphibian and odonate species. In addition to species data, the main data source is a 150-year time-series of vectorised historical topographical maps of Switzerland. The results show that the spatio-temporal indicators explain more of the patterns in current biodiversity than the purely spatial ones.

298 MODELING WILD BEE HABITAT FROM LANDSCAPE FEATURES

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For several decades, insect populations have declined in Germany. The loss of insect pollinators, such as wild bees, will lead to fundamental limitations in the production of agricultural goods and will have a negative impact on the diversity of wild plants. Amongst others, wild bees decline as their habitats are often destroyed by modern agricultural practices. Wild bees need e.g. extensive grassland, verges, and hedges where they can find nectar and pollen among a large variety of plants over an extended period and can build their nests. Therefore, knowledge on the link between landscape and wild bee occurrence is important.
In former research, experts assessed land cover/use types regarding their potential to offer habitat for wild bees (Zulian et al. 2013). The work presented here sets these expert assessments in relation to wild bee collections in the field. In this way, wild bee diversity and the occurrence of functional traits in different landscape types are analyzed. Additionally, the effect of temperature is considered, a parameter which influences bee activity to a high degree.
The results of this work could help to understand if costly field collection to monitor wild

bees could be guided by estimating the appropriateness of landscape for wild bees by land use/land cover data and expert evaluation. This information could support the German "Action Program for Insect Conservation" which demands a national monitoring of insect populations by field collections.

301 INTERPRETABLE MACHINE LEARNING FOR FORECASTING DYNAMICAL PROCESSES IN ECOSYSTEMS

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As biodiversity declines, there is a crucial need for accurate mechanistic models that can capture the ecological dynamics of real ecosystems in order to predict and mitigate collapses. Empirical dynamical modeling has paved the way to study and forecast ecological dynamics, yet such non-parametric approach provides short-term, limited insights. Mathematical ecology has developed a great variety of insightful models, yet it remains a daunting task to obtain an agreement with real world systems. In this talk we present a unique approach that bridges the best of both worlds: combinging the forecasting ability of non-parametric methods with the interpretability of mechanistic models. The proposed method allows to undirectly infer parameters of a generic mathematical model (a system of differential equations) from different ecological time series by using optimisation technique commonly employed in the training of neural networks. By embedding prior scientific knowledge in the structure of mechanistic models, the approach generalises better, is more interpretable and requires less data than neural networks. We present case studies and show that the acquisition of short time series in ecosystems at different ecological stages allows for better estimation than a unique, longer time series. This is essential considering how short funding horizons constrain the collection of long time series, resulting in many currently available ecological data sets being shallow.

MOD1-b - Spatiotemporal Scales and Novel Methods in Modelling Biodiversity at a Landscape Level

225 DETECTING HORIZONTAL/ SPATIAL STRUCTURAL DIVERSITY ACROSS SCALES

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Biodiversity can be understood by three dimensions: composition, function and structure, which occur across scales ranging from the genetic to the landscape level. We advanced and developed methods to detect horizontal/ spatial structural diversity features in continuous remote sensing data, such as the Normalized Difference Vegetation Index (NDVI). We employed second-order texture metrics that consider the spatial arrangement of pixel values, and we introduced structural diversity entropy, a modification of the Shannon Index, as a unified metric to quantify horizontal structural

diversity. Depending on the metric formulation, the number of gray levels and the scale considered, we detect diversity features, such as patches and line features. These latent landscape features are characterized by internal heterogeneity, and they populate transition zones between what we call dominant features (characterized by internal homogeneity), which we retrieved with a scale-space decomposition method. We followed an empirical Bayesian approach to model structural diversity across scales, and we applied these methods to different data in the northern high latitudes to advance our understanding of the physical processes involved in landscape structure. Together, dominant and latent features provide a more comprehensive description of landscape structure that includes diversity, and combining extents gives insights into the relation between horizontal structural diversity and spatial scales.

135 LANDSCAPE BIODIVERSITY ANALYSES USING EDNA AND EARTH OBSERVATION IN CALIFORNIA

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Novel biodiversity surveys across large spatial and temporal scales are direly needed to manage conservation under global change. Using modern ecological models and community science, we integrate environmental DNA (eDNA) and Earth observation to produce a snapshot of regional biodiversity patterns and provide multi-scalar community-level characterization. In Spring 2017, 278 eDNA samples were collected from coastal, shrub and lowland forest sites in California, a complex ecosystem and biodiversity hotspot. We found that local habitat classification was indicative of community composition, and that distinct communities and organisms in different kingdoms were predicted by different environmental variables. Nonetheless, the gradient forest model that used 915 families recovered by eDNA analysis as response variables and used BioClim variables, Sentinel-2 satellite data, human impact, and topographical features as predictor variables, explained 35% of the variance in community turnover. Elevation, sand percentage, and photosynthetic activities (NDVI32) were the top predictors. From the gradient forest model, we generated a statewide community turnover map at 100 m resolution which can facilitate conservation planning and ecological management. Overall, we demonstrate that combining eDNA with environmental predictors, including remote sensing data, is a novel method to model biodiversity at landscape scales and create new biodiversity baselines that span the tree of life.

462 SPATIOTEMPORAL RHIZOBIOME CHANGES INFERRED FROM ANCIENT DNA SHOTGUN SEQUENCING

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The Arctic is known to warm much faster than the global average, leading to drastic changes in ecosystems such as the migration of the tree line northwards. Alongside plant community changes, the associated soil and root microorganisms are expected to change as well. Rhizobiome analyses mainly focus on single species and their adaptation to experimental warming but knowledge about whole plant community changes and subsequently their associated microbes is scarce. Understanding dynamic changes in biotic interactions on spatial and temporal gradients will help to predict future ecosystem adaptations and turnovers as a response to climate change.
We investigated sedimentary ancient DNA from Lake Lama, Taymyr Peninsula (Arctic Siberia), covering the last about 22.000 years using shotgun metagenomics. Preliminary evaluation of the data shows that mycorrhizal fungi experience a shift in their composition with the Pleistocene-Holocene transition from Thelephoraceae and Tricholomataceae dominated Pleistocene to Glomeraceae dominated Holocene. Alongside, we detected a decrease in overall mycorrhizal diversity. This coincides with the migration of woody taxa such as Pinaceae in the area and also an overall increase in rhizobial microbial taxa. Further comparison to shotgun data from other geographical locations in Siberia as well as the Tibetan Plateau alongside statistical analysis will be used to assess changes in the arctic rhizobiome in correlation to plant community turnovers.

459 TREE CANOPIES AND BIODIVERSITY: FROM STANDS TO TREE-TREE INTERACTIONS

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Tree species richness (TSR) has proved to play a crucial role to maximize ecosystem functioning in forests, e.g. promoting productivity and biodiversity across trophic levels. However, it remains unclear the mechanism by which the tree affects the complexity of the forest or, conversely, how the forest shapes the structure of the tree.
Here we made use of a large-scale biodiversity-ecosystem functioning experiment in subtropical China (BEF-China) with a long gradient of TSR (1– 24 species) and to the high-resolution technology terrestrial laser scanning (TLS), which allows measuring the three-dimensional (3D) structural elements of trees. Between 2012 and 2019 we quantified, on the stand level, a 3D stand structural complexity index (SSCI), and, to identify mechanisms underlying stand structural complexity, we look at the tree-tree level and measured how functional dissimilarity and divergences in branch traits between neighbouring trees affect crown complementarity.
We observed that species mixing allowed trees to occupy canopy space more efficiently mainly due to changes associated with crown morphology and branch plasticity. Fostering greater spatial complementarity, TSR promoted structural complexity. We found a positive relationship between TSR and structural complexity that became stronger over

time. Our findings highlight that TSR plays a crucial role in the structure and complexity of canopies at different scales.

418 A SPATIAL FINGERPRINT OF LAND-WATER LINKAGE OF BIODIVERSITY BY RS AND E-DNA

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Aquatic and terrestrial ecosystems are tightly connected via spatial flows of organisms and resources. Such land-water linkages integrate biodiversity across ecosystems and suggest a spatial association of aquatic and terrestrial biodiversity. However, knowledge about this spatial extent is limited. By combining satellite remote sensing (RS) and environmental DNA (eDNA) extraction from river water across a 740-km^2 mountainous catchment, we identify a characteristic spatial land-water fingerprint. Specifically, we find a spatial association of riverine eDNA diversity with RS spectral diversity of terrestrial ecosystems upstream, peaking at a 400 m distance yet still detectable up to a 3.3 km radius. Our findings testify that biodiversity patterns in rivers can be linked to the functional diversity of surrounding terrestrial ecosystems and provide a dominant scale at which these linkages are strongest. Such spatially explicit information is necessary for a functional understanding of land-water linkages and provides a reference scale for adequate conservation and landscape management decisions.

460 EARTH OBSERVATION FOR BIODIVERSITY MODELLING IN TERRESTRIAL ECOSYSTEMS

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The European Space Agency (ESA) has funded a project, "Earth Observation for Biodiversity Modelling" (EO4Diversity), in support of EC and ESA joint Flagship Action of Biodiversity and vulnerable ecosystems. The project focuses on three Earth System Science pilots for Biodiversity (Ecosystem productivity and health; Ecosystem accounting, monitoring and reporting towards policy obligations; Ecosystem resilience to invasive species), as core biodiversity policy priorities.
The main EO4Diversity objective and innovation is to predict and monitor biodiversity in terrestrial ecosystems by integrating the state-of-the-art multi-sensor EO imagery and products with next-generation ecological models. The project will benefit from time series Sentinel's data in order to maximise the scientific and societal returns of the Sentinel

missions.The project addresses important biodiversity science gaps, including
(i) filling data gaps in the geographic, temporal, habitat and taxonomic composition coverage from in situ biodiversity observations;
(ii) filling knowledge gaps, thereby assessing global species diversity;
(iii) forecasting ecological degradation in order to define effective actions to reduce terrestrial biodiversity loss; as well as
(iv) filling gaps in the data-policy link which may lead to a disconnection of biodiversity data that EO can generate and policy strategies including the EU Biodiversity Strategy for 2030, the UN SDGs and the Convention on Biodiversity post-2020 targets.

MOD2 - A model for life: toward a universal biodiversity projection platform

547 BIODIVERSITY PATTERNS AND DYNAMICS FROM LOW-LEVEL ECO-EVOLUTIONARY MODELS

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There has been an increasing effort towards developing predictive models to understand biodiversity patterns and response to environmental change. This has led to a variety of mechanistic models that vary in their properties, processes implemented and in the ecological level of the agents. The simulation of agents at lower ecological levels (individuals or populations) at biogegraphical scales has the ability to unify ecological and evolutionary first principles as well as ecological theories across levels of organization. Here, I provide an overview on cross-level mechanistic modelling, focusing on recently developed individual-based, ecological and eco-evolutionary models for plant and animal biodiversity applied to simulation experiments across environmental gradients or long temporal extents. Presented models are able to depict plant metacommunity patterns across vertical, depth and elevation gradients as well as genomically-explicit eco-evolutionary and diversification dynamics caused by natural or human-induced environmental change. These emergent patterns stress how the interplay of genetic and ecological traits, spatial processes and local interactions can cascade up to biogeographical levels. This is important, as ecological and evolutionary dynamics at large scales are difficult to experiment in real-world systems, but that can be tackled with mechanistic models and should be popularized for conservation assessments.

351 CAN INCLUDING BIOLOGICAL MECHANISMS IMPROVE BIODIVERSITY FORECASTS?

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Common forecasting approaches often fail to predict what appear to be individualistic responses of organisms to environmental change. Accounting for physiology and other aspects of organismal biology may account for the variable responses, but how can we tractably incorporate organismal biology in general models? Challenges include generalizing how biological mechanisms mediate responses to spatial and temporal

environmental variation and assembling the required biological data. I will summarize insight from montane insect resurvey projects, which highlight how traits that influence physiology shape ecological and evolutionary responses to climate change. I will then introduce TrEnCh project computational and visualization tools that meet the need to Translate Environmental Change into organismal responses. Finally, I will discuss paths toward better accounting for biological mechanisms in forecasting biodiversity responses to environmental change.

324 A MODEL FOR LIFE: THE NEED FOR A UNIVERSAL BIODIVERSITY PROJECTION PLATFORM

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Time is running out to limit further devastating losses of biodiversity and nature's contributions to humans. Addressing this crisis requires accurate predictions about which species and ecosystems are most at risk to ensure efficient use of limited conservation and management resources. Most current models cannot easily be reconfigured for other species or systems, omit key biological processes, and cannot accommodate feedbacks with Earth system dynamics. Therefore, we are ill-prepared to pinpoint when, where, and how we need to act to prevent the largest extinction event in human history. To fill these gaps, we envision developing an adaptable, accessible, and universal biodiversity modeling platform that can project essential biodiversity variables, explore the implications of divergent socio-economic scenarios, and compare conservation and management strategies. We illustrate that building this biodiversity forecasting platform is possible and practical. The next step is to create a global council and to raise start-up money to create a prototype. Although the money needed to fund this ambitious project is greater than what is available from traditional grants, the overall amount is small in comparison to similarly bold efforts in climate science, astronomy, and physics. We need to make rapid progress on developing a universal biodiversity prediction system because, in the end, we cannot protect what we cannot predict.

590 WHY MOVING BEYOND STATIC MODELS REQUIRES EMBRACING THEIR SUCCESSES

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Biodiversity scientists have been calling for more mechanistic modelling approaches for more than a decade. Yet, static species distribution models (SDM) remain the most prominent modelling tool in conservation and global change assessments. Why is that so and what can we learn from this success story? Often, the prominence of SDM is explained by their comparably low data requirements and easy-to-use software packages. Here, we argue that the success is at least partly driven by the very active developer (and user) community. New users can rely on a huge literature base including textbooks and dedicated how-to-guides, as well as method comparisons not only of the algorithms themselves but for different steps within the modelling cycle ranging from data preparation to final prediction. In the presentation, we will reflect on these steps, identify open questions remaining for more mechanistic biodiversity models and provide perspectives for how to meet these challenges.

390 THE CHALLENGE OF TRANSCENDING SCALES: AN EXAMPLE WITH MOVEMENT PARAMETERIZING

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The accelerating loss and fragmentation of natural habitats are major threats to biodiversity, the very foundation of our life-supporting system. High land pressure at the global scale reduces opportunities to preserve large amounts of habitat. Conserving habitat connectivity, that relies on organisms' easiness to move between habitat patches, thus appears as the only possible option to sustain biodiversity. But setting up priority targets to preserve or enhance connectivity is not straightforward as it requires to estimate and parameterize the fluxes of organisms among habitat patches. To date, most connectivity conservation studies use dispersal kernels for this purpose. We combine individual-based modelling and laboratory-based movement observation to address this challenge of parameterising the movement of individuals to flows of individuals in schematic landscapes. We show that usual approaches over-estimate connectivity, but also that individual and contextual variability matter. We also show that landscapes with spatially heterogeneous resistance to movement can lead to counter-intuitive movement fluxes. Constant back and forth between observations and models and between models is mandatory to deal with the many problems of scale encountered in ecology and ecological modelling.

616 DEMOGRAPHIC-DISPERSAL FORECASTING FOR TERRESTRIAL AND MARINE POPULATIONS UNDER ENVIRONMENTAL CHANGE: THE RANGESHIFTER AND MERMADE PLATFORMS

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Individual-based population models provide an important tool in our armoury for forecasting how species will respond to environmental changes. Furthermore, they can provide a flexible approach for assessing how well alternative management interventions are likely to work in improving the fate of species of conservation concern. We will present two simulation platforms that have been developed to facilitate the use of individual-based simulation in this context and that have also been developed to be interoperable with other modelling platforms from other domains such as land-use modelling.
RangeShifter, first published in 2014, provides an environment for spatially realistic, individual-based modelling and forecasting. The software incorporates considerable flexibility in the degree of complexity with which both demography and dispersal is represented and also enables some evolutionary modelling. Since publication it has been used for a wide range of applications, primarily focused in applied spatial ecology at a landscape scale. RangeShifter 2.0 and an R version, RangeShiftR have recently been published and their redesign will facilitate their joint use with other platforms.
MerMADE is a new platform that has much in common with RangeShifter but that has been developed to incorporate the 3D nature of marine environments, currents and a range of behavioural processes that individuals exhibit during pelagic dispersal.
We will illustrate both software packages with examples, highlight opportunities for using them in their current forms and indicate key directions in which we plan to develop them. We will also discuss challenges in deploying such high-resolution, individual-based modelling approaches at large spatial and temporal extents as well as potential approaches for addressing them. Finally, we will sketch out how we see these tools being integrated with other available platforms for interdisciplinary forecasting and scenario development.

491 INTEGRATED MODELLING OF BIODIVERSITY IN THE LAND SYSTEM

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The ongoing loss of biodiversity is expected to be exacerbated by future global change. Efforts to halt this loss depend on our ability to anticipate and mitigate the worst impacts before they arise. The complex interplay of climatic, socio-economic and ecological processes poses a major challenge, however, and requires the use of integrated models that account for biodiversity loss as part of broader land and Earth System dynamics. In this presentation, we explore the scope for robustly modelling and contextualising the social-ecological processes involved in biodiversity loss. We develop integrated, process-based models of ecosystem and land use change, capable of being embedded in global modelling frameworks that provide coherent exogenous driving factors. We investigate feedbacks between land management choices and biological impacts within systematic climatic and socio-economic scenarios, using examples of pollinator populations in intensifying agricultural areas and ecosystem responses to changes in protected area network designs. We then highlight three important foci for a biodiversity projection platform: 1) overcoming technical challenges in developing or coupling models in social-ecological systems; 2) revealing emergent effects that depend upon cross-scale and cross-sectoral feedbacks; 3) appropriately handling data and model uncertainties to develop robust and usable projections.

538 TOWARDS THE NEXT GENERATION OF GENERAL ECOSYSTEM MODELLING

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Ecosystems are facing unprecedented pressures as a result of human activities. Combinations of models with each other and with data will be critical to understanding how and why ecosystems are changing, in part for the development of our science but also to guide plans to mitigate impacts. Here, I will present recent developments to the Madingley Model (www.madingleymodel.org), a General Ecosystem Model that aims to provide a mechanistic understanding of how ecosystems are structured, how they function, and for how anthropogenic changes might alter that structure and function. I will discuss some recent and ongoing developments including: improving the representation of vegetation, representing vertical structure, incorporating stoichiometry, integration with data and linking with other models, and how such improved models could contribute to a universal biodiversity projection system.

MOD3 - Connecting Science to Action: Inspiring Ordinary Citizens to Become a Positive Environmental Force

393 CASE STUDIES FROM BC, CANADA

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British Columbia, Canada, has some of the richest biodiversity in Canada but also the highest number of species at risk. By 2020, at the end of the Aichi decade for biodiversity action, BC had fallen short and not met a single Aichi target. Local citizens and communities are stepping in to demand more action, support Indigenous-led biodiversity and conservation actions, and implement local biodiversity projects.
The session will present a series of case studies to illustrate how Drawdown BC workshop alumni are implementing biodiversity solutions at the local level. Case studies will be presented through pre-recorded videos, photographs, and slides.
Case studies will include: community involvement and engagement for wetlands preservation; farmer-to-farmer regenerative agriculture mentorship; citizen protection of salmon bearing streams and waterways; and political activism at all levels by newly empowered citizens.
Our session Connecting Science to Action: Inspiring Ordinary Citizens to Become a Positive Environmental Force will be one 90-minute presentation and participatory experience that also draws on all session presentations in an integrated manner.

385 DRAWDOWN FRAMEWORK FOR CLIMATE SOLUTIONS

E. Gill[1]
[1]Drawdown BC, North Vancouver, Canada

Drawdown BC's model for inspiring ordinary citizens to get into action on biodiversity and other climate solutions is centered on the findings of Project Drawdown. Project Drawdown is a rigorous scientific research project to map, model and measure existing solutions with the potential to help humanity reach 'drawdown' - the point in time when the concentration of greenhouse gases in the Earth's atmosphere begins to decline year after year - by 2050. Project Drawdown produced a best-selling book in 2017, updated its research and rankings in 2020, and continues to publish research through its website. This session explores Project Drawdown biodiversity solutions, and illustrates through experiential learning our Drawdown BC model for citizen-to-citizen transfer of scientific knowledge. Drawdown research has inspired the development of Drawdown movements across the globe to support local, community-based action to implement climate solutions, realize national climate goals, and build citizen connections. Drawdown BC is one such organization. We facilitate educational workshops to participants with working knowledge of these climate solutions and tools for getting into action.
Our session Connecting Science to Action: Inspiring Ordinary Citizens to Become a Positive Environmental Force will be one 90-minute presentation and participatory experience that also draws on all session presentations in an integrated manner.

392 GETTING INTO ACTION MODEL

M. Sheardown[1]
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Drawdown BC workshops present a proven model for citizen-to-citizen education, knowledge transfer, and inspiration to action. Through a hands-on participatory session, attendees will experience the key elements of our workshops that inspire citizens to action. These include land acknowledgements, grounding exercises, breakout 'rooms' to facilitate peer-to-peer learning, exploration of emotional responses to climate solutions, techniques for creating community and connection, strategies for making biodiversity solutions accessible and rooted in hope and fun, and personal action planning.

The success of our model of participation and action is also rooted in community to foster cross-learning, and leverage the diverse identities, skills, networks, professions, and interests of workshop participants. Action planning is informed by Will Grant's theory of Four Levels of Action and the relative effectiveness of each level.
Participation in our action-planning process to apply Drawdown BC workshop models for Getting Into Action will provide participants with tools and ideas for interactions with community groups to implement biodiversity solutions at the local and community levels.
Our session Connecting Science to Action: Inspiring Ordinary Citizens to Become a Positive Environmental Force will be one 90-minute presentation and participatory experience that also draws on all session presentations in an integrated manner.

384 INSPIRING ORDINARY CITIZENS TO BECOME A POSITIVE ENVIRONMENTAL FORCE

E. Gill[1]
[1]Drawdown BC, North Vancouver, Canada

How can ordinary citizens to play a more active role in implementing biodiversity solutions at the local and community level?
This presentation argues that when given a balance of opportunity, education and hope, small groups of ordinary citizens can, and will, self-organize to preserve and restore ecosystems and biodiversity on our planet. This will be demonstrated through stories and transferable best practices from Vancouver Canada's Getting Into Action program by Drawdown BC, which has resulted in collective action, scaled-up solutions, and citizen-to-citizen education across local communities.
The five-session Getting Into Action program guides participants from feeling hopeless and helpless about the climate crisis to creating a plan for self-directed action, typically far beyond the familiar household "green" practices. Participants select actions of interest, investigate replication of these, explore collaborations with each other, and determine mechanisms for scaling their actions to municipal and federal levels. The facilitators, session videos and resources and group members provide support and inspiration.
The fundamentals leading to this program's ongoing success will be outlined alongside examples focused on participants' environmental actions and outcomes in ecosystem areas. Interactive discussion with the Forum participants will encourage this model for citizen engagement to be duplicated in other programs and locations.

MOD4 - Challenges and opportunities for using the IPBES Nature Futures Framework for scenarios and modelling

427 USING NATURE'S FUTURES AS A LENS FOR DEVELOPING EUROPEAN LAND USE SCENARIOS

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Ambitious international biodiversity and restoration targets have been set, including the Convention on Biological Diversity's post-2020 targets and the European Union's Green

Deal. Yet, there is a huge gap between target setting and the implementation through land cover and land use change, and scenario studies are needed to help bridge it. We used CLUMondo, a spatial explicit model to simulate land system pathways for Europe until 2050. The model explores how and where environmental targets can be implemented while delivering projected commodity demands by the SSP framework. We created alternative pathways to achieve the EU targets based on the Nature Future's Framework societal perspectives, favoring landscapes providing carbon, species conservation or cultural heritage respectively.
Our results show that, irrespective of the NFF perspective, meeting environmental targets requires European landscapes to change. In some areas, commodity demands conflict with reaching the environmental targets. Although similar land use changes (e.g., preserving natural grasslands and forests through agricultural and forest intensification) are observed under different perspectives, their magnitude and spatial distribution differs. As landscape change drivers have so far largely been underrepresented in biodiversity assessments, we reflect on how these emerging land use pathways can enable a more comprehensive evaluation of future biodiversity changes and the collective well-being.

110 BEYOND VALUES: HELPING PEOPLE COLLABORATE WHEN WORLDVIEWS COLLIDE

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The action gap between climate and biodiversity urgency and the policies that are proposed to bend the curves can be understood as an issue of information, beliefs, values and means. Supporting effective landscape stewardship requires all four elements are tackled sequentially. Since 2014, the members of the Forest Stewardship Council and the FSC certificate holders have tried to incorporate the concept of Intact Forest Landscapes in the management of certified forests. The discussion has proved challenging, despite a common vision shared by all members to support the existence of forest forever and for all. The difficulty stems from the existence of different worldviews and narratives about how change happens in forest landscapes. Focus Forest is a partnership between FSC International and academic institutions aimed at reconsidering the foundations of agreements at the landscape scale. Focus Forest is an attempt to make operational the Nature Futures Framework in landscape dialogues that accommodate the diversity of worldviews and interests. We present a set of definitions, frameworks and the methods used to build agreement between conflicting values on the basis of a common understanding about how particular landscapes work. We show how managers can overcome information deficits, conflicting beliefs, divergent values and power asymmetries in science policy interfaces to design transformative pathways using collective intelligence and multi stakeholder engagement.

480 NFF USED FOR COMMUNITY BIODIVERSITY MONITORING IN TROPICAL DRY FOREST

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Tropical dry forest TDR is one of the most enraged ecosystems globally, with less than 48% of its distribution remaining. In Colombia TDF have been categorized as Critically Endangered (CR) following the Red List of Ecosystems criteria and is a key ecosystem for maintaining sustainable livelihoods of rural communities. The Montes de Maria region in Colombia has still one of the biggest remanent of TDF, embedded in a history of violence that forced the migration of local communities during more than one decade. Nature Futures Framework (NFF) was used for framing a community biodiversity monitoring process in three local association that returned to Montes de Maria after the violence period. Using NFF for defining a common vision for the territory, challenges, opportunities, and actions for achieving the visions were identified by implementing a game were local stakeholders achieved different targets related to each desire future. Following the use of NFF a biodiversity monitoring framework was stablished using Essential Biodiversity Variables for local communities to track their progress toward a positive nature future.

MOD5-a - Models and scenarios for biodiversity & ES at regional to global scales

373 BIOLOGICAL INVASION SCENARIOS – THE NEGLECTED DRIVER IN BIODIVERSITY SCENARIOS

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Among the five major drivers of biodiversity loss and ecosystem service erosion, biological invasions is the only one currently absent from global biodiversity scenarios. Following an upsurge in global data availability for biological invasions, recently the first global alien species narratives (ASN) (i.e., qualitative storylines under multiple future global change assumptions) have been constructed (Lenzner et al. 2019, Roura-Pascual et al. 2021) and linked to ongoing scenario initiatives. Additionally, first quantifications are in progress, as well as efforts to establish stronger links between the ASNs with important scenario and modelling work like the Nature Futures Framework. Here, we will highlight the importance for including biological invasions into global biodiversity models and scenarios and provide insights into the recent developments and ongoing work. These include quantifications of the ASNs, the contextualization of the ASNs to different spatial scales and their relevance in the ongoing Post2020-Global Biodiversity Framework. Additionally, we will highlight the potential for collaboration across modelling and scenario efforts to start a broader initiative on how such scenario integration across initiatives might progress.
Lenzner et al. (2019) A framework for global twenty-first century scenarios and models of biological invasions. BioScience.
Roura-Pascual et al. (2021) Alternative futures for global biological invasions. Sustainability Science.

369 EFFECTS OF GLOBAL CHANGE ON ECOSYSTEM SERVICES PROVIDED BY VERTEBRATES IN EUROPE

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In a scenario of continuous climate and land-use change, loss of biodiversity is expected to affect the functioning of ecosystems and the ability of natural systems to deliver ecosystem services. Yet, there is no clear mechanistic understanding of the relationship between biodiversity and ecosystem functioning for multitrophic, vertebrate communities. In this study, we used local species occurrences to generate local food webs across Europe. Using metabolic theory, we evaluated the energy fluxes between consumers and resources in each local food web, and directly related these fluxes to specific ecosystem functions and services provided by terrestrial vertebrates. Subsequently, we addressed how the future distribution of species, as well as predicted changes in climate and land use, will impact the provision of ecosystem services across Europe, at a resolution of 10km. We, therefore, provide a framework predicting how global change will alter the delivery of ecosystem services, and identify areas under higher risk of loss of these services. This is an essential step to determine conservation priority areas, as well as conservation options to be discussed with stakeholders.

413 PATHWAYS FOR HALTING AQUATIC BIODIVERSITY LOSS EXPLORED BY A GLOBAL MODEL

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The biodiversity of freshwater ecosystems is among the most threatened globally, and so are the ecosystem services associated with them. To bend the decreasing trend, major factors are protection of habitat, restoration of natural flow and connectivity, improvement of water quality, halt overexploitation and reduce climate change. To explore these potential solutions, we implemented a simplified biodiversity model, with an ecosystem intactness index as indicator and based on meta-analyses of case studies, within a global land-use and climate model (IAM) framework. We also included a process-based model of phytoplankton and aquatic vegetation. We used this to evaluate the potential contribution of several combinations of measures on freshwater biodiversity and selected ecosystem services. The measures were bundled in two nature conservation strategies and two SSPs; they included protection of carbon and water retaining areas, implementation of riparian buffer zones, agricultural nutrient management, urban water treatment, different hydropower options and climate change mitigation. We conclude that while in the Baseline scenario a further decline is projected, and these measures alone would not be able to bend the trend, an ambitious combination of measures might result in an average stabilization of the quality of aquatic ecosystems and even some improvement in some parts of the globe.

572 OCEAN SYSTEM PATHWAYS (OSP) FOR DRIVING MARINE ECOSYSTEMS & FISHERIES MODELS

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FishMIP is the marine ecosystems and fisheries model inter-comparison project, a component of IsiMIP. So far, the ecological models used in FishMIP have been used to project the effects of climate change on global marine ecosystems along RCP and SSP GHGs concentration pathways and these results have been used to inform recent IPCC and IPBES reports.

For its next round of simulations, FishMIP intends to achieve envelope projections of marine fisheries. This will require considering simultaneously the ecological and the human sides of fisheries dynamics. The coupled social-ecological models will still be driven by SSP-based GHGs emissions to consider the effects of climate change. But dedicated scenarios of the human drivers of fisheries are also necessary to prescribe the economic, political, and societal factors that contribute to shaping the evolution of fishing fleets. Such SSP-based Ocean System Pathways (OSPs) scenarios developed in FishMIP cover oceanic, bentho-demersal, small pelagic and emerging fisheries as well as aquaculture. They are turned into quantitative bio-economic models' driver's trajectories that are needed to simulate fishing effort evolution, fishery catches and aquaculture production for major fleets at global, regional, sub-regional and national scales. The OSPs form the basis of the next FishMIP simulation protocol that includes a model assessment phase based on historical simulations and a projection phase based on the SSP scenarios.

565 SCENARIOS AND MODELS TO ADDRESS FOOD-CLIMATE-BIODIVERSITY NEXUS FOR THE OCEAN

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Earth's capacity to sustain life and support human wellbeing is threatened, raising concerns for food security, climate mitigation and safeguarding biodiversity. A key challenge the world is facing is to feed the future human population in a just and equitable way, while also achieving biodiversity conservation and climate mitigation goals. Overcoming this challenge requires exploring pathways that will lead us to 'desirable' futures in which such food-climate-biodiversity (FCB) goals will be met simultaneously. An integrated modelling for the ocean called Dynamic Integrated Marine Climate, Biodiversity, Fisheries, Aquaculture and Seafood Market Model (DIVERSE) has been developed to examine questions related to FCB at a global scale. DIVERSE is supported by a system of linked and harmonized infrastructure of environmental, biodiversity, fisheries, and socio-economic data. Using direct and indirect drivers of changes in the marine human-natural system developed from the Shared Socio-economic Pathway (SSP), we found that unmitigated climate change will reduce seafood nutrient availability and increase the uncertainties of the contributions from mariculture, particularly in high seafood nutrient-dependent tropical areas. Climate adaptation to enhance nutrient availability and secure biodiversity are limited when global warming level is beyond 2 oC under most SSPs. Our findings underscore various transformative pathways to achieve desirable "Nature's Futures" for the ocean.

34 GLOBAL SPECIES LOSS UNDER FUTURE EU CLIMATE AND FOREST MANAGEMENT SCENARIOS

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Although taking action to reduce global warming is imperative, policies for climate change mitigation can backfire on global biodiversity. For example, regional climate policies can alter demand for forest biomass, causing subsequent market changes in global value chains of wood. In turn, these changes can reverberate at the global level with resultant impacts on biodiversity in regions far away from where the biomass is

used. Therefore, in this study, we assessed potential global species loss resulting from future forest management scenarios in the EU28 under two climate mitigation pathways (RCP6.5 vs RCP2.6). We used a Life Cycle Assessment Indicator (LCA), built upon species loss data resulting from different land uses and forest management intensities, which we coupled to the "Global Biosphere Management Model" (GLOBIOM) to project land use until 2100. Our results showed how the shift to low-intensity forest management practices could reduce species loss within the EU28. However, under the RCP2.6 scenario (high climate mitigation), the global impacts on species from habitat loss and degradation could double those from RCP6.5 (no mitigation), due to the greater EU28 demand for energywood imported from regions rich in endemic and vulnerable species. When defining ambitious climate mitigation strategies, modelling the future value chains of forest biomass is crucial to the a priori detection of outsourcing and its resultant potential contribution to global species loss.

610 ASSESSING EU POLICIES FOR BIODIVERSITY AND CLIMATE

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The European Union is in the process of setting legally binding restoration targets, an unprecedented conservation goal for its geographic scale, ambition and political commitment. The draft targets suggest that habitat restoration of terrestrial, freshwater and coastal system should contribute to improve the conservation status of at least 30% of species and habitats currently in an unfavourable status. Restoration efforts should also target carbon rich ecosystems. At the same time, the EU Biodiversity Strategy commits Member States to protect at least 30% of land and the seas, including 10% under strict protection, through a representative and effective network of protected areas. In order to support the EU and its 27 Member States in identifying priority areas to protect and restore to achieve these ambitious goals and contribute to the achievement of the European Green Deal, the European Commission has funded the BIOCLIMA project. Here I will present BIOCLIMA's multi-criteria spatial planning approach to investigate synergies and trade-offs between conserving and restoring land to achieve biodiversity targets or to maximize protection or restoration of vulnerable carbon stocks while accounting for land-competition for agriculture and forestry. I will discuss the benefit of this approach over traditional conservation planning methods and the challenges and opportunities of combining spatial planning methods with Integrated Assessment Models.

MOD5-b - Models and scenarios for biodiversity & ES at regional to global scales

542 BIODIVERSITY LOSS EMBEDDED IN CONSUMPTION: A GLOBAL FOOTPRINT ANALYSIS

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It is increasingly acknowledged that international trade accelerates biodiversity loss by coupling distant regions of production and consumption. Quantifying biodiversity loss

embedded in consumption (so-called biodiversity footprints) helps to identify levers for reducing biodiversity losses not only from a production perspective, but also via consumption and trade. Here, we assess biodiversity footprints associated with (inter)national traded goods and services for nearly 70 countries and world regions. To that end, we couple an environmentally extended multi-regional input-output model with the global biodiversity model GLOBIO. This enables us to evaluate biodiversity losses associated with multiple relevant pressures associated with production and consumption, including greenhouse gas emissions, land use, infrastructure and mining. In this presentation we will show the contributions of these different pressures to the biodiversity footprints, differences in footprints among countries and regions, and footprint shares of sectors and consumption categories. These insights might support policy- and decision-makers in developing adequate responses to prevent or reduce further losses of biodiversity, for example through trade regulation, sustainable supply certification, and product labelling.

541 ON THE FAIRNESS OF SCENARIOS OF BENDING THE CURVE OF BIODIVERSITY LOSS

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The Convention on Biological Diversity's 2050 Vision envisions "Living in harmony with nature". To achieve this vision, approaches such as changes to agricultural or consumption practices or conservation efforts will be necessary. We analysed seven scenarios for bending the curve of terrestrial biodiversity to identify changes in land use between 2010 and 2050. We then identified how equitable the different scenarios are and which stakeholders are key to delivering them successfully. To achieve No Net Loss, the Post-2020 Global Biodiversity Framework needs to take into account who currently manages land, land tenure rights into the future, and future management plans. This would enable protection of biodiversity in an equitable way.

400 THE INTERNATIONAL TRADE IN FOOD: ENVIRONMENTAL VERSUS SOCIOECONOMIC FOOTPRINTS

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International trade is generally perceived as a positive economic force yet is simultaneously the cause of much environmental damage. Of all traded commodities, food has been found to have the greatest impact on biodiversity with richer countries tending to import biodiversity impacts from developing countries. Studies of the environmental impacts of international trade generally focus on one footprint, e.g. biodiversity impacts, greenhouse gas emissions or scarce water usage. However, if the UN's Sustainable Development Goals are to be met, sustainable trade policies cannot be based around environmental targets alone.
Land use change is currently the primary driver of biodiversity loss and the FAO estimates that agriculture has caused around 40% of the deforestation within the tropics and sub-tropics. Using a new method to calculate the local biodiversity impacts of both land use change and greenhouse gas emissions, we use the EEMRIO model, EXIOBASE, to compare the embodied biodiversity footprint due to the international trade in food with socioeconomic footprints, e.g. employment and gender equality. We identify trade-offs – products with a high biodiversity footprint but also contribute to socioeconomic goals - and synergies – products that have a high biodiversity footprint but relatively little

socioeconomic benefit. We use the UK as a case-study but our method is applicable to any region and could also be applied to track the embodied impacts of a region's exports.

586 WHAT IS THE POINT OF BIODIVERSITY AND ECOSYSTEM SERVICE SCENARIOS?

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With ever-more sophisticated models and scenarios for biodiversity and ecosystem services we can project regional and global changes far into the future. Researchers frame this as an essential part of enabling decision makers at multiple scales to make well-informed choices about policy, management, investment decisions, infrastructure decisions, and much more. But is this true? To what extent are increasingly sophisticated models matching the information needs of these decision makers? And to what extent are researchers integrating key non-biological factors - the economic, demographic, political, and social factors - into scenarios?
I will briefly review recent studies of large-scale biodiversity and ecosystem service scenarios, and examine how far they align with and acknowledge the needs of policy makers and other decision makers. I will also discuss the extent to which scenarios account for social and political realities, such as where people live now and in the future. I will not present new models or methods here. My goal in this talk is to spark a debate among model builders and users about the point of these modelling exercises and whether they achieve their aims.

477 EQUITY AND JUSTICE IN GLOBAL BIODIVERSITY SCENARIOS AND MODELLING

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In face of the ecological crisis and the rapid loss of biodiversity and ecosystems, issues of equity and justices and questions on how to conserve and protect our plant in a just and inclusive manner are gaining momentum. It is becoming clear that protecting nature requires protecting people, too. Global scenarios and modelling exercises for nature are at the forefront of imagining and assessing possible new futures for humans and nature. Nonetheless, they have so far largely neglected the consequences of conservation strategies on humans lives, despite some exceptions. This paper brings together different perspectives, on equity and justice and connects these to biodiversity scenario and modelling work. This paper will first identify the main dimensions and questions regarding equity and justice dimensions that could be addressed through global scenarios and models. Secondly, building on recent work to develop two alternative conservation scenarios grounded in different values of nature, Half Earth and Sharing the Planet, we will illustrate how equity and justice can be conceptually and methodologically approached in both scenarios. By highlighting commonalities and differences, this paper aims to explore the role – and the possible critical aspects and limitations – that scenarios and models for nature can have in supporting research on equity and justice in nature futures. As this work is in its early stages we like to discuss with other scenario-builders and modelers.

79 EXPLORING THE ROLE OF AGRICULTURAL TRADE IN THE FUTURE OF NATURE AND PEOPLE

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Agricultural trade has been identified as a leverage point to reverse global biodiversity declines. It however plays a complex role in biodiversity declines from land use change, with heterogeneous net land use impacts across commodities and regions, leaving unclear the potential for a more positive contribution. We explore with the GLOBIOM global land use model the role of agricultural trade in achieving ambitious biodiversity goals. We estimate the environmental (biodiversity, GHG emissions) and socio-economic (food security, value added) impacts of scenarios combining alternative assumptions about trade (exacerbated liberalization, frictions and reconfigurations) and broader efforts to bend the curve of biodiversity loss (ambitious conservation, supply-side and demand-side efforts). Preliminary results show positive socio-economic impacts and negative environmental impacts in a scenario prolongating historical trends. Exacerbated liberalization worsens environmental impacts for mixed socio-economic impacts, while trade restrictions have mild environmental gains and negative socio-economic impacts. High levels of trade could be maintained with much lower environmental impacts if assuming additional conservation and supply-side efforts, pointing to a significant potential for sustainable trade. Assuming additional demand-side efforts is more disruptive, with much larger environmental gains but also large declines in value added and trade flows.

465 TOWARDS AMBITIOUS 2050 GOALS: ASSISTING GLOBAL DECISIONS TO A SUSTAINABLE FUTURE

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Renowned organizations advocate to halt ecosystem degradation and to wiser use of natural assets in order to maintain human livelihoods and safeguard biodiversity. The Convention on Biological Diversity plays a crucial role in this redirection, organizing the discussions for new goals that will guide its parties environmental actions until 2050. Our work subsidizes these discussions, evaluating different levels of global efforts to achieve better results for biodiversity and ecosystem services (ES). We optimized areas for restoration, conservation and conversion activities, accounting for 2050 projections on agricultural and urban expansion, population growth and climate change. In order to plan these actions now to maximize future outcomes, we formulated multiple scenarios differentiating on:
1) global effort levels for a net increase of ecosystems;
2) efforts to increase agricultural productivity;
3) restrictions for restoration on a local level;
4) the combination of biodiversity and ES metrics.
We demonstrated that it is possible to achieve environmental gains without compromising agriculture production. Yet, we showed that an integrated agenda to mitigate climate change and a closer look at the impacts of high population growth are crucial to achieving better results that aim to bend the curve for biodiversity and ES.

Hence, only cooperative and well-planned land-use decisions can make important progress in addressing the multiple challenges humankind has to overcome.

463 THE IMPACT OF AGRICULTURAL INTENSIFICATION ACROSS BIODIVERSITY METRICS

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One of the most important drivers of biodiversity loss is conversion of natural habitats into agricultural areas. However, many measures aimed at increasing agricultural production, such as fertilization or pesticide use, can also have negative impacts on biodiversity. These biodiversity impacts of intensification remain largely unaddressed or are conflated with those of agricultural conversion. Here, we will present models of intensification impacts on species richness, total abundance and average range size for agricultural landscapes containing the four most important crops at global level: maize, wheat, soybean and rice. We use biodiversity data from the project PREDICTS: Projecting Responses of Ecological Diversity In Changing Terrestrial Systems and EarthStat data to account for agricultural intensification. In terms of species richness and abundances, we observe different effects of intensification across temperate and tropical biomes, and across the four crops. However, intensification leads in most agricultural landscapes to an increase in average range size, which indicates a switch towards more common and widespread species. Our results suggest that the impacts of intensification are different across biodiversity dimensions and different from the impacts of land-use change. These insights will lead to a better understanding of biodiversity and ecosystem service outcomes in agricultural landscapes.

MON1-a - Scaling up terrestrial biodiversity monitoring - needs, challenges and opportunities

119 MAPPING AN INVASIVE SHRUB WITHIN GRASSLANDS USING SUPER-RESOLUTION IMAGERY

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Alien invasive plant species are one of the main drivers of global biodiversity loss. Advances in deep learning and super-resolution image reconstruction holds great potential for mapping and managing alien invasive plants to help conserve biodiversity. Within the commercial timber production landscape of KwaZulu-Natal, South Africa, endangered grassland corridors are threatened by American bramble invasion. Here we aim to improve our understanding of bramble invasion dynamics through using super-resolution satellite mosaics. Super-resolution satellite mosaic classified bramble with very high accuracies (86%) compared to other conventional satellite imagery. Using landscape analyses, we identified plantation tree harvesting and prescribed burning to be major drivers increasing bramble cover within the landscape. Bramble cover was highest two years after plantation trees have been harvested, whereas continuous prescribed burning

positively influenced bramble. Bramble cover was also high close to streams. We recommend the adoption rotational harvesting for controlling bramble, as harvesting entire plantation blocks throughout the landscape will dramatically increase invasion potential of bramble. Current bramble removal programmes should prioritize riparian areas and use high priority grasshopper habitat to identify vulnerable terrestrial habitat. Special attention is needed to control bramble two years after harvesting, as this is when bramble cover is highest.

93 AN OVERVIEW OF BIODIVERSITY MONITORING TOOLS: CHALLENGES AND OPPORTUNITIES

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Evidence-based decision-making in natural resource management and conservation is often constrained by lack of robust biodiversity data. Technology offers opportunities for enhanced data collection through a range of satellite-based and Earth-based sensors and techniques. This paper reviews lessons learned from the application of four key technological monitoring solutions (satellite-based remote sensing, cameras, acoustic recording devices and environmental DNA) to identify factors affecting their relevance and applicability. Most tools, if relevant to local user needs and integrated into goal-based monitoring schemes, can contribute to creating the enabling conditions necessary for effective biodiversity monitoring, improving data availability and quality for various taxa when compared with traditional observer-based methods. The paper concludes by discussing how different methods can be used to complement each other and when traditional observer-based methods are still relevant, especially in biodiversity-rich but resource-poor countries.

95 GROUND-NESTING POLLINATORS NEED PROTECTION AS PART OF SOIL BIODIVERSITY

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While the Convention on Biological Diversity employs a habitat-oriented definition of soil biodiversity including all kinds of species living in soil, the Food and Agriculture Organisation, since 2002 assigned to safeguard soil biodiversity, excludes them by focus on species providing directly four ecosystem services contributing to soil quality and functions: nutrient cycling; regulation of water flow and storage; soil structure maintenance and erosion control; carbon storage and regulation of atmospheric composition. Many solitary wasps and 70% of wild bees nest below ground and require protection during this long and crucial period of their lifecycle. Recent research has demonstrated the extent of threats to which ground-nesting pollinators are exposed e.g., chemicals and deep tillage. Ground-nesting pollinators change soil texture directly by digging cavities, but more important is their indirect contribution to soil quality and functions: 87% of all flowering plants require pollinators. Without pollinators, soil would lose all ecosystem services provided by these flowering plants e.g., litter, shadow, roots for habitats and erosion control. Above- and below-ground biota are in constant interaction. Therefore, and in line with the Convention’s definition, the key-stakeholder, the Food and Agriculture Organization should protect ground-nesting pollinators explicitly within soil biodiversity conservation.

195 DERIVING PLANT GENETIC DIVERSITY FROM IMAGING SPECTROSCOPY SYSTEMS

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Declining genetic variation within species is a key factor in biodiversity loss, but one which is costly and laborious to monitor at large scales. Among remote sensing approaches, imaging spectroscopy can overcome limitations of ground-based measurements and provide spatially wide, temporally dense, and spectrally extensive information, which is indicative of many plant traits, and could be associated with genetic information. We combine spectral information with ground-based sampling of Fagus sylvatica L. (common beech) as a model towards establishing links between spectral and genetic diversity over large areas and at regular intervals.
We selected 19 sites with well-preserved forests dominated by F. sylvatica and distributed across the species range in Europe. The spectral data originate from hand-held ASD FieldSpec measurements of top-of-canopy leaves from 10 (7 at one site) dominant trees from a patch at each site, and airborne AVIRIS-NG and spaceborne acquisitions of the sites by DESIS and PRISMA systems. Genetic data comprise genomic sequences of nuclear DNA from the selected trees at each site. Relationships between spectral and genetic signatures are now being analyzed on a tree- and patch-level to elucidate evolutionary, demographic, and adaptive aspects of genetic diversity, which may be remotely sensed. Based on this analysis, we will present and discuss the potential of imaging spectroscopy to assess the genetic variation within species at a landscape level.

601 DEEP LEARNING AND COMPUTER VISION WILL TRANSFORM ENTOMOLOGY

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Advances in computer vision and deep learning provide potential new solutions to the challenge of understanding ecological responses to environmental change such as the potentially global insect decline. Cameras and other sensors can effectively, continuously, and non-invasively perform entomological observations throughout diurnal and seasonal cycles. The physical appearance of specimens can also be captured by automated imaging in the lab. When trained on these data, deep learning models can provide estimates of insect abundance, biomass, and diversity. Further, deep learning models can quantify variation in phenotypic traits, behaviour, and interactions. Here, I connect recent developments in deep learning and computer vision to the urgent demand for more cost-efficient monitoring of arthropods.

90 MONITORING THE EFFECTIVENESS OF HABITAT CONSERVATION IN SWITZERLAND

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Since the early 1990s, Switzerland designated about 7000 sites of national importance to protect precious habitats and their biodiversity. These legally protected sites are a crucial element of the network of protected sites in Switzerland and comprise mires, dry grasslands, flood plains and amphibian breeding sites. In 2011, the program "Monitoring the effectiveness of habitat conservation in Switzerland" was initiated to monitor changes in a regular six-year cycle, to evaluate whether conservation targets are met, i.e. whether habitat area and quality is being maintained. We scaled up the monitoring by

combining labor-intensive field surveys in a subset of the sites by remote-sensing approaches monitoring all 7000 sites. Remote-sensing showed an overall increasing wood cover in mires and dry grasslands, indicating land-use abandonment which was particularly pronounced at higher elevation (>800m). Biodiversity and ecological indicators derived from vegetation surveys in 900 sites (7000 10-m^2 plots) point out negative effects of abandonment and a decreasing habitat quality with increasing elevation. The negative developments because of wood encroachment suggest the urgent need to re-establish traditional land-use regimes in abandoned sites to prevent further habitat and diversity losses. We therefore established an early-recognition system, enabling federal and cantonal offices for the environment to identify changes and to take measures to counteract negative developments.

166 BIODIVERSITY MONITORING IN THE 21ST CENTURY: LESSONS LEARNED

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Increasing numbers of protected areas across the globe have not slowed the loss of biodiversity in recent decades, resulting in the need for increasingly urgent and extensive actions. At the same time, scientific knowledge about biodiversity remains limited across large spatial scales and for a high number of taxa. New and emerging technologies provide opportunities for large scale, semi-automated data collection and processing. Automated species identification, expert-based identification platforms, standardized data input and data exchange via cloud-based assessment tools such as QField allow for near-real time data analysis that should enable timely management decisions. The latter is required to foster effective management in protected areas. For various reasons, many of these tools and techniques currently remain infeasible for implementation.
In the ongoing research project BioMONITec, our aim is to identify and test new conservation technologies that are applicable for protected area managers and other land practitioners. In this presentation, we will share our experiences and give examples for how new technologies are used like multi-rotor drones, in-situ measurement devices (soil temperature, water level), online near-real time data sources (e.g., Sentinel, ERA5) and improved digital data collection tools for field work (e.g., QField, SMART). We discuss their utility from a practical perspective and reflect on comparability with traditional field collection methods.

59 MODELLING BIODIVERSITY FROM FOREST STRUCTURE ACROSS ECOCLIMATIC GRADIENTS

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Biodiversity – forest structure relationships (BSRs) underlie the use of forest structure as a remotely-sensible proxy of biodiversity. However, little is known how BSRs generalize to continental scales, or how climate interacts with structure to jointly drive local patterns in biodiversity. In this study, we used spatial GLMMs based on field measurements and airborne lidar from the NEON network to characterize the role of climate in constraining BSRs across the United States. Findings provide evidence for significant broad-scale BSRs; namely, between plant/tree diversity and forest structural metrics in the vertical and horizontal planes. Vascular plant diversity was positively related to horizontally-heterogenous and bottom-skewed canopies, while tree diversity was positively associated with canopy cover and structural heterogeneity. Climate variables related to stress, energy and seasonality affected broad-scale patterns in diversity, with water availability (but not temperature) exerting significant effects on

structural conditions. Importantly, climate and structure interact to jointly explain variance in BSRs along coldness, mean temperature, and evapotranspiration gradients. Our findings reinforce the importance of local context dependence in assessing nonstationary biogeographical patterns in forest biodiversity and provides an empirical foundation for generalizing remotely-sensed estimates of climate and forest structure to model biodiversity over vast extents.

MON1-b - Scaling up terrestrial biodiversity monitoring - needs, challenges and opportunities

381 DNA BARCODING, BIODIVERSITY CHARACTERISATION AND BIOMONITORING

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Research programs led by the International Barcode of Life (IBOL) consortium have transformed the use of DNA sequencing for specimen identification and species discovery. DNA barcoding is based on the principle of sequencing short standardised regions of DNA (DNA barcodes) to tell the world's species apart. This enables large-scale characterisation of species diversity and distributions, elucidation of ecological networks and species interactions, and high-throughput monitoring of biodiversity change. The BIOSCAN Europe initiative has been recently launched as part of IBOL, to bring together existing European networks, scientists, and projects that work on the monitoring of biodiversity using DNA. It aims to build an efficient European system of interconnected facilities for rapid DNA identification and monitoring of species. This presentation will summarise the progress of the global IBOL programme, outline the BIOSCAN Europe initiative, and its collaborations with wider biodiversity genomic projects. It will also summarise the challenges, opportunities, and strategic priorities for DNA barcoding programmes to enable effective characterisation of biodiversity and establish reference resources to support high-throughput biodiversity biomonitoring and to build the foundation for a global biosurveillance system.

618 AIRBORNE ENVIRONMENTAL DNA - AN EMERGING TECHNOLOGY FOR BIODIVERSITY MONITORING

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Biodiversity monitoring is a daunting task, traditionally requiring prohibitive amounts of time and taxonomic expertise. Metabarcoding and environmental DNA (eDNA) has propelled the field of biodiversity monitoring into a new era. Metabarcoding allows the simultaneous identification of multiple species using short characteristic gene sequences, while eDNA refers to the DNA released by organisms into water, sediment, or air. While metabarcoding of eDNA has proven itself to be a very sensitive and powerful tool to efficiently survey a wide range of organisms in aquatic ecosystems, the metabarcoding of airborne eDNA is in its infancy.
In this talk we give an overview of the recent break-throughs showing that airborne

eDNA from plants, vertebrates and insects can be targeted for biodiversity monitoring and we discuss the state of this emerging technology and lay out the challenges ahead.

472 PLANT-INSPIRED ROBOTICS FOR UNDERSTANDING AND PRESERVING NATURAL BIODIVERSITY

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Advances in robotics, material science, and Artificial Intelligence can together offer innovative solutions for a deeper analysis of natural processes and intervene consequently with effective strategies. At the same time, a sustainable approach for the design of new technologies is needed to reduce current problems related to energy impact and e-waste.
In this framework, plants are interesting models to imitate in order to develop more sustainable technologies for precision agriculture, monitoring and remediation of contaminated sites. They show sophisticated abilities of morphological development, distributed sensing, efficient use of energy, communication, and have unique adaptation skills to changing or stressing conditions.
Taking inspiration from plants, we can generate new multi-functional materials for morphological adaptation and computation, growing robots, strategies for climbing and adhesion, multi-sensory information processing and distributed architecture of functionalities, new forms of energy, that can find applications as new biodiversity monitoring technologies and represent new paradigms towards novel environmentally sustainable, high-tech solutions.

482 BIODIVERSA+: IMPROVING TRANSNATIONAL BIODIVERSITY MONITORING ACROSS EUROPE

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Harmonization of existing monitoring schemes across Europe is crucial, due to the large diversity of monitoring schemes, size and capacity of individual countries. Promoting and supporting transnational biodiversity monitoring in a coordinated way is therefore a major objective for Biodiversa+ that gathers 74 research programmers and funders and environmental policy actors from 37 European and associated countries (global budget >800 Mio € over 7 years). It builds on the achievements of its predecessor Biodiversa, and is jointly developed with the European Commission as part of the European Biodiversity Strategy for 2030. Biodiversa+ aims at reinforcing and coordinating monitoring schemes to improve the survey of habitats, protected areas, pollinators/insects, invasive alien species and health-related biodiversity facets across Europe. This will lead to better characterization, understanding and reporting on biodiversity dynamics and trends - and link to the drivers of biodiversity loss. The presentation will elaborate on the activities foreseen: (1) to harmonize protocols, data format and interoperability, and methods; (2) to develop and deploy new technologies and approaches, and promote citizen science, and (3) better use of biodiversity monitoring data by research & innovation, and policy. In 2022 Biodiversa+ will also launch a >40 Mio € Call for Research Proposals linked to biodiversity monitoring.

574 A MULTI-STRATEGY APPROACH TO SCALE UP BIODIVERSITY MONITORING WITH DNA

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Comprehensive knowledge of biodiversity and its response to climate change and land use transformation are major challenges for megadiverse countries that lack long-term monitoring platforms, host overwhelming diversity and face low budget investment in science and conservation. DNA barcoding and eDNA monitoring are opportunities to trigger the assessment of biodiversity but cost accessibility needs to be improved. In Colombia, we set up a pilot project that links the local community, students, research institutes and the private sector to weekly monitor plants, fungi and insects in a tropical dry forest merged in a matrix of cattle activities and oil industry. In the first six months we have a local community that has transformed their perception of the territory, have sorted >15.000 insects with new records of families for the country and discovered a population of a critically endangered species of plant. DNA barcoding coupled to samplings expects to triplicate the amount of genetic information available for Colombia in a year. In addition, we are optimizing protocols to increase cost-effectiveness in the use of the MinIOn device for barcoding. Finally we are implementing eDNA surveys in soil, water and sediments focusing in bacteria and fungi as bioindicators of oil mining activities. Bringing together different actors of the society we are seeking the implementation of DNA information and technologies to reduce the gap of biodiversity knowledge and face societal needs.

526 USING DRONES AND SPECIES-SPECIFIC ASSAYS FOR FAST EDNA SURVEYS

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Efficient biodiversity monitoring is needed to track species distributions in ever-changing landscapes. Currently eDNA metabarcoding enables such monitoring efforts on an unprecedented scale. It offers non-invasive and indirect observations of biospheres and alleviates the need for experts in the field to identify specimens. And yet, collecting and evaluating samples from multiple locations can be an arduous, time consuming, and expensive task. We built a lightweight and versatile pumping and filtering system that we mounted on a drone for fast sample collection weighting less than 700 grams. This combined system with a flight time of 25 minutes allows us to implement comprehensive sampling strategies such as flying continuous transects across water bodies or to integrate multiple point samples spread out in difficult terrain. We coupled the drone-based system with assays to target specific species of interest within a set of rivers and lakes. These species-specific assays are significantly faster to deploy for the detection of select known species. While we tested for common fish species here, our system could be applied to the detection of rare species to support their conservation or invasive species whose arrival requires an immediate intervention. Using drones and species-specific assays therefore enables us to explore a broader field of rapid applications for biodiversity monitoring from water sampling to species detections from eDNA.

MON2-a - Detecting and attributing biodiversity change: linking essential variables to indicators and goals

366 AN UNCERTAIN FUTURE: GLOBAL EFFECTS OF LAND-USE CHANGE ON LOCAL BIODIVERSITY

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Habitat loss and fragmentation have traditionally been regarded as two major drivers of biodiversity loss. Satellite images allow us to track these two processes over time and at the planetary scale. However, similar coverage of biodiversity mapping is lacking. Attributing land use and fragmentation to biodiversity change would allow us to generate forecasting scenarios. The challenges are substantial, however. Comparing biodiversity across sites is far from straightforward, and most biodiversity monitoring programs are incompatible. Yet, we are in a position where we can create planetary-wide assessments and projections of local biodiversity. Bridging across disciplines, here we show how land-use change and fragmentation affect local biodiversity. Moreover, by predicting the future evolution of these drivers, we provide an envelope of scenarios. Contemplating the uncertainty around something as relevant as biodiversity change makes us wonder how we can reduce it. It is apparent that we need a coordinated sampling strategy. Still, there are unresolved questions about where we should sample, with what protocols, under which responsible organizations, and with what funding. We are far from understanding biodiversity at a planetary scale comparable to how we understand Earth's climate. Yet, what is at stake for human societies around the world, is at a minimum comparable to those derived from climate change.

70 PREDICTING GLOBAL BIODIVERSITY DYNAMICS WITH NEW DATA AND TECHNOLOGIES

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Human alterations to climate, lands and oceans are now affecting organisms and species worldwide, with broad ecological consequences. Ecosystems globally are being transformed - and new ones are emerging - through the extinction, invasion, altered energetics, changed behaviors and newly evolved phenotypes of the species that define them. Both drivers and ecosystem consequences of these changes are connected across scales.
A range of remote and in situ sensor technologies and data flows combined with novel computational and statistical techniques now support a global ecology that is centered on organisms yet addresses biodiversity and ecosystem change at the planetary scale. This provides a previously unthinkable empirical integration of biological processes across scales, allowing the assessment of species changes from the level of single individuals to multiple ecosystems. These advances have begun to transform our scientific understanding of global ecological dynamics and our ability to predict planetary health. I will illustrate these new opportunities, and remaining limitations, for addressing classical and newly emerging ecological questions and the integration of biological processes across spatial and temporal scales.

80 CLIMATE CHANGE AND LAND USE INTERACT TO DRIVE INSECT BIODIVERSITY PATTERNS

T. Newbold[1], *C. Outhwaite*[1], *P. McCann*[1], *J. Millard*[1]
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When habitats are modified by human land-use change, microclimatic conditions are altered, typically creating hotter and drier conditions. Moreover, the natural habitats on which many species rely are fragmented, impeding the movement of species distributions in response to climate change. These changes create the conditions for important interactions between the effects of land-use change and climate change. We present a global study testing for an interactive effect of recent climate change in responses of insect biodiversity to land use. We use a spatial analysis of data for nearly 18,000 insect species from 6,000 locations in 13/14 terrestrial biomes, derived from the PREDICTS biodiversity database. We show declines of around 50% in the abundance of insects where intensive agriculture combines with rapid recent climate warming. Importantly, we show that the interactive effect of climate change and land use is particularly strong for insect pollinators. This suggests likely negative impacts on the production of crops that depend on animal pollination. Overall, our results highlight the large declines in biodiversity that are expected to occur if climate change and land-use change continue unabated.

204 DETECTING AND ATTRIBUTING TRENDS IN GENETIC DIVERSITY

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Intraspecific genetic diversity defines a species' ability to adapt to new environments. Anthropogenic activities are modifying species habitats, and altering species population sizes, distributions and levels of intraspecific genetic diversity. While advances in technology, data infrastructure, and open science are facilitating initiatives to analyze publicly accessible genetic datasets from thousands of species at the global scale, inconsistent trends in species genetic diversity are emerging. These findings underline the importance of scalable approaches that prioritize the necessary elements for macrogenetic global assessments and best practices that need to be considered and adopted if genetic monitoring across species and spatial scales is to track biodiversity trends and inform policy efforts. This talk will highlight the state of knowledge in detecting changes in intraspecific genetic diversity and underline areas of research uncertainty and exciting developments in the detection and attribution of genetic diversity change.

330 A DETECTION AND ATTRIBUTION FRAMEWORK FOR BIODIVERSITY CHANGE - KEY INGREDIENTS

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Understanding human causes of trends in biodiversity change worldwide is of great scientific interest, and central to conservation policies aimed at meeting the biodiversity targets set out in the Global Biodiversity Framework (GBF). In this talk, I will define the four main steps of a detection and attribution framework for biodiversity change; these steps include biodiversity observation, estimation of biodiversity measures, statistical trend detection, and the causal attribution of trends to drivers. The detection and attribution framework, therefore, links observations, including remote sensing and in situ monitoring, to policy-relevant indicators using robust statistical methods to make inferences about the causes of change with clear statements of confidence. I propose to base the framework on the Essential Variables (EV) concept developed by the Group on Earth Observations Biodiversity Observation Network (GEO BON). EVs are a compact set of metrics describing the state of genomes, species, populations, or ecosystems that provide a common foundation for trend detection and indicator calculation. This

integration would support the efforts to detect attribute trends in the EVs that underpin indicators for the GBF. I will briefly address how the detection and attribution framework can guide more effective forecasts and the adaptive adjustment of biodiversity monitoring networks to reduce uncertainties in our understanding of biodiversity change in the future.

MON2-b - Detecting and attributing biodiversity change: linking essential variables to indicators and goals

516 DETECTING BIODIVERSITY CHANGE ACROSS SCALES FROM MICROBES TO MAMMALS

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Biodiversity change is an essential feature of all ecological systems, from microbes to mammals. With increasing concern over future trajectories of biodiversity, integrated biodiversity change assessments that emphasize robust detection and attribution methods are in increasing demand. It remains a major scientific challenge to robustly compare estimates of biodiversity change across datasets. This challenge stems in part from the different observation and sampling approaches that are used for the smallest animals and microbes compared to those used for larger plants and animals. Yet for place-based assessments, there is a need to compare trends across different groups. In coastal British Columbia, Canada, researchers at the Hakai Institute have been tracking biodiversity change at a shared field site for over a decade. We have developed a new bias-correction to allow integration and comparison of diversity trends inclusive of groups as diverse as microbes, parasites, seaweeds and mammals, thereby largely overcoming the challenge of integrating diverse datasets. We report a coherent assessment of biodiversity change as well as a framework for building integrated assessments that can support detection and attribution exercises. This kind of analysis is an important advance to gain the most information from biodiversity monitoring efforts, and could provide needed information to guide local management decisions in the face of ongoing environmental and climate change.

275 DISENTANGLING SAMPLING EFFECTS OF HABITAT LOSS ON DIVERSITY CHANGE ACROSS SCALES

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Habitat loss is consistently regarded as one of the greatest agents of biodiversity change in the Anthropocene, but both detection and attribution can be greatly confounded by confusion about exactly which comparisons are made, and at which scales. This is particularly a challenge when synthesizing multiple studies across different taxa and realms. Here, I use habitat loss as a 'case study' to show how both detection and attribution of biodiversity change require an explicit consideration of sampling and scale (in both time and space, although space will be the emphasis here). In particular, detecting and attributing biodiversity change require "apples to apples" comparisons of

metrics of biodiversity and how it changes, and to do so, a rigorous dissection of geometric (sampling) and demographic (ecological) effects are required. Further dissection can help identify possible mechanisms of change by attributing them to changes in abundance, evenness, spatial distribution and/or compositional change. I will illustrate these concepts with a mixture of theoretical arguments, case studies and global syntheses on habitat loss (and habitat gain via restoration), and highlight how the approach can be used to more accurately detect and attribute biodiversity change in response to other types of anthropogenic drivers.

423 ABUNDANCE DECLINE IN EU AVIFAUNA REVEALS CROSS-CONTINENTAL BIODIVERSITY CHANGE

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Although global assessments provide evidence of biodiversity decline, some have questioned the strength of the evidence, with local assemblage studies often showing a more balanced picture of biodiversity change. The multifaceted nature of biodiversity and imperfect monitoring datasets may partially explain these findings. Here, using an extensive dataset, we find significant biodiversity loss in the native avifauna of the European Union (EU). We estimate a decline of 17–19% in the overall breeding bird abundance since 1980: a loss of 560–620 million individual birds. Both total and proportional declines in bird numbers are high among species associated with agricultural land. The distribution of species' population growth rates (ln) is centred close to zero, with numerical decline driven by substantial losses in abundant species. Our work supports previous assessments indicating substantial recent biodiversity loss and calls to reduce the threat of extinctions and restore species' abundances, for the sake of nature and people.

613 COUPLING 'PHYLOGENETIC COMPLETENESS' AND ECOSYSTEM CHANGE DETECTION FOR BIODIVERSITY CONSERVATION

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Detecting linked changes in biodiversity and ecosystem function at policy relevant scales is a critical endeavor with potential to advance conservation efforts aimed at maintaining a habitable planet for humanity. Mounting evidence links multiple components of biodiversity to ecosystem functions across systems and scales. One component that has received limited attention within the Essential Biodiversity Variable (EBV) framework is phylogenetic diversity, which is of particular importance in capturing the outcomes of evolutionary processes that have generated and honed the vast array of innovations represented in the tree of life. We present the concept of 'phylogenetic completeness'

(PC) as an informed approach to conservation that minimizes the loss of branches in the tree of life and focuses species preservation strategies on those that maximize the completeness of evolved genomic and functional variation. We show how PC is derived and mapped for major organism lineages globally and characterize the phylogenetic diversity under PC-informed and random scenarios of species extinction. We then briefly review 1) approaches for detecting ecosystem structure, function and diversity using remotely sensed EBVs and 2) the hypothesized mechanisms that connect them. We discuss options for coupling ecosystem and phylogenetic change detection towards the goal of prioritizing conservation efforts that jointly and flexibly maximize ecosystem integrity and phylogenetic completeness.

421 BIOLOGICAL INVASIONS: WHAT IS NEEDED FOR GLOBAL POST 2020-BIODIVERSITY POLICIES?

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The global patterns and future trajectories of biological invasions are insufficiently understood. Progress in data mobilization, supplemented by new tools for data integration have facilitated the compilation of comprehensive databases of world-wide alien species distributions such as GloNAF (https://glonaf.org/). Similarly, the compilation of the Alien Species First Record-database provides a basis for analysing spatio-temporal patterns of alien plant species accumulation (Seebens et al. 2020). Combined, these novel data sources have substantially advanced the understanding of the (macro)ecology of biological invasions, and they provide the foundation for exploring future trends of alien species spread and impacts.
In this talk, I will synthesize key insights into global patterns and drivers of biological invasions, and how this expertise can be harnessed for policy design, monitoring and implementation. I will introduce the Alien Scenarios-Project (https://alien-scenarios.org/), which for the first time develops long-term scenarios and models for biological invasions worldwide (Lenzner et al. 2019). Finally, I will provide a perspective on priority actions needed to meet invasion-related target in the Post 2020-Global Biodiversity Framework (Essl et al. 2020).
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MON2-c - Detecting and attributing biodiversity change: linking essential variables to indicators and goals

611 THE EFFECTIVENESS OF TERRESTRIAL PROTECTED AREAS

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We are facing an extinction crisis fuelled by anthropogenic pressures and climate change; protected areas can be a useful tool to help to slow or even reverse these detrimental effects on biodiversity and prevent land use change. It is important to track the successes and shortfalls of protected areas through continuous monitoring and

comparative studies, so that we are best prepared for the future of conservation. In particular, my research aims to determine how protected areas can be future proofed for the conservation of mammals. Mammals are an important taxa to consider in this context as they are sensitive to habitat fragmentation through land use and climate change. I explore the effects of protected area characteristics such as their size, connectivity, border complexity, and IUCN management and governance categories on mammal species richness and abundance. My analyses have shown that on a global scale there is higher mammal species richness inside protected areas than outside them. I have also demonstrated a significant increase in mammal abundance at sites located further within protected areas, especially, those sites furthest from the boarder that are surrounded by a larger percentage of natural habitat. Species abundance is also higher at lower elevation sites with high natural habitat surrounding them. This research aids our understanding of how we can best achieve the CBD's '30x30' target, with the most effective outcomes for biodiversity.

189 PROJECTING JOINT TRENDS IN PLANT DIVERSITY AND ECOSYSTEM PROCESSES

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Biodiversity supports fundamental ecosystem functions, including primary production and decomposition of organic matter. These key functions are the major determinants of carbon and nutrient dynamics in ecosystems and feedback processes between the biosphere and the atmosphere. At this juncture, the role of plant diversity must be comprehensively clarified, given the potential consequences of vegetation simplification resulting from anthropogenic influences. Here, I explain how vegetation homogenization and the associated loss of plant diversity can be potentially serious in altering feedbacks in the climate–biosphere system. Through biodiversity monitoring, experiments, and modeling, a series of studies find that increasing plant species richness promotes primary production and thereby carbon sequestration, contributing to climate stabilization. Plant species richness is also a determinant of decomposition. Conversely, loss of plant diversity, both living and dead, jointly impedes both primary production and decomposition and thus slows nutrient cycling, possibly slowing plant growth and carbon sequestration. Although further work will be required, I emphasize the need to predict the cumulative and sequential effects of vegetation simplification and the associated biodiversity loss on ecosystem functions, which will be essential in the context of land use and global climate change.

434 SHIFTING CLIMATIC IMPRINTS RESHUFFLE NORTHERN COMMUNITIES

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Climate change is a pervasive threat to biodiversity. While recent studies have emphasized range shifts as the prime driver of regional community change, less is known about its interplay with resident species' responses. We analyzed four decades of distribution data for 1,478 species of birds, mammals, butterflies, moths, plants and phytoplankton along a 1200-km high-latitudinal gradient. With progressing climate change, the relative imprint of specific climatic drivers shifted non-uniformly. The proportion of unique species among decades was low, while the relative position of species within their climatic niche shifted substantially over time, either towards or away from their optimum. Such diverging responses – driven mostly by resident species – restructure communities across a full biome, raising concerns about ecosystem integrity in the face of accelerating climate change.

353 ASSESSMENT OF BIODIVERSITY AND FIRE REGIMES RELATIONSHIP ON A GLOBAL SCALE

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Fire is a natural phenomenon that has played a critical role in transforming the environment and maintaining biodiversity at a global scale. However, nowadays some species could have difficulties to recovery from fires from different fire regimes. Maps showing spatial species distribution and it study under fire regimes could contribute to envionmental management in the face of global change. The main objective of this work is to study the relationship between species distribution and fire regime at global scale. To the this end, we created a spatial species distribution map based on 1,086 species of forest birds from GBIF database, climate, social, topography, environmental and soil factors using maximum-entropy approach. On the other hand, applying an unsupervised K-means clustering approach for fire regimes were identified and mapped globally. Fire regime is explained in terms of seasonality, patches, size and variability of burned areas, a global dataset accesed from Fire_CCI project. The relationship between biodiversity and fire regimes is assed by Chi Square and Bonferroni test. The result show that there is a significant association between these variables with a p-value of 2.2e-16. It is observed that there is an association between large biodiversity ratios in fire regimes characterized by small patch and burned area while small biodiversity ratios were associated to fire regimes characterized by large and intense forest fire.

262 DETECTING AND ATTRIBUTING TRENDS IN ESSENTIAL ECOSYSTEM SERVICE VARIABLES

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Ensuring the sustainability of ecosystem services requires accurate monitoring of trends and attribution of global change drivers and pressures. The Group on Earth Observations Biodiversity Observation Network has expanded their Essential Biodiversity Variables (EBVs) framework to include Essential Ecosystem Service Variables (EESVs). EESVs detect changes in ecosystem services and in interactions between humans and nature. EBVs and EESVs are inherently linked. Biodiversity increases the resilience of ecosystem services, while complex trade-offs and synergies among services impact biodiversity. We are developing monitoring approaches for detecting ecosystem service change by integrating datasets (e.g., field surveys, census, social media, earth observation). Through two case studies, we use Bayesian Belief Networks to assess how a suite of global change drivers impact ecosystem services and to quantify how the strength of trade-offs and synergies among ecosystem services is shifting through time. The first case study in Southern Quebec monitors trade-offs and synergies among services related to maple syrup production a key service of economic and cultural importance to Canada. The second case study evaluates how multi-level policy decisions influence water quality purification services. Selection of appropriate policy relevant EESVs and attribution of drivers of change will support decision making and the sustainable use of ecosystem services in the future.

605 DETECTING CHANGE IN BIODIVERSITY TIME SERIES: THE SIGNALS WITHIN BIOTIME

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The Anthropocene is characterized by fast change in human use of resources and the climate. We ask how biodiversity has changed in this period. Using time series in the BioTIME database, we quantify how biodiversity has changed within and across communities, in space and time and across taxa. Turnover in species composition emerges as the most prevalent signal of biodiversity change. Colonizations and extinctions are accelerating but are approximately balanced. There is also a balance between winners and losers in population trends. But balanced change does not imply a simple shuffling of species. The identities of winners and losers show important patterns regarding biotic homogenization, and shifts in body size.

MON3-a - From the species to the individual: investigating plant diversity on the scale that matters most

509 MULTIMODAL REMOTE SENSING OF AQUATIC PLANT DIVERSITY

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For their morpho-physiological peculiarities and phenotypic plasticity, aquatic plants occupy the extremes of the global vegetation spectrum and display contrasting patterns of diversity along ecological and geographical gradients.
Monitoring of aquatic systems at various scales is limited by logistic constraints and costs. Remote sensing (RS) is an ideal candidate tool to quantitatively and efficiently assess aquatic vegetation, but potentials were so far hampered by sensor availability and features. With the technical developments of airborne and spaceborne platforms in the last decade and increasing operational uptake, ecologically significant applications of RS to aquatic vegetation have become a reality, e.g. for: i) mapping of plant species and communities (including diversity); ii) assessing their physiological and ecological status (e.g. spatial-temporal dynamics); and iii) estimating biophysical and biochemical parameters from spectral response (spectro-functional traits). A synoptic picture of intra- and inter-specific variability of aquatic plants derived from RS allows to scale up from functional traits and community assembles to ecosystem processes, advancing functional ecology studies in aquatic systems in unprecedented ways.
This work will provide theoretical background and an overview of state-of-the-art, practical examples of RS of aquatic plants, covering leaf to canopy and ecosystem scales, highlighting both capabilities and gaps still to be filled.

173 PATTERNS OF TREE PHENOTYPIC INTEGRATION AND INTRA-INDIVIDUAL TRAIT VARIATION

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Plants show variation in terms of trait expression within species and individuals, but traits do not vary independently. In fact, traits co-vary together in integrated phenotypes or species. According to ecological theory, this phenotypic integration could be limited by trait variation. However, patterns of phenotypic integration and how they vary in response to trait variation still remain poorly understood, particularly at the intra-individual scale. We studied the effects of local tree diversity and intra-individual leaf trait variation on individual phenotypic integration in ca. 500 trees of 21 species in a tree diversity experiment in subtropical China. From every tree, we collected up to 15 leaves and measured a set of leaf functional traits to assess functional indices and plant trait networks properties. Overall, phenotypic integration decreases with increasing trait variation, indicating a trade-off between these two properties of the phenotype. Further, within-tree trait variation tends to decrease along a gradient of increasing local tree diversity, while we did not detect a direct effect of diversity on phenotypic integration. Thus, our results indicate that a positive effect of local diversity on trait integration mainly occurs via trait variation. This suggests that phenotypic integration and trait variation could represent two alternative strategies of the individuals to respond to the environment.

155 TRAIT VARIATION IN TREES AND SPECIES: INSIGHTS FROM TREE DIVERSITY EXPERIMENTS

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Plant functional traits are an essential tool for understanding ecosystem functions and processes. Mainly evaluated at the species level, trait variation within species has gained increasing attention in the last decade. We go even further and argue that intraspecific trait variation has to be considered together with its within-individual component, if we are to understand ecosystem functioning at larger scales.
In our projects, we aimed at unravelling diversity effects in tree-tree interactions, by quantifying the amount and importance of leaf trait variation at local scales, its mediation by species richness and its interaction with abiotic factors.
We compiled leaf traits related to resource allocation, growth strategy and herbivore and pathogen defense at the within-tree level from multiple tree diversity experiments around the world. To handle such large amounts of samples, we acquired leaf-level spectral data in the field to predict trait values. Comparing scales, we found that within-tree variation accounted for up to 39% of the total trait variation. In addition, we found evidence of local tree diversity effects, weakening with interaction distance. Within these local scales, tree diversity also mediated – mainly strengthened – the effects of abiotic resources.
Overall, our results highlight the unneglectable relevance of within-individual and intraspecific scales of trait-based approaches for understanding biodiversity-ecosystem functioning relationships.

78 ASSOCIATION STUDY OF GENETIC VARIATION AND SPECTROSCOPIC IMAGING VARIANTS

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Plants are the trophic basis of terrestrial ecosystems and their diversity structures ecological communities. Genetic diversity is a key determinant of adaptive potential for species in a changing climate. Remote sensing of plants via the reflection of light from leaves and canopies facilitates large-scale and long-term repeat monitoring of plant populations in natural settings. How leaves reflect light is determined by aspects of physiology and function emerging from the interaction of plant genomes with the environment. These include leaf structure, and contents of pigments, water, and other abundant constituents like lignins, phenolics, and proteins.
In this study, we first asked whether we can observe larger variation in leaf reflectance among plants with different genotypes, than among plants of the same genotype when accounting for differences in environment and measurement uncertainty. We compared variance in leaf reflectance calculated from field spectroradiometer measurements with inbred lines of Nicotiana attenuata from wild accessions, recombinant inbred lines (Multiparent Advanced Generation InterCross design), and transgenic lines (modified in the expression of specific genes). We then aimed to identify associations between genetic variation and spectral variation. The preliminary results from QTL mapping identify several SNPs associated with reflectance at certain wavelengths and the corresponding candidate genes indicate plausible underlying mechanisms.

561 SCALABLE SPATIAL ANALYSES OF FUNCTIONAL GENETICS IN REAL PLANT COMMUNITIES

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The genetic diversity of populations provides their basis for adaptation. The investigation of genetic diversity, both on the population and the species scale, thus provides important information to predict, and intervene in, the fate of plant communities under global change. While we have entered the genomics era, most available genetic information still exists for variants of neutral genetic markers which cannot be directly linked to functional traits, especially at the scales of species and communities. We lack understanding of the functional genetic diversity of individual plants in the wild, and how it affects the sustainability of their communities. In long-lived tree species, functional genetic variation of established individuals may determine whether whole forests persist or die back. In agriculture, a solid understanding of the genetic properties of cultivars and their expression under variable real-world conditions is needed to implement desired traits in increasingly sophisticated intensification designs such as mixed cropping systems. The Spatial Genetics group at the University of Zurich works on scalable, spatially resolved investigations of plant functional genetics in the complex real-world settings of forests and cultivated fields. I will present recent work combining remote sensing of functional genetic variation with scalable and field-robust analyses in Fagus sylvatica, Fagus orientalis and Nicotiana attenuata.

101 THE WOOD AND THE TREES: TAXONOMIC TRANSPARENCY FACING THE INTRICACIES OF NATURE

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Throughout the history of biology, biologists have been tasked to make the endless diversity of life accessible by classifying organisms in groups, like species, genera and families, and cataloguing them. By doing so, information can be stored and inferred from one individual or population to another in a relatively efficient manner. However, since its beginnings, modern taxonomy has been faced with fierce and ongoing disagreements, both on its fundamental principles, and on many particular classificatory issues.
This has made it clear that no perfect standardised taxonomic system exists that can fully do justice to all organisms across the tree of life and their intricacies. Meanwhile, taxonomic decisions often matter, and much research depends strongly on species boundaries, as for instance research on intraspecific and interspecific variability, or research quantifying biodiversity. This raises important challenges, both for taxonomy itself, and for the other biological sciences that often depend on its products by referring to delimited and described species.
Departing from taxonomic controversies and their consequences in Citrus (Rutaceae), Ophrys (Orchidaceae), and Quercus (Fagaceae), I explore these challenges, and formulate proposals to overcome them. In particular, I argue that greater transparency about taxonomic decisions, both in taxonomy itself, and in other disciplines making use of it, will allow greater flexibility in function of the needs of individual cases.

MON3-b - From the species to the individual: investigating plant diversity on the scale that matters most

116 THE EVOLUTIONARY LEGACIES ON TRAIT DISTRIBUTIONS AND ECOSYSTEMS FUNCTIONING

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Ecological communities have distinct structures regarding the number of co-occurring species, composition, and functional and phylogenetic arrangements. What are the forces that drive the assembly of species within communities that lead to differences in composition and diversity? The answer to this broad but fundamental biological question remains elusive because of the balance and relative effects of different assembly processes. Species traits play a critical role in determining the colonization and persistence of species within communities and across regions through evolutionary time, as well as their ecosystem functions and capacity to provide services to humanity. There is considerable evidence supporting trait differentiation among different lineages; however, we do not yet know how legacies from lineages' past distributions influence the extant trait distributions and their responses to environmental variation. This question was evaluated using data from multiple dimensions of plant diversity globally and novel Bayesian models. Our results show that species' traits tend to be conserved over evolutionary time and are linked to lineages' climatic and biogeographic origins. The analyses presented here contribute to advancing understanding of how legacies of evolution in prior environments influence present-day ecosystem structure and function and the responses of plants to shifting abiotic conditions under global change.

8 GENOMICS OF WITHIN-SPECIES MIXED PLANTING AGAINST INSECT HERBIVORES

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The idea that mixtures contribute more than solitary has long been studied from ecological and agricultural viewpoints. It is well recognized that genetic diversity exerts positive effects on plant resistance and other ecosystem functions. However, it remains difficult to select positively interacting genotypes from a huge number of accessions. Inspired by a magnetic interaction model, we first incorporated neighbor genotype similarity into genome-wide association study (GWAS) and genomic prediction. Then, we applied our methodology for insect herbivory and abundance on thousands of Arabidopsis thaliana individuals grown in Switzerland and Japan. Two-factor GWAS incorporating self and neighbor genotypes better explained variation in insect herbivory and abundance than normal GWAS. Based on the idea of genomic prediction, we extrapolated trait values and found genotype pairs that could mitigate insect herbivory in its mixed stands. Overall, our study suggests a genetic strategy to elicit positive biodiversity effects on plant resistance. The proof-of-concept using the model plant species highlights the way to implement varietal mixture in plant protection.

314 AN EVOLUTIONARY MANAGEMENT TO HARNESS EUROPEAN BEECH AGAINST CLIMATE CHANGE

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The European beech, Fagus sylvatica, is one of the most characteristic forest trees in Central Europe. Besides economic importance, beech forests harbour large parts of the continental biodiversity, which is threatened by climate change. The drought years 2018 and 2019 have shown that beech harbours substantial genetic variation at genomic loci associated with drought resistance. This knowledge of the genomic basis of drought resistance and drought sensitivity can help to monitor but also to accelerate adaptation to climate change. With this knowledge, we are developing a practice-oriented evolutionary management for this species. The aim of this management is to increase the proportion of drought-resistant beech in forests in such a way that the function of beech forests for ecology, economy and society is maintained in the long term. We are evaluating the efficiency of various evolutionary measures to increase the proportion of drought-resistant beech forests using population genomic monitoring, experiments and modelling, in order to generate concrete recommendations for action in forestry practice and for policy.

2 ECO-EVOLUTIONARY CONTRIBUTIONS TO BIODIVERSITY CHANGES

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An increasing amount of studies demonstrate the role of genetic diversity for community assembly and ecosystem functioning. Moreover, studies have shown that genetic and species diversity may frequently and dynamically interact when shaping community dynamics and ecosystem functioning. Genetic and species diversity result from four processes key to evolutionary biology (i.e., selection, gene flow, genetic drift, and mutation) and community ecology (i.e., species sorting, dispersal, ecological drift, and speciation). Here, we propose that by explicitly taking these key processes and their interactions into account - in theoretical or empirical studies - we can increase our mechanistic understanding of eco-evolutionary dynamics for community assembly and ecosystem functioning in time and space. Quantifying the contribution of each evolutionary and community process to community assembly and biodiversity changes can be done via, for example, eco-evolutionary partitioning metrics. The drivers of these contributions can then be further analyzed via statistical models. Finally, synthesizing the key interactions between evolutionary and community processes across a variety of species, ecosystems, and regions can improve identification of the most likely scenarios when evolutionary and ecological processes interact, and identify in which systems or spatial locations we might expect strong eco-evolutionary changes in biodiversity.

395 GENETIC DIVERSITY LOSS IN THE ANTHROPOCENE

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More species than ever before are at risk of extinction due to anthropogenic habitat loss and climate change. But even species that are not threatened have seen reductions in their populations and geographic ranges, likely impacting their genetic diversity. Although preserving genetic diversity is key to maintaining adaptability of species, we lack predictive tools and global estimates of genetic diversity loss across ecosystems. By bridging theories of biodiversity and population genetics, we introduce a mathematical framework to understand the loss of naturally occurring DNA mutations within a species. Analyzing genome-wide variation data of 10,126 geo-tagged individuals from 19 plant and animal species, we show that genome-wide diversity follows a power law with geographic area, which can predict genetic diversity loss in simulated populations. Given pre-21st century values of ecosystem transformations, we estimate that over 10% of genetic diversity may be lost, already surpassing the United Nations targets for genetic preservation. These estimated losses could rapidly accelerate with advancing climate change and habitat destruction, highlighting the need for new forecasting tools that facilitate implementation of policies to protect genetic resources.

MON4-a - Radar-based approaches to monitoring the abundance, morphological diversity and movements of aerial taxa

118 HIGH-RESOLUTION RADAR MONITORING OF AUSTRALIAN MOTH AND LOCUST MIGRATIONS

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An upgraded Insect Monitoring Radar (IMRU) has operated at Hay, New South Wales, in the inland plains of temperate eastern Australia, since 2017. The radar observes 24/7 and detects individual insects at heights between 100 m and 2.5 km; its outputs are estimates of height, speed, direction, orientation, ascent rate, size, shape, and wingbeat frequency. Subsequent analyses consolidate these data into samples extending over 1 h in time and 150 m in height. Two broad classes of insects predominate during the night-time hours, with characters (size, shape, wingbeat frequency, and temperature tolerance) indicative of small and large moths (in both cases most likely of a range of species). Moth migrations were most intense during spring and autumn and ceased in mid-winter. A second class of large insect, exhibiting different characters, was present in late summer 2021 and could be attributed to Australian plague locusts Chortoicetes terminifera, which were numerous locally at that time. Migrations of all three insect types typically continued throughout the night, at heights to around 1 km (2 km in warmer weather), were predominantly windborne, and led to overnight displacements of a few hundred kilometres. Their intensity varied from night to night in association with changes in temperature and wind direction arising from the passage of synoptic-scale weather systems. Within each night, speed, direction, and orientation all exhibited coherent variations with both height and time.

362 WEATHER SURVEILLANCE RADAR FOR INSECT BIODIVERSITY MONITORING

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Concerns have been raised about potentially widespread declines in insect abundance and diversity, but progress in evaluating these claims has been hampered by the lack of standardised monitoring data. Weather surveillance radars (WSRs) routinely detect insects, but since animals are not of interest to meteorologists, they are discarded as unwanted "noise". That "noise" is a veritable treasure trove of information on insect diversity and abundance, but what is required is a way to link what a radar sees to the insects that we wish to monitor. This presentation will describe the ongoing work in the "BioDAR Project" that brings together ecologists and radar scientists to collaborate on a programme of work that will produce, test, and disseminate computer algorithms to turn radar noise into high-quality biological data. We will discuss three main areas of work: (i) the generation of a database of insect models to predict their reflections in radar data; (ii) empirical analysis demonstrating that radars can provide a proxy for insect abundance and diversity; and (iii) maps of aerial insect biodiversity and abundance that can be used to investigate pressing issues in conservation. The final part of the project will combine our classification algorithms, empirical studies, and national mapping data, and make them freely available to all. We hope that the final datasets will be of great interest to a range of end-users, including governments, farmers, and conservation groups.

199 SIMULTANEOUS MONITORING OF THE AERIAL BIOMASS FLOW OF INSECTS, BIRDS AND BATS

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The airspace is a prime habitat for birds, bats, and insects. Their movements link distant locations and are a primary source of biomass exchange. Knowledge on the resulting patterns on the ground from these movements is ever-increasing, especially for birds, with visual and acoustic counts, trapping, thermal imaging, individual tracking, and lidar/radar technology all contributing essential pieces to the puzzle. Only recently, however, have we started quantifying and characterizing the actual aerial movements, using either individual tracking or radar/lidar technology. While tracking is still primarily limited to the study of individual movements, recent developments in radar methods are allowing for large-scale, near-continuous monitoring of aerial biomass flow. Distinguishing multiple biological taxa, even at higher taxonomic ranks, however, remains notoriously difficult using radar. Here, we present two case studies from the US and Europe using a vertical-looking radar to simultaneously quantify the aerial movements of insects, birds, and bats with an overall accuracy of > 85%. Birds are furthermore subdivided into several subgroups using their flight characteristics, and for insects and bats similar developments are on their way. This monitoring system offers enormous potential for providing important information to a wide range of stakeholders, including agriculture, governments, academia, and the wind farm and aviation industries.

212 TEMPORAL AND SPATIAL PATTERNS IN AERIAL INSECT BIOMASS ACROSS THE UNITED STATES

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Recent reports of widespread insect declines have highlighted the paucity of long time series data for insect abundance and biomass at large spatial scales. Identifying regional patterns and temporal trends requires standardized sampling across diverse habitats and taxa. In this study, we use weather surveillance radar to quantify insect aerial biomass, creating a standardized data set of insect monitoring spanning a decade (2012-2021) from 135 stations widely distributed across the continental US. We focus on three objectives; describing the distribution of aerial biomass across the United States, identifying regional patterns of recent insect declines and increases, and exploring drivers of temporal variation.
Across the continental US, aerial insect biomass decreased with latitude and increased unimodally with longitude, peaking in the plains region. Temporal trends at the continental scale showed high interannual variation but no overall declines in annual insect biomass. Long term trends varied across stations and biomes, with declines concentrated in temperate broadleaf forests and grasslands. Our findings indicate the robustness of US insect populations, and identify regions of aerial insect decline. Radar data on large scale insect abundance should be combined with long term monitoring of biodiversity and species composition, to provide insight in the robustness of regional populations and insect-provided ecosystem services under conditions of global change.

35 NEW TECHNOLOGIES AND APPLICATIONS IN ENTOMOLOGICAL RADAR

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Entomological radar is one of the most important tools for insect migration observation with the capability of detection and measurement. The traditional entomological radar can be generally categorized into two types including scanning radar and vertical-looking radar. In recent, many advanced radar techniques are introduced to develop new entomological radar systems. These types of radars are with the high spatial and temporal resolution to distinguish individuals. Meanwhile, biological parameters measurements are also improved in precision and expanded in range. The new entomological radar systems have been gradually deployed and operated in China since 2018. In Yunnan province, there are three Ku-band high resolution and full polarization radars for monitoring cross-border insect migration. In 2020, the massive migration of Ceracris Kiangsu Tsai was successfully monitored by radar at Jiangcheng and it was reported to the department of prevention and control for the first time. In addition, because the new entomological radar has high range resolution and is able to obtain a more precise vertical profile of density, it was used to carry out a joint observation experiment with weather radar, so as to establish the relationship between echo reflectivity of weather radar and insect density. As thus, the development of the entomological radar can not only improve the small-scale observation, but also support the large-scale analysis of insect migration based on weather radar.

230 QUANTIFYING INSECT MOVEMENTS ACROSS EUROPE WITH A RADAR NETWORK

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Each year, massive numbers of migratory animals move through the skies in pursuit of increased survival or reproductive output. While patterns of bird migration are increasingly well characterized, our current knowledge on insect movements remains fragmentary, even though the phenomenon surpasses other migrations in abundance and biomass, and has enormous implications for agriculture, economy, and human welfare. Over the past decades, the development of vertical-looking radar in particular has led to fascinating insights, but research has so far been limited to a single or a few locations. In a joint, cross-European effort, we created a network of 17 vertical-looking radars, stretching from Southern France to Finland, to quantify insect abundance and movements from March to October 2021. In this talk, we present patterns of migration traffic rates, biomass flux, and movement directions across these sites, and how they vary as a function of space, time, and habitat. We highlight patterns and differences in movement activity at various temporal scales, ranging from diurnal to annual seasonality. In addition, we identify the underlying drivers of these observed spatial and temporal patterns and variability by linking them to a set of environmental variables.

MON4-b - Radar-based approaches to monitoring the abundance, morphological diversity and movements of aerial taxa

123 BIRD MIGRATION AT THE EDGE – STOPOVER DISTRIBUTIONS NEAR ECOLOGICAL BARRIERS

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Stopping-over is critical for migrating birds. Yet, our knowledge of bird stopover distributions and their mechanisms near wide ecological barriers is limited. Using low elevation scans of weather radars in Israel, we quantified large-scale bird departure patterns during spring and autumn in between two major ecological barriers, the Sahara Desert and the Mediterranean Sea. We found that bird distributions differed between the seasons, with higher densities in the desert and its edge, as well as inland from the sea, during spring and a predominantly coastal distribution in the autumn. Bird distributions were primarily affected by broad-scale geographic and anthropogenic factors rather than fine-scale habitat properties. Notably, artificial light at night strongly attracted migrants, especially in the autumn. Autumn migrants also selected sites located close to water sources. Our findings substantially advance the understanding of bird migration ecology near ecological barriers and facilitate informed conservation efforts in a highly populated region.

226 TOWARDS A DATA-INFRASTRUCTURE FOR MONITORING AND FORECASTING MIGRATION

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The migrations of birds, bats and insects are relevant for a diverse array of stakeholders from aviation safety, wind energy, habitat and bird conservation to human health. Radar networks have tremendous potential for monitoring these migrations and establishing the knowledge base for answering scientific questions as well addressing societal challenges that require real-time monitoring and forecasting migration. For example, radar-based monitoring is currently used as a decision support tool for military aviation in several countries and similar systems are being designed for wind energy to support curtailment procedures to reduce the impact on migratory birds.
However, what is currently not resolved in Europe and most of the world is a data infrastructure that facilitates diverse applications. We describe the steps needed to develop an infrastructure with a data pipeline including data acquisition, a long term archive, processing and visualization tools and delivery of biodiversity products for diverse stakeholders. As a case study, we describe current pipelines for forecasting migration. We highlight the contrasting state of affairs in the US and in Europe and steps that are needed to work towards developing sustainable services. Our roadmap could be used by other countries around the world to work towards a global infrastructure for monitoring and forecasting migration flows.

31 CLASSIFYING AND COUNTING ANIMALS BY RADAR – ECHO-SIGNATURES AND FLIGHT BEHAVIOUR

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Birds, bats, and insects can be classified by their echo-signatures while flying though a fixed pencil-beam or when kept for a longer time within the beam of a tracking radar. In a fixed beam, they can be counted, if the dot-like echoes are sufficiently separated from each other (like in most birds and bats migrating at night). Tracking provides longer signatures and additional information on flight behaviour (direction over ground, ground-speed, vertical speed as well as heading and air-speed, if upper winds are measured by tracking pilot-balloons). – Applying the tracking radar "Superfledermaus" in both ways provided information a) on the vertical distribution of migrating birds and its variation with topography, over time, and according to persistent wind systems between Europe and the West African Savannas, b) on topography and wind moulding directions of autumn migration in the same region, c) on the behavioural reactions of migrating birds to wind, mountain ridges, coastlines, desert-crossing, and resting areas. – For studies in the Sahara, one radar was transformed into a mobile unite (with fixed-beam capacity only). Such units became the standard instruments from 2010 onwards, either with the original range (~4-5 km for small birds) or with shorter range and widened opening angle of the beam for mainly practical applications, e.g. to measure the intensity of migration in front of wind-turbine parks.

112 SAFEGUARDING MIGRATING BIRDS TO INFORM WIND ENERGY DEVELOPMENT

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Renewable wind energy is expanding in biodiverse regions of the world, where impacts of development on wildlife can be minimized with informed turbine placement and operation. To inform risk prediction and mitigation for wildlife, specifically nocturnally migrating birds that collide with wind turbines, we demonstrate novel integration of terrestrial and aerial habitat use data collected by a network of weather surveillance radars across the North American Great Lakes, a continentally important migration corridor. Generally, migrants were concentrated in terrestrial stopover habitats within 20 km from shorelines and within heights swept by turbine rotors prior to dawn. The proportion of passage migrants using stopover habitats varied widely at local and regional scales, creating predictable opportunities for bird-friendly wind energy development. This approach for using comprehensive networked radar data across broad extents could provide critical information for reducing bird collisions and negative habitat-related impacts, which would improve sustainability of wind energy globally.

303 BIRDCAST: ENHANCING BIODIVERSITY KNOWLEDGE THROUGH APPLIED RADAR ORNITHOLOGY

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Migratory birds represent dynamic and global communities. Recent methodological and analytical advances suggest an inspiring future for research and conservation to capture this broad dynamism in studying birds' complex roles in terrestrial, aerial, and aquatic systems and relationships of these roles, more generally, to the planet's biodiversity. BirdCast is a collaborative project employing expertise of computer scientists and ornithologists to harness the power of big data to study movements of birds, best known for its characterizations of bird migration with data collected by the US weather surveillance radar network to forecast where, when, and how many birds will migrate and to observe these movements in near real-time. Here, we discuss how and to what ends we use 2.5 decades of radar data to study magnitudes and extents of bird migration over the US, to address challenges of and opportunities for monitoring birds' nocturnal movements at scales relevant to their biologies, and ways we use radar to remotely sense interconnected spatiotemporal patterns. We highlight approaches to:
1) develop bird migration forecast models,
2) predict bird-aircraft collisions,
3) study impacts of light pollution on nocturnally migrating birds,
4) investigate changes in migration systems, and
5) estimate bird mortality and recruitment through the lens of biodiversity research to highlight the enormous potential for defining and supporting broad understanding of complex, biological systems.

312 POLARIMETRIC ECHO CLASSIFICATION FOR HIGH-RESOLUTION AEROFAUNAL ANALYSES

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The demand for biomass monitoring by weather radars at various spatial scales has increased in recent years given improved data processing techniques and the prospects of weather radar data products e.g. in migration research or in risk mitigation in various human-wildlife conflicts. Such radar-based services require reliable high-resolution target identification in a variety of environmental settings and for various types of migrations of aerial biota. Existing non-polarimetric methods enable migration analyses based on layered composite quantifications above each radar with a spatial resolution of about 100 km.
In the present work, we show a novel Bayesian classification methodology based on polarimetric moments available from dual-polarisation weather radars, and its potential applications in aeroecology. The key achievement of the methodology is the quantification of aerofauna in each range gate at a spatial resolution of about 1 km. As a second important benefit both insects and birds can be separated simultaneously from all other echo types. The bin-based methodology allows for spatially more flexible high-resolution applications for a broader set of migration types compared to existing layer-based approaches. We compare the performance of the polarimetric methodology to established standard methods used in radar biology and discuss its extended potential for biodiversity monitoring in different types of migrations which unveil novel areas of application.

246 A THREATSCAPE FOR THE AEROCONSERVATION OF MIGRATORY BIRDS

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During their long-distance annual migrations, landbirds move between terrestrial and aerial habitats when descending to and ascending from stopover habitats. In doing so, they are potentially exposed to a wide array of anthropogenic hazards in the lower airspace known to be responsible for avian mortality due to bird collisions. Therefore, identifying areas where migrating birds stopover in high densities and are likely to encounter anthropogenic threats with high collision risk could inform their aeroconservation needs during a critical stage in the annual cycle. We developed a threatscape map for nocturnally migrating landbirds with scored collision risk for buildings, communication towers, aircraft, wind turbines, roads and power lines across the continental United States. We pair that threatscape with maps of stopover habitat use to identify high risk areas and to ask whether birds migrating through the northern Gulf of Mexico and Great Lakes coasts are at greater risk of mortality from collisions during spring or autumn. Further, we evaluate to what extent anthropogenic risk is concentrated within urban areas. We pose that effective conservation of migratory birds should consider the airspace, where birds are likely to be at the greatest collision risk when transitioning between terrestrial and aerial habitats.

489 MODELING AVIAN STOPOVER DISTRIBUTIONS ACROSS THE CONTIGUOUS US USING RADAR DATA

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As billions of avian migrants transverse North America, they must contend with ever-changing landscapes driven by natural and anthropogenic forces. While airspaces facilitie migrant passage, terrestrial landscapes serve as essential rest stops to restore energy reserves and act as refugia from adverse weather—making it critical to understand where and how diverse landscapes are used. Remote sensing of biotic diversity has advanced considerably in the past few decades, ushering in a new era of multi-sensor synthesis, bringing together diverse observational data streams to map, monitor, and model land use by migrant populations. We focus on the contiguous United States, modeling bird migrant stopover densities across 143 weather surveillance radar stations from 2016–2020. We build our analytical dataset by articulating observations from NLCD, MODIS, VIIRS, and Landsat. Amassing more than 100,000 radar scans, linked with 45 predictor variables, we model spring and fall stopover locations at 1-km spatial resolution using 1,000-boosted regression tree models. Migrant hotspots emerge from this continental scale approach, and we observe positive habitat associations with deciduous forests, riparian corridors, and wetlands. Understanding the scope and impact of human development on natural communities is pivotal for sustainable development, habitat planning, and the intentional conservation of biodiversity.

MOU1-a - Global mountain biodiversity

215 ALPINE AQUATIC BIODIVERSITY: PATTERNS, DRIVING FACTORS, AND FUTURE PERSPECTIVES

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Whereas research on terrestrial mountain ecosystems and their biodiversity is steadily growing, life in alpine waters remains to date largely understudied. This is the case despite the undisputed importance of mountain aquatic habitats for biodiversity and ecosystem services. This is also in contrast to evidence for increasing effects of climate change, habitat degradation, pollution, flow regulation and water extraction, and alien species introductions on mountain freshwater species, ecosystems, and the functions they fulfil. Here we present the outcomes of a literature review on current knowledge of biodiversity in alpine waters worldwide, from microbes to vertebrates, and at supporting the formulation of a research agenda in mountain aquatic biodiversity. We specifically discuss the main environmental conditions shaping life in aquatic mountain habitats, the spatio-temporal distribution patterns of species along environmental gradients, and the main stressors threatening alpine biodiversity at all organizational levels. In the light of the challenging objectives set by global agendas including the UN Sustainable Development Agenda, the recently launched EU Biodiversity Strategy for 2030, and the UN Decade on Ecosystem Restoration 2021-2030, we conclude with an outlook on knowledge gaps and on the investments that are needed for the conservation and restoration of freshwater mountain ecosystems.

346 THE CURRENT FATE OF THE WORLD'S CLOUD FORESTS

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Tropical cloud forests (TCFs) are one of the world’s most species- and endemism-rich terrestrial ecosystems. While still under-documented due to their complex terrain and isolation, TCFs are believed to harbour the world’s greatest diversity of epiphytes, mosses, ferns, lichens, bromeliads and orchids and, in turn, an array of animals adapted to them for food and habitat that provide critical ecosystem functions. Many of these species are highly range restricted and therefore vulnerable to primary habitat loss. TCFs are threatened by direct human pressures and climate change, yet the fate of these extraordinary ecosystems remains insufficiently quantified. With discussions of the post-2020 biodiversity framework underway, TCFs are a defining test case of the success and promise of recent policy targets and their associated mechanisms to avert the global biodiversity crisis. We present a global assessment of the recent status and trends of TCFs and their biodiversity and evaluate the efficacy of current protection measures. We show that cloud forests occupied 0.4% of the global land surface in 2001 and harboured ~3,700 species of birds, mammal, amphibians and tree ferns. Worldwide, ~2.4% of cloud forests (in some regions, more than 8%) were lost between 2001 and 2018. A large proportion of loss in TCF cover is still occurring despite formal protection. Increased

conservation efforts are needed to avert the impending demise of TCFs and their unique biodiversity.

45 ON NATURE AND PEOPLE IN MOUNTAINS WORLDWIDE: A GLOBAL COMPARISON

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Much social and ecological knowledge required to support decision-making in sustainable mountain biodiversity management and conservation is available in the mountain research community and among societal actors and governmental institutions. Here we report on a first attempt to adopt the IPBES framework to systematically collect this knowledge by means of a global online survey. Information obtained from 142 respondents was spatially analysed using the GMBA mountain inventory V2.0, a new inventory of the world's mountains including more than 8000 polygons and is presented along the main IPBES components of social-ecological systems. Many of the reported trends and patterns in biodiversity and nature's contributions (NCP) to people follow recently reported global trends, with a deterioration in ecosystem condition and trends towards a decrease in NCP delivery, which affects the wellbeing of mountain populations. However, analyses of expert perceptions and of the literature also revealed interesting nuances, including differences in the importance of various drivers and their interactions along the elevational gradient; trade-offs and synergies between nature conservation and the amelioration of human livelihoods locally; and context-specific differences in the upstream processes elicited by socio-economic development in the lowlands. The IPBES framework in turns allowed us to elicit expert knowledge in a systematic way and ensure that the data are largely comparable.

391 STAKEHOLDER PERSPECTIVES ON WHICH SDGS NEED TO BE PRIORITISED IN MOUNTAINS

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The Agenda 2030 is an integrated vision of environmental, social, and economic changes needed to benefit people and nature. Due to its relevance to all societal sectors, its goals (the SDGs) and their implementation are multidimensional and complex. Achieving effective progress towards the SDGs thus requires the acknowledgement and understanding of diverse perspectives and priorities among stakeholders to inform negotiations and align actions. Here, we specifically focus on stakeholders from mountain regions, with the aim to identify common perspectives and shared SDG priorities. To do so, recognizing that all SDGs are individually important, we applied a Q method approach to analyze people's perspectives on which SDGs need to be prioritised to successfully achieve the full SDG agenda across the world's mountains. A global online survey, with a focus on the Andes, European Alps, and Himalayas, yielded a total of 166 responses ranking the SDGs by priority level. Using principal component analysis and factor flagging, we identified hierarchical clusters of group perspectives on SDG priorities. For compromise seeking and consensus building, we developed a score that, based on the individual and group perspectives analyzed, revealed SDGs having consensus support for prioritization. Globally, among the survey participants, SDGs 4, 3, and 15 emerged as top priorities. This approach, incorporating diverse perspectives, can guide priority setting across regions and spatial scales.

196 GLOBAL SURVEY ON ALIEN INVASIVE SPECIES IMPACTS AND MANAGEMENT IN MOUNTAINS

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Invasive species are a major driver of change in global biodiversity and ecosystems. However, knowledge on the impact of invasive species' on biodiversity, nature's contributions to people, and human well-being in mountains is currently lacking.
To better understand regional variation in species impacts on nature and societies in mountains as well as stakeholder perceptions on these impacts and on management options, we conducted a global survey across IPBES regions and a broad range of stakeholders, including managers, land-owners, farmers, policy makers, conservation, and scientists.
Based off over 600 responses from mountain regions in all IPBES regions we evaluate: how stakeholders rank invasive species relative to other global change drivers in their regions; the diversity of invasive species in montane systems, including the organism types, and native or non-native status; the most commonly identified invasive species of concern; perspectives on the impacts of invasive species on water, soil, biodiversity, pollination and disturbance processes along with their role in resource provisioning, human safety, human health, recreation and culture. Additionally, we assess how invasive species management practices are guided, who is involved and how such activities are funded. We hope the insights from this survey will serve to inform policy and foster interdisciplinary action towards sustainable management practices for invasive species in mountain regions.

481 MOUNTAIN BIODIVERSITY AND THE SUSTAINABLE DEVELOPMENT GOALS

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Mountain ecosystems are centres of cultural and biological diversity, and provide vital ecosystem services (including water, food, income, and protection from natural disasters) both in mountain communities and far beyond. However, the costs of conserving biodiversity may be incurred at different scales and locations than the benefits from resulting ecosystem services. This means we need to explicitly account for synergies and tradeoffs between biodiversity conservation and other Sustainable Development Goals (such as eliminating poverty and food insecurity) at different scales. Here, we synthesise insights from database analyses, expert surveys, literature reviews, and household questionnaires to uncover the challenges faced in conserving mountain ecosystems generally, and in particular, opportunities for synergistic nature-based solutions in mountains in Tanzania, Bolivia, and Nepal.

442 HUMAN POPULATIONS IN THE WORLD'S MOUNTAINS: PATTERNS AND POTENTIAL CONTROLS

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Climatic and demographic change in the world's mountains will have increasingly profound ecological and societal consequences. Quantifying the number of people living in mountains is crucial to ensure that interventions in these complex social-ecological systems, including efforts to protect their biodiversity and ecosystems, are proportionally resourced. However, comprehensive and reproducible population analyses have traditionally been lacking. Here, we present an open workflow to quantify the sensitivity of global mountain population estimates, both globally and regionally, to alternative input data choices. We also explored relationships between mean population density and selected potential covariates, including protected area extents, across elevational bands within individual mountain regions. Global mountain population and urban mountain population estimates were found to vary greatly. Population increased at least twofold between 1975 and 2015 in ~35% of mountain sub-regions. Population densities are more strongly associated with climatic than with topographic and protected area metrics, and these dependencies appear to have strengthened slightly; such insights may contribute to improved predictions of future mountain population distributions. Overall, our work emphasises that irrespective of data choices, many people are likely to be directly affected by – and themselves affect – mountainous environmental and ecological change.

MOU1-b - Global mountain biodiversity

132 TINTENSTRICH COMMUNITIES IN SWITZERLAND

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Cyanobacteria are known for their ability in colonizing extreme oligotrophic habitats, they can be found in both the coldest areas on Earth (e.g., glaciers surface, cold deserts) but also in the warmest ones (e.g., hot springs). They are the first colonizers of oligotrophic environments thanks to some major adaptive features, like tolerance to high UV radiation, the ability in fixing carbon and nitrogen, and their high desiccation tolerance. These attributes allow them to develop the so-called Tintenstrich ("ink strip") Communities (TC): black crusts that form on rock walls mostly in correspondence of water runoff. So far, few studies investigated the composition of these peculiar structures, and results showed that also eukaryotic green algae, fungi, and even lichens could occur in their formation. The lithology and the morphology of the substrate seemed to play an important role in defining the composition in TC. In this study TC cyanobacteria community characterization through Next Generation Sequencing technology is used to understand their variation with to solar exposition, altitude and the substrate. Furthermore, the presence of cyanotoxins (cyanobacteria secondary

metabolites potentially toxic also to mammals) will be assessed looking for both cyanotoxin-specific genes and the secondary metabolites through High-Resolution Liquid Chromatography Tandem Mass Spectrometry to provide essential information regarding the potential cyanotoxin risk in these Alpine environments

288 ALPINE SOIL MACRO-INVERTEBRATE COMMUNITIES ALONG HIGH ELEVATION GRADIENTS

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Fortunately, the number of soil fauna studies is constantly increasing, but few focus on high alpine areas. We conducted a comprehensive pitfall trap survey on ground-dwelling macro-invertebrates in alpine grazed grassland spanning from 1500–3000 m along three elevation gradients in the LTSER area "Val Mazia/Matschertal", South Tyrol, Italy. The aim was to investigate (i) changes in community composition with elevation, and (ii) seasonal community dynamics, focusing on the 3000-m sites where soil fauna data is very rare.
On each of the 12 plots (3 for each 500-m step), we installed 3 pitfall traps per sampling period: 3x 2 weeks at the lower and 2x 3 weeks at the higher sites (in sum active for 6 weeks).
Preliminary results showed high taxa numbers for the 2500–3000-m sites with on average 26.00 (±1.00) and 23.67 (±1.73) taxa per sample, respectively. In contrast, on the 2000-m sites considerably lower numbers of taxa were found (19.67 ±4.51). Drawing first conclusions, we are surprised by the high macrofauna diversity in the high alpine sites, and a uniform and species-poor community at the 2000-m sites. For example, Julidae, almost absent in former investigations, were found in many 3000-m pitfall traps along with Craspedosomatidae; the snow-rich winter 2020/2021 might have benefited their development. Trait analysis on carabid beetles along the gradient showed an increase of wingless and predatory species, while at lower elevations winged and herbivore species predominate.

328 HOW STABLE ARE MICROBIAL COMMUNITIES: THE CASE OF NIVICOLOUS MYXOMYCETES

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For the majority of soil protists, diversity can be assessed only using metagenomics or isolation techniques, since they are not directly observable in the field. Nivicolous myxomycetes (Myxomycetes, Amoebozoa) represent an exception, as they produce relatively large fructifications visible with a naked eye, often brightly colored. They occur in mountains with stable winter snow cover worldwide, prey on undersnow microbial communities, and serve as a flagship group among protists, representing microscopic eukaryote diversity.
From 2013 to 2021, we have performed seven-year-long monitoring of nivicolous myxomycete diversity along an elevational transect in the northern German Alps, resulting in almost 1600 records, with 85% of them DNA barcoded. Quantitative data on the occurrences of myxomycete fructifications are accompanied by a set of ecological parameters, including data on soil temperature at sampling sites and precipitation levels throughout the year.

Species richness, genetic diversity, and taxonomic structure of nivicolous myxomycetes along an elevational gradient and across years were evaluated. In addition, occurrences of one species were genotyped with MIG-seq to infer its reproductive mode, intraspecific genetic diversity, and persistence of particular genotypes over the years at the same localities. We report our ecological observations, including the elevational zonation of species and genotypes and the reaction of populations to extreme weather events.

25 CONSERVATION IN THE ALPS: THE MEDITERRANEAN AND ALPINE PLANT DIVERSITY AT RISK

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Conservation in the European Alps is a central topic, as this region is one of the largest natural plant diversity hotspot in Europe. However, a thorough conservation assessment and prioritization, based on multidimensional diversity and uniqueness, for present and future global change conditions is critically needed. Here, we investigate the efficiency of the European Alps' reserve network, and of its potential expansion, in protecting the multifaceted diversity and uniqueness of the European Alps flora at present, and for the year 2050/2080 under two SSP scenarios. Accounting for half of the European Alps Flora, we modelled at 100 m resolution over the study area the current and future distribution of plant taxonomic, phylogenetic and functional diversity/uniqueness, under three dispersal scenarios. For each timeline and dispersal scenario, conservation prioritizations were generated allowing spatial recommendations of conservation priority to be obtained. Overall we found multifaceted diversity/uniqueness to generally decrease in the future, the Mediterranean and Alpine flora to be greatly at risk for all scenarios, and conservation recommendations to follow these geographical threats. Furthermore, although the design of the European Alps' reserve network showed a good adaptability towards current and future SCP recommendations, a network expansion of at least 20% of the studied region would be necessary to protect half the diversity and uniqueness of the European Alps.

99 UNVEILING THE UNSEEN MICROBIAL DIVERSITY IN THE WORLD'S GLACIER-FED STREAMS

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Today, we understand the microbial diversity of the deepest ocean better than of the streams that drain the roof of our planet. Here, we present results from the first most comprehensive survey of microbial diversity across more than 140 glacier-fed streams from around the world — an endeavour enabled by the 'Vanishing Glaciers' project of The NOMIS Foundation. Our data unravel an unexpectedly diverse microbiome with representatives spanning the tree of life, and a including a rich virome as well. Strikingly, our findings suggest that the sediments of the glacier-fed streams harbor a microbial assemblage that is distinct from the microbes in the streamwater. Using a suite of

phylogenetic and genomic apporaches, we will highlight some of the adaptive strategies that the microbes have evolved to dwell in one of the most extreme ecosystem on Earth. We will also highlight the functional diversity of the glacier-fed microbiome and its implications for key ecosystem processes. It is time to shed light on this unseen diversity now because glaciers are melting before our eyes, and the stream ecosystems that they nurture are changing at unprecedented pace. Our presentation will shed light on the microbial diversity that we may be losing as glaciers shrink.

396 SPATIO-TEMPORAL REPORTING ON MOUNTAIN BIODIVERSITY CONSERVATION WITH SDG 15.4.1

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Current reporting on progress towards SDG 15.4.1 (Coverage by protected areas of important sites for mountain biodiversity) is performed at national scale based on the intersection of the World Database of Protected Areas and mountainous Key Biodiversity Areas. However, the occurrence of multiple mountain ranges within countries and differences in the protection of mountain biodiversity amongst them calls for a disaggregation of SDG 15.4.1 to support locally relevant decision making and management. With the availability of a new highly resolved inventory of the world's mountains, including more than 8000 polygons (the GMBA mountain inventory V2.0), such a spatial disaggregation of SDG 15.4.1 to individual mountain ranges can be effectively done. By capitalizing on the hierarchical structure of this new inventory and the attribution of individual mountains to parent ranges and systems, reporting can be performed across scales, from local to subnational, national, regional, and global. To illustrate the potential of higher resolution reporting, we present the latest values of SDG 15.4.1 for the mountain ranges and systems of the GMBA inventory V2.0. We further compare time series across countries as well as mountain ranges within countries, discuss differences in how to aggregate the data and the interpretation of the resulting outcomes, and introduce an interactive tool to browse SDG 15.4.1 online.

157 HOW HUMAN DISTURBANCE AFFECTS MYCORRHIZAL ASSOCIATIONS IN MOUNTAIN SYSTEMS

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- The mutualistic association between mycorrhizal fungi and plants is crucial in shaping plant communities. However, in the context of increasing human pressure on natural ecosystems, little is known of the impact of anthropogenic disturbances on mycorrhizal associations.
- To better understand this interaction, we combined a global database of plant distributions along mountain roads with a database of mycorrhizal association types to investigate how mycorrhizal type distribution responds to anthropogenic impact across a range of environmental conditions in mountain regions worldwide.
- We found that roadside disturbance significantly increased Arbuscular Mycorrhizal (AM) associated plant cover in mountain ecosystems with diverse mycorrhizal types, while it caused an overall reduction of AM-associated plant cover in

ecosystems dominated by AM associations. Furthermore we found disturbance to be a stronger predictor of mycorrhizal type associations than elevation or temperature.
- We conclude that changes in mycorrhizal associations caused by anthropogenic disturbance play a non-negligible role in mediating the impact of human activity on ecosystems. Understanding how these patterns vary depending on the mycorrhizal types present in a given ecosystem will help us better understand and predict changes in plant communities following human disturbances.

RES1 - Taking Action to Secure a Future for the World's Threatened Trees

138 USING BIG DATA TO IDENTIFY VULNERABILITY AND OPPORTUNITIES FOR TREE DIVERSITY

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Global climate and land use change will differently affect tree species, and unlike other organisms, trees may be especially vulnerable to climate change due to their long generation times and low migration capacity. While objectives on forest landscape restoration initiatives focus on tree cover, explicit goals on tree diversity are missing in part due to the lack of quantitative assessments on how climate, land use change and restoration could differently affect tree species. Here, we perform a global data-model-synthesis gathering data on occurrences, traits and phylogenetic information for >49,000 trees and show that around half tree diversity is at stake in the next century. Our results revealed that ca. 35% tree richness may be compromised in landscapes worldwide under Paris agreement (RCP 4.5) by mid-century, increasing up to ca. 46% depending on the mitigation scenarios. Exposure to climate change in combination with limited dispersal scenarios poses a great challenge to key forest foundation species. In addition, drivers of land use change especially affected Southern America and Subtropical Africa, while migration capacity is the most sensitive driver in in the Tundra. Opportunities for tree diversity restoration exist, however, in human dominated landscapes. These results suggest that half tree diversity is at stake but there are potential opportunities to set ambitious to enhance tree diversity worldwide.

172 STATE OF THE WORLD'S TREES - MOBILISING ACTION FOR THE WORLD'S THREATENED TREES

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The State of the World's Trees report, published in autumn 2021, highlights that at least 30% of the world's trees are threatened with extinction. This equals over 17,500 tree species, more than double the number for threatened mammals, birds, reptiles, and amphibians combined. For the first time we now have comprehensive information on the distribution and conservation status of all the world's tree species: which species are at risk of extinction, where are those species found, and why are they threatened?

Despite the seriousness of the threats to trees, there is also hope. We present new analysis of in situ as well as ex situ conservation action for the world's trees species, including mechanisms to track global progress of tree conservation action. We suggest how this information and tracking can be used to inform the post-2020 global biodiversity framework. Combining information on conservation status of tree species with up-to-date information on conservation action which is underway, we can better inform and prioritise further conservation needs on a global, regional and national scale.
In this presentation, we explore further how the results in the State of the World's Trees report can be used to catalyse better informed conservation action for the world's most threatened trees and their habitats contributing to international biodiversity targets. We provide inspiring success stories of successful conservation, habitat restoration and practical ways to take action.

RES2 - Recreating Nature in the Age of the Anthropocene: Designing Landscapes and Regional Corridors to Support Wild Pollinators

345 PLANT, SOW OR JUST LET GROW? ENGAGING CITIZENS IN INSECT-FRIENDLY MANAGEMENT

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2019 was the start of a campus wide, bottom-up initiative to promote biodiversity at Freie University (Free University) of Berlin, Germany. Transforming the until then low-cut, tidy loans has been one of the main goals from the start, thereby challenging the persistent aesthetical paradigm of mowed lawns and often exotic, ornamental plants. Four, oftentimes intertwined approaches are currently pursued by the initiative: (1) reducing mowing frequency and promoting spontaneous vegetation, (2) 'directed' spontaneous vegetation, that includes active removal of invasive and/or problematic plants as well as fostering and seeding selected species, (3) sowing areas using regional seeds, and (4) transposing pant rosettes and saplings from culture and donor areas to areas on campus. While (1) is organized and carried out by the university's administration, (2 - 4) are carried out by volunteers from within and outside university and in cooperation with local NGOs and stakeholders. The effect on pollinators of these different approaches has in part been quantified (1, 3), and participatory rewilding and monitoring is ongoing (e.g. through a public butterfly monitoring, a wild bee identification course and collaboration with neighbors and local nature conservation initiatives). The effect of the different managing strategies on both humans, and non-human beings, will be discussed, with a focus on pollinators.
Homepage of Blühender Campus/Campus in bloom, english version in progress

170 ALL-IRELAND POLLINATOR PLAN – COMING TOGETHER TO REDESIGN LANDSCAPES

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Data shows that one third of Ireland's 99 wild bee species are threatened with extinction. Rare species are disappearing through habitat loss and common species are struggling because of how we currently manage the rest of the landscape. To tackle this, the All-Ireland Pollinator Plan was published in 2015, making Ireland one of the first countries in Europe with an overarching strategy to address this problem. It is a voluntary plan that is

supported by more than 100 governmental and non-governmental organisations. Following a successful first year phase, a new Plan for 2021-2025 has identified 186 actions to make Ireland more pollinator friendly. Clear, accessible evidence-based guidelines have been written for all sectors explaining what actions can be taken to help. These have been widely and voluntarily adopted by farmers, local authorities, transport authorities, gardeners, community groups, businesses and schools. As these groups engage with actions to redesign landscapes and create corridors to support wild pollinators across the island, we discuss the many lessons we have learned. It has demonstrated that it is possible to engage across sectors, and you can bring people together to address a biodiversity crisis. Importantly, it has shown that data is the impetus for change. It allows identification of the correct evidence-based actions, and through tracking and monitoring, creates the momentum to facilitate real progress.

280 LINCOLN POLLINATOR ACTION PLAN: PLANTING FOR BIODIVERSITY AND CLIMATE RESILIENCE

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The Lincoln Land Conservation Trust in Lincoln, Massachusetts, USA has developed in partnership with Evan Abramson of Landscape Interactions and Dr. Robert Gegear, a professor of biology at UMass Dartmouth, a roadmap for creating biodiversity and climate resilience across the Town of Lincoln by rebuilding functionally diverse native ecosystems through site-specific planting palettes and pollinator habitat designs that target at-risk species. Three Case Study sites on permanently conserved land and a demonstration garden site at the Birches School (an independent, co-educational Pre-K through 8thGrade school) represent different landscape typologies and replicable Toolkits for each have been developed. Through a series of public events, the community has been engaged and educated about native pollination systems, at-risk species, and biodiversity. Town residents, along with landowners across the region, have purchased curated Plant Kits based on the Toolkit planting palettes in the Lincoln Pollinator Action Plan. All together, the Case Study sites, the Birches School demonstration garden, and the residential landscapes create a corridor of habitat that targets at-risk pollination systems. In connecting protected and restored native pollination systems through corridors, we are helping to increase the abundance, species richness, and geographic distribution of wild pollinators.

568 USING SPECIES TRAIT DATA TO ENHANCE POLLINATION SYSTEM DIVERSITY

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Over the past two decades, human activity has significantly degraded the integrity of pollination systems across New England. Many historically abundant native plant and pollinator species are now locally extinct, with others soon to follow if immediate conservation action is not taken. The loss of these plant-pollinator systems poses a significant threat to the diversity and function of natural ecosystems, due to the fundamental role that pollination products play in supporting wildlife across trophic levels. Despite this, we currently lack the ecological data required to develop effective conservation and restoration strategies for pollination systems at risk.
The Beecology Project aims to fill this gap by recruiting citizen scientists from across New England to collect and submit observations of native pollinator-plant interactions using the Beecology web app. The first phase of the project has focused on the floral

preferences of threatened bumblebees, with subsequent phases to include nesting and overwintering site preferences, as well as other pollinator groups and geographic locations.
Since 2018, Beecology has significantly advanced bumblebee conservation efforts by providing data-driven, species-level recommendations for native pollinator habitat creation and restoration. This has allowed members of the general public to not only improve the quality of habitat, but also help determine the causes of wild pollinator decline.

285 IMPROVING BEST LANDSCAPING PRACTICES FOR POLLINATOR CONSERVATION

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As land use change drives global insect declines, the value of enhancing landscapes in the built environment has become increasingly important to help support pollinator taxa and critical ecosystem services they provide. Efforts to rebuild habitat and promote connectivity across the landscape spectrum from agro-ecosystems and utility or transportation rights-of-way to suburban yards and urban green space have continued to gain momentum. Despite these initiatives, emphasis has often been placed on providing abundant floral resources of limited diversity, easy to source, and preferentially showy blooming plants that target more generalist pollinators. This "catering to the masses" approach potentially neglects the overall rich structure of plant-pollinator networks, particularly for rare or more specialist species, including those central to crop production or biodiversity maintenance. Increased data is needed to construct more informative plant–pollinator networks, provide more comprehensive plant recommendations, and ultimately develop more sustainable and ecologically appropriate best landscaping practices. Examples focused on landscape plant community composition, rare species interactions, and data-driven plant production and marketing of pollinator-friendly plants are discussed.

567 DESIGNING BIODIVERSITY IN THE ANTHROPOCENE

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Humanity's impact on the Earth is so profound that a new epoch has been declared. The Anthropocene is defined by rising carbon emissions and sea levels, the mass extinction of species and the transformation of land by development. One million species are threatened with extinction globally, including over half the native bee species in North America.
Biodiversity should be seen as a key ally in dealing with climate change, not as a victim of it. Animal and plant species diversity means ecological resiliency: crucial in an era of unpredictable climate and more frequent, intense and longer weather extremes.
Farms, wildlands, sub/urban greenways and rural communities provide vast opportunities for expanding biodiversity through native pollination system corridors. What happens at the pollination scale has repercussions through the food web to the largest predators and humans. Yet most efforts to restore pollinator habitat have increased the numbers of a few common species, not the range of wild pollinators needed for ecosystem resiliency. Seeing lots of bees does not mean that a landscape is pollinator-friendly.
Since 2019, Landscape Interactions has worked across the Northeast to design, plan and implement functionally diverse pollinator habitat by targeting species at risk in each project location. By publishing scalable, replicable models of habitat design and restoration for free, the building blocks for a regional network of resilience are already being created.

SES1 - Biodiversity changes in social-ecological systems – use of data and knowledge to support societal transformation towards sustainability

209 PARTICIPATORY DEVELOPMENT OF ARCHETYPES FOR MANAGING ECOLOGICAL INFRASTRUCTURE

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Ecological Infrastructure (EI) plays a crucial role in the functioning of ecosystems, but their integrity and thus ecosystem functioning are threatened by global change processes. The newer action plans for biodiversity conservation do however not only target ecosystem functioning, but highlight the importance of fostering the provision of Nature Contributions to People (NCP). Given that conservation interventions often incur high costs, this raises the question if biodiversity hotspots can be managed by free-riding on the management for NCP.
We tackle this question by developing socio-ecological system archetypes for managing EI. These archetypes comprise of landscape units that are identified by sets of NCPs co-produced by socio-ecological systems. These units are linked to social-ecological interactions including governance mechanisms and policy instruments using a tiered-approach based on Ostrom's framework. We utilise these archetypes in combination with biodiversity data in an iterative process between scientists and stakeholders to inform conservation, restoration, and management practices to secure a functioning EI in Switzerland. We close by discussing how the development of such archetypes using a combination of qualitative and quantitative, expert-based and computer-aided methods can make data on biodiversity and NCPs tangible for decision-makers.

575 PREDICTING SPECIES DISTRIBUTION AS BASIS FOR BIODIVERSITY CONSERVATION PLANNING

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Species distribution models (SDMs) have developed tremendously in the last decade, but are still largely under-used in biodiversity conservation, although new initiatives are increasingly appearing on this aspect. Here, I review some recent key developments and applications of SDMs related to biodiversity conservation. Developments include the use of standards to assess model quality before inclusion in biodiversity assessment, the use of hierarchical approaches to avoid problems of niche truncation that can affect model projections, focal approaches to develop new predictors, and the need for integrated modelling pipeline that account for all these new developments. Applications include the use of SDM predictions to support biodiversity sampling and monitoring efforts, the prediction of nature contributions to people (NCPs), the delineation of ecological infrastructures, and the spatial prioritization of biodiversity conservation based on all these components, taking the example of the ongoing Swiss biodiversity modelling pipeline and Swiss ecological/green infrastructure developments. I conclude with some perspectives on the use of SDMs to further support biodiversity conservation by better incorporating prediction it in the management of social-ecological systems.

63 CONCURRENT GLOBAL CHANGES IMPACT BIODIVERSITY AND FUNCTION OF EARTH'S GRASSLANDS

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Among the greatest current challenges for ecological research is developing a predictive understanding of links between biodiversity and ecosystem function, on one hand, and ongoing, global-scale changes to nutrient cycles and species distributions, on the other. Yet, without strong scientific data that informs the conditions under which global change will alter biodiversity to cause cascading impacts on ecosystem functioning, effective planning and policy will be jeopardized. While the ecological research challenges are global in scale, experiments and sampling to measure changes in the composition and function of ecological communities must be done at local scales. I will discuss my experience with conceiving and implementing a globally distributed, collaborative network of identically replicated grassland experiments, the Nutrient Network, that is generating unique data on the condition-dependence of biotic responses to global change. In my talk, I will present some of the network's insights into the interactions among ongoing global changes to Earth's ecosystems, including nitrogen influx and climate, that control biodiversity and ecosystem processes in the world's grassland ecosystems.

447 BRAZILIAN CERRADO: A BIODIVERSITY HOTSPOT AT THE CROSSROAD OF THE GLOBAL CRISES

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The Brazilian Cerrado is the second biggest biome in South America and a global hotspot for biodiversity conservation which 44% of its original cover was converted mainly to agricultural use. Land-use changes in the region are a significant share of the country's greenhouse gases emissions. Currently, agricultural expansion negatively affects climate change mitigation, biodiversity conservation, and indigenous and traditional communities' protection. Regional temperature and precipitation changes place the biome in a potentially even more conflicting scenario. Because only a small fraction of the biome is protected in public nature reserves, protected areas in private lands are essential for mitigation and adaptation strategies. Pastures are the major land use category in Cerrado, covering 29% of its area, being most underused and with some degree of degradation. They represent an opportunity for restoration programs and agriculture expansion without further deforestation. We modeled restoration scenarios on pasture areas considering biodiversity, water-related ecosystem services, potential carbon stock, and agriculture aptitude to understand the trade-offs between each feature and the conflicts with agriculture. Conflicts with agriculture are significant and represent an obstacle that will demand the involvement of multiple stakeholders to ensure effective conservation and restoration efforts.

27 BIODIVERSITY OFFSETS – A GOVERNANCE TOOL TO ACHIEVE NO NET LOSS AND NET GAIN

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The presentation deals with the new concept and instrument of biodiversity offsets. The aim of offsetting schemes is to achieve no net loss or even net gain of biodiversity and

ecosystem services. Offsets obey a mitigation hierarchy and reflect the precautionary and polluter-pays principle in regard to project impacts. The talk offers insights into current debates on biodiversity offsetting policies, outlining theoretical principles and the latest research findings. At the same time the focus is on transdisciplinary approaches, practical application and case studies highlighted from a socio-ecological point of view. Today there is a lively international discussion among practitioners and scientists on the optimal legal framework, metrics and designing of offsets and habitat banks to ensure success and to minimise the risks of failure or misuse. Contributing to the debate, this talk presents the activities, practices and governance of biodiversity offsetting already implemented in selected EU member states, and the lessons that can be learnt from them.

506 SPATIAL ASSOCIATION BETWEEN TERRESTRIAL CARBON STORAGE AND BIODIVERSITY

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Climate change and biodiversity loss are the most critical environmental crises humanity has faced. These crises also interact in many ways with strong connections via land use change, which can drive shifts in both carbon storage as well as the biodiversity present. Integrated land management strategies could offer potential co-benefits in addressing both crises. However, a current overview of the geospatial interactions and correlations of carbon and biodiversity impacts via land use is still lacking. Various correlations between carbon storage and biodiversity loss have been found, varying between climate zones (boreal, temperate, tropic, and sub-tropic regions), biodiversity or ecosystem measures (e.g., species- and habitat-based metrics), carbon pools (biomass and soil), and modelling approaches. To assess the state of knowledge of these carbon-biodiversity interactions, we provide a meta-analysis and review of spatially explicit research studies on the spatial association between carbon and biodiversity. The results suggest that boreal and temperate forests present a weak or even negative correlation, which diverges from most of the congruent evidence from the tropics and subtropics. However, there should be significant caution when extrapolating this spatial generality, given the distinctive surrogates both for carbon and biodiversity. These review findings may help facilitate biodiversity conservation while working to meet climate targets.

SES2 - Placing biodiversity research within a social-ecological context

609 UNDERSTADING CHOICES FOR NATURAL CAPITAL AND OTHER LIVELIHOODS ACROSS SYSTEMS

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Multiple interventions are inacted at the community level that aim at community development, biodiversity and
ecosystem service conservation, building capacity at local scales and promoting livelihoods. Such interventions are meant to have double dividends across many livelihood dimensions; however, trade-offs may emerge decreasing success of individual interventions and their scalability. Here we examine the extent to which interventions in

(i) coffee and avocado agroforestry,
(ii) charcoal production,
(iii) water use, and
(iv) human-wildlife interactions can be synergistic or exhibit strong trade-offs.
We find that depending on the angle of the intervention we may or not have a strong relationship with natural capital, being it biodiversity, water or wildlife. Further, we find that there might be some cases where combined interventions may lead to more vulnerability to the communities, or present difficult choices to make. This suggests that stronger attention is needed on the trade-offs of multiple interventions, to avoid surprising outcomes and how to achieved concurrent goals of conservation and livelihoods.

57 COUPLED SETTLEMENT AND HABITAT NETWORKS AS SOCIAL-ECOLOGICAL SYSTEMS

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Many species depend on networks of well-connected habitats (i.e. habitat networks) for their survival. Similarly, settlements that are well-connected by roads and traffic (i.e. settlements networks) are essential for the prosperity of many human societies. However, the integrity of habitat networks is threatened by numerous processes taking place in settlement networks, such as the expansion of settlements or increases in traffic. Due to these interactions, settlement and habitat networks are regarded as a social-ecological system. Unravelling the complex interactions between settlement and habitat networks can lead to new insights in biodiversity conservation. In this talk, we will give an overview of several studies that we have conducted on coupled settlement and habitat networks. The first study is a simulation study on the effect of settlement and road network configurations on habitat connectivity. In the second study, we assessed the trade-offs between increasing habitat availability in habitat networks and creating multiple urban centres in settlement networks (i.e. a common urban planning goal). We draw some general conclusions from these two studies. Lastly, we will briefly introduce the new EMPHASES project in which we study long-term time series of settlement and habitat networks in Switzerland. We conclude that coupled settlement and habitat networks are a useful framework to study the interactions between important social and ecological processes.

94 ECOLOGICAL RESTORATION IN OIL PALM WITHOUT YIELD LOSS

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Widespread expansion of oil palm plantations has led to dramatic losses of biodiversity and ecosystem functioning in tropical lowlands. As we enter the UN Decade on Ecosystem Restoration, whether and to what extent biodiversity and ecosystem functions in oil palm landscapes can be restored remains unknown. Here, we present findings from a long-term ecological restoration experiment encompassing below- and aboveground biodiversity and key ecosystem functions in an oil palm landscape restored with tree island planting. Overall, experimental tree islands enhanced biodiversity and ecosystem functioning compared with conventionally managed controls. Yet, the influence of tree islands on biodiversity and ecosystem functioning varied depending on island size and planted tree diversity. Importantly, ecological benefits from restoration did not result in

reduced oil palm yields. Ecological restoration of oil palm landscapes with tree islands is a promising strategy to enhance biodiversity and ecosystem functioning in tropical lowlands that can be aligned with economic development.

589 BIODIVERSITY DYNAMICS AS A DRIVER OF SOCIAL-ECOLOGICAL SYSTEM TRANSITIONS

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Sustainable management of social-ecological systems requires an understanding of how anthropogenic climate- and land use change may disrupt interactions between human societies and the ecosystem services they depend on. Within the ecological subsystem, responses to global environmental change may depend on the level of biodiversity present (i.e. remaining). Within the sociological subsystem, responses may be mediated by economic processes that alter the dependency of locally generated ecosystems services. Recent theoretical frameworks have identified how socio-economic processes can create alternative development pathways for social-ecological systems subject to environmental change. Incorporating potentially mediating effects of biodiversity within these frameworks is challenging, however, in part due to the time lags and associated legacy effects of past human activities on the current state of biodiversity. Here we examine how the role of biodiversity may be reflected in current social-ecological system dynamics, and the implications of these impacts for system responses to anticipated environmental changes. Using a mathematical modelling framework, we systematically compare biodiversity effects involving a range of time lags between anthropogenic impacts and ecological responses. In these analyses, we pay particular attention to the probability of these effects initiating critical transitions in social-ecological system states.

372 DRIVERS AND CONSEQUENCES OF ARCHETYPICAL SHIFTING CULTIVATION TRANSITIONS

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Shifting cultivation represents an important social-ecological system in many tropical landscapes, but transitions away from shifting cultivation are increasingly common. So far, our knowledge on the drivers and consequences of such shifting cultivation transitions is incomplete, focusing on certain transitions, drivers, consequences, or regions. Here, we use an archetype approach, validated through systematically identified literature, to describe eight archetypes encompassing the transition from shifting cultivation to
1) perennial plantation crops,
2) permanent agroforestry,
3) passively regrowing forest,
4) permanent non-perennial crops,
5) pasture,
6) wood plantation,

7) non-cultivated non-forested land, and
8) actively restored forest (ordered in decreasing prevalence).
We then discuss factors favouring and disfavouring each archetype. Our archetype analysis shows that shifting cultivation transitions are diverse in themselves, in their drivers, and their consequences; in line with commonly observed system dynamics in social-ecological systems. This is calling for a critical and contextualized appraisal of the continuation of, as well as the transition away from shifting cultivation when designing land system policies.

162 UNDERSTANDING SOCIAL-ECOLOGICAL SYSTEM DYNAMICS WITH POSSIBILISTIC MODELS

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Ecologists, physicists or sociologists have proposed some frameworks to interpret social-ecological systems, but scarce theories and formal models appear today convincing to anticipate their (future) dynamics. Theoretical models such as potential surfaces are not fully adapted and often not well fitted to observed trajectories. To understand them and start managing them, we would need to have an exhaustive view of the system dynamics.
This becomes today possible with a new kind of models borrowed to theoretical computer sciences: possibilistic models. Combined to other properties such as qualitative and rule-based definitions, we recently applied such models to theoretical as well as to more realistic social-ecological systems. After validation, such models reveal counter-intuitive trajectories, be they homeostasis, tipping points or collapses.

382 BIODIVERSITY MEDIATES HUMAN-ENVIRONMENT INTERACTIONS ACROSS GLOBAL SYSTEMS

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Global change progressively threatens nature and the ecosystem services (ES) that support social-ecological systems. However, biodiversity can mediate anthropogenic impacts by increasing ecosystem resilience. While linkages between biodiversity and ES are established, we lack understanding of whether mediating effects of biodiversity are global and ubiquitous, and how they might differ between social-ecological systems. Here, we examine the potential for biodiversity to mediate anthropogenic driver-ES relationships using global datasets for three distinct systems: mountains, islands and deltas. We find that in 82% of cases, greater biodiversity (species richness and intactness) is connected to a weakened or reversed association between anthropogenic drivers and ES. These patterns declined with global change: most frequent in mountains, then islands, then deltas. Weaker or reversed associations were found across ES types, most commonly between biodiversity intactness and climate change or land use change. Further, we investigated the contribution of biodiversity and abiotic and anthropogenic drivers to ES. ES supply was most strongly and consistently associated with abiotic drivers, but biodiversity and anthropogenic drivers were also important to individual ES. Our results empirically show how biodiversity can act as a resource and mediate social-ecological relationships, but that both of these roles can be compromised as systems become more modified.

SOI1 - Soil biodiversity for global welfare

404 BACK TO THE ROOTS, INSPIRED BY NATURE. PRACTICES TO INCREASE SOIL BIODIVERSITY

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Soil can't be made by humans, but easily destroyed by human activity. Even with sophisticated laboratory equipment, we only are able to breed a fraction of the microbial diversity which we can find in healthy soils. The microbial community, also called the microbiome, is extremely important to make soils function.
At GRAND FARM and VERMIGRAND, we try to mimic nature. Instead of breeding a limited diversity of microbes ourself, we hired earthworms to do the job. They do not only produce a diverse microbiome, but this one has already profen to succesfully establish in soils for millions of years. In the course of the evolution plants adapted to take advantage of the characteristics of earthworm faeces, also called Biohumus. Nutrients, enzymes, vitamins, humic substances and especially the microbiome of the Biohumus is utilised by plants.
When Biohumus is mixed into peat free soil substrates, plants communicate with the inoculated microbiome through root exudates. They use microbes as a kind of toolbox for nutrient mineralization, disease suppression or communication between plants.
The application of compost extract as a coating for seed is affordable and does not need additional equipment for application. The plant root is not only acting as a breeding station for the diversity of microbes in the soil due the release of root exudates, but also is a transport system while growing towards subsoil.

43 SOIL MICROBIAL DIVERSITY IS CRUCIAL FOR PLANT HEALTH

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Soil biodiversity is important nutrient cycling and ecosystem functioning. This has a direct impact on plant health and performance. Plant-associated microbial diversity originate from seeds and soil. Both, the vertical and horizontal transmission route is essential for a healthy plant microbiome and local adaptations to the environment. However, breeding and intense plant production systems contribute to loss of biodiversity and natural resources. In the past, human activities influenced the interconnected microbiomes significantly. These shifts resulted in high pre- and post-harvest yield losses, drug-resistant plant and human pathogens, and a spread of antimicrobial resistance (AMR). This typically depleted microbiome signature of the Anthropocene is often followed by a dysbiosis, which leads to outbreaks of viruses, pests and pathogens. Microbiome management and biotechnology is one option to restore and improve soil and plant microbial diversity. Examples for research and commercialization are presented and should inspire the development solutions to restore and save plant- and soil-associated microbial diversity for ecosystem and the closely connected human health.

244 THE FUNDAMENTAL IMPORTANCE OF CONSERVING SOIL BIODIVERSITY

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Soil microbes are the most abundant organisms on the planet, yet there are still fundamental gaps of knowledge in the importance of soil biodiversity in maintaining multiple ecosystem functions. Similarly, relatively little is known about the global drivers and the global change vulnerabilities of soil biodiversity worldwide, even for the most dominant taxa. In this talk, I will show part of my work aiming to address the major gaps of knowledge associated with the soil microbiome of natural, agricultural and urban ecosystems. In particular, I will present some of my recent work aiming to (1) identify the role of soil biodiversity in regulating multiple ecosystem functions; (2) provide insight on the vulnerabilities of soil biodiversity to global change drivers at a global scale; and (3) highlight the fundamental importance of conserving soil biodiversity for future generations.

398 DO MICROBIAL AND PLANT DIVERSITY INTERACTIONS REGULATE ECOSYSTEM FUNCTIONS?

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Biodiversity is a critical contributor to the functioning of terrestrial ecosystems, driving key process such as carbon and nutrient cycling. Below- and aboveground diversity are tightly linked, and ecosystem functioning is modulated by biotic interactions between plant and soil microbial communities. However empirical evidence for relative contribution of above and belowground biodiversity and their interaction is lacking. This presentation will provide combined results from global survey and manipulative microcosm experiment to identify relative contribution of plant, microbial diversity and their interaction on individual functions and multifunctionality. Results from this combined approach demonstrated that plant and soil microbial diversity independently predict a unique portion of variation in above- and belowground ecosystem functioning, with soil fungal diversity strongly and positively linked to aboveground functions. Relationships between belowground diversity and ecosystem functions were influenced by plant species and trait diversity. These findings support the call to maintain and conserve both above- and belowground diversity to sustain ecosystem multifunctionality under projected global changes.

297 THE IMPORTANCE OF SOIL BIODIVERSITY IN GLOBAL ECOSYSTEM RESTORATION

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The conservation and restoration of natural ecosystems is among our most effective strategies we have to help in the fight against biodiversity loss and climate change. However, these strategies are impeded by the uncertainties in our understanding of global restoration. In particular, a key uncertainty is the rate of soil carbon accumulation over time following land abandonment or natural regeneration. We explore how this carbon accumulation potential varies across the globe, and how this process is governed by a complex soil microbial community. Ultimately, a better understanding of global microbial biogeography can help us to improve confidence in our understanding of soil carbon turnover across the globe, which can improve efforts to understand future changes, and manage ecosystems effectively in the face of ongoing climate change.

450 IMPACT OF PESTICIDES ON SOIL BIODIVERSITY AND SOIL HEALTH

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Pesticides are widely used to combat disease and pests and to secure food production. It is still poorly understood whether pesticides influence soil health and soil biodiversity. In order to study this, we investigated the occurrence of 46 synthetic pesticides in 120 agricultural fields in Switzerland. We found pesticides in any field investigated. Also after 20 years of organic farming without application of synthetic pesticides, we found up to 16 different synthetic pesticides. We even detected traces of pesticides in selected soil samples collected from Antarctica. In a next step, we tested whether the occurrence of pesticides is linked to soil biota and soil functions. We observed that the abundance of a common group of beneficial soil fungi, the arbuscular mycorrhizal fungi (AMF), was negatively linked to the number of pesticides in the soil. Moreover, the application of fungicides in agricultural fields across Europe reduced AMF richness and the ability of AMF to acquire nutrients for plants. Thus, the application of specific pesticides could hamper soil health, soil biodiversity components and the natural ability of soils to feed plants with nutrients. We further observed that pesticide residues in the soil are a critical driver of the soil microbiome influencing the abundance of a wide range of fungal and bacterial taxa. Further studies need to investigate these unexpected consequences of pesticide use for agricultural production and natural soil processes.

232 HARNESSING ROOT-MICROBE INTERACTIONS FOR OPTIMISING ECOSYSTEM FUNCTIONING

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Root-microbe interactions are central to ecosystem functioning and its response to changing environmental conditions, both in natural and in managed ecosystems. There is an increasing awareness that root exudates – complex mixtures of sugars, acids, and hormones that are excreted by plant roots – are an important mechanism through which roots communicate with, and fuel, microbes, and that alterations in plant root exudation can drive belowground responses to changing environmental conditions. Moreover, recent advances in root ecology highlight that root systems are not only described along a fast-slow growth axis, but also along a collaboration axis, that describes the investment of roots into symbionts like mycorrhizal fungi and other beneficial microbes. Here, I will show recent experimental evidence on how root exudates vary with plant functional groups and root traits, and how root exudation rate and composition are affected by climate change. I will then link these changes in root exudation to changes in soil microbial communities and their functioning, and what the implications are of these changes for ecosystem functioning under climate change, focussing on carbon cycling and plant growth and community composition. I will then discuss potential ways through which we can harness root-microbe interactions for optimising ecosystem functioning in managed and natural ecosystems.

SOI2-a - Soil biodiversity and function scenarios

125 GLOBAL DISTRIBUTION OF SPRINGTAIL DENSITY, DIVERSITY AND METABOLISM

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Springtails (Collembola) are among the most abundant soil animals regulating soil fertility and flow of energy through above- and belowground food webs. They may contribute significantly to the terrestrial animal biomass and animal-driven soil processes, but the global distribution of springtail diversity and density, and how these relate to energy fluxes remains unknown. Using a global dataset collected from 2,470 sites in the framework of #GlobalCollembola, we estimated total soil springtail biomass at 29 Mt carbon (threefold higher than wild terrestrial vertebrates) and record peak densities up to 2 million individuals per m² in the Arctic. Despite a 20-fold biomass difference between tundra and the tropics, springtail energy use (community metabolism) remains similar across the latitudinal gradient, owing to the increase in temperature. However, local species richness was not related neither to springtail density nor community metabolism. It was highest in the tropics, but comparably high in some temperate forests and even tundra. We show how springtail community metrics are related to climate, soil parameters and anthropogenic factors, and discuss potential importance of top-down and bottom-up controls. Contrasting temperature responses of biomass, diversity and activity of springtail communities suggest that climate warming will alter fundamental soil biodiversity metrics in different directions, potentially affecting terrestrial food webs and soil functions.

145 WHY NATURE CONSERVATION OF SOIL BIODIVERSITY IS NOT A SIDE EFFECT

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It has been shown that soil biodiversity is linked to many ecosystem functions and services related to human health and well-being. And soil biodiversity has its own value, too. Like biodiversity in other realms, it faces multiple threats that are often neglected in most biodiversity assessments and nature conservation actions. Currently, we do not find evidence for positive effects of nature conservation on soils, for example when looking at the effect of European protected areas on multiple soil functions. Furthermore, conservation management considers soils from a limited perspective only: we explore the role of soils in nature conservation management by taking German protected areas and respective management plans as examples of the European reality. A low occurrence of soil-related terms in German management plans demonstrates the lack of common soil

concepts and their communication. After exploring three dimensions (i.e., policy, evidence, management), we are able to highlight potential ways forward to improve nature conservation as a central instrument for soil biodiversity protection. One of the first steps would be to establish a comprehensive monitoring system; so finally, we will focus again on Germany and explore the status of soil biodiversity monitoring there.

163 STRUCTURE AND FUNCTION OF THE SOIL MICROBIOME ON A GLOBAL SCALE

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Despite the pivotal roles of microbes in nutrient cycles, we know little about key differences in the composition of their communities and functions across different global habitats. This knowledge is essential to provide a basis for understanding and modelling of microbial ecosystem functioning. By using a comprehensive dataset of soil microbes obtained from diverse soil habitats, we examined the global distribution of dominant prokaryotic and eukaryotic taxa. Our results suggest that environmental filtering rather than geographic distance is the primary determinant of the community structure of both prokaryotic and eukaryotic microbes. We also found significant differences in global assembly patterns among different microbial groups depending on their symbiosis with plants as well as their functional traits. I will discuss the implications of our results for understanding the main processes shaping microbial communities together with an account of the effect of environmental changes on the global diversity and ecosystem functioning of microbes.

503 SOIL BIODIVERSITY CHANGE CONTRIBUTES TO POLICY OPTIONS

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Globally, soils harbor significant amounts of biodiversity that play critical roles in maintaining multiple ecosystem processes including plant productivity, decomposition and nutrient cycling. Changes in soil biodiversity (bacteria, fungi, protists, animals) affect ecosystem function and the provision of ecosystem services (food, clean water, air) we depend on. Recently, the IPCC- IPBES reports confirmed that two interconnected environmental crises on earth, biodiversity decline and climate change need urgent attention. The path from knowledge of soils and soil biodiversity to policy action must include successfully used science tools and analyses to address when changes in soil biodiversity threaten loss of services and, the future options. Monitoring of environmental parameters (climate change, biodiversity loss) has been a successful means of alerting us to crises and is a tool recognized by policy makers. Now, science-based policy responses to these crises and land use change can be based on new (e.g. Soil BON) and ongoing (LUCA) standardized monitoring of soil biodiversity at global scales over time. This accelerates our knowledge of how, when and where soil biodiversity and functions are vulnerable to these crises. Assessments, research networks and monitoring and tools like scenario modeling provide policy makers with systematic sets of knowledge-based scenarios of crises and soil biodiversity change, and scientific ranges of confidence (low to high) for the future.

223 SYNTHESIS OF GLOBAL DISTRIBUTION OF TESTATE AMOEBAE DIVERSITY

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Testate amoebae are a common group of shell building amoeboid protists. They occur in soils, freshwater habitats, and to a lesser extent marine environments. They play a key role in microbial foodwebs and are useful bioindicators due to their responses to major ecological gradients (e.g. water availability, pH and nutrients). This makes them well placed to address questions on the comparative ecology of microorganisms and macroorganisms, so helping to create a unified approach to ecology. Their shells allow species-level identification and are preserved in sediments, peat, dried or frozen soil or moss samples, and they are commonly used in palaeoecology for quantitative inference and as model organisms for microbial biogeography. This diverse group of single cell eukaryotes, have been studied for over 200 years, however, their diversity and distribution has not yet been investigated and visualised at a global scale. With the help of the global testate amoebae community we have built a global dataset. Published and unpublished data were collected from 10,817 sites around the world as a basis for understanding patterns in their diversity and environmental factors influencing it, as well as to identify geographic gaps that require more attention in further research. We will show the latest results of this ongoing work.

75 DEVELOPING A GLOBAL SOIL BIODIVERSITY INTACTNESS INDICATOR

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Human activities, particularly land-use change and habitat degradation, are driving major changes in biodiversity worldwide. However, studies of such effects have focused overwhelmingly on above-ground taxa: indeed, despite the importance of soil biodiversity in nutrient cycling, water drainage and developing soil structure, there have so far been no global indicators of its status and trends.
I discuss the challenges faced by any indicator for the less taxonomically resolved soil biota, and present an initial version of a possible soil biodiversity intactness indicator. It is based on statistical models of an updated release of the PREDICTS database (a global compilation of biodiversity data from assemblages in different land uses), with a greatly expanded soil biodiversity component (an additional 46 studies, 2,726 sites and 3,857 taxa).
This indicator can be used to estimate how local soil biodiversity worldwide may respond

to different scenarios of land-use change, by projecting these models using land use projections from the Intergovernmental Panel on Climate Change (IPCC) Shared Socioeconomic Pathways (SSP) scenarios corresponding to different intensities of global climate change. The proposed indicator may be an important step towards better understanding and monitoring of global soil communities and how they might change in the future.

120 SOIL MICROBIOME PREDATORS: THEIR GLOBAL BIOGEOGRAPHY & FUNCTIONAL IMPORTANCE

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The soil microbiome, particularly bacteria and fungi, determines major ecosystem functions and processes such as controlling plant performance and global elemental cycling. However, the soil microbiome is not functioning on its own but is embedded within a huge complexity of soil biodiversity. Especially microbiome predators of which protists and nematodes are the most important groups determine microbiome composition and functioning. I will here present an overview of the main determinants of microbiome predators, their biogeography and, most importantly, their functional importance in soils. I will highlight the multiple functional roles of microbiome predators, which I will show to fundamentally impact the microbiome. Last, I will shortly show the importance of other functional groups of protists and nematodes including parasites and plant pathogens. Together, I envision perspective to be integrated in a broader overview on multiple soil biota given in this session to stimulate a broader investigations and integrative approaches to study soil biodiversity.

SOI2-b - Soil biodiversity and function scenarios

478 DRIVERS OF SOIL MULTIFUNCTIONALITY IN TERRESTRIAL ECOSYSTEMS

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Soils provide essential ecosystem functions and services through a variety of mechanisms, making them an important resource for human well-being. However, global change factors such as climate change and modern land use threaten to alter this critical role. Here, we use four key soil enzymes, water-stable aggregates, and microbial activity and biomass as measures of soil multifunctionality in the context of land use and climate. Using structural equation modeling, we quantify the relationships between soil multifunctionality and abiotic factors (soil texture, carbon and moisture, pH, and climate) in different land use types. To do this, we use two different datasets: 532 soil samples from across Europe in the Land Use/Land Cover Area Frame Survey (LUCAS) and soil samples from the Global Change Experimental Facility (GCEF), a large-scale field experiment in central Germany investigating the effects of climate change and different land use types.

142 THE ROLE OF SOIL MICROBIAL DIVERSITY IN ECOSYSTEM MULTIFUNCTIONALITY

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Soils are responsible for the provision of countless ecosystem functions and services, vital for the well-being of diverse communities of organisms. Soil microorganisms especially have a key role in nutrient cycling and ecosystem multifunctionality. Microbial diversity and community composition are shaped by their local biogeochemical context, which affects how these functions are being carried. With expected global changes in climate and land-cover, it is crucial to refine our understanding of how the effect of microbial diversity on ecosystem multifunctionality varies depending on the soil system. To tackle such large-scale challenge related to soil biodiversity and functioning, we created iSBio: The International Soil Biogeography Consortium, a global collaboration network of experimental platforms, with over 100 collaborating institutes, already connected through the TeaComposition network. Following a global soil sampling campaign, we linked long-term standardized decomposition measurements with soil functions (including microbial respiration and aggregate stability) and diversity measurements to unravel the context-dependency of these relationships. We used measured and extracted climatic and soil properties to define the direct and indirect roles of these components on the diversity-functionality relationship in a structural equation modelling framework.

274 RUSSIA: AN IDEAL PLACE FOR STUDYING THE ECOLOGICAL PREFERENCES OF ENCHYTRAEIDS

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Enchytraeids (Enchytraeidae d'Udekem, 1855) are small annelid worms. They play an important role in the soils of many terrestrial ecosystems due to their high population density and metabolic activity. The project named "Soil-living Enchytraeids of the Northern Palearctic" (RSF 21-14-00227) aims to fill the gap in knowledge about enchytraeids of Russia and neighbouring countries.
Within the borders of Russia, a north-to-south transects through almost all terrestrial ecosystems can be drawn. European Russia covers biomes from tundra to steppe-deserts. Furthermore, it combines a unique set of factors that simplify the work of a soil ecologist. Compared to other European countries, the natural ecosystems of Russia are relatively little disturbed. Flatness of European Russia determines a clear pattern of latitudinal geographic zonality.
For this study, more than 100 soil samples were collected at 21 localities in European Russia during 2021. Seven different biomes were covered: tundra, north taiga, middle taiga, mixed forests, forest-steppes, steppes and desert-steppes. Enchytraeids were extracted by the method of wet funnels and then identified to the species level.
As a result, groups of polyzonal (Enchytraeus buchholzi s.l., Fridericia bulboides, etc.), boreal (Cognettia sphagnetorum s.l., C. glandulosa s.l.), nemoral (Stercutus niveus,

Buchholzia appendiculata, F. paroniana) and steppe (E. dichaetus) species were described.

536 IMPACT OF LAND-USE INTENSITY ON ABOVE- AND BELOWGROUND DIVERSITY AND FUNCTIONING

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Increasing land-use intensity has been shown to exert negative effects on above- and belowground diversity. The consequences for the functioning of soil biological communities are poorly understood. Moreover, little is known about how landscape-scale factors affect local scale soil diversity and functioning.
In 10 landscape sectors (1km^2) of the Swiss lowlands, we quantified belowground bacterial and fungal diversity and aboveground plant diversity on a total of 50 pairs of grassland sites. The sites within on pair were similar in terms of abiotic conditions, but differed in terms of management intensity (intensive versus extensive). In addition to quantifying above and belowground diversity, landscape parameters were assessed, and soil physico-chemical parameters, soil biological activity and decomposition of organic material as an important soil function were assessed at all sites. This was done within the scope of the Swiss Citizen Science project 'proof by underpants' using the degradation of cotton underwear and the tea bag index as metrics.
By analyzing this unique dataset we will show how local land-use and landscape parameters affect above- and belowground diversity and the functioning of biological communities. This allows unprecedented insights into how above- and belowground biodiversity are linked and how their interactions modulate ecosystem functioning.

318 SOILTEMP: A GLOBAL DATABASE OF MICROCLIMATE MEASUREMENTS

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While meteorologists do their best to remove what they consider as local "noise" (trees, buildings and topographic features) in weather data, these sources of "noise" are home to many organisms and thus are critical for ecologists. Indeed, it is the local temperatures near the ground or below the vegetation - often tens of degrees different instantaneously from weather station data - that set the bounds of organisms' range limits and dictate ecosystem processes such as primary production and hydrological, nutrient, and carbon cycles. Understanding the soil, its biodiversity and functions, does require the use of relevant and correct climate (and climate change) data.
SoilTemp aims to solve this issue: a global database of microclimate measurements, currently hosting data from close to 30.000 sensors. The SoilTemp database has already allowed major breakthroughs in gridded climate products, amongst others through the launch of global maps of soil temperature. Here, I will present the other exciting ways in which SoilTemp could support global soil research through its in-situ time series, gridded microclimate products, and strong links to biodiversity data across the globe.

156 THRESHOLDS AND TIPPING POINTS IN ECOSYSTEM RESPONSES TO GLOBAL WARMING

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Terrestrial ecosystems are important in providing key services to humankind, but under global warming the provisioning of these services is at risk. There is, however, little consensus on how the functioning of terrestrial ecosystems will change under projected scenarios of global warming, or when we will reach or surpass thresholds and tipping points. This is largely because we have failed to unravel ecosystem responses to warming in terms of the underlying non-linear responses of plants, soil organisms, and their communities. Since plants and their associated soil organisms (i.e., pathogens, mutualists, and decomposers) can vary in their responses to temperature change, global warming may disrupt or decouple interactions among coexisting and co-evolved species. This may have unforeseen consequences for key ecosystem functions, such as carbon cycling. In our new ERC-funded project *THRESHOLD*, we aim to advance our knowledge of how non-linear temperature responses transcend levels of ecological organization. We use a global network of forest-tundra and forest-alpine ecotones to assess how responses of ecosystem carbon cycling to global warming will be pushed across thresholds and tipping points. We further perform mesocosm experiments under a range of different temperatures, to estimate how ecosystem process responses to global warming can be predicted from the reordering of plant and soil communities, as well as from the functional traits that they possess and express.

164 HOW URBANIZATION AND LAND-USE CHANGE DRIVES SOIL FAUNA COMMUNITY

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Globally, the urban settlements and urban population have doubled in the last three decades, and are projected to grow even faster in the coming years. During the rapid urbanization, humans became a dominant species, and leading to multiple environmental changes and biodiversity loss in cities. Nevertheless, we are co-habiting with millions of other species in urban areas. Yet, unfortunately, despite hundreds of years of discovery, many of these co-habiting species have not been identified, let alone aboriginal species who inhabited these lands and their role in ecosystem functions. Human disturbance and heat-island effects are generally increasing across a rural-urban landscape gradient. This give us an opportunity to assess whether and how urbanization affects community structure of soil fauna whether this depends on the environmental conditions of habitats. We explore how changes of soil fauna community based on samples collected in 13 cities from China and multiple ecosystem functions (soil carbon and nutrients stock, soil functional gene) in urban (urban parks and residential gardens) and non-urban (forest and agricultural lands) systems.

350 PUSHING FORWARD OUR UNDERSTANDING OF SOIL BIODIVERSITY DISTRIBUTION

I. Calderon Sanou[1], L. Zinger[2], M. Hedde[3], T. Münkemüller[1], W. Thuiller[1]
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Although soil organisms represent one-quarter of the whole biodiversity on earth, our current understanding of the main drivers of soil biodiversity along environmental gradients is mostly restricted to a limited set of aboveground macro-organisms. In light of increasing global threats to ecosystems, the inclusion of soil organisms into macroecological studies is crucial to improve predictions of ecological responses of terrestrial ecosystems to global changes and support their conservation. Moreover, multitrophic approaches that account for multiple groups of interacting organisms in the

ecosystem allow a more holistic understanding of soil biodiversity and its drivers. Here, I will present some results illustrating how we can advance our understanding of the response of soil multitrophic diversity to rapid environmental changes at regional and local scales, by combining soil environmental DNA metabarcoding data, mathematical and statistical tools derived from network theory, and food web ecology. First, I will show a case study in the subarctic birch forest of Northern Norway where the effect of severe moth outbreaks has cascaded locally from plant communities to the entire soil food web, creating a shift in the ecosystem state. Second, I will present a comparative analysis showing how soil multitrophic diversity responds to environmental gradients in temperate mountains, and provide new insights into the mechanisms structuring soil multitrophic communities.

VAL1 - An interdisciplinary discourse on biodiversity values

236 ECONOMIC VALUATION OF BIODIVERSITY: METHODS AND CASE STUDIES

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This study reviews the literature on economic valuation of biodiversity. In particular, we summarize the main methods developed by this stream of the literature and discuss their pros and cons considering their capacities to communicate to the audience/interviewees' different value concepts associated with biodiversity. We complement this analysis with illustrative examples of the application of these methods, and provide an overview of the obtained economic estimates of the value of biodiversity, with a focus on Europe.
Among the methods presented, we discuss in more detail choice experiments (CE), where an individual is requested to decide between a set of alternative attributes and levels of biodiversity. We will also provide an overview of biodiversity attributes used in CE and discuss corresponding valuation outcomes in the context of transdisciplinary discourses on biodiversity value and to the design of biodiversity conservation policies.

355 BIODIVERSITY AND TWO KINDS OF INTRINSIC VALUE

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I argue that biodiversity may have intrinsic value--i.e. may be valuable for its own sake--but only if we adopt a certain conception of intrinsic value. I explain a new distinction between two types of intrinsic value ("weak" and "strong") and show why the distinction matters for how we think about biodiversity.
Intrinsic value is roughly the sort of value something has on its own, independently of its uses. On the strong conception of intrinsic value, something has intrinsic value only when it is directly morally considerable (i.e., when we have moral obligations to the entity). On the weak conception of intrinsic value, something has intrinsic value when it is valuable or valued for its own sake. I will explain this distinction and argue that biodiversity plausibly has intrinsic value in the weak sense but not the strong sense. Some environmental thinkers have argued that biodiversity cannot have intrinsic value, but their objections tend to focus on the strong sense. Thus, focusing on the weak sense provides a way for the conversation to move forward.

198 WHICH VALUES FOR WHICH BIODIVERSITY?

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With the increasing talk about biodiversity in current discussions among different groups of people we are exposed to many new questions about the implications of difference, variation, abberation, noise and exception for humans and the world at large. While philosophers and scientists have been successful in trying to find universal rules behind the bewildering complexity and variation of things, there has been very little consideration of potential rules by which diversity itself matters. This also makes it difficult to talk about values of diversity or more specifically biodiversity. I will therefore first try to show how biodiversity from the cellular to the ecoystem and landscape level affects function and then ask which values could be related to these functions and how they may be constructed, perceived and acted upon by people. Empirical evidence shows that biodiversity does matter at most levels where it has been investigated and that people generally perceive it as positive even though they find it difficult to assign measurable value to biodiversity itself or to its functions. People (and selective forces in nature!) may act to keep biodiversity at levels where functions and values are high, avoiding too much similarity as well as too much difference.

443 CAN BIODIVERSITY HAVE RELATIONAL VALUE?

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When values are included in biodiversity conservation efforts, usually one of two approaches are used: instrumental values focus on the benefits from nature for people whereas intrinsic values reflect the idea of nature's value for its own sake. Yet neither of these approaches effectively captures a wide range of values that motivate many people to care for land, ecosystems and species. For many people, relationships with nature and with other people via nature better characterize how they value and view their biophysical environment. Because these relationships are usually to specific species, animals, forests, etc., it is unclear if biodiversity itself might have relational value. This question is especially relevant because both biodiversity and the concept of relational values are central to IPBES (the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services). In this talk I will explore ways that biodiversity might (or might not) have relational value. I will consider when biodiversity is a useful framing for the value of nature, and when other framings might be more appropriate. I will draw on data from 32 interviews with farmers in Val Müstair and the Lower Engadine area of Switzerland, focused on understanding respondents' relational values. I also discuss the broader implications of a relational values approach for biodiversity conservation efforts.

149 SOCIAL CONSTRUCTIONS AND IMPLICATIONS OF MARINE WILDERNESS IN THE EU SEAS

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The transboundary nature of marine ecosystems and their more difficult accessibility create challenges for the conceptualisation of effective marine conservation. This study investigates the values associated with marine wilderness imaginaries in the EU seas. Wilderness remains one of the most powerful, although often problematic concepts in terrestrial conservation, while at the same time there is a paucity of comparable work related to marine biodiversity conservation. As the EU places new targets for strictly protected areas in the Biodiversity Strategy 2030, across both land and sea, it is worth investigating how people involved in implementation of marine environmental policies across Europe relate to this concept. This study investigates social constructions of marine wilderness imaginaries amongst people from national to the EU and Regional Sea Conventions level, using semi-structured interviews, ethnography, and a Q study. The results show a very wide and divergent values and beliefs associated with existence and definition of what marine wilderness could be in an otherwise comparatively homogenous group in terms of the overall worldviews. Cultural, educational, and familial backgrounds can be linked to the discrepancies in the differing social constructions of marine wilderness. The variety of different values associated with wilderness is thus likely to influence the way common EU policies will be implemented in the future.

VAL2-a - Philosophy and Biodiversity

105 ASSESSING VALUE-DRIVEN APPROACHES TO DEFINING BIODIVERSITY

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Despite persistent efforts, an unambiguous and unanimously accepted definition of "biodiversity" is still elusive. One important source of disagreement is whether "biodiversity" is a normative concept that expresses something we value about nature and can only be defined by reference to such values.
In this talk, I offer a novel interpretation of this approach. I will reconstruct normativist accounts as a solution to problems of empirical underdetermination in the face of limitations of experimental design. According to this view, the concept of biodiversity is descriptive as well as normative. Furthermore, I will discuss the most common criticism leveled against the normativist approach, according to which there are very different ways in which natural variety can be valued, not all of which are universally shared. I will argue that accounts of procedural moral objectivity, as suggested for the definition of social indicators such as "well-being", can be useful here.
On a conceptual level, I will show that descriptivist and normativist positions are not completely independent of each other, but rather represent two different approaches of dealing with epistemological problems of studying natural variety at multiple levels of organization. On a practical level, this will allow the formulation of adequacy conditions for biodiversity indicators. Instead of single indicators, we should use tables of indicators representing different dimensions of biodiversity simultaneously.

76 BIODIVERSITY VS. PALEODIVERSITY MEASUREMENTS: THE INCOMMENSURABILITY PROBLEM

F. Bocchi[1]
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In this presentation, I compare measurements of biodiversity to measurements of paleodiversity. My intent is to understand whether commonly used inferences from

paleodiversity measurements to biodiversity estimates are epistemically well-motivated. I claim that justifying such comparative evaluations (e.g. using paleodiversity data to show we are currently facing a biodiversity crisis) is harder than it appears. I argue that paleodiversity measurements are incommensurable with contemporary measures of biodiversity, given the different ways that biodiversity is conceptualized, and quantifed accordingly. Specifically, unlike current biodiversity measures, paleoestimates rely heavily on an understanding of biodiversity as species counts, like the famous Sepkoski (1982) diversity curve of marine invertebrates.
But the understanding of current biodiversity is not reducible to species inventories. I call this mismatch the "incommensurability problem". I do not argue that paleodata are useles in conservation efforts, but that paleodiversity is not directly commensurable to estimates of contemporary biodiversity and loss without additional qualifications. I conclude by proposing a possible solution to the incommensurability problem, inspired by Santana (2014). Santana has suggested to eliminate "biodiversity" from research agendas, and instead focus on biological values.

72 OTHERNESS IN NATURE AND THE PROTECTION OF (BIO)DIVERSITY

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Different arguments in favour of the moral relevance of the concept of biodiversity (e.g., in terms of its intrinsic or instrumental value) face a range of serious difficulties, despite that biodiversity constitutes a central tenet of many environmentalist practices and beliefs. That discrepancy is a considerable challenge for environmental thought. Contributing to the debate on potential moral reasons for protecting biodiversity, this paper adds a new angle by focusing on the potential of the concept of otherness – specifically individual and process otherness in nature – for providing additional moral reasons in favour of the protection of biodiversity. Two arguments are presented. One draws on the process otherness of active nature and an additional argument draws on the individual otherness of nonhuman living beings. The upshot is that each of these arguments – if successful by being conditional on a range of premises – provides a moral reason in favour of the protection of biodiversity.

278 DIACHRONIC BIODIVERSITY

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In addition to the standard synchronic sense, I claim that there is also a diachronic sense of biodiversity. Existing discussion of biodiversity focuses on synchronic biodiversity: a valuable state of affairs which is instantiated at a particular point in time. But biodiversity can, I argue, also be meaningfully instantiated diachronically: over periods of time. For example, two islands with different plant and animal life collectively possess greater synchronic biodiversity than two islands with identical plant and animal life. Similarly, a planet such as Earth that has supported radically different plant and animal life (indeed, radically different ecosystems) in different epochs has more diachronic biodiversity than a hypothetical planet in which there have been fewer great extinctions. The biodiversity of biological entities across time is, I claim, as real as the biodiversity of biological entities at a particular point in time.
I then discuss the relation between synchronic and diachronic biodiversity — the question of how biodiversity at one point in time affects biodiversity across periods of time. Finally, I sketch some ways that the concept of diachronic biodiversity might be employed in thinking about and valuing ecological systems.

74 CONCEPTIONS OF ECOCIDE AND BIODIVERSITY

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The concept of ecocide is neologism of the 1970s. It was used to chastise the US war in Indochina that involved acts of destroying nature. It generated discussion whether an Ecocide Convention should be adopted by international community. The notion of ecocide was largely in dormancy till early 2000 when it expanded to cover the human treatment of the home planet and its diversity of life. In international criminal law, the concept of ecocide has been, however, used as attempt to create a new category of international criminal law. An expert panel of Stop Ecocide International put forward a proposal to include 'ecocide' as a part of international criminal law, along with genocide, crimes against humanity, war crimes and crimes of aggression. According to its definition, "'ecocide' means unlawful or wanton acts committed with knowledge that there is a substantial likelihood of severe and either widespread or long-term damage to the environment being caused by those acts." The purpose of the paper is to take a philosophical look at issues revolving the notion of ecocide with special attention to biodiversity. Especially, we will examine the issue whether of ecocide should considered in reductionistic terms or not. Reductionism refer here to idea that ecocide is reducible to damaging human interests; anti-reductionism considers that human interests may not play any role in considerations of crimes against nature.

VAL2-b - Philosophy and Biodiversity

82 INDIGENOUS WORLDVIEW PHILOSOPHY

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Most philosophical positions are rooted in western enlightenment assumptions of human superiority to and separation from nature, the notion of human cultural progress, and individualism—all part of what anthropologist Marshall Sahlins called the 'western illusion of human nature.' Virtually all prior and contemporaneous cultures had a different orientation, one of human interconnectedness and partnership with the biocommunity and a cyclical panpsychism. Social anthropologist Robert Redfield concluded that there are essentially two worldviews—a set of implicit assumptions that guide one's values, philosophy, and attitudes towards life. We name these the dominant and the Indigenous worldviews. The dominant worldview considers the cosmos fragmented, amoral and disenchanted and has led to the disruption of ecological systems, including child development, worldwide. The Indigenous worldview considers the cosmos interconnected, moral and sacred, and is associated with greater biodiversity preservation. The Indigenous worldview and corresponding philosophy represent the longest empirical "experiment" ever done in biodiverse and culturally diverse settings. The Indigenous worldview of interconnection and circular effects, sentience and cooperation among natural systems, is supported by scientific evidence today, from physics to biology. We present forty precepts showing how the Indigenous worldview supports biodiversity and the dominant worldview does not.

213 BIODIVERSITY AS A SOURCE *RATHER THAN A* RESOURCE

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The convention on biological diversity conceptualizes biodiversity as genetic resources, a type of natural resources that is placed under state sovereignty. However, due to its non-material and informational nature, biodiversity is a very untypical type of natural resource. I suggest that the conceptualization of biodiversity as a source rather than a resource is more successful in capturing the utility of biodiversity together with the inspiring, aesthetic and educational role that it plays for many people.

219 HOW CAN RIGHTS BE MADE RELEVANT TO BIODIVERSITY?

P. Baard[1]
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I will focus on the relation between ecosystems and sovereignty, with a specific focus on the role that rights. If rights could be reasonably applicable to biodiversity, this would provide a powerful tool for conservation regardless of sovereignty. Rights provides ways of reasoning about biodiversity that can manage many challenges that value-based approaches cannot, evident in the difficulties of establishing what value to ascribe biodiversity and its components.
A part of this investigation consists of establishing what characteristics of an ecosystem or species that can merit a meaningful use of the concept of rights in an ambition to strengthen the moral standing of ecosystems relative sovereign states. This would have the benefit of establishing the conservation of ecosystems despite sovereignty being in question, when ecosystems transverse the boundaries of sovereign states, or when a state omits conservation.
Identifying such characteristics of species or ecosystems may either merit rights unto themselves or that they are the to be preserved to fulfill the claims of more conventional right-holders. But how can one make sense of biodiversity, often defined as a quality of ecosystems, and its relation to rights? Do qualities such as ‘variation’ or ‘species richness’ merit moral standing, or do they merit extrinsic conservation reasons?
The presentation will be based on a postdoc proposal for a three-year project that will commence during spring 2022.

266 REASONS FOR VALUING MICROBES: INTRODUCING A MICROBIAL ETHICS

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Neither animals nor plants, but a form of life which supports nearly all other life forms on earth, that’s what microbes are. Due to inhabiting human and animal bodies and to the diverse presence of numerous microbial species both in the plant world as well as in all terrestrial and marine ecosystems, microbial species represent an extremely high proportion of biodiversity.
However, despite their important, life-sustaining function for all ecosystems and living beings, Environmental Ethics has rather been quite about the microbial world. Likewise, the scientific and popular discussion about biodiversity conservation rarely focusses on microbes.
In this presentation, we want to shed light on why a look into the world of microbes is essential for both Environmental Ethics and biodiversity conservation efforts. To do so, we will proceed in three steps. First, we will introduce the different values we hold to be

important regarding microbes, distinguishing between inherent, instrumental and relational values. We will elaborate on values such as knowledge production, transformation and aesthetic value, and justify their application to microbes. In a second step, we will discuss the normative implications that follow from the preceding for the treatment of microbes, i.e. show a pathway towards developing a Microbial Ethics. Finally, we want to highlight why a modified view of and approach to microbes will also be valuable for the ethical foundation of biodiversity conservation.

273 COHABITABILITY AND BIODIVERSITY

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Land use changes are among the major drivers of biodiversity loss. Although humans can reduce land use, it is impossible to avoid land use for human purposes due to for example habitation and food production related needs. Thus, assessing the quality of such land use becomes a crucial ethical question which should also be addressed from the viewpoint of biodiversity and nonhuman flourishing. This requires establishing new philosophically useful concepts that are also strongly ecologically informed to capture the linkages between human activities and biodiversity impacts appropriately. In this presentation, I will propose that the concept of cohabitability could serve as a focal guiding concept for addressing the environmental ethics of land use with particular attention to biodiversity. Subsequently, I will also reflect upon the relationship between cohabitability and biodiversity in two contexts: urban planning and yard keeping in (urban or peri-urban) residential areas.

Plenary Lectures (in alphabetical order)

THE ECOLOGY & MANAGEMENT OF POPULATIONS FROM LOCAL TO GLOBAL SCALES

Yvonne Buckley
Trinity College, Ireland

Population ecologists develop theoretical and pragmatic knowledge of how and why populations change or remain stable, how life histories evolve, and devise management strategies for populations of concern. However, forecasting the effects of global change or recommending management strategies is often urgent, requiring ecologists to work without detailed local evidence while using data and models from outside the focal location or species. I explore the comparative ecology of populations from local to global scales to determine how to to develop generalisations within and between species, using available demographic, environmental, life-history, occurrence, and trait data. I outline the strengths and weaknesses of using broad climatic variables and climatic suitability to represent environmental variation in comparative analyses. I will show how the contributions of traits, environment, and their interactions can be used to understand life history strategy. As demographic data accumulates at landscape and regional scales for single species, and throughout plant phylogenies, we will have new opportunities for testing macroecological generalities within and across species.

EVOLUTION IN THE AGE OF US: MECHANISMS AND CONSEQUENCES OF HUMAN-MEDIATED SELECTION

Shane C. Campbell-Staton
Ecology & Evolutionary Biology, Princeton University, USA

Human modifications to the natural world present extreme and novel environments for many species around the globe, and offer unique opportunities to study biological change in real-time. Understanding the proximate (physiological/developmental) and ultimate (evolutionary) mechanisms that drive adaptive responses to human-altered environments is among the most pressing concerns of contemporary organismal biology. Studies of anthropogenic selection offer novel perspectives on classic and outstanding questions across evolutionary biology and may have important implications for contemporary human health. Dr. Shane Campbell-Staton's research integrates diverse experimental and methodological techniques to gain a deeper understanding of how human activity and decision-making shape biological stress and evolution in the modern world. This plenary will highlight current and future research at the intersection of evolution and human-induced global change - including extreme weather events, pollution, and armed-human conflict.

BIODIVERSITY AND HEALTH: THE ECOLOGY OF INFECTION AT THE ANTHROPOGENIC INTERFACE

Thomas R. Gillespie
Emory University, Atlanta, USA

As a disease ecologist working at the interface of biodiversity conservation and global health, I strive to determine how and why anthropogenic changes to tropical forests place wildlife, people, and domesticated animals in such ecosystems at increased risk of pathogen exchange. I will discuss how collaborators and I have pursued these questions using diverse pathogen study systems (gastrointestinal eukaryotic parasites, bacteria, and viruses) within ecosystems experiencing distinct forms of disturbance (i.e., selective logging, forest fragmentation, tourism) throughout the biodiverse tropics. This effort entails a combination of epidemiology, molecular ecology, behavioral ecology, social and clinical survey, and spatially-explicit modeling. This mixed-methods approach has allowed us to understand disease dynamics on many fronts and guide policies that protect human and wildlife health, while simultaneously promoting the sustainability of the ecosystems within which they live.

PRIORITY TRANSITIONS FOR A NATURE-POSITIVE ECONOMY

Akanksha Khatri
WEF, Geneva

The World Economic Forum's Global Risks Report over the past more than 5 years have consistently ranked biodiversity loss and ecosystem degradation as one of the Top 3 risks in terms of likelihood and disruption to the global economy. With more than half the world's GDP – USD 44trillion – moderately or highly dependent on nature and its services, it is unsurprising that investors and finance ministers are actively looking for ways to factor this in their risk management strategies and pivot financial flows towards more nature-positive activities.
Three socio-economic systems: i.e. Food, Land and Agriculture; Extractives and Energy and Infrastructure and the Built Environment are responsible for almost 80% of nature loss. And therefore these systems have the most to gain from valuing and investing in nature-based solutions. In this talk and paper, I will present the case for valuing and investing in nature across the three key socio-economic systems and how the returns can be more resilience in addition to financial gains. I will also make the case for a positive ambition loop between policy and regulatory measures and coalitions of more progressive businesses. Lastly, systems change will require all actors to be on-board including how citizens (both urban dwellers and indigenous and local communities) connect with nature.

TRANSFORMATIVE CHANGE FOR BIODIVERSITY: A RESEARCH AGENDA ON NARRATIVES

Sina Leipold & Heidi Wittmer,
Department of Environmental Politics, Helmholtz Centre for Environmental Research – UFZ

Recent work on transformative change for biodiversity underscores the crucial importance of compelling narratives for achieving the global biodiversity vision. In biodiversity science, there is a longstanding discussion on the need to re-frame biodiversity from a story of loss to a story of hope. We argue that compelling stories or narratives can help policy makers, practitioners and the public to make sense of the importance of biodiversity and why changes in many other sectors are needed. This will help to move them to make the difficult choices involved in drastically reducing negative environmental impacts of our agrifood systems, energy, transport and many other production systems and to protect and restore the natural systems we depend on. This requires reducing consumption levels, especially in the global North and socio-economic inequalities. We propose a research agenda on biodiversity narratives that helps

understand and create stories of hope. To do so, we connect scientific expertise on narratives and stories with insights and needs of decision makers, practitioners and the public. We would like to invite the biodiversity community to discuss how biodiversity science can inspire and contribute to formulating a positive vision for the future that helps motivate people.

NAVIGATING THE SPACES BETWEEN CONSERVATION SCIENCE AND POLICYMAKING

Rafael Loyola
International Institute for Sustainability, Brazil

Considering the current global biodiversity and climate crisis, conservation science is still not put into practice as often as it should be. More than ever, we need to explore and expand spaces to create opportunities for better collaboration and communication between science and our society. But where are we failing? Do we have our priorities right? Are we documenting and learning from our successes and failures? Who are we including or excluding in the spaces between research and implementation? Maybe it is time for a paradigm shift - not only in the ways we do conservation, but also in how we think about it. This shift would open new avenues towards modern ways of implementing conservation evidence into practice through teaching, training and evaluation integrated into cooperation and communication with other disciplines and non-scientists. Ultimately, it will help us correctly measure success and influence cooperation with policymakers in conservation and promote integration of more diverse perspectives and knowledges from yet underrepresented parts of the conservation science landscape.

THE NATURE FUTURES FRAMEWORK: A NEW GLOBAL FRAMEWORK FOR BIODIVERSITY SCENARIOS

Carolyn Lundquist[1] and Henrique Pereira[2]
[1]School of Environment, University of Auckland, [2]iDiv - German Center for Integrative Biodiversity Research at the Martin-Luther-Universität Halle-Wittenberg, Germany

What is the future we want for nature? Do you imagine vast areas in national parks or marine reserves? Do you imagine reconnecting city dwellers with nature through green space, green rooftops and community gardens integrated in urban planning? Is your vision for nature dominated by indigenous land and ocean management practices, or nature restoration projects by local community groups? We each experience and value nature in many ways, and there are many positive futures for nature. In this presentation, we will introduce you to the IPBES Nature Futures framework which has been developed by the IPBES task force on scenarios and models. This new framework for biodiversity scenarios represents the different ways in which nature and its contributions to people are perceived and valued. The NFF is represented by three values for nature. These are: Nature for Nature, focusing on the intrinsic values of nature such as biodiversity and maintaining ecosystem integrity; Nature for Society, which includes the material benefits and natural capital that nature provides; and Nature as Culture, which can be represented by concepts such as reciprocity and living in harmony with nature. The NFF can be used to chart different pathways to desirable futures based on our values for nature, and help us to identify those transformative changes required to ensure a better future for nature and people.

INDIGENOUS PEOPLES' FOOD SYSTEMS: NUTRITION, FOOD SOVEREIGNTY, HEALTHY PLANET

T.E. Martinez-Cruz
Free University of Brussels and Food & Agricultural Organisation of the United Nations, Brussels, Belgium

Indigenous Peoples are guardians of the planet's biodiversity - 476 million Indigenous Peoples (6% of the population) maintain and sustain 80% of the planet's biodiversity. Despite centuries of marginalization and discrimination, Indigenous Peoples are champions of resilience, having adapted to a broad range of lands and territories, from the frozen lands of the artic to the arid lands of Africa and Australia. Despite the sometimes inhospitable conditions, they have developed rich food systems that play a crucial role in supporting food and nutrition sovereignty and sustainability. Their food practices are key to preserving biodiversity. Different to the productivity focus of conventional food systems, Indigenous Peoples' food systems are about food generation, multipurpose use, and are connected to values of identity, culture, reciprocity. With nature at their center, they are crucial for biodiversity conservation. Globally, only three crops contribute to 60% of the world's caloric intake. A single Indigenous Peoples' Food Systems can contain more than 250 local co-existing foods, providing rich and nutritious diets. Indigenous knowledge and practices allow to obtain food even in the most challenging conditions due to their deep knowledge of their environment and its cycles makes them champions of adaptation and resilience. Indigenous Peoples' food systems offer a key approach and solution to the challenges of climate change and biodiversity loss we collectively face.

NATURALNESS AND THE VALUE OF BIODIVERSITY

Katie McShane
Colorado State University, USA

Biodiversity is typically described as (1) valuable because of the role that it plays in ecosystem functioning, (2) valuable because of the ecosystem services that it provides to humans, and/or (3) intrinsically valuable – good in its own right. If this is why biodiversity is valuable, however, the strong preference that many people have for natural biodiversity over artificial biodiversity is puzzling. Particularly given the disruptions brought about by climate change, artificial biodiversity (variety achieved by creating new biological entities – through genetic modification, synthetic biology, etc.) might do a better job of facilitating ecosystem functions and providing ecosystem services, and it should be equally intrinsically valuable compared to natural biodiversity.

In this paper, I argue that a broader understanding of the value of biodiversity is needed to understand why people value natural and artificial biodiversity so differently. I consider three values in particular: the value of familiarity, the value of community, and the value of discovery. In each case, I argue that the naturalness of the biodiversity matters to its value. If this is right, then the loss of natural biodiversity threatens at least some values in a way that could not be compensated for by the introduction of artificial biodiversity, even in cases where that introduction goes as well as possible.

BUILDING ECOLOGICALLY SMART CITIES: URBAN BIODIVERSITY IN THE ERA OF THE ANTHROPOCENE

Harini Nagendra
Azim Premji University, India

We seem to be living in almost biblical times, with floods, droughts, heat waves, forest fires, pandemics and other disasters threatening cities across the world. Cities everywhere, but especially in the global South, are on a breakneck path to growth. It has never been more clear why we must begin to think ecologically about our urban future. Across the world, clearers were originally built on a firm basis of local ecology, drawing on the biodiversity in the rivers, lakes, forests, grasslands and coastal areas around them for food, water and building material. Yet over centuries we have forgotten this ecological history. Instead, human pressures have transformed the ecology of cities beyond recognition. Drawing on examples from India and other cities across the world, this talk will discuss how we need to re-design cities to accommodate ecology, building Ecologically Smart Cities, ensuring human wellbeing and justice alongside resilience to climate change and urban stresses.

SHEPHERDING SUB-SAHARAN AFRICA'S BIODIVERSITY TOWARDS A GREEN ANTHROPOCENE

Alice Ruhweza
WWF International, Nairobi, Kenya

Sub-Saharan Africa's (SSAs) iconic wildlife and biodiversity-rich landscapes are of immense potential value to the continent and the world. However, those natural assets are jeopardised by increasing anthropogenic pressures.

Elevated levels of consumption in higher-income countries and the demands of international corporations manifest in significant and growing resource extraction from SS African countries. In addition, biodiversity in SS Africa faces severe pressures from growing domestic pressures, including rapidly increasing human populations, which are likely to double by 2050 and quadruple by 2100.

Current levels of funding and capacity are inadequate, and these shortfalls will only become more extreme as anthropogenic pressures increase. Consequently, there is a risk that much of SSA's biodiversity wildlife could be diminished, lost or degraded over the coming decades, and numerous species may be pushed to extinction.

Long term, however, the prospects for nature conservation in SSA will improve as population stabilises, populations urbanise, governance improves, poverty declines, agriculture intensifies, green economies strengthen, and societal appreciation of nature grows. Eventually, capacity and funding for conservation in SSA will grow, threats should decline, and we postulate that the region will be likely to enter a 'Green Anthropocene' where the prospects for conservation are brighter.

LIVING FOR THE CITY: EXPLORING THE SOCIAL-ECOLOGICAL DRIVERS OF URBAN BIODIVERSITY

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Despite the previous misconception of cities as inhospitable wastelands, urban environments often serve as biodiversity hubs for an array of species – both more and less common. Consequently, urban ecosystems have become central targets for biodiversity management and conservation, as well as environmental proxies for understanding how species may adapt to myriad novel environmental challenges. Advancing our understanding on both the social and ecological drivers that influence biodiversity will thus greatly inform how we conserve biodiversity in both urban and nonurban systems. To build a comprehensive understanding of urban systems and biodiversity, we must integrate and reconcile how societal drivers – including wealth inequality, governance, racism, classism, and community norms – structure urban environmental mosaics. In his talk, Dr. Chris Schell will discuss how structural and systemic inequalities, especially economic and racial inequality, shape patterns of urban biodiversity within and across cities. In doing so, he will discuss how leading with an environmental justice lens is pivotal to promoting conservation, sustainability, and resilience in a human-dominated world.

WHY WE NEED TO TRANSFORM BIODIVERSITY SCIENCE

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Current biodiversity science is not fit for purpose. Its focus on non-human species and protected areas has separated people from nature, resulting in injustices while keeping a blind eye to the destruction of biodiversity outside protected areas and the political-economic root causes of biodiversity loss. In this key-note lecture I will illustrate the limitations and blind spots of dominant biodiversity research agendas and priorities to make the case for transformation. I will also outline what will be needed to equip biodiversity research to support the transformative changes in societies and economies that are so desperately needed for human and ecological well-being. This includes a deprioritization of current dominant approaches towards three main priorities: 1) a focus on understanding and fostering plural human-nature relations; 2) critical analysis of power relations and vested interests that cause biodiversity loss and block transformation; 3) participatory research to ensure just and equitable practices. Recognizing that such calls to change research are not new, it is vitally important to also reflect why change in science is so slow. To this end, I will discuss obstacles and resistance to transformation from within the scientific community itself. The broad and interdisciplinary biodiversity research community must urgently come together to reflect on its own power relations and vested interests and how these obstruct the transformation of biodiversity science.

Poster Sessions

AGR1 - Intercropping – exploitation of biodiversity benefits in arable fields

439 SYNTHESISING LOCAL EFFECTS OF AGRICULTURAL DIVERSIFICATION ON MAMMAL DIVERSITY

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Agriculture is a major cause of biodiversity decline worldwide. Agricultural diversification measures, such as the inclusion of natural elements, crop diversification, or rotational grazing, may reduce impacts on biodiversity, but their effectiveness has not been systematically quantified. This impedes our ability to evaluate the benefits of diversification measures for biodiversity and identify measures to reduce impacts of agriculture. Here, we synthesise local mammal diversity data in croplands, forest plantations, pastures, and corresponding natural reference sites (3,917 diversity measures across 496 sites and 174 studies) to estimate the effects of several agricultural diversification practices on mammal species abundance and richness. Our analysis shows that mammal abundance in croplands and forest plantations absent of natural elements is considerably lower compared to natural habitat, but that abundance in sites containing natural elements can be similar to abundance in natural habitat. Effects on mammal richness vary. For example, mammal richness is generally higher in polyculture compared to monoculture cropland, but we did not find similar patterns in poly- or monoculture forest plantation stands. We also found diverging responses to pastures. Our findings address the potential of agricultural diversification measures to reduce impacts of agriculture on mammal species diversity and can inform the implementation of strategies to meet biodiversity targets.

257 IDENTIFYING AND MAPPING THE SEMIOCHEMICALS OF "PUSH-PULL" MIXED CROPPING SYSTEMS

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Greenleaf desmodium (desmodium intortum) is used as an intercrop in maize (zea mays) and sorghum (sorghum bicolor) fields across east Africa. In combination with border grasses used as trap crops (e.g. brachiaria spp.), this forms a "push-pull" system for biological crop protection which can repel insect pests (e.g. spodoptera frugiperda) and supress parasitic plants (e.g. striga hermonthica) - the "push" - while trapping the repelled pests - the "pull" - and increasing soil nitrogen. This system has been adopted by over 250 000 farmers, but the effectiveness varies from farm to farm. The UPSCALE project, a part of the European Union's Horizon 2020 initiative, aims to expand usage of push-pull across five African countries by studying its effectiveness, expanding crop combinations and assisting farmers to adopt the system.
As part of UPSCALE we are sampling plant volatiles and crop leaves for subsequent analysis by mass spectrometry to identify and trace spatial distribution of the molecules

that are driving the push-pull effect. The plant volatile profiling can then be used to explain efficiency differences and to expand the existing push-pull system e.g. to other species with similar volatile profiles. The leaf metabolites indicate plant health and nutritional status while also showing effects of neighbour plant volatiles and root exudates. Here we present the analytical process from sampling to data evaluation and show the results from initial small-scale sampling runs.

455 EVALUATION OF THE POTATO-SOYBEAN INTERCROPPING SYSTEM IN MALAWI

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Trials were planted at Bvumbwe and Kandiyani Agricultural Research Stations in the 2020/2021 cropping season with 5 treatments
1. Potato
2. Soybean
3. Potato + Soybean (1:1 alternate rows)
4. Potato + Soybean (2:1 alternate rows)
5. Potato + Soybean (3:1 alternate rows),
laid in Randomized complete block design (RCBD) replicated 3 times. Agronomic data were subjected to analysis of variance in Genstat Discovery Edition and means were separated by the least significant difference ($LSD_{0.05}$). At Bvumbwe the result indicate that there was no significant differences in grain yield for the soybean and ranged from 1,953 kg ha^{-1} to 3,893 kg ha^{-1}. For potato, no significant differences were observed in the yields of big tubers in the sole potato, 1:1 and 3:1 intercrop with the 2:1 intercrop registering significantly lower yield below the potato monoculture. Tuber yield ranged from 3,496 kg ha^{-1} to 7,656 kg ha^{-1}. At Kandiyani the result indicate that soybean grain yield was significantly higher in the monoculture and the 1:1 intercrop above the 2:1 and 3:1 intercrop and ranged from 833 kg ha^{-1} to 2,227 kg ha^{-1}. No significant differences were observed in the yield of big tubers across treatments and ranged from 1,384 kg ha^{-1} to 1,708 kg ha^{-1}. At all the sites all the intercrops indicated grain and tuber yield advantage above the monocultures of both soybean and potato respectively (LER>1) suggesting compatibility of the soybean and potato in the intercrops

327 DIVERSITY OF COWPEA IN MAIZE INTERCROPPING FOR SUSTAINABLE HIGHLAND AGRICULTURE

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Intercropping maize (Zea maize) and cowpea landraces (Vigna unguiculata) is one of the ways to improve food security and soil fertility whilst generating cash income of the rural poor. Cowpea is an important component of most traditional cropping systems in the tropics. It provides leafy vegetables and/or grains and forages and acts as a cover crop. We characterized cowpea landraces populations in Northern Thailand Highland agricultural areas of their genetic, morphological, and agronomic characteristics, and the seed composition, including total protein, amino acid, sugar, fatty acid and tocopherol were evaluated. The results showed that there were variations within and between cowpea landraces populations in all morphological and physiological characters included seed crude protein and fatty acids. Cowpea landraces of northern Thailand is genetically

variable, and structured according to origin of origin of collection which could be the consequence of local adaptation and human preference. The discovery of high levels of protein, and fatty acids in some cowpea populations indicates the potential for utilizing cowpea for its high protein content for alternative plant-based protein crop, a prospect that should be taken into account when planning conservation strategies or when cowpea variability is used in breeding programs.

ARC1 - Arctic biodiversity under global change – from documenting changes to identifying pathways toward sustainable development

458 FACE-IT: DEVELOPING ADAPTIVE CO-MANAGEMENT OF ARCTIC FJORDS IN TRANSITION

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Arctic ice is melting, turning sea-terminated into land-terminated glaciers. This rapid loss of cryosphere is accompanied by biodiversity changes, with likely far-reaching effects on ecosystem functioning in Arctic fjords and related human activities. FACE-IT is an EU-funded Horizon 2020 project, aiming to enable adaptive co-management of social-ecological fjord systems in the Arctic in the face of rapid biodiversity changes and its consequences. The concept of FACE-IT rests on a comparison of selected Arctic fjord systems at different stage of cryosphere loss in Greenland, Svalbard and Finnmark, Northern Norway. The underlying two-pronged hypothesis is (1) that the biodiversity of Arctic coastal zones is changing in accordance with the rates of cryosphere changes, and (2) that such biodiversity changes affect local communities, food production, livelihoods, fisheries, tourism and other ecosystem services. FACE-IT includes the participation of Arctic stakeholders to ensure that Indigenous and local knowledge, perceptions, and concerns about ongoing changes are taken into account in defining innovative and adaptive co-management approaches towards a more sustainable future. In this way, FACE-IT will deliver significant contributions towards the implementation of the new integrated EU policy for the Arctic.

570 ADVENTIVE COMPONENT OF FLORA IN NORTHEASTERN YAMAL TUNDRA

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The study of flora's adventive component is an actual task of modern vegetation science. Timely identification and monitoring of adventive species contributes to biological invasions prevention and the conservation of ecosystem biodiversity. It is also important to distinguish truly dangerous invasive species and those that do not pose a significant threat to natural communities.
Adventive (incl. invasive) species have been studied in many Russian regions, but only a few works are devoted to the Arctic (Druzhinina, Myalo, 1990; Tishkov, Morozova, 2021, etc.).2011 to 2021 In the northeast of Yamal, in the border of subzones C and D (CAVM, 2003), geobotanical studies were carried out, including the identification and subsequent

monitoring of the flora. The flora of the studied area consists of 205 species of vascular plants: 136 native and 69 adventive. The number of native species is close to the neighboring regions (Rebristaya, 2013). Adventive species account for 34% of the flora, which is higher than the estimate of 22-25% given for the Russian Arctic (Sekretareva, 2004; Tishkov, Morozova, 2021). The majority of them are the result of an unintentional introduction, as well as work on biological reclamation of disturbed areas with the sowing of grass seed mixtures. Almost half of them are able to overwinter in the conditions of northeastern Yamal but are not able to renew. In 2011-2014, when no reclamation was carried out, the adventive species share was only 6%.

419 BIODIVERSITY OF TERRESTRIAL MAMMALS IN THE EURASIAN TUNDRA BIOME

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Widespread research of mammal diversity in the Eurasian tundra biome had started much later than in other zonal biomes, and had less spatio-temporal data. Many remote regions of this area with severe climate and short summer have not been monitored yet. Inventory of terrestrial mammals is complete, and research of "white spots" (high-latitude Arctic islands) will probably not add new species in checklist. The aim of study of the biodiversity of terrestrial mammals in Eurasian tundra is identifying the complete species composition of the mammals and determining the species of different fauna complexes.
Maps of tundra species ranges have been researched, and database "Tundra biota" have been created. Forest-tundra was not included in the study area. The distribution of species with observing reproduction in researching area was analyzed. Maps of range of marginal populations of some species (Gulo gulo, Vulpes vulpes) were mapped with indicating if they visiting or mating. The spatio-temporal migration routes of taiga species into the tundra have been investigated.
Currently, the Eurasian tundra is inhabited by 27 species of terrestrial mammals. They include 12 typical tundra species or tundra fauna complex. The mammalian fauna of the tundra zone also includes 5 polyzonal, 5 boreal, 3 mountain species and 2 synanthropes. Rodents dominate in the taxonomic spectrum (17 species). Other orders are Carnivora (5), Eulipotyphla (2), Artiodactyla (2) and Lagomorpha with 1 species.

263 TRANSFORMATION OF BIODIVERSITY OF BIRDS AND MAMMALS IN THE MIDDLE EUROPEAN TAIGA

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Biodiversity of Taiga Biome in Europe is well represented by natural ecosystems of middle taiga. An increased human impact on this territory (deforestation and fires) has led to the significant loss of these ecosystems in the south of Arkhangelsk region with the subsequent transition of autochthonal spruce-dominated forests to the secondary, early successional mixed birch forests with pine inclusion, and fields around settlements. This structure resembles a landscape pattern of forest-steppe ecotone.
Since 1992 year we have been researching bird and mammal populations at the Moscow University scientific field station (between the Vaga and the Northern Dvina rivers) to evaluate an anthropogenic and climate change impact, and landscape fragmentation affect on biodiversity of middle boreal forests and of small forest remnants surrounded by fields. These forest remnants often located in hardly accessible for plowing forms of relief

(with glacier erratic boulders).
We conclude that such landscape pattern and climate change has contributed to the migration of some species of southern origin further north in the taiga biome. They include wild boar, striped and Ural field mouses, common vole, magpie, corncrake, common quail, gray partridge. At the same time autochthone boreal species (lynx, red squirrel, Siberian flying squirrel, wood lemming, northern red-backed vole, wood grouse, eagle-owl, three-toed woodpecker) are becoming endangered due to the habitat loss and fragmentation.

340 LATITUDE DOES NOT EXPLAIN PLANT SPECIES RICHNESS ACROSS WESTERN SIBERIAN TUNDRA

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Western Siberia is one of the most important areas of economic activity and industrial development North of the Arctic Circle. Tundra plant communities of the region are changing rapidly due to climate change, fossil fuel extraction and reindeer herding. Statistical modeling allows us to estimate the spatial distribution of plant diversity as well as its driving factors at large spatial scale. Our research is based on the Western Siberian part of the Russian Arctic Vegetation Archive (AVA-RUS, http://avarus.space), with 1483 Braun-Blanquet plots observed from 2005-2018. We used a General Additive Model to estimate the community level species richness across the Western Siberian tundra, with climate variables and topography identified as main explanatory factors.
Our results show a clear gradient from areas with low species richness in southern lowlands and the Ob' delta to high species richness areas on the Gydan peninsula. Areas with high and low species richness occur in all three main bioclimatic subzones within the study region, but the arctic deserts of Bely Island generally have a low species richness. The decrease in species richness in the southern part of the region might be a result of reindeer herding and gas extraction that are widespread across the region, especially in its southern and western parts. By intersecting current nature protection areas with our species richness map, we document that areas with higher species richness are currently poorly protected.

521 DISTRIBUTION OF VASCULAR PLANTS IN THE WEST SIBERIAN ARCTIC

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New open data sources, remote sensing information and GIS technologies provide opportunities for mapping distribution of plant species. In this work, we modeled distribution of Betula nana, Salix lanata, Empetrum nigrum s.l., Rubus chamaemorus, Arctous alpina, Duschekia (Alnus) fruticosa and other vascular species widespread in the West Siberian Arctic using maximum entropy method implemented in MaxEnt program. To conduct the modeling a database of species occurrences in the north of West Siberia was created using archives of the AVA, GBIF, Herbarium of Moscow State University and article information. We used layers from the CHELSA bioclimatic dataset as environmental input data. This data was supplemented with the July's land surface temperatures obtained from MODIS for 2000-2019. We also carried out spectral unmixing for plant communities dominated by Betula nana and Duschekia fruticosa. The analysis revealed space and ecological patterns in the distribution of vascular species

in the study area. It is shown that the pools of species are linked to the certain bunches of environmental conditions and plant community types. Some of the species mark such important ecological borders as Arctic-Subarctic boundary. It was also estimated that some of the species have a joint distribution and utilize the territory in a similar way. The obtained results could be used as a baseline for monitoring climate and anthropogenic associated changes in biodiversity of this Arctic region.

BEF1 - Scaling diversity-functioning relationships from plot-scale experiments to real-world landscapes: emergent mechanisms

433 SPECIES RICHNESS INCREASES STABILITY IN A LARGE-SCALE FOREST EXPERIMENT

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Extreme climate events including droughts are a threat to forests and their functioning across the globe. As the frequency and intensity of such events increase, understanding the drivers promoting ecosystem stability becomes crucial for forest management. In this study, we examined the underlying drivers that may promote community stability in a large-scale biodiversity experiment (BEF-China) that features a planted species richness gradient of 1 to 24 coexisting tree species. We used Structural Equation Models to examine how tree species richness, asynchronous species dynamics, average species-level population stability and drought-tolerance traits relate to community stability. Tree species richness increased community stability via increasing asynchrony. That is, asynchrony of inter-annual variation in productivity among tree species acted as buffer against stress-induced reductions in productivity. This asynchrony was positively correlated with diversity in drought-tolerance — considering traits related to stomatal control and resistance-acquisition strategies — but not to the community-weighted means of these traits in the community. Our results demonstrate key mechanisms by which tree species richness stabilizes forest productivity. As observational studies in forests found similar stabilizing effects of species richness, we see potential to upscale the reported mechanisms to real-world forest ecosystems.

486 GENETIC IDENTITY AFFECTS TREE GROWTH PLASTICITY IN RESPONSE TO BIODIVERSITY LOSS

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Many experimental and observational studies have indicated that genetic identity and abiotic environment can interactively influence plant performances. However, we know very little about how interactions of genetic identity and biotic environment affect plant growth. Here, we used 10-year data of tree individuals with various maternal information in a large-scale biodiversity experiment (BEF-China) to test how genetic identity variation affects tree growth and growth plasticity in response to neighborhood biodiversity loss. We found that variation of tree growth is partly explained by genetic identity and the extent of variation explained by genetic identity increases with forest development. Furthermore, trees of different genetic identity show differential growth responses to neighborhood species richness. Our findings demonstrate that both genetic identity and species diversity should be considered to achieve the goal of promoting forest productivity.

BEF2 - Functional diversity in space and time: measurements, models and experiments to advance trait-based ecology

379 FUNCTIONAL DIVERSITY RANGE SHIFTS UNDER GLOBAL CHANGE

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Environmental factors can explain global plant trait variation, and thus climate change will alter global patterns of plant functional diversity. This can have consequences for biogeochemical energy and matter fluxes. We previously found the two main principle components of global plant trait variation to be explained by climate and soil:
(i) size variation at the organ and plant level, and
(ii) economics balancing tissue persistence against plant growth potential.
Here, we aim to quantify global functional diversity range change.
For this purpose we derive the range of functional diversity on a global scale for ecoregions. In a second step we predict functional range diversity from current and projected climate and soil data. We explore the functional range shifts based on future climate scenario simulations within the coupled model intercomparison CMIP6.
Our findings have the potential to give rise to further local analyses, target conservation areas and to build predictions of biodiversity loss on food webs and biochemical cycles.

579 TOWARDS IDENTIFYING ALL SWISS PLANT SPECIES FROM PHOTOS AND HABITAT INFORMATION

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Extensive monitoring of biodiversity is key to identify hotspots of the ongoing biodiversity crisis, define appropriate mitigation strategies, and evaluate their success. Citizen scientists can greatly enhance such monitoring, but their observations can contain misidentifications. In collaboration with the National Data and Information Center on the Swiss Flora we develop a plant identification tool based on image classification and spatial ecological modelling to provide identification feedbacks to citizen scientists via smartphone app and validate submitted observations. We fit a pretrained EfficientNet b4 model with a loss function that accounts for taxonomic relatedness on >1 Mio photos of ca. 2400 plant species (2/3 of the Swiss flora) that are compiled from various biodiversity databases. For the ecological part, we train an artificial neural net on ca. 7.5 Mio observations to discriminate between the same species based on environmental and phenological predictors. Currently, the image classifier has a top-1 accuracy of 73.4% and a top-5 accuracy of 90.9%. When combining image- and ecology-based predictions, the statistics increase to 78.5% and 93.3%, respectively. With a two-year sampling campaign and photo compilation effort from private archives we are currently expanding the data set to include as many additional species as possible. In addition to identifying species from images, our algorithm can be employed to conduct entire biodiversity assessments from movies.

200 FUNCTIONAL DIVERSITY AND LONG-TERM RESILIENCE IN EUROPEAN NATURAL FORESTS

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Forest ecosystems are facing increasing pressure through climate change. Dynamic global vegetation models (DGVMs) aim to project future forest trajectories, in order to help forest managers and policy makers to anticipate and maximize forest stability. Although first studies show that functional diversity can have a strong impact on model results[1], the representation of functional trait diversity is largely lacking in models aiming to investigate long-term forest resilience[2]. Here, we show how functional trait diversity changes simulated long-term forest resilience in a state-of-the-art flexible trait-based DGVM in European natural forests. We compare model experiments and estimate the overall effect of functional diversity to long-term forest regeneration. We found that highest biomass values can be maintained also under future climate conditions if functional diversity is high enabling environmental and competitive filtering. Our results suggest that planting only the successful strategies in today's temperate forests would not produce as much biomass as if other strategies were also included. We emphasize that an interplay of both - functional diversity and competition - is important for successful forest regeneration in the future climate.
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2. Albrich, K. et al. Simulating forest resilience: A review. Glob. Ecol. Biogeogr. *29*, 2082–2096 (2020).

556 BIOCLIMATIC MODELS OF SEED MASS VARIABILITY OF THE PINUS GENDER OVER SIBERIA, RUSSIA

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Pinus gender is widely spread over northern Eurasia and presented in two subgender: two-needled (Pinus) and five-needled (Strobus); in Siberia – Pinus sylvestris and Pinus sibirica, respectively. Our goal was to construct bioclimatic models that predict seed mass of Scots pine and Siberian pine in a warming climate during the century. Data on multi-year seed mass were mainly derived from the literature and collected during field works. Data of climatic variables (January and July data and annual precipitation) were derived from climate data site (www.meteo.ru). Our bioclimatic models were based on climatic indices Growing degree-days > 5°C, Negative degree-days<0°C, and Annual Moisture Index, that were calculated from January and July data and annual precipitation for both contemporary and future climates. The future 2080s climate anomalies for January and July temperatures and annual precipitation were derived from the ensemble of twenty CMIP6 general circulation models and two scenarios of a mild climate ssp126 scenario and an extreme climate ssp585 scenario. Our multiple linear regression bioclimatic models related seed mass for each tree species with climatic indices for current and future climate. Seed mass changes along the north-eastern climate gradient from heavier in the south to lighter in the north.
The reported study was funded by RFBR, project number 20-05-00540.

576 UNRAVELLING THE FUNCTIONAL DIVERSITY OF A DEHESA WITH SUN-INDUCED FLUORESCENCE

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Capturing and interpreting the variation of the functional diversity across space and over time is a major goal for tracking the status of terrestrial ecosystems and predicting their evolution over time. However, field surveys are resource-limited in space and time. Remote sensing has a great potential to overcome these limitations and several reflectance-based metrics have already been proposed to measure the functional diversity, however a solid monitoring framework is still far to be reached. In this context, we present a novel approach for quantifying the functional diversity of a Mediterranean dehesa (Spain) based on the exploitation of sun-induced chlorophyll fluorescence emitted by vegetation. Based on the spectral variation hypothesis, which states a positive relationship between the spectral heterogeneity across space and biodiversity, we tested different heterogeneity metrics based on sun-induced chlorophyll fluorescence and reflectance measured by the HyPlant airborne imaging sensor to estimate the functional diversity. We show that the patterns observed in the functional diversity maps are related to the expected drivers of the spatial heterogeneity in this Mediterranean ecosystem. Furthermore, we discuss which factors explain the spectral variability of sun-induced fluorescence and vegetation indices based on a modelling study, fostering the exploration of sun-induced fluorescence heterogeneity as a novel metric to map the functional diversity.

BEF3 - Climate change impacts on biodiversity and ecosystem functioning: Lessons learned from climate change manipulation experiments

578 THE MULTIBEF PROJECT: MULTI–SCALE B-EF RELATIONSHIPS UNDER MULTIPLE STRESSORS

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Freshwater ecosystems and biodiversity are facing severe pressures, including climate change. To understand the ecological effects of multiple-stressors induced by climate change (e.g., droughts and temperature increase) we need to account for the complexity of relationships between the different facets of biodiversity and ecosystems across scales. For instance, biodiversity – ecosystem functioning (BEF) relationships depend on the level of biological organization (between vs. within species), structure of food-webs (e.g. diversity, trophic levels) and of the spatial scale (e.g. distance among ecosystems, biomes). Hence, the consequences of multiple stressors also depend on fundamental properties of biodiversity, ecosystems, and BEF relationships. For instance, meta-community theory predicts that weaker recolonization rates among distinct ecosystems impedes the resilience of ecosystems after a perturbation event like droughts. In taking advantage of field experiments with small freshwater ecosystems (water-filled tree holes), MULTIBEF will assess how key ecosystem functions, i.e. detritus processing and secondary production, are affected by gradients in biodiversity, droughts and temperature gradients on multiple ecological scales: food-webs, regions and biomes. Knowledge gained through this project will help prioritizing local management efforts intended to mitigate the effects of climate change on small and discrete freshwater ecosystems.

CIT1 - Towards Blue Green Cities: nature-based solutions for enhancing urban ecology

42 ECOSYSTEM SERVICES ASSESSMENT TO SUPPORT THE NATURE-BASED SOLUTIONS

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There is growing awareness that nature-based solutions (NBS) can rebalance the relationship between people and nature, simultaneously provide environmental, social, and economic benefits through the delivery of ecosystem services. However, the co-benefits of NBS can be difficult to measure and are often overlooked in cross-sectoral decision-making processes. This paper provides an overview of the recent work mapping and assessing physical and monetary benefits of the evidence-based implementation. Using Taipei, Taiwan as a case study, we provide a comprehensive overview of trialed and tested NBS efforts that used nature to address challenges in water, food, and energy nexus. This includes regulating water supply and water quality, reducing the heat effect

in cities, generating energy, and cultivating edible plants, respectively on the incorporation of permeable pavement, plant microbial fuel cells, bio-filtration basins, and rain gardens. We stress the urgent need for taking a further step towards accounting for nature and its contributions to people in policymaking on a city level.

CIT2 - Growing African Cities, Culture and Biodiversity

6 ANALYSIS OF C02 AND CH4 DISSEMINATION IN NATURE AND ITS IMPACT ON BIODIVERSITY

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Straddling the Democratic Republic of Congo and Rwanda, at an altitude of 1,460 m, Lake Kivu is one of the ten great lakes in Africa, alongside the main ones that are Victoria and Tanganyika. Kivu contains very high concentrations of gases (carbon dioxide, methane, sulfur dioxide, and fine particles in particular), produced by human activity, volcanic activity in the region, and the decomposition of organic matter. It has 2,700 km2 of this body of water, a depth that approaches 500 meters in places. It is estimated to contain 60 billion cubic meters of dissolved methane and about 300 billion cubic meters of carbon dioxide accumulated over time. Note that no statistics are given for sulfur dioxide and fine particles.
A DELAYED BOMB.
Such a concentration of gas is nevertheless problematic because it could potentially serve as a detonator for a limnic eruption, characterized by the sudden degassing of the lake which then spreads the layers of gas accumulated over the years. In such circumstances, the human consequences can be dire.
Since 2011, degassing technology has been implemented in Kabuno by the French company Limnological in order to extract quantities of CO2 and CH4 by disseminating them in nature in order to possibly mitigate the explosion. However, this dissemination is probably not an adequate solution to prevent all the dangers they represent for biodiversity, the environment, and the population.

147 CULTURE AND FOREST CONSERVATION IN COMMUNITIES IN GHANA: A CASE OF AKYEM TAFO

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Culture and traditions have been at the centre of affairs of communities, especially in the conservation of natural sites reserved as sacred. As cultural heritage sites, these places have been the seat for the conservation of nature, culture and, traditions communities. However, due to modernisation, the place and voice of culture and traditions in these practices has been low, thus, affecting their conservation potentials. Relying on the qualitative case study approach, I explore the extent to which culture and traditions still inform local community participation in dedicating forests to a deity, on the inherent taboos regarding resource exploitation, and on other traditional beliefs and customs, in order to understand the environmental and conservationist implications of these rules and practices which act as catalysts to forest conservation and ecotourism development in the Akyem Tafo community in the Eastern Regions of Ghana.

564 KNOWLEDGE OF URBAN TREES IN MEDELLÍN, AS A BASIS FOR THEIR CONSERVATION

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Urban trees provide multiple environmental benefits that improve human health and well-being. The identification of the species and their morphological and ecological characteristics allow greater appropriation and better management by the community and the professionals in charge of this resource. With the purpose of providing the dissemination of this diversity, a virtual catalog of the existing species in Medellín and in the urban area of the Aburrá Valley was developed. The catalogue contains 328 registered species. For each species, 30 botanical and ecological characteristics are recorded. It includes an advanced search tool called Species Selector that allows to find those species that meet certain characteristics defined by the user, and facilitates the process of selecting the most appropriate species to establish in the city. Additionally, we evaluated functional traits and carry out a phenological study of different species. The results allow to understand their relationship with climatic variables and to identify the offer of ecosystem services, for example, removal of pollutants, carbon sequestration, microclimatic regulation and provision of habitat for wildlife. Finally, we proposed a set of criteria for the selection of tree species according to their potential to provide benefits optimally, and the design of urban forest management strategies that contribute to the sustainability and resilience of cities.

CIT3 - Urban Biodiversity – European best practice examples for a better future

20 CAN GREEN ROOFS COMPENSATE FOR THE LOSS OF BIODIVERSITY IN CITIES?

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Urbanization is one of the most significant anthropogenic alterations on the surface of the earth and poses one of the greatest threats to global biodiversity.
Green roofs are known to deliver several important ecosystem services otherwise provided by natural green.
However, integrated research on above- and below-ground biodiversity and what is driving species richness and community composition on green roofs is limited.
The aim of our study is to check if green roofs can compensate for the loss of biodiversity in cities caused by urbanization.
Our focus will be on Collembola as they have important functions in soil dynamics such as litter decomposition and nutrient cycling and on the pollinator groups (bees and wasps) as they play an important part in every aspect of our ecosystem.
We have sampled invertebrate communities on twenty extensive green roofs over a half year period from March until September for two consecutive years (2020 and 2021), in the city of Antwerp, Belgium.
We found that overall collembolan diversity on the green roofs was low (10 species) and we only found a significant difference in abundance with the age of the green roof.
No other significant differences between roofs with different characteristics were found.
The same results are found as to the pollinator groups. No statistically significant differences were found related to the height or the surface area of the green roof.

633 CO-PRODUCTION IN CITY MAKING: GUIDING PRINCIPLE FOR SUSTAINABLE URBAN DEVELOPM.

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Co-production is widely recognised as a powerful role player in supporting the achievement of the UN Sustainable Development Goals (SDGs) and improving living conditions in urban areas. The New Urban (NUA) acknowledge that co-production contributes to sustainable urban development by
(i) promoting holistic understandings of planning,
(ii) paying attention to site-specific characteristics and actor constellations,
(iii) complementing hierarchical knowledge building with integrative approaches. Co-production has the potential for what Anna Tsing calls" collaborative survival" - co-inhabited with various other species - and Donna Haraway's "response-ability" by linking it to community preferences and needs, which contribute to realistic solutions as Ostrom refers. Definitions referring to the capacity of responding responsibly and with care for the worlds, we co-inhabit. We will present direct and collaborative planning experiences beyond the North-South divide. The aim is both to highlight them and to put them in contact to understand further collective capacity-building process of planning modes able to cope with sustainability. The cases studies range from multi-and trans disciplinary real-world laboratories that work with innovative approaches, characterised by their experimental nature and involve research institutions such as universities, to urban activist-driven projects, with collaborative concepts via sharing economies, urban gardening or pro-cycling projects.

21 CONSERVING WILDFLOWER BIODIVERSITY IN CITIES: ZURICH A CASE STUDY

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Cities are dynamic living ecosystems in which human actions directly intertwine with natural processes. The plants that occur within cities often seem to exist only at our will: we plant and sow, mow and trim the greenery of our urban spaces. Seed dispersal, pollination, colonization, and competition are still major drivers of plant diversity, evolution, and biogeography in cities. We believe that with the right design, species selection, and promotion, we can work with rather than against these 'wild' natural processes in our pursuit of helping make cities sites of biodiversity conservation. Our work explores this interplay between human dispersal and biologically driven patterns in urban wildflowers in Zurich. We examined how design and land use history have impacted the biogeography of Zurich's flora. We explored the ecological patterns associated with isolation and patch size in determining the biodiversity of even tiny green "islands" spread throughout a sea of concrete. Utilizing modern genetic methods, we have examined how species' life histories and human sowing may be introducing and mixing new genotypes with established urban genotypes. We have set up a project to highlight the self- dispersing flower species which emerge in our gardens/balconies of their own volition. In doing so, we brought volunteers into dialogue about wildflowers in cities, their self-propagated dispersal, and the perception of wilderness and wildflowers in a city.

COM1 - Habitat loss and management Africa & Communicating biodiversity to engage and inspire people to act

64 CHARACTERISING THE SPATIO-TEMPORAL DYNAMICS OF WEST-AFRICA FOREST FRAGMENTS

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Despite the acknowledgement that tropical forests are essential for ecological functioning and social well-being, anthropogenic pressures continue unabated and at an increasing rate. Recent research has shown that forest fragmentation and loss are particularly high in predominantly agricultural landscapes and for smaller patches, reflecting easier access to exploit the forest. As such, there is an urgent need to identify and monitor the dynamics of remaining tropical forest patches and map their multiple benefits and values. Recognizing their existence will help ensure that they continue to provide their social-ecological functions and may help reduce the anthropogenic and environmental pressures on them. Moreover, it is important to identify forest patches in agricultural landscapes as their continued existence raises questions on why they continue to persist, despite continual pressures to convert forested land to other land uses. This study inventoried forest patches in West-Africa using multi-source satellite remote sensing datasets and time-series analysis methods to computemetrics describing their spatial and temporal dynamics. The approach enables us to monitor persistence and change in arable landscapes over four decades. By evaluating patches in relation to social, political, economic, and biophysical variables, we identify the main drivers of their spatio-temporal dynamics and prioritize their selection for in-depth social-ecological field investigation.

218 CONVERGING AND COMPETING AIMS OF SUSTAINABILITY IN CHINA

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Along with the fast development of renewable energy in China, there are conflicts between renewable energy, forests, biodiversity, and tourism. Some wind parks were built in nature conservation areas. After the central government declared the carbon targets, Chinese local governments are taking actions to reach carbon targets with a clear statement to generate more renewable energy from local resources, such as solar PV and wind. Beyond this, there are also many demonstration projects that combine the interests of renewable energy as well as nature conservation. This article compares the different cases about the converging and competing aims of renewable energy and nature conservation through the implementation of environmental protection and renewable energy policies at the local level in China. One case is China's Environmental Protection Foundation litigation against Liankai's wind park project in Changdao(Long Island), Shandong Province. Long Island has a long history to develop wind energy while it is also a nature conservation park, particularly for birds. In 2017, all wind facilities were dismissed in Long Island. The other case is about the collaboration of wind energy, tourism development, and natural conservation in Shenxianling, Hunan province, which becomes a popular internet tourism resort. This article would compare these two cases to find the key factors that lead to conflicts or co-development among different sustainability aims.

217 IMPLEMENTATION GAPS IN BIODIVERSITY CONSERVATION POLICY IN CHINA

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Policies play a vital role in setting actions for biodiversity conservation management. China set an ambitious biodiversity conservation target since it joined the CBD. However, one obvious gap exists between China's conservation target and the policy implementation results. In order to understand the barriers to biodiversity conservation policy implementation, this study examined local actor's perception of biodiversity conservation policy implementation based on an adaptive management logic. We systematically investigated the policy implementation situation of Protected Areas in Fujian Provinces in China. Face to face interviews were conducted with different level forestry officials, NGOs, researchers, and local people. Findings show that a series of barriers obviously affect biological conservation policy implementations. These barriers include conflict priorities between local government and local forestry bureau, inadequate funding, insufficient professional contingent, controversial land tenure, and a lack of scientific support for protected area establishment, area enlarging process, and daily management. In order to improve biological conservation, it is important to re-structure the relationship between local government and local forest bureau, clarify the land tenure, provide attractive remuneration for employees, and strengthen cooperation with research institution to improve the research capability.

222 POWER ADJUSTMENT IN CHINA'S NATIONAL PARK POLICY PROCESS

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As the national park movement has become popular around the world, it has evolved into a policy in many countries. China also started the process of national parks construction in 2013. To understand the mechanism of and power struggle behind the national park policy, it's necessary to explain the localization of the national park movement under China's authoritative system. This article adopts the process-tracking method and conducts document collection and expert interviews. It firstly analyses two window periods of "concept introduction" and "policy formulation"; secondly, analyses the social network, problem cognition, and policy design of each window period. In general, this article draws the following conclusions: During the "concept introduction" period, the central government introduced the concept of "national parks" under the inspire of the global national park movement, hoping to help China out of the dilemma of nature conservation. During the "policy formulation" period, the empowered Central Development and Reform Commission re-diagnosed the dilemma as the problem between centralization and decentralization and adjusted the national park policy accordingly. This article further believes that the most urgent problem facing the implementation of China's National Parks Policy is the power dispute between central and local governments. And a well-structured coordination mechanism will be the key point to promote the progress of the implementation of policy.

COM2 - Communicating biodiversity to engage and inspire people to act

313 BOOSTING WILD BEE DIVERSITY IN VILLAGES

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In the last years, the ongoing decline of wild bees received enormous attention. With flowering green spaces, gardens, and nesting sites in dry stonewalls or wooden barns, villages have the potential of becoming refuges for wild bees, away from the pesticide load in agricultural landscapes. In a project in cooperation with Biodiversity Center Rhön (Germany), we study which local and landscape-scale factors within and around villages affect wild bees. In the second part of the project, we use our results for developing effective protective measures and, of particularly importance, to educate villagers how to enhance wild bee diversity. We recorded bee diversity, flower resources and nesting sites in 40 villages in five typical habitats in each village: private gardens, farm gardens, public areas, ruderal areas, and graveyards. The results and tips for bee-friendly measures are communicated via a serial of brochures, aiming to raise the general awareness of wild bee needs. Moreover, we present a large set of effective measures in a best-practice village. Along an educational trail, stakeholders, commune staff, villagers, gardeners, landscape architects and all those interested in nature conservation can collect ideas and gain knowledge how to promote bees in and around villages. Our objective is to show locals and visitors possibilities to create bee biotopes within the village and to connect the village with surrounding bee habitats. Everyone can help boosting wild bees!

581 DESIGNING INTERSPECIES ENCOUNTERS AND EDUCATIONAL MEDIA FOR BIODIVERSITY

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Promoting experiences of nature in people's everyday lives is an important element within public efforts to protect biodiversity. We present the transdisciplinary, SNF-funded research project "Mitwelten. Media Ecological Infrastructures for Biodiversity" (https://www.mitwelten.org/) which aims to use new technologies ('Internet of Things') to enable new kinds of encounters with nature in settlement areas. The project builds on theoretical foundations from media and design research and collaborates with practitioners from ecology, nature conservation, landscape architecture and horticulture. Media-technological infrastructures, design interventions and participatory strategies are developed and tested in three contrasting field studies of human-nature negotiation processes: the historic botanical gardens of Merian Gärten, Klybeck’s (former) harbor area (both in Basel), and a nature conservation and recreation area in Reinach (Basel agglomeration). Exemplary design prototypes utilizing a sensor-actuator network include a multifunctional bus stop and a set of outdoor furniture which both combine habitecture with educational media, as well as a guidance system to coordinate interspecies encounters. Local data on biodiversity (birds, pollinators, ...) is displayed via the interactive use of GIS data and enriched by more general scientific data and knowledge.

A website based on the same system makes this content publicly available through map-based multimedia formats.

585 HOW TO GET THE MEDIA'S -- AND THE PUBLIC'S -- ATTENTION

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What kind of biodiversity stories attract an audience? Which studies are likely to interest an editor? How can you make it easier for a journalist to pass on your knowledge? Using the international branch of the Swiss Broadcasting Corporation (SWI swissinfo.ch) as a case study, I'll look at some of the biodiversity stories published there and talk about why and how we covered them. We can also take a peek at how these particular stories performed in terms of reader engagement.

228 CATALYZING POST-2020 BIODIVERSITY ACTION BY EFFECTIVE COMMUNICATION

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We are now at critical moments to make strategies for post-2020 biodiversity action. It is essential to adopt a whole-of-society approach so as to bend the curve of biodiversity loss. The Convention on Biological Diversity has launched the Sharm El Sheikh to Kunming Action Agenda for Nature and People to catalyze engagement with various stakeholders through voluntary commitments and actions for biodiversity conservation and its sustainable use. Such initiative could mobilize innovative governance in realizing biodiversity targets. However, as of November 2021, a total of 293 commitments have been registered in the pledge system and are far from meeting the ambitious goal of accelerating transformative changes. One of the challenges for robust commitments is that the public lacks the understanding of biodiversity. It is essential to inform on biodiversity knowledge and engage the largest stakeholders for extensive biodiversity action. We explore the potential communication strategies through case analysis to disseminate biodiversity targets and relevant knowledge to the non-specialist public. Our study can help catalyze whole-societal robust voluntary commitments and boost its implementation for post-2020 global biodiversity targets.

104 LIVE-CENTRED DESIGN: SUPPORTING SCIENCE COMMUNICATION AND COMMUNITY ACTIVATION

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One of the biggest challenges in addressing current and existential crises, such as climate change and the biodiversity crisis, is the successful communication of scientific knowledge and the subsequent enabling impact on societal behaviour change. This presentation focuses on design-based approaches and explores their potential for

fostering general interest in science and increasing public awareness for biodiversity issues. It also presents methods that can contribute to the motivation and empowerment of active participation in transformative change. Presented is a study project that was carried out in cooperation with the Senckenberg– Leibniz Institution for Biodiversity and Earth System Research, as well as the Master's programme in Design Management at the Macromedia University of Applied Sciences in Munich under the direction of the NGO Symbio(s)cene. The student project was intended to deeply explore the problem of increasing deforestation in the eastern lowlands of the Chiquitano region in Bolivia by applying a live-centred design approach, to develop a holistic communication strategy that informs and activates the local population. The aim of this project was to utilise design-based research and development approaches and methodologies to articulate knowledge in a way that could not only be understood cognitively, but could also be individually and socially experienced to create a lasting resonance with local people.

387 RAISING CONSUMER AWARENESS TO MAKE AGROFORESTRY COFFEE A REAL CLIMATE SOLUTION

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Globally, we drink 2 billion cups of coffee every day! In commodities trading, coffee is second only to petroleum, with annual exports values at USD$19 billion and supporting the livelihoods of more than 125 million people.
And while industrial agriculture is considered a primary contributor of total greenhouse emissions, coffee plots when properly managed as regenerative organic and agroforestry systems, bring a multitude of environmental benefits. Imitating forest habitats, agroforestry coffee sustains above-ground plant and animal species and nurtures an intricate web of below-ground microbial life. Coffee that’s grown under layers of diversified shade trees and in healthy soils offers an incredible opportunity for carbon sequestration and real climate solutions.
Today, organic coffee farmers are working hard to replicate the forest cover, strengthen local biodiversity and sequester carbon from the atmosphere, while providing us with delicious coffee. And we should be paying our fair share to incentivize their efforts!
We’re in a critical moment in history, and we cannot afford to underestimate the impact of our choices. We can leverage change through our purchasing power. It’s time to wake up and choose coffee that’s both empowering for the farmer and regenerative for the planet! Together we can mobilize this enormous industry, to make coffee an important piece of the climate solution puzzle.
And after our cup of coffee, let’s do the same with everything we consume!

253 SYMBIO(S)CENE: ART AND SCIENCES COLLABORATION FOR AN ERA BEYOND THE ANTHROPOCENE

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Symbio(s)cene is a non-profit initiative with a vision to contribute to shaping a new mindset that promotes thinking beyond the Anthropocene. The biodiversity and climate crises make global, profound and transformative change urgently necessary. We are convinced that a new way of thinking, rooted in a renewed humans-nature relationship, is necessary to promote this change. It requires a new awareness of nature, an openness

to and appreciation of other living things, and a new aesthetic that appreciates the beneficial character of natural materials and structures. With the Symbio(s)cene initiative, we want to show examples that demonstrate that a future worth living in is already within reach, and we want to contribute with projects that accelerate the emergence of a new mentality that embraces a positive human-nature relationship. The distinctive proposition of our initiative is a holistic approach that interconnects sciences and arts – giving space to both cognitive and emotional dimensions of knowledge. The poster will present our motivation and goals, and will provide examples for current and future activities.

137 EFFECTIVE BIODIVERSITY COMMUNICATION TO BUILD BACK BETTER IN THE POST-COVID ERA

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The COVID-19 pandemic is considered a watershed event which has affected all aspects of contemporary society including human-environment interactions. Biodiversity and its related ecosystem services are related with all aspects of development (e.g., food security, health promotion, and poverty reduction), in sustaining economic growth in agriculture, industry and energy generation, and in maintaining healthy ecosystems. Effective governance of the world's biodiversity therefore serves a vehicle for inclusive development and comes with multiple benefits for sustainability. Communication cuts across all aspects of effective biodiversity governance and has to be reinforced for success. Moreover, moments of crisis such as occasioned by the prevailing pandemic, provide opportunities for reflection and innovation towards biodiversity communication in order to inspire action.. As the building back agenda gains traction, this article addresses some of the core lessons from the pandemic for biodiversity communication. This is to enhance the governance of biodiversity and charts a pathway forward for sustainability as we commence final decade of action to deliver the SDGs.

CUL2 - Convivial Constitutionality: historical-institutional perspectives on human-predator interrelations and conservation policies

69 KIN, COEXISTENCE, AND COPING WITH WILDLIFE IN HIMALAYAN COMMUNITY FORESTS, INDIA

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India's wildlife are designated as custodians of the State, with enigmatic species playing a central role in narratives of the nation. Communities who live alongside these animals –– even those engaged in forest conservation –– have typically been excluded from decisions about wildlife management. In the Uttarakhand Himalaya, a biodiversity hotspot, van panchayat community forests support agro-pastoralist livelihoods and forest conservation. Yet their impacts on wildlife are sparsely documented, leaving open questions about whether and how community forest management contributes to conservation-compatible landscapes. Are wildlife perceived as a threat to livelihoods, or as kin who belong in these forests? What political, institutional, and historical factors

shape these relationships? Using legal analysis, interviews, and household surveys conducted from 2019-2021 in Johar Valley, Uttarakhand, we explore the changing nature of human-wildlife relations in van panchayats. While reporting increased prevalence of human-wildlife conflict and associated hardships, most participants express persistent ethics of care and responsibility towards wild animals. Individual understandings of wildlife are mediated by tradition and spiritual connections, management regimes, livelihood demands, and everyday encounters. These experiences inform communities' decisions and coping strategies for coexisting with their wild neighbors, and are key to understanding their role as conservation actors.

DAT1 - Integrating biodiversity and human well-being data

238 SWISS-WIDE ECOSYSTEM SERVICES ASSESSMENT

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Ecosystem services (ES) are key factors for the livelihood of our society, and understanding their spatial distribution and interactions is therefore essential to maintain their supply as well as to promote nature conservation. However, large-scale ES assessment are scarce due to the lack of data and methods, especially for a representative set of ES including non-material (also referred to as cultural) services. In this study, our objective was to map a set of 17 ES for the whole of Switzerland, at a 25-m resolution. We used and created spatially explicit models to generate a set of ES maps. We used newly developed species distribution maps to deepen and enrich our knowledge about the spatial relationship between biodiversity and ES. We applied clustering analysis to identify synergies and trade-offs among the panel of evaluated ES and to determine bundles of ES and biodiversity. Results from this study allowed to show hot spots and cold spots of ecological value including both ES and biodiversity in the Swiss landscape, and to compare these values in areas of different landscape management policies (conventional, natural parks and protected areas). This work provides not only advanced and replicable methods for ES assessment, but also the first representative set of ES maps for the whole of Switzerland and thereby useful tools for decision making at different levels of territorial governance.

DAT2 - Be FAIR and CARE; synergies, tradeoffs, and perspectives in biodiversity data for science, policy, and action

533 EKLIPSE: BRIDGING THE GAP BETWEEN POLICY AND KNOWLEDGE ON BIODIVERSITY IN EUROPE

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Eklipse was created in 2016 to help governments, institutions, businesses and NGOs make better-informed decisions when it comes to biodiversity in Europe. Eklipse is recognised by the European Commission as a key European science-policy platform for brokering knowledge for policy-makers (e.g see EU publication on Science Service). Since 2016, Eklipse has answered requests on a vast range of topics related to biodiversity and ecosystem services - often on contentious policy-relevant issues- by synthesizing the best available knowledge to facilitate actionable policy recommendations.
To reach this goal, Eklipse uses a proven and robust process that responds to the evidence needs of requesters by ensuring tailor-made outreach of results to knowledge requesters and society more broadly. The process of knowledge synthesis is a crucial element of any science policy interface. Eklipse's Method Expert Group (MEG) has identified and described 21 different methods to synthesize the different types of knowledge needs requested. On this basis, Eklipse identifies and tailors a set of methods for each specific request.
What also makes Eklipse different is that all activities are built on a strong ethical infrastructure, including the implementation of 12 different measures.
Here, we will present the innovative and robust Eklipse approach and demonstrate how it supports and contributes to the fast evolving EU Science-Policy Interface landscape to enable transformative change.

269 WHAT FACTORS INFLUENCE THE QUALITY OF OPEN DATASETS IN ECOLOGY AND EVOLUTION?

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Most leading journals in the biological sciences now mandate open data upon publication. Yet, there is very little oversight to ensure the quality of archived datasets, and we currently have a poor understanding of the factors associated with high quality (FAIR) data-sharing. We assessed 362 open datasets shared by 100 principal investigators (PIs) in the fields of ecology and evolution to identify predictors of data quality. Datasets generally scored low on completeness and reusability, but these metrics were slightly higher for more recently archived datasets and PIs with less seniority. Journal data sharing policies had no effect on data quality, whereas PI identity explained the largest proportion of the variance in both data completeness (27.8%) and reusability (22.0%), suggesting that a PI's training and lab culture are key determinants of data quality. Greater incentives and training for individual researchers could help improve data sharing practices in ecology and evolution, and the FAIRness of biodiversity data.

357 IPBES GOES FAIR & CARE! DATA AND KNOWLEDGE MANAGEMENT POLICY ADAPTED

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Two years have passed since the Multidisciplinary Expert Panel and the Bureau of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) approved the IPBES Data Management Policy (https://doi.org/10.5281/zenodo.3551078). Since then, the policy has been implemented within the Platform and revised to explicitly include considerations of the handling of indigenous and local knowledge.
Inclusivity and collective benefit as it relates to open science are now recognized as guiding principles in the policy. To inform implementation, the CARE Principles for

Indigenous Data Governance now compliments the FAIR guiding principles for scientific data management and stewardship. With the inclusion of these concepts and responsibilities, the IPBES data management policy has been renamed to the IPBES data and knowledge management policy.
The policy aims to improve the accessibility of products, transparency of the underlying processes to create them, and the CAREful handling of ILK within IPBES.
In this contribution, we seek to inform the community about the latest development of the IPBES data and knowledge management policy, the progress to date with the implementation of the policy, and emerging projects.

446 EXERCISING INDIGENOUS DATA SOVEREIGNTY WITHIN HERBARIUM COLLECTIONS

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Here, we bring discussions of Indigenous data sovereignty to the biodiversity data community, with a focus on herbarium collections. Speaking primarily from the perspectives of Indigenous peoples of North America, we outline five key concepts for consideration, including:
1. The need to recognize that many Indigenous peoples view plants as relatives, which introduces special relationships that extend to herbarium collections; and,
2. The need to reunite Indigenous communities with their relatives (i.e., specimens) and data, which relies on relationship building among communities and herbaria. These two concepts facilitate:
3. The need for Indigenous communities to be able to co-curate and correct their data, and exercise governance over their data and specimens. Our key concepts include two additional challenges:
4. The need to regulate appropriate access to Indigenous data and specimens, based on cultural norms and protocols; and,
5. The need to protect Indigenous data in light of specimen digitization and open data regulations, which removes community control over their data and places it at greater risk of exploitation.
We outline paths forward via a survey of herbaria to determine the extent and awareness of Indigenous data housed in their collections, and share our ongoing activities to co-develop an Indigenous data sovereignty framework at the C. A. Taylor Herbarium (SDC) at South Dakota State University.

252 DEVELOPING A FAIR ATLAS OF KNOWLEDGE FOR INVASION SCIENCE AND BEYOND

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Biological invasions are on the rise, and their global impacts on ecosystems, economies and human health are a major challenge. Invasion science is critical to mitigate invader impacts, yet due to the strong increase of data and information in this area, it has become difficult to acquire and maintain an overview of the field. Additionally, relevant information is often hidden behind paywalls. As a result, existing evidence is often not found, knowledge is too rarely transferred to practice, and research is sometimes conducted in pursuit of dead ends. With an ongoing project, we aim to address these challenges by developing an interactive atlas of invasion science that can be extended to other disciplines in the future. This online portal will be an evolving knowledge resource providing FAIR information for researchers. Users will be able to get an overview of the major research questions and hypotheses in invasion science, will be able to "zoom in" and find out about refined versions of these research questions and hypotheses, and discover relevant studies connected to them. The portal will apply cutting-edge visualization techniques, artificial intelligence and novel methods for knowledge synthesis. In the presentation, we will introduce our approach and discuss ideas for a complementary initiative in the field of restoration ecology.

FIN1 - Transformative Change in Economic and Financial Systems

229 ´BIODIVERSITY IN GOOD COMPANY`: FROM PIONEER TO ROLE MODEL

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The 'Biodiversity in Good Company' Initiative was the first cross-sectoral business network worldwide that is specifically committed to the protection and sustainably use biodiversity. Initiative members are small-, medium- and large-scale companies based in Germany and operate globally. By signing the Initiative's Mission
Statement and Leadership Commitment they commit to report progressively on a biennial basis on their activities on biodiversity.
Today we look back on a wealth of over 10 years of practical experience in biodiversity mainstreaming. What works best? And what does not? We will share our most valuable lessons learned and leverage points for transformative change.
As one of our core activities, we have been providing concrete starting points and hands-on tools for companies on how to integrate biodiversity on their premises, in corporate volunteering programs and their value chains. Other activities range from the coordination of a dialogue platform for mutual exchange of expertise, sharing best practices to the organization of business awards. We actively build multi-stakeholder partnerships with businesses, industry associations, politics, environmental organizations and research institutions.
Having started as a pioneer, the approach has now become a role model. We want to pave the way forward for many more successful activities in the future. Our vision is a world where business engagement for biodiversity means success - for businesses, society and nature.

539 DEVELOPING A GLOBAL BIODIVERSITY CREDIT STANDARD

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Banks must now report on their biodiversity impacts, including their loans - a reporting requirement for companies trading in the EU. There is also much private investor interest in biodiversity. The report 'Conservation Finance 2020' by the Coalition for Private Investment in Conservation noted an increase in private sector investment in biodiversity conservation from US$2-18 billion in 2016-2020. Yet it concluded that this growth would be very much faster if it were not being hampered by inability to suitably quantify biodiversity. A biodiversity credit standard is now urgently needed. However, quantifying biodiversity is much more difficult than carbon (simply tons of carbon). Working with the Plan Vivo Foundation (https://www.planvivo.org), which runs a long-standing, ethical carbon credit standard, and a range of other stakeholders, we have been developing a biodiversity standard based on a 'basket of metrics' to measure biodiversity and its change in a standardised way globally. The concept is similar to the 'basket of goods' used in the retail price index to measure inflation in different contexts around the world. At least 5 biodiversity metrics are required for the standard; these must be appropriate to the local context, to the satisfaction of a panel of experts in biodiversity and statistics. We are also working on a system to select suitable sites for biodiversity investment before applying the standard. We report on progress and welcome discussion and critique.

FIN2 - Ecosystem Services in Sustainable Finance

422 MANAGING SECONDARY TROPICAL FORESTS ENSURES BIODIVERSITY AND LIVELIHOODS

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Planting trees in the tropics can help combat climate change as carbon accrual can be rapid. Yet failed reforestation projects abound, in part due to a lack of silvicultural knowledge. Initiatives also face challenges of reaching meaningful scales due to lack of attention to the livelihoods needs of rural landowners. Located in the forests of the Panama Canal Watershed, the Agua Salud Project (AS) studies the ecosystem services provided by seasonal tropical forests and how they change with land use and climate change. The AS secondary forest monitoring network includes 54 sites monitored annually, amounting to over 1,100,000 individual measurements. Locally derived allometric equations afford the ability to accurately predict carbon accrual with forest regrowth averaging 6.9 Mg CO2e per ha per year over the first 30 years. While some authors have hailed the possibility of win-win solution of protecting regenerating secondary forest for biodiversity, timber production, and livelihoods, a recent analysis has shown that secondary forests in central Panama could only be expected to produce 6.65 m3 of timber at a value of $345 per ha after 30 years. Yet economic projections of early results of enrichment planting trials where 350 individuals of a diverse set of timber and other species chosen to enhance forest structure and diversity estimate a Net Present Value (NPV) of $10,000 per ha over this same period. We discuss these results in the context of our carbon offset program.

388 CARBON, CLIMATE AND COFFEE: PUSHING THE NEEDLE ON ENVIRONMENTAL SERVICE PAYMENTS

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This pilot project brings together the know-how and experience of organic coffee farmers and their cooperative structures, coffee roasters and importers, scientific researchers, data systems experts and development organizations in order to achieve mutually beneficial, supply-chain collaboration. Supporting coffee farmer's capacity to: track and understand the environmental impact of their production practices; promote best organic practices for climate resiliency and healthy production; and, encourage coffee consumers, roasters and importers to pay a "carbon premium" back to the farmer for the environmental services rendered – allows the entire supply chain to assume its respective responsibility for CO2 emissions and lean towards greater climate justice.
The Cool Farm Tool is a carbon calculator that helps identify the environmental impact of a farmer's land-use management choices – including plant types and densities, fertilization practices, residue management, water use, and on farm energy-use for processing and transportation. Meanwhile, tracking and reporting on a farmer's progress with the Cool Farm Tool, allows producer organizations to showcase their top-performing farmers as "climate-resiliency" innovators, and encourage further investment in their efforts.
CoopCoffees, a roaster/importer and project partner has already committed to offsetting its collective CO2 emissions as an incentive to coffee farmers and a potential model for the coffee industry at large.

534 OPTIMIZATION MODELS FOR SUSTAINABLE CITY PLANNING IN ECOSYSTEM PERSPECTIVE

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Complex urban realities need sustainable projects. This necessity requires investments aimed at increasing people's well-being, environmental quality and economic growth. In order to achieve them, an economic evaluation protocol defined with a multi-criteria logic is proposed. This consists in a multi-parametric geo-referenced analysis scheme to support the optimal allocation of financial resources available among alternative investment projects through ecosystem services. The assessment framework represents reference scheme for supporting decision-systems of public and / or private authorities in the assessment process on investment alternatives aimed to the cities' planning in ecosystem perspective. By placing in stakeholder's interests, ecosystem services values and design constraints, functional relationships among general objectives and sustainable indicators (of financial and economic type) are organized within optimization models of linear programming borrowed by Operational Research. The economic evaluation of urban ecosystem services is carried out by Night-time lights data as a proxy of socio-economic and environmental variables. This allows to describe a discrete-choice model for underlining most suitable areas to be selected according financial constraints (budget limit) and ecosystem-services targets to achieve. By this, optimal projects portfolio of investments for the sustainable development of the city can be derived.

FRW1 - Freshwater biodiversity crisis: horizon scanning of challenges and solutions

337 MONITORING MACROINVERTEBRATE COMMUNITIES AT LARGE SCALES USING EDNA SAMPLES

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Macroinvertebrates serve as key indicators in ecological assessments of aquatic ecosystems as the community composition informs about environmental and anthropogenic pressures on rivers. Established monitorings are costly, time-consuming and rely on expert knowledge. In contrast, the sampling of eDNA provides a cost and time efficient way to characterize aquatic communities over large spatial scales and ecological gradients. Here, we use a biomonitoring for macroinvertebrates over a large biogeographic gradient to compare the established kick-net method with two metabarcoding approaches (universal and specific primers). For this, we sampled macroinvertebrate communities and focused on the detection of Ephemeroptera, Plecoptera and Trichoptera at 92 river sites. Compared to the universal primers, the specific primers captured more species assigned to those three orders. On average, we detected significantly more species with eDNA than with kick-net sampling. Compared to the universal primers, the specific primers recovered more taxa assigned to species level, showed a larger overlap with kick-net data over all sites, and detected similar community turnover patterns between sampling sites like kick-net. Still, kick-net detected more distinct taxa, as eDNA in particular missed species with few counts or detected at few sites. Our study shows the importance of methodological choices to implement established and novel river biomonitorings along large environmental gradients.

358 THE ALLIANCE FOR FRESHWATER LIFE

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Global pressures on freshwater ecosystems are high and rising. Viewed primarily as a resource for humans, current land use and water management practice have led to catastrophic declines in freshwater species and the degradation of freshwater ecosystems, including their genetic and functional diversity. An improved understanding of all facets of freshwater biodiversity is required to inform better decision making and for establishing the socio-economic context for sustainable water management. Here we introduce the Alliance for Freshwater Life (AFL), a global initiative that seeks to unite specialists in research, data synthesis, conservation, education and outreach, and policymaking. The AFL aims to provide a common platform and the critical mass required for the effective representation of freshwater biodiversity at policy meetings, to develop solutions balancing the needs of development and conservation, and to better convey the important role freshwater ecosystems play in human well-being. We introduce examples of ongoing and future research aimed at developing tools and frameworks for better management, closing knowledge gaps about the distribution and status of freshwater

biodiversity, and identifying the necessary data and knowledge needed to balance human needs with sustaining freshwater biodiversity.

286 RECYCLING OF POTENTIAL WATER POLLUTANTS WITH BLACK SOLDIER FLY (BSF)

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Some of the main sources of freshwater pollution are manure from livestock farms, untreated wastewater, waste from fish farms, human feces, and food waste.
All of these substances can be used to make a variety of products. I have utilized this process in recycling vegetable waste, producing ecoptotein. Now we develop this process to increase the sustainability of the fishing industry in Kamchatka.
One promising method of recycling is feeding wastes to BSF. The result is the following products:
Live and frozen larva. Effective complementary food for chickens.
Dried larvae. Used as a food for poultry, pigs and fish.
BSF fat. Used in cosmetology and pharmaceuticals.
Protein concentrate. Used to prepare sports nutrition.
Fertilizers. Consisting of the waste products of larva, in addition to microelements, it contains large amounts of precursors of humic acids and beneficial microorganisms.
Chitosan. Obtained from puparia and dead imago, it is used for medical purposes.
Canned larva. Fed to insectivores, such as hedgehogs, spiders, scorpions, rodents, large fish and birds.
The production of the larva is an absolutely waste-free practice. BSF cannot disturb the ecosystem of European countries, Russia, or North America. The most important advantage is the high convertibility of waste to protein. In my experience, to obtain 1 kg of protein, it is required about 6 kg of feed.

488 FRAGMENTATION OF FRESHWATER FISH HABITAT DUE TO GLOBAL HYDROPOWER EXPANSION

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Dams contribute to water security, energy supply, and flood protection, but also fragment habitats of freshwater fishes, limiting their dispersal and movements to feeding and spawning grounds. Currently only 37% of rivers longer than 1,000 km remain free flowing and national plans and energy transition scenarios forecast a future increase in hydropower capacity, with potentially detrimental consequences for fishes. Here, we investigate the impact of hydropower expansion on freshwater fish habitat connectivity worldwide based on a dataset of ~11,500 lotic fish species. We use a global dataset of ~40,000 current dams as baseline and calculate future changes in fragmentation under different policy scenarios. We find that current levels of fragmentation are highest in the United States, Europe, South Africa, India, and China. Increases in fragmentation due to hydropower dams currently under construction or planned are especially high in the tropics, including the Amazon, Niger, Congo, Salween, and Mekong basins. Energy policy ambition levels highly influence the projections and will therefore play a crucial role in

limiting fragmentation. Finally, we prototype a tool to optimize tradeoffs between fragmentation and energy benefits for basin-level dams' portfolios. Such tool can guide strategic hydropower planning, identification of species and basins at risk, and prioritization of restoration measures, such as dam removal and construction/assessment of fish bypasses.

151 MODELLING EDNA TRANSPORT IN RIVERS REVEALS SPATIOTEMPORAL BIODIVERSITY PATTERNS

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The ever-increasing threats to riverine biodiversity call for the development of novel approaches for a complete assessment of biodiversity across spatial, temporal and taxonomic scales. Environmental DNA (eDNA) is a promising approach to this end, as it allows efficient and taxonomically broad biodiversity assessments. Moreover, when coupled with eDITH, a mechanistic model for eDNA transport in river networks, eDNA can uncover the full structure of biodiversity at an unprecedented spatial resolution, hence providing insights into ecosystem processes and sustaining targeted conservation measures. Here, we applied eDITH to an eDNA metabarcoding dataset covering three taxonomic groups (fish, invertebrates, bacteria) and three seasons (spring, summer, autumn) for a Swiss catchment, initially sampled at 73 sampling sites. Using the eDITH model, we upscaled biodiversity predictions to about 2000 individual reaches, allowing an assessment of patterns of alpha and beta diversity across seasons and taxonomic groups at a space-filling, fine scale over the whole network. We found that both alpha and beta diversity varied considerably depending on season and taxonomic group, and that stream size was generally a poor predictor of these patterns. Conversely, riverine biodiversity is shaped by a complex interplay of environmental variables, abiotic and biotic factors, which need be accounted for via mechanistic approaches such as eDITH for a correct assessment of its structure.

54 AQUATIC INSECT BIODIVERSITY IN KOSOVO: CHALLENGES AND SOLUTIONS

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Kosovo contains some reliable data on aquatic insects and the population status of the species inhabiting the country's freshwater ecosystems. There are 140 species of aquatic insects in Kosovo, according to the categories of the Kosovo Red Book on Fauna.
The challenges: land degradation, transformation, and contamination are causing a loss of aquatic insect diversity. The second major challenge is the current lack of sufficient collective political will and a lack of societal understanding of the importance of insect well-being for our well-being. Furthermore, biodiversity data collecting is disorganized, with most of it taking place in academic institutions or as part of a variety of short-term, internationally financed programs.
The solutions: new research and investigation in the field of the aquatic insect fauna, new legislation on protection of habitats and species in place, better communication of the value of insects, and inclusion of citizen science concept in Kosovo. Moreover, encouragement of the policymakers to give maximum attention to freshwater ecosystem conservation, insect conservationists need to liaise better with decision-makers and stakeholders at the conceptually familiar scale of the landscape towards saving insects. This means that we must communicate the importance of insect conservation much better, especially using the tools of insect conservation psychology, which includes the important and interrelated components of education and citizen science.

250 SPATIO-TEMPORAL PATTERNS OF BIODIVERSITY AND FOOD-WEBS ACROSS A CATCHMENT

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Accurate characterisation of ecological communities with respect to their biodiversity and foodweb structure is essential for conservation. However, combined empirical study of biodiversity and multi-trophic food webs at a large spatial and temporal resolution has been prohibited by the lack of appropriate access to such data from natural systems. Here, we assessed biodiversity and food-web characteristics across a 700 km^2 riverine network over seasons using environmental DNA. We found contrasting biodiversity patterns between major taxonomic groups; richness (α-diversity) with both statistically significantly increases and decreases towards downstream positions within the catchment for fish and bacteria respectively, but these trends were dependant on season, while invertebrate richness remained unchanged with increased downstream position. The local food web, formed by the same taxonomic groups, also showed a variation in their structure, e.g., link density and nestedness, to both space and time, but these patterns did not necessarily mirror those of biodiversity and functional feeding characteristics. In order to conserve species diversity in communities as well as their functional trophic integrity, we must study jointly patterns of biodiversity and food-web characteristics, as our results suggest that they are not directly scalable to each other even at the same spatial and temporal scales.

558 EFFECTS OF NUTRIENT ADDITION ON FRESHWATER SPECIES ASSEMBLAGES: A META-ANALYSIS

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Eutrophication has a significant impact on aquatic ecosystems worldwide. Although many local lab and field experiments have quantified these impacts, a systematic global synthesis of the effects of nutrient additions on freshwater species assemblages is still lacking. In this research, we performed a quantitative global meta-analysis to assess the response of freshwater species assemblages to nutrient additions in both rivers and lakes. We first carried out a systematic literature search in order to identify studies that report the abundance of invertebrate, macrophyte and fish taxa in relation to both nitrogen and phosphorus addition. Next, we established mixed effects meta-regression models to relate the biotic responses to nutrient addition. We quantified the responses based on various abundance-based metrics, including individual abundance, total abundance and evenness. We also included moderators that may modify biotic responses to nutrient addition. The results of our research will help to quantify and understand broad-scale responses of freshwater species and assemblages to eutrophication, as a key step to identify effective conservation strategies for freshwater ecosystems.

FRW2 - Research and implementation to restore and protect Blue-Green biodiversity

525 CLIMATE CHANGE SHIFTS THE TIMING OF NUTRITIONAL FLUX FROM AQUATIC INSECTS

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Organisms time reproduction with both seasonal changes in environmental conditions and the phenology of resources. While it is known that climate change has the potential to decouple resource supply from consumer demand, the underlying ecological mechanisms and fitness consequences of mismatch are not well understood. Here, we use long term records of aquatic and terrestrial insect abundances and egg-hatching times of multiple aerial insectivore species, to investigate mismatches between the availability of, and demand for nutrients that are crucial to developing offspring. We show that the phenologies of aquatic and terrestrial insects are asynchronous, and that their relative abundances drive the seasonal availability of omega-3 long-chain polyunsaturated fatty acids (n-3 LCPUFAs) for aerial insectivores. Aquatic insects, which have high n-3 LCPUFA content, reach peak biomass earlier in the breeding season than terrestrial insects, which are nearly devoid of these physiologically-vital fats. We also find that aquatic and terrestrial insect phenologies have advanced substantially faster those of aerial insectivores, shifting the seasonal availability of n-3 LCPUFAs for these rapidly-declining species of consumers. Furthermore, due to the fundamental differences in n-3 LCPUFA content between aquatic and terrestrial insects, phenological mismatches between aerial insectivores and aquatic insects cannot simply be offset by seasonal advancements in terrestrial insects.

577 UNRAVELLING FOOD WEBS IN AQUATIC-TERRESTRIAL SYSTEMS WITH STABLE ISOTOPES

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Biotic interactions, i.e. in food webs, contribute substantially to energy fluxes in aquatic and terrestrial ecosystems and are important drivers of biodiversity. However, food webs are strongly influenced by anthropogenic climate change and land use. These factors do not just influence the species composition of ecosystems, but also how species interact with each other. Moreover, aquatic and terrestrial systems likely react differently to climate change and land use, but are generally studied in isolation from each other. Moreover, aquatic and terrestrial ecosystems are often highly connected with each other, e.g. aquatic insects providing important food sources for terrestrial species and terrestrial systems providing subsidies for aquatic systems, e.g. by leaf litter input. During this research project, leaf litter-based food webs in terrestrial, aquatic and interconnected

systems will be studied in natural and managed Swiss forests at different altitudes using field sampling combined with mesocosm experiments. Food webs will be analysed using bulk and compound-specific stable isotope as well as fatty acid analysis to determine how these terrestrial and aquatic systems are connected with each other and how they are affected by climate change and management. Ultimately, this research project will provide novel insight into the effects of climate change and land management on aquatic, terrestrial and interconnected food webs.

FRW3 - The role of coordination and harmonization for detection of trends in freshwater biodiversity at a global scale

529 CHALLENGES IN FRESHWATER BIODIVERSITY: THE CASE OF DATA PUBLISHING

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Species distribution data are crucial for understanding biodiversity dynamics and the underlying drivers. This is especially the case for freshwaters, which are among the most endangered ecosystems globally. However, a huge body of data gathered by scientists and water managers is currently difficult to access as systematic data publishing practices have not been fully adopted yet and data embedded in scientific papers and research project websites are often challenging to extract, while – at the same time – data and knowledge generated through publicly-funded research or monitoring programmes are considered a common good.
The Freshwater Information Platform (FIP) aims at pooling freshwater related research information from multiple projects and initiatives to make it easily accessible for scientists, water managers, conservationists and the interested public. The FIP consists of several major components, three of which form its "data publication unit". We present the FIP as a tool to support open access freshwater data publication, arguing it will improve the capacity to protect and manage freshwater biodiversity in the face of global change. We further focus on the linkages to and cooperation with other global initiatives in the field like Freshwater BON and the Alliance for Freshwater Life as well as on actions to support the Freshwater Network of GBIF.

FRW4 - The importance of being small: biodiversity conservation in ponds and other small freshwater systems

108 IT'S JUST A DITCH… OR IS IT? ECOSYSTEM SERVICE PROVISIONING IN AGRO-LANDSCAPES

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Suitably managed, ditches and riparian strips can represent biodiversity hotspots within increasingly homogenous and depauperate agroecosystems, hosting rich communities of plants, macroinvertebrates, fish and riparian wildlife. With agricultural intensification and extensification increasing and climate change modifying agroecosystems globally, it is imperative that agro-landscapes are carefully managed to avoid exacerbating ecosystem service losses and the associated degradation of ecosystem functioning. Agricultural water extraction, storage behind dams, diversions, dredging and clearing of riparian vegetation can impact more naturalized flow regimes. We explore the influence of managed low flows on ecosystem functioning in human-made drainage/irrigation ditch systems situated in agricultural watersheds with fragmented natural capital. We also highlight a case study of an agriculturally-dominated watershed that is the focus of the Environmental Change Onehealth Observatory (ECO^2), a Canadian federal interdepartmental project to study consequences of erosion of natural capital and associated ecosystem services on: 1. Biodiversity; 2.[Re]emergence of infectious diseases of importance to human health; and 3.[Re]emergence of infectious diseases of importance to livestock health, with the aim to find a balance between providing food and other commodities which support the well-being of Canadians with the need to provide increased biosphere stewardship.

GOV1 - The influence of environmental, social and governance (ESG) reporting on investors' decisions - is this an alternative, effective way to achieve biodiversity conservation goals? & Building back better in the post-COVID era: Locking in insights for sustainable ocean governance

62 THINKING AND ACTING IN A DISRUPTED WORLD: GOVERNANCE, ENVIRONMENT AND PEOPLE

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Problems are defined and dealt with in view of the "general phenomenon", not reduced to particularities, fragmented issues, academic formats or segmented public policies. Scientific reports rarely reach the highest levels of decision unscathed, decision makers tend to meet the interests of political and economic groups. Information and technical

aspects of "how to do it", fails to engage policy-makers and or the general public. Changing the paradigms of development, growth, power, wealth and freedom, embedded in political, technological, economic and educational institutions, depend on institutional capacity, judicial impartiality, information transparency, and social spaces for citizen participation and enlightened political decisions, in view of accountability, transparency, Impact and results. Inclusive, ecosystem and transformative actions can originate in social and cultural niches of learning, both in academia and in society at large. Ethical aspects should be considered, but changes depend on the adoption of new ways of being in the world. The process encompasses the mutual support of four dimensions: the intimate (personal world); interactive (group allegiances); social (politics and economics); and biophysics (environmental conditions). There is a synergy between all of these dimensions: they can amalgamate around common goals (ecosystems), or they can antagonize each other (disorder and chaos). Earth's and humanity's recovery are addressed as complementary aspects.

571 WIND ENERGY-LAND USE-BIODIVERSITY NEXUS STATUS IN NORTH AFRICA: CASE OF TUNISIA

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Climate change is one of the most critical challenges of our society due to its adverse impact on the earth's ecosystem and on the world economy. Improving energy system efficiencies and encouraging the expansion of renewable energy has become exceedingly important for climate protection. Tunisia has started to diversify its energy mix and to devise ambitious renewable energy plans to meet its growing energy demand in the future while contributing to climate protection. Wind energy, as a component of the green transition, has been given a lot of attention since the last two decades, and currently, wind energy increasing deployment, biodiversity conservation, and land take nexus are emerging.In this intervention, we analyze the tradeoffs of the different mentioned components (wind energy-land use-biodiversity) in the updated RE policy framework and identify opportunities for improvements for a sustainable expansion of Wind farms in Tunisia.

290 REVIEW OF THE EFFECTS OF PPES ON BIODIVERSITY PRODUCTIVITY IN THE OCEAN

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The advent of COVID-19 has amplified the presence of single-use plastic pollutants in the ocean. In Africa for instance, plastic wastes such as personal protective equipment are disposed of indiscriminately into the environment which when washed into the ocean, can create environmental problems and low fisheries yield. Single-use PPEs production and accumulation in the aquatic environment are occurring at alarming rates due to

inadequate recycling, poor disposal in landfills and indiscriminate use. It is estimated globally that about 129 billion facemasks and 65 billion gloves are used each month contributing to the widespread environmental contamination. This study analyzed and discussed the effects of plastic wastes (PPE) on the biodiversity of aquatic environments (ocean) vis a vis the management of PPEs across the globe. A systematic review was conducted to achieve this objective. The studies reviewed showed that single-use PPEs have the potentials to release pathogenic microorganisms, harmful chemicals, heavy metals, and toxic substances into the environment and thus can have negative impacts on biodiversity and seafood security. In order to limit the identified negative effects, regulating the use of single-use PPEs and promoting reusable masks should be encouraged. Educating and empowering coastal communities to act collectively to minimize plastic pollution (PPEs) is also a recommended measure for the protection of ocean resources.
Keywords: Biodiversity

MOD1 - Spatiotemporal Scales and Novel Methods in Modelling Biodiversity at a Landscape Level

184 TOO MANY CANDIDATES: NEW COVARIATE SELECTION METHOD FOR MODELLING BIODIVERSITY

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As earth observation data are made available at an unprecedented rate, species distribution modelers are increasingly challenged by high-dimensional spaces of candidate covariates to define realistic niches. In the context of a Swiss-wide biodiversity modelling effort, our goal was to develop a covariate selection method aimed at optimizing the predictive abilities and parsimony of species distribution models fitted in a situation of numerous candidate covariates. Combining a collinearity filtering algorithm and model-specific regularization techniques, we devised an innovative "embedded" covariate selection method to select for each of 70 test species the best subset of a panel of 104 candidate covariates. Using model scores derived from three modelling algorithms (GLM, GAM and RF), the value of the proposed embedded covariate selection method was assessed relative to alternative "filter" and "random" methods. Overall, the embedded method accounted for about 90% of the top models. Mean AUC' (TSS) value obtained under this method was 0.05 (0.04) and 0.11 (0.09) units greater than the filter and random ones, respectively. The performance of the embedded method was not affected by the characteristics of the species data (number of records, spatial coverage, organism mobility and size). We encourage future species distribution modelling studies facing the same challenging context of high dimensional candidate covariate spaces to use this method.

243 INTEGRATION OF ECOLOGICAL PROCESSES IN SPATIAL CONSERVATION PRIORITIZATION

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Protected areas are one of the main spatial tools to safeguard biodiversity globally, however they are often designed without taking into consideration ecological processes. We apply a recently developed R package for a spatially-explicit mechanistic simulation model (RangeShiftR), which incorporates habitat suitability, demographic as well as dispersal processes to identify priority regions to cover species abundance and source-sink dynamics to understand if current protected areas cover such regions. Our approach is innovative in designing priority conservation regions taking into consideration ecological processes that can sustain biodiversity in the long-term. We apply this approach to a case-study with South-Asian mammals.

MOD2 - A Model for Life: Toward a universal biodiversity projection platform (by invitation only)

451 INVASIVE SPECIES CONTROL THROUGH REINFORCEMENT LEARNING

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Spatial processes characterise many management problems in ecology, epidemiology and conservation. For instance, determining where to act in a network in order to minimise the spread of a disease, or where to restore habitats in order to maximise the abundance of an endangered species are fundamentally spatial in nature. Searching for the optimal strategy has often been done through structured decision making. However, most of traditional approaches reach their limit when handling complex spatial processes, as they lack the ability to scale with the size of the environment. Here we utilise Reinforcement Learning, which has the potential to generalise across both large state spaces and large action spaces, thanks to Deep Neural Networks as function approximators. We illustrate the power of this method by modelling the control of an invasive species in a homogenous landscape. By varying the species' growth rate and dispersal rate, we analyse how the number of actions required for eradication vary accordingly. We then proceed to offer a perspective on how these methods can be utilised for wider applications, such as a decision making tool within a biodiversity modelling platform. Finally, we highlight some considerations for incorporating artificial intelligence techniques in such large scale projects.

185 TOWARDS A REFERENCE PLATFORM FOR BIODIVERSITY MODELLING IN SWITZERLAND

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Within the Biodiversity Strategy and Action Plan framework, the Federal Office for the Environment (FOEN) mandated the ValPar.ch and Swiss Catchment projects to model and map Swiss biodiversity. Because of its national scope, this task opened the opportunity to develop a reference platform for spatial modelling of species distribution. The development of the modelling tool, hereafter called "pipeline", is supervised by a group of biodiversity modelling experts. Integrating statistical and geomatic operations, the pipeline is a computer code developed in R allowing for the semi-automated production of thousands of species models and maps at a 25-meter spatial resolution. To achieve this, the pipeline uses a new set of > 5,000 environmental covariates and integrates cutting-edge species distribution modelling methods. Among several more, these methods include: an embedded covariate selection procedure, multiscale nesting options for tackling niche truncation, an algorithm-specific grid search for identifying optimal model parameters and the ensemble of small models approach. An effort has been made to make the pipeline flexible (plenty of customizable options), participative (new modules can be patched), and user-friendly (runnable with one csv file). The approval of the pipeline by the national biodiversity modelling expert group makes it a promising tool to become the reference platform for biodiversity modelling in Switzerland, in partnership with InfoSpecies and the FOEN.

475 BIODIVERSITY RESPONSES TO CLIMATE CHANGE AND LAND USE IN THE TROPICS

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A universal biodiversity projection platform requires an understanding of biodiversity responses to major pressures across all world regions. Yet, biodiversity data are biased towards North America and Western Europe. I will present recent work demonstrating that biodiversity responses to climate change and land use, and crucially the interaction between these pressures, are stronger in the under-studied tropics than elsewhere. Further, tropical species are more likely to have traits that render them more sensitive to environmental pressures, and we have shown that functional diversity is affected more negatively by human land-use modification in the tropics than elsewhere, with potentially important consequences for ecosystem functioning. Overall, our results highlight an urgent need to fill biodiversity data gaps in tropical regions, and to understand better how biodiversity is responding to environmental pressures across world regions.

MOD3 - Connecting Science to Action: Inspiring Ordinary Citizens to Become a Positive Environmental Force

53 AUGMENTING SDG 11 IMPLEMENTATION AND BIODIVERSITY FINANCING THROUGH INNOVATION

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Africa is one of the least studied regions in terms of biodiversity dynamics and climate variability hence lacks strategies to protect and sustainably utilise forest resources for

national development. This therefore means that the implementation of Sustainable Development Goal 11 (sustainable cities) could be the hardest to achieve in Africa. Social innovation (SI) practices can promote socio-economic development by bringing about changes in the way social agents act and interact with each other through the creation of new institutions and new social systems. The United Nations One Planet Sustainable Lifestyles and Education Programme piloted the "Polycentric Infrastructure and Community Development Paradigm for Sustainable Urban Transitions (PICD-SUT)" framework in Malawi in order to demonstrate how SI can augment sustainable livelihoods and mobilise biodiversity finance. This exploratory study aims to expound on how the implementation of the PICD-SUT framework can enable African cities to utilise SI as a strategy to reduce biodiversity loss and improve forestry sector financing. The paper concluded that cities in Africa can augment sustainable development and climate change resilience by mainstreaming transformative biodiversity management policies that incorporate SI strategies as a means for enhancing partnerships and technology transfers as this can reduce biodiversity loss through improved collaboration between urban dwellers, rural communities and non-state actors.

MOD4 - Challenges and opportunities for using the IPBES Nature Futures Framework for scenarios and modelling to identify transformative pathways for biodiversity and people

527 A PLURALISTIC NATURE FUTURES FRAMEWORK FOR POLICY AND ACTION

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The Nature Futures Framework (NFF) is a new tool developed to catalyze the development of qualitative and quantitative scenarios of positive futures for nature. This new framework places nature at the center of the development of future scenarios, and is a substantial departure from conventional approaches to scenario development. The NFF represents the different ways in which nature and its contributions to people are perceived and valued. These values can be envisioned in a triangular framework with three 'corners', each representing a different perspective on human relationships with nature: 1) instrumental or material benefits of nature (Nature for Society); 2) intrinsic values of nature, including the diversity of species, habitats, and ecosystems that form and sustain the natural world (Nature for Nature), and 3) relational values where humans are an integral part of natural systems, and societies, cultures, traditions and faiths are intricately intertwined with nature (Nature as Culture). The NFF allows for translation of the framework into a diverse range of nature-centered scenarios, each representing a particular location within the triangle (including midpoints between corners). The NFF embraces pluralism and inclusivity in knowledge systems and worldviews to chart different paths to desirable futures for people and nature to support the transformational change necessary to achieve the 2050 Vision for Biodiversity.

497 ADAPTING THE NFF TO PROTECT THE FUTURE OF EUROPEAN VERTEBRATE TROPHIC NETWORKS

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Ambitious biodiversity and environmental targets have been set at both international and regional levels, notably under the Convention on Biological Diversity's (CBD) post-2020 targets, and the European Union's Green Deal. In the FutureWeb project, we aimed at understanding how future climate and land use changes will impact vertebrate species and diversity while accounting for their trophic interactions and dispersal abilities, and how conservation options can mitigate those impacts.
First, we harnessed biological data, developed new climate scenarios and then mapped the European landscape changes required to ensure that land based environmental targets can be met under different socio-economic and climate change scenarios.
Then, using a newly developed trophic species distribution model, we forecasted vertebrate trophic networks and associated metrics across space in Europe and according to a range of climate and land use change scenarios by 2050 and 2080. By implementing a range of plausible futures following three primary perspectives that capture people's relations to nature, we show how vertebrate species distributions, interactions and overall local network properties could be maintained through a coherent and resilient trans-national protected area system.

468 MODELLING A LANDSCAPE USING NATURE FUTURES FRAMEWORK: A CASE STUDY IN JAPAN

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Future scenario analysis that recognizes the plural values of biodiversity is effective to bend the curve of biodiversity decline. This study conducted a quantitative scenario analysis combining the Nature Futures Framework (NFF) and process-based landscape model LANDIS-II at the Bekambeushi River Watershed in northern Japan.
The BaU was set by referring to the recent trend of forestry and agricultural management. Three desirable scenarios, NC (Nature-as-Culture), NN (Nature-for-Nature), and NS (Nature-for-Society), were designed based on questionnaire surveys to stakeholders and local administrative plans. Landscape changes for each case were simulated with the LANDIS-II from 2015 to 2100. The both common and scenario-specific biodiversity indicators were evaluated. The common indicators focused on fundamental landscape characteristics. The scenario-specific indicators were introduced by considering the value perspectives represented by each corner of the NFF.
In the NN scenario, both forest and pasture areas were abandoned and rewilded. In the NS scenario, the forest management was continued to produce timbers by intensive selective logging, and the pastureland abandonment was slowly progressed and converted for solar PV installation. In the NC scenario, the forest and pastureland, which shape the identity of residents, were managed even in 2100. Through this scenario exercise, we identified and discussed the challenges to operationalize the NFF on the local landscape.

604 ECOSYSTEM STRUCTURE, FUNCTION AND HUMAN PRESSURE ON NIGERIAN PROTECTED AREAS

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Focus on ecosystem restoration during this current decade (2021-2030) hints at the sheer extent of degraded natural and managed ecosystems across all biomes and agro-ecologies. Why and how ecosystems degrade in areas of land persistence are still not well known as in areas of land transitions. Drawn indicators from the IPBES Nature Futures Framework and GEOBON Essential Biodiversity Variables were selected to be cross-cutting and relevant for Land Degradation Neutrality SDG 15), biodiversity and climate change.
We examine changes to ecosystem structure and functions as well as human pressures on protected areas — PAs in Nigeria. Nigeria, a vast agroecological diverse country, presents an opportunity to consider the interlinkages between natural and human systems of smallholder farming regions in tropical rainforest and dryland contexts. Persistent and change patterns of seven land categories were related to changing vegetation conditions. Analysis of changes in the indicators was conducted across scales (that is, by land-use type, agro-ecological zones, protected area and site-based). These differentiated analyses provided insights on changes to ecosystem structure and functions at multiscale. That detected breakpoints occurred only at sites of decline provided insights into ecosystem degradation processes. The decline in forest loss areas was 2.5-fold that of persistent forests, whereas persistent wetlands were 3-fold that of loss areas, particularly in protected areas.

MOD5 - Models and scenarios for biodiversity & ES at regional to global scales

425 THREATS OF GLOBAL WARMING TO THE WORLD'S FRESHWATER FISHES

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Climate change poses a significant threat to global biodiversity. Whilst freshwater fishes have been largely ignored in climate change assessments, they are set to experience adverse effects given their dependence on flow and water temperature regimes. Here, we develop and apply a new model to assess threats of future flow and water temperature extremes to ~11,500 riverine fish species at different global warming levels. We find that in a 3.2°C warmer world (no further emission cuts after current governments' pledges for 2030), 36% of the species have over half of their present-day geographic range exposed to climatic extremes beyond current levels. Threats are largest in tropical and sub-arid regions, and increases in maximum water temperature are more threatening than changes in flow extremes. In comparison, 9% of the species are projected to have more than half of their present-day geographic range threatened in a 2°C warmer world, which further reduces to 4% of the species if warming is limited to 1.5°C. Our results thus highlight the need to limit global warming if freshwater biodiversity is to be safeguarded.

We further showcase how our results can be integrated into sustainability assessment tools like life cycle assessment to inform policy makers and global supply chain managers about the potential impacts of carbon-intensive processes or products on freshwater fish diversity.

365 BIODIVERSITY FOOTPRINTS OF NITROGEN EMISSIONS

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Addressing biodiversity loss requires understanding not only of the pressures directly affecting biodiversity, but also the indirect drivers behind these pressures. Footprint analysis reveal the impacts associated with consumption patterns and the role of international trade in enabling the disconnection between the place where the impacts occur and the places where their indirect drivers take place. So far, most of the biodiversity footprint studies focused on analyzing the indirect drivers of biodiversity impacts from land use and climate change. Here, we present for the first time a global analysis of the biodiversity footprints of nitrogen emissions, more specifically from NH3 and NOx. In this work, we start by applying the GLOBIO model to quantify the biodiversity impacts from nitrogen deposition at the global level, next we link the biodiversity impacts to a multi-regional input-output model to quantify the biodiversity footprints of nitrogen emissions. Footprint analysis allow not only developing demand-side conservation measures, but also mainstreaming biodiversity into economic sectors and therefore enabling more targeted conservation strategies.

559 REFINING THE BIODIVERSITY INTACTNESS INDEX TO BETTER REFLECT HUMAN IMPACTS

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The Biodiversity Intactness Index (BII) is an estimate of the average fraction of naturally-present biodiversity that a region's ecosystems have retained in the face of human impacts. Because intact ecosystems deliver more ecosystem functionality with greater resilience to people living locally, BII is an excellent choice for the Nature Futures Framework. BII also places all countries relative to a fair baseline – a pristine state – meaning that it captures historical as well as recent biodiversity loss. Lastly, because it relates biodiversity to land-management decisions, it is also useful to businesses wishing to become nature-positive. The first global map of BII, which we published in 2016, showed that the proposed Planetary Boundary (an average of 90%) had already been crossed, but various conceptual and statistical issues meant it was nonetheless overoptimistic. In this talk, we present a refined formulation of BII that better reflects changes in community composition; refined statistical models (based on an expanded database) that incorporate effects of landscape-scale drivers and landscape history as well as site-level drivers; and projections showing how the map of BII has changed and may change in future. The Natural History Museum's Biodiversity Trends Explorer summarises the status and temporal trends of BII for each country and region.

407 THREATS OF LAND USE TO THE GLOBAL DIVERSITY OF VASCULAR PLANTS

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Land use is considered a main driver of biodiversity loss worldwide. However, quantifying its effects on global plant diversity remains a challenge due to incomplete data. We estimate threats of land use to global vascular plant species diversity based on a novel integration of local observational data of plant assemblages in relation to land use, a global land use map, and species point-occurrence data. First, we assess plant species loss per ecoregion using a countryside species-area relationship model. Next, we estimate the contribution of each ecoregion to global species extinction based on the extinction estimate per ecoregion and the beta diversity among the ecoregions, quantified based on the occurrence records. We estimate that around 11% of vascular plant species are threatened with global extinction. Further, 88% of the ecoregions contain at least one species threatened with global extinction. We found the highest number of global extinctions in the Neotropic and Palearctic realms. In these regions, cropland and intensively used pasture contribute most to the global extinction threat. Our spatially explicit approach allows identifying hotspots of global extinction threat, as well as the contribution of specific land types to this threat, which in turn may inform the development of measures to protect or restore plant diversity globally.

484 BIODIVERSITY MODELS TO INFORM SUSTAINABLE AGRICULTURAL POLICIES AND PRACTICES

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Models can be used to provide important information on the impacts of agricultural policies and practices on biodiversity. But for this information to be useful for private industry or policymakers it needs to provide details beyond many global models such as the differing impacts of specific crop types, management techniques, etc. Here we present an analysis of how agriculture is impacting biodiversity across the globe using the PREDICTS modelling framework. We show the impacts of different crop types and management techniques on the Biodiversity Intactness Index. We discuss how these results can be used to inform sustainable management at the site level, sourcing decisions at the corporate level, and spatial planning and policy decisions at the national level. We examine how the model results can be integrated with scenario outputs to estimate future prospects for biodiversity and to provide guidance on sustainable pathways. We present these models as a step towards understanding how to balance human needs with those of nature, but show where crucial biodiversity data is lacking and discuss the difficulties in matching biodiversity models with scenario outputs.

MON1 - Scaling up terrestrial biodiversity monitoring - needs, challenges and opportunities

126 TOWARDS TRAINABLE BIOHYBRID SENSORS VIA OSTRACOD-MICROFLUIDICS INTERFACE

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Miniaturised analytical systems are a recent technology milestone which is showing growing interest in aquatic ecology, although this technology has not been exploited to study cognitive behaviours of organisms in aquatic micro-environments. These engineered systems can be useful for testing and modulating behavioural models in artificial microenvironments, allowing to investigate hypotheses about ecological mechanisms and interactions with environmental cues that impact on biodiversity. Herein, a miniaturised testing arena was developed to investigate information processes and learning of Heterocypris incongruens, a freshwater ostracod relevant as bioindicator of environmental conditions. After dedicated training phases, a microchannel-based caging system enabled to unveil the ability of H. incongruens in associating light stimuli with food and stress sources, indicating its ability in exploiting light cues through translucent valves to increase its fitness.
Information on ostracods learning ability can be exploited to produce a new paradigm of complex integrated biosensors with "collaborative" trained bioindicators for environmental monitoring. These findings represent the first evidence of such complex cognitive processes in Ostracoda paving the way to new research directions for Lab-on-a-Chip systems, focused on behavioural ecology, as well as to the development of novel biohybrid systems for biomonitoring tasks.

203 GLOBAL FOREST CANOPY HEIGHT AND DENSITY RELATIONSHIPS FROM SPACEBORNE LIDAR

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Forest structure is a useful proxy for carbon stocks, ecosystem function and species diversity, but it is not well characterised globally. Earth observing sensors, operating in various modes, can provide information on different components of forests enabling improved understanding of their structure and variations thereof. The Ice Cloud and Elevation Satellite (ICESat) Geoscience Laser Altimeter System (GLAS), providing LiDAR footprints from 2003-2009 with close to global coverage, can be used to capture elements of forest structure. Here we evaluate a simple allometric model that relates global forest canopy height (RH100) and canopy density measurements to explain spatial patterns of forest structural properties. The GLA14 data product (version 34) was applied across subdivisions of the World Wildlife Federation ecoregions and their statistical properties were investigated. The allometric model was found to correspond to the ICESat GLAS metrics (median MSE: 0.028; inter-quartile range of MSE: 0.022-0.035). The relationship between canopy height and density was found to vary across biomes, realms and ecoregions, with denser forest regions displaying a greater increase in canopy density values with canopy height, compared to sparser or temperate forests. The combination of the single parameter of the allometric model, maximum canopy density and maximum canopy height values can inform on both species and niche diversity, highlighting areas for conservation.

265 MONITORING CONFIGURATOR: BIODIVERSITY ASSESSMENTS IN PROTECTED AREAS

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Protected area (PA) networks are key for global biodiversity conservation. While the numbers of PAs are increasing, their effectiveness in halting ongoing biodiversity losses has been limited. A fundamental approach to guide decision-making in PAs is to conduct monitoring to inform adaptive management. Alongside traditional field collection methods, new and emerging biodiversity monitoring technologies are becoming widely used as tools for decision-making. The increasing numbers of currently available methods and techniques makes it difficult for non-experts to stay up-to-date and prepared to design and implement adequate biodiversity monitoring systems in PAs. Nevertheless, such effort is highly needed as innovative technologies provide new ways to make monitoring more efficient in space and time. For this reason, we currently design a monitoring configurator, which identifies appropriate methods, tools and techniques in an appropriate work flow for different monitoring purposes and different types of PAs. Our focus emphasizes free and open-source tools. The backbone of the configurator is a tool catalog, where biodiversity monitoring tools are structured in a standardized way. Designed mainly for biodiversity practitioners, the monitoring configurator should support selection of appropriate tools for biodiversity monitoring and improve quality and quantity of biodiversity data sets in PAs.

MON2 - Detecting and attributing biodiversity change: linking essential variables to indicators and goals

342 ECOSYSTEM EXTENT ACCOUNTING OF BIODIVERSITY AT FEDERAL LEVEL

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The performance of ecosystems for the conservation of biodiversity should become a part of the national accounting, according to SEEA-EA. A monitoring of spatially explicit ecosystem balances allows to indicate quality losses and to justify conclusions to ensure sustainable land use.
As essential variable representing the state and performance of ecosystems, a biodiversity area indicator is presented here. The indicator uses a hierarchical ecosystem classification, according to CORINE Land Cover. The spatial extension and change of ecosystems are regularly monitored nationwide for Germany. For this purpose, a combination of repeatedly available high-resolution land cover data with non-area specific data was defined. This combination allows a comparative assessment of the ecosystem inventory regarding both area and quality. The proposed indicator uses biotope value points from the German federal compensation guideline. Ecosystem types derived from the land cover model are specified by EU reporting such as NATURA 2000, Water-Framework Directive and High Nature Value Farmland as well as by the German Federal Forest Inventory.
In addition to the assessment by biotope value points, a monetary evaluation is carried out. It consists of comparable average costs for the restoration of a single biotope value point. This economic calculation step uses the data of a detailed habitat-related cost estimates of the nature conservation agencies working group for NATURA 2000 implementation.

582 CLIMATE DATA MACROECOLOGISTS – FROM SOLAR RADIATION TO SITE WATER BALANCE

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In macroecological analyses climate is commonly described by seasonal and annual statistics of precipitation and temperature, although there is consensus on the importance of further climatic conditions such as evaporation or solar radiation. One important cause for this mismatch is the lack of available data. Here, we make freely available a global time series and climatologies of solar radiation, vapor pressure deficit (VPD), potential evapotranspiration (PET) and site water balance (SWB) at biologically meaningful and yet unprecedented spatiotemporal resolution (monthly, 30 arcsec). Building on the CHELSA-approach to mechanistically downscale of ERA5 reanalysis outputs, we use the physically realistic Penman-Monteith equation to calculate PET and combine it with information on precipitation and available soil water content to calculate SWB. The resulting time-series data from 1980 to 2018 demonstrates marked trends in most factors, for example an increase in VPD, although distinct differences exist between biomes. First comparisons with independent test data from field stations indicate that the layers generated are of decent accuracy. We envision that this set of climate data can substantially contribute to understand the distributions of species, especially for plants and in remote regions with few weather stations.

511 DIVERSITY OF DESERT VEGETATION OF SINAI, EGYPT

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Despite that Sinai is a global hotspot for desert vegetation, there is no comprehensive overview of the Sinai vegetation. Based on a large database and formal classification, we provide a phytosociological overview of Sinai desert vegetation.
From published literature and our field surveys, we created a comprehensive vegetation plot-database of the study area. The database clustering tendency was determined (Hopkins' test analysis) and the optimal number of clusters was estimated (Elbow method). We ran modified TWINSPAN analysis and used the Silhouette algorithm to improve the validity of the resulting groups.
We divided the Sinai desert vegetation into nine classes: Salicornietea fruticosae, Retametea raetam, Haloxylonetea salicornici, Retamo-Tamaricetea fluviatilis, Acacietea tortilis, Artemisietea herbae-albae, Anabasietea articulatae, Chiliadenetea iphionoidis, and Stellarietea mediae. We identified 25 vegetation groups, seven of which are new, representing the four major vegetation groups: salt desert, lowland desert, mountain desert, and ruderal desert. Therophytes and chamaephytes are the dominant life forms. The Saharo-Arabian, Mediterranean, Mediterranean-Irano-Turanian, and Irano-Turanian-Saharo-Arabian chorotypes are the most common. The vegetation of the salt desert and lowland deserts is species-poor, whereas the vegetation of the mountain deserts is relatively species-rich. The species diversity is greatest in the ruderal desert vegetation.

190 ASSESSING THE POTENTIAL OF ALIEN TREE SPECIES FOR REGIONAL FOREST RESTORATION

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Although considering alien species as a tool for natural forest restoration still remains controversial, harnessing alien species when they are already present in an ecosystem might result in overall benefits for nature and society. In this study we evaluated whether the presence of an alien tree species supports or hinders the establishment of naturally regenerating forests in Shiretoko National Park, Japan. We focused on Larix kaempferi, which is widely present yet non-native to the region, and examined how this alien species affects two factors influencing the success of restoration: wind disturbance and deer herbivory. We examined the following effects of L. kaempferi plantations on natural regeneration: (1) the windbreak function for protecting native tree growth and (2) the nursery function to promote the regeneration of native tree saplings and seedlings under high herbivory pressure. Additionally, we tested the hypothesis that alien species act as nurse plants, facilitating the long-term restoration of naturally regenerating forests. Through remote sensing, vegetation inventory, and simulation modeling, we revealed the positive relationship between alien tree species and the regeneration of native tree assemblages. Especially when alien species have already established, the utilization of alien species as nurse plants could be an effective restoration tool at early stages of ecosystem recovery, with aliens mitigating environmental barriers for native species recovery.

394 COASTAL ESSENTIAL BIODIVERSITY VARIABLES FROM SATELLITE FOR SCIENCE AND POLICY

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The post-CBD agreements have set ocean biodiversity targets. To assess the progress on targets meeting those targets, they are linked to indicators measuring Essential Biodiversity Variables (EBV). Satellite remote sensing is proposed as a tool to complement in-situ observations. It can measure some EBVs in a more standardised and frequent manner and increase the spatial coverage and reduce lag between data collection and data availability to decision makers. We focus our analysis in definition of habitats through ocean colour satellites. However, to develop the appropriate products, we need to collect observation requirements from stakeholders.
We present the observation requirements of seven case study partners collected using semi-structured interviews for this process. Case study partners, who consist of managers and data providers to local environmental managers of sandy intertidal, subtidal seagrass and pelagic marine habitats. In addition to user-requirements definitions, we will present preliminary results from EBV relevant products, taking into consideration the complexities of optical remote sensing in the shallow coastal areas.

MON3 - From the species to the individual: investigating plant diversity on the scale that matters most

24 RESOLUTION IN SPECIES DISTRIBUTION MODELS SHAPES PATTERNS OF PLANT DIVERSITY

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Species distribution models (SDMs) are statistical tools that relate species observations to environmental conditions to predict species' potential geographic distributions. The quality of SDMs depends on good modelling practices including ascertaining the ecological relevance of predictors for the studied species and choosing an appropriate spatial resolution. There is still no consensus regarding how inappropriate resolution of predictors can impede understanding and mapping of multiple facets of diversity. Here, we modelled the distribution of 1'180 plant species across the European Alps for two sets of predictors (climate and soil) at resolutions ranging from 100 m to 40 km. We assessed predictors' importance for each resolution, calculated taxonomic (TD), phylogenetic (PD) and functional diversity (FD) accordingly, and compared the resulting diversities across space. In accordance with previous studies, we found the predictive performance to generally decrease with decreasing predictor resolution. Overall, multifaceted diversity was found to be strongly affected by resolution as exhibited by weak to average linear relationships between 100 m and 1 km ($0.13 \leq R^2 \leq 0.57$). Our results demonstrate the necessity of using highly-resolved predictors to explain and predict sessile species distributions. Using coarser resolution might cause multifaceted diversity to be strongly mispredicted, with important consequences for biodiversity management and conservation.

334 REMOTELY SENSED FOREST FUNCTIONAL TRAITS: DOES THE INDIVIDUAL TREE MATTER?

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Trait-based approaches have been increasingly used in plant ecology and biodiversity research. Compared with traditional labor-intensive forest surveys (often tree-based), remote sensing provides an efficient way to measure functional traits over large areas. Remotely sensed traits are typically computed at pixel level (composites of individuals and species), leading to continuous maps at medium to high resolution. Recent advances in LiDAR and high-resolution imagery allow mapping functional traits for millions of individual tree crowns (ITC) at large scales with spatially explicit data. We used two approaches to estimate functional traits in a subtropical forest and compared trait distributions, trait–trait relationships and functional diversity patterns derived from ITCs and pixels at changing grain and extent. We found that LiDAR-derived morphological traits showed more differences between individual tree- and pixel-based approaches than hyperspectral reflectance-based physiological traits and less variance in traits could be captured with increasing pixel size. The similar spatial patterns of functional richness indicated functional diversity could be effectively assessed from traits at either ITC or pixel level if a suitable pixel size was chosen. We conclude that whether the ITC- or pixel-based approach is more suitable depends on the spatio-temporal resolution of the data

and whether the research focuses on species- or community-level functional trait ecology.

354 TRANSCRIPTOME DYNAMICS OF ENVIRONMENT REGULATED FLOWERING IN ASEASONAL TROPICS

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There are a large number of species in the tropics, which make a huge contribution to the biodiversity. It is very important to understand and predict the possible impact of climate change on them. Flowering is a key activity for plants to optimize their reproduction. This study attempted to understand the mechanism of environmental regulation of plant flowering, in order to deepen our understanding of how plants adapt to the environment changes in aseasonal tropics. The 3-year time course RNA-seq, flower phenotype, and meteorological data will be analyzed together to study intraspecies and interspecies flowering in south-east Asia, and a predictive model will be built. This study will offer a good example for community-wide ecological genomics and help to build a framework of molecular phenology.

MON4 - Radar-based approaches to monitoring the abundance, morphological diversity and movements of aerial taxa

329 TRACKING DESERT LOCUST SWARMS USING DUAL-POLARISATION WEATHER RADAR

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Desert locusts (Schistocerca gregaria) are the most dangerous of all migratory pest species globally; a typical 1 km^2 swarm eats as much food per day as ca. 35,000 people. The damage caused by locust swarms makes tracking their movements a matter of substantial public interest. Dual-polarisation weather radar may provide a novel tool for tracking locust movements. Radar signals respond not only to the presence of materials in the air column, but also to the size, shape and orientation of the objects detected; the large size and elongated shape of locusts, combined with their tendency to fly above ground vegetation in huge swarms containing many millions of individuals, makes them ideal subjects for radar detection. This talk will describe our successful efforts to detect, discriminate, and track airborne locusts in Oman and India during the desert locust outbreaks of 2018-2021, as part of the Bill and Melinda Gates Foundation "PestDAR" project. These methods provide an initial data analysis pipeline for the integration of locust detection into weather radar analysis. We also demonstrate that swarm characteristics can be extracted, including approximate area, density, and the speed and bearing of the swarm while in range of the radars. With a growing weather surveillance

radar network across regions of locust activity, we hope that these methods will be of use to the wider locust monitoring and mitigation community.

370 ESTIMATION OF BIRD SPECIES COMPOSITIONS IN WEATHER RADAR DATA BY CITIZEN SCIENCE

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Citizen science bird observation repositories established in the past 20 years have accumulated millions of entries of species-specific information across vast areas. These databases potentially hold a great trove of information for biodiversity monitoring studies. They can be used either as stand-alone data or as a complement for other research tools, e.g. in aeroecology. While several hundred publications have been written on a variety of topics based on bird checklists worldwide, unstructured non-checklist observations have received little attention in academia. In the present study we show the suitability of non-checklist count data to determine migration schedules for a set of 115 passerine and non-passerine bird species in Finland and how to pair these schedules with populations estimates and weather radar observations. We discuss challenges inherent to this type of data and present suitable processing steps to address human- and bird-induced effects in the data. The methodology is based on information collected by online bird portals by default, such as species, number of individuals and location, and is therefore suitable to be adopted for other repositories with unstructured bird observation data. The approach taps into an underrated long-term and large-scale data source that can be used in bird migration and related climate change research to depict changes in migration behaviour and phenology or as a complement to related studies based on breeding bird surveys.

MOU1 - Global mountain biodiversity

153 EXPLORING ITALIAN ALPINE WILDFLOWER HONEY: CRITICALITIES, DIVERSITY AND VALUE

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Honey is an important food and the result of interaction between bees as pollinators and the environment, and wildflower honey produced in the Italian Alps is the expression of the floristic biodiversity of these fragile habitats. Mountain beekeepers have recently reported great difficulty in producing this kind of honey. To explore the characteristics of alpine wildflower honey and its connections with the features of the local flora, the comparison among six different wildflower honeys produced the Alpine area of Vallecamonica was performed through different analytic techniques (as SPME-GC-MS, HPLC-Orbitrap) alongside the melissopalynological analysis and botanical definition of the production area. Even though the apiaries were placed in mountain grasslands stations rich in Alpine herbaceous species, the honey could be defined as rhododendron/raspberry unifloral or raspberry and rhododendron bifloral while the honey produced at the lowest altitude differed due to the presence of linden, heather, and chestnut. The non-compliance of the honey could be due to habitat (meadows and pastures) fragmentation,

but also to specific compounds involved in the plant-insect relationship, such as kynurenic acid, in the sample rich in chestnut pollen, or nicotinaldehyde, for which a high correlation with raspberry pollen was found. Alpine grasslands are disappearing, to protect these important habitats is crucial for both wild and "domesticated" mountain pollinators.

519 UPWARD RANGE SHIFT OF A DOMINANT ALPINE SHRUB RELATED TO SNOW COVER CHANGE

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Pronounced climate warming has resulted in a significant reduction of snow cover extent, as well as poleward and upslope shifts of shrubs in Arctic and alpine ecosystems. However, it is difficult to establish links between changes in snow cover and shrub distribution changes due to a lack of in situ and long-term snow records in relation to abundance shifts of shrubs at their leading and trailing edges. We used remote sensing to extract long-term changes in both snow cover and shrub distributions in the alpine tundra of the Changbai Mountains, Northeast China. First, we analyzed spatio-temporal changes in snow cover during the snowmelt period (April 1st to June 15th) over the past 54 years (1965–2019). Then, we analyzed distribution changes of the dominant evergreen alpine shrub, Rhododendron aureum, using 31 years (1988–2019) of Landsat NDVI archives. Finally, we tested the relationship between snowmelt date and the distribution of R. aureum. We found that the fraction cover of R. aureum experienced greater loss than gain in the last 30 years. R. aureum expanded at the leading edge, establishing in snow-rich habitats, yet retracted further at the trailing edge due to loss of snow habitats. We found that further advances in snowmelt dates would lead to the upward range shift of R. aureum in a warming climate. Our study highlights that long-term changes in snow cover due to climate change have already had marked impacts on plant species distributions in alpine ecosystems.

584 DIVERSITY, USES AND ECOSYSTEM SERVICES OF WEINMANNIA SPECIES ACROSS THE ANDES

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The genus Weinmannia belongs to the family Cunoniaceae, that is distributed in the Austral and Holotropical phytogeographical kingdoms. Weinmannia sect. Weinmannia can be found in the Andean region, and it comprises around 75 species of trees and shrubs, often dominant elements in high Andean forest. Even though these species are fundamental ecosystem services providers in Andean forests, there are several taxonomical issues in species delimitation that need to be addressed. The aim of this contribution is to illustrate the species diversity in the genus Weinmannia, known uses and ecosystem services provided to local communities. Three big morphological groups of species can be defined based on vegetative characters: simple leaved, pinnate leaved and auriculate leaved. In the simple leaved group, a redefinition of Weinmannia balbisiana and its allies is needed. Some authors recognize up to eight varieties of this species, and additionally most herbarium specimens do not resemble the Type. In the pinnate leaved group diffuse limits between species are common and finally many of the auriculate leaved species are now considered as possible hybrids. Among the known uses some practices such as wood fuel production, timber and bark extraction are threatening the species conservation. On the other hand, the widespread use of Weinmannia species

as melliferous plants in honey production and in ecological restoration projects ultimately contribute to the conservation of the species.

154 MOUNTAIN AGROBIODIVERSITY: POTATO LANDRACES OF LIGURIAN APPENNINES

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Potato (Solanum tuberosum L.) is an important food crop worldwide. This widespread diffusion determined a vast biodiversity, with several landraces created by natural and anthropic selection. The mountainous inland of Genoa (Italy) is a historical centre for potato cultivation, and landraces have been preserved in this area by farmers' associations, such as the Consorzio della Quarantina. This work aims to provide phytochemical and morphometric characterization of three potato landraces from this consortium (Quarantina Bianca, Quarantina Prugnona and Rubra Spes) by analysing their bio-agronomical performance at different elevations. The commercial cultivar Kennebec was used as a control. Only Quarantina Bianca did not present significant differences from Kennebec in the morphometric analysis. Significantly differences were observed in the main phytochemical parameters, as the content in ash, total flavonoids, total phenols, chlorogenic acid, caffeic acid, ferulic acid and radical scavenging activity. Only starch and solanine content were not statistically different. A remarkable result was a more consistent yield for all the varieties with the increase of elevation in the agronomical trials. The results indicate that Genovese landraces are a good choice to make use of marginal lands in the Genovese mountains and, in general, landraces could represent quality and sustainable food chains for mountain communities, contributing to a varied and more sustainable diet.

448 HISTORICAL SIGNATURES OF BIODIVERSITY ASSEMBLY IN THE EUROPEAN ALPS

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Quaternary climate fluctuations can affect biodiversity assembly through speciation in two non-mutually-exclusive ways: a glacial species pump, where isolation in glacial refugia accelerates allopatric speciation, and adaptive radiation during ice-free periods. Here we detected biogeographic and genetic signatures associated with both mechanisms in the generation of the European Alps biodiversity. Age distributions of endemic and widespread species within aquatic and terrestrial taxa (amphipods, fishes, amphibians, butterflies and flowering plants) revealed that endemic fish evolved only in lakes, are highly sympatric and mainly of Holocene age, consistent with adaptive radiation. Endemic

amphipods are ancient, suggesting preglacial radiation with limited range expansion and local Pleistocene survival, perhaps facilitated by a groundwater-dwelling lifestyle. Terrestrial endemics are mostly of Pleistocene age, and are thus more consistent with the glacial species pump. The lack of evidence for Holocene adaptive radiation in the terrestrial biome may be attributable to a faster range expansion of these taxa after glacial retreats, though fewer stable environments may also have contributed to differences between terrestrial areas and lakes. The high proportion of young, endemic species make the Alps vulnerable to climate change, but the mechanisms and consequences of species loss will likely differ between biomes because of their distinct histories.

292 FUNCTIONAL TRAITS OF CARABIDS (COLEOPTERA: CARABIDAE) ALONG AN ELEVATIONAL GRADIENT

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Ground beetles (Coleoptera: Carabidae) are one of the most widespread families of Coleoptera and considered as bioindicators of environmental changes. In the present study, we aimed to assess ground beetle communities along an elevational gradient to understand how their functional traits change along this gradient. From May until October 2020, we installed pitfall traps in extensive pastures in the LTSER area "Val Mazia/Matschertal", South Tyrol, Italy, spanning four different elevations (1000 m, 1500 m, 2000 m, and 2500 m). For the analyses, we considered three different functional traits: body length, wings development and diet.
An overall number of 5679 carabids belonging to 39 species were collected during the sampling season. Preliminary results show a significantly lower diversity at 2000 m (Shannon: 0.52; Evenness: 0.24), even though the community has a larger mean body length (12.09 ±1.43 mm). We also see a clear switch from winged and herbivore species at the lower elevations to wingless and predator species at the higher elevations.
The bigger size of the community at 2000 m could be due to less competition with other species of carabids, since this is also the elevation which exhibits the lowest diversity. The increase in wingless species at the higher elevation is an adaptation to windy conditions. The switch in dietary habits is probably related to a major availability of prey and a more opportunistic feeding at the upper elevations.

272 BIODIVERSITY OF MOUNTAIN BIOMES OF RUSSIA AND THEIR MAPPING

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There are two forms of biodiversity at the regional level (Whittaker et al., 2001)– inventory-epsilon-diversity as an assessment of ecosystem diversity and differentiating-delta-diversity as an assessment of diversity between ecosystems along climatic gradients and between botanic-geographical regions. Biomes as aggregates of species populations in their spatial distribution can be accepted as a structural unit of ecological diversity. The concept of diversity of terrestrial ecosystems and their classification (Walter, Breckle, 1991) is used for the work. Ecosystem diversity at the regional level is presented on the biogeographic map "Biomes of Russia" and in the monograph "Biodiversity of biomes of Russia». 35 plain and 31 mountain biomes have been identified. The bioclimatic conditions and biodiversity of ecosystems of the high-altitude belts (according to the groups of organisms: vascular plants, mosses, lichens and terrestrial vertebrates) are reflected in the characteristics of orobiomes. The botanical

characteristics provide information about the richness and composition of the flora, the ratio of climax and associated ecosystems. In the characteristics of the animal population, preference is given to its ecological structure. The use of biomes as reference units of biodiversity accounting makes possible an integral analysis of the botanical and zoogeographic components of the biotic cover, as well as the combined study of biotic and abiotic components of ecosystems.

RES1 - Taking Action to Secure a Future for the World's Threatened Trees

532 CONIFER TREE SPECIES HABITATS IN SIBERIA UNDER CURRENT AND FUTURE CLIMATE

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Species composition of the Siberian forests dominated by conifer trees is changing rapidly due to logging, fires, invasive insects and phytopathogens. Conifer forests are also subject to current climate change. Our goals were to evaluate potential conifer forest-forming tree species habitats in Siberia under current and future climate to plan adaptation and conservation measures for these species and forests. We used our Siberian bioclimatic models: SiBCliMTree that simulates major forest-forming tree species distributions. This model are of static envelope-type that predict tree species from three bioclimatic indices characterizing warmth, cold, and moisture conditions: growing degree days, negative degree days, and annual moisture index. Additionally to climatic indices, models included permafrost, a critical ecosystem determinant in Siberia occurring on 80% of Siberia. Coupling our bioclimatic model with the climatic indices and the permafrost distributions we predicted potential distribution of forest-forming tree species in current and the 2080s climates. Climatic anomalies by 2080s were derived from a CMIP6 climate model ensemble for two climate change scenarios: the ssp126 and ssp585 reflecting the smallest and the largest temperature increase correspondingly. Conifer species ranges and diversity were projected by the end of the 21st century over Siberia. The study was funded by the Russian Science Foundation, project number 22-26-00192.

169 LONG-TERM RESTORATION SUCCESS AFTER SELECTIVE LOGGING IN BORNEAN RAINFORESTS

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Forest restoration ranks high on the global environmental agenda, but the limitation to the success of restoration projects due to tree mortality is often not tracked. We investigated the long-term effects of active forest restoration following selective logging on tree and liana seedling communities in the tropical rainforest of Sabah, Malaysian Borneo. We assessed whether active restoration can help to create self-sustaining and species-rich forests by measuring whether restoration measures conducted two decades ago are now showing in the forest structure through regrowth and reproduction. To this end, we compared tree and liana communities in previously logged forest plots that underwent active forest restoration about 20 years ago (in the form of tree planting and

removal of lianas), with comparable plots where only natural regrowth of vegetation occurred. We found that the diversity of seedling communities, as well as the relative abundance of seedlings from the most-commonly planted tree family Dipterocarpaceae did not show a direct dependency on active or passive restoration management. However, seedling diversity and Dipterocarp seedling abundance did depend on adult tree diversity, which, in turn, had increased with active restoration. Our results suggest that active restoration has indirect effects on seedling diversity and abundance through changes in forest stand composition and can, thus, promote long-term forest recovery in previously selectively logged forests.

SES1 - Biodiversity changes in social-ecological systems – use of data and knowledge to support societal transformation towards sustainability

231 MODELLING BIODIVERSITY IMPACTS OF LAND-USE CHANGE IN AREAS OF COCOA CULTIVATION

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Interest in economically and ecologically sustainable cocoa has grown in recent years, especially in West Africa, a hotspot of the cocoa industry and associated land-use based threats to habitats and biodiversity. As such, cocoa-based agroforestry systems are promoted as a win-win option for long-term yields and multiple benefits, including to biodiversity. Yet, even though recent studies have shown such agroforests can support biodiversity, their value relative to natural areas and open-land systems is not fully known.
Here, we present work using a large collection of observational data to model the biodiversity intactness of different land uses associated with cocoa using mixed-effects models. We incorporate the land use history of agroforests, differentiating between natural and planted shade.
Our results highlight that high levels of intactness can be sustained by retaining the natural shade in existing agroforestry systems, and that incentivising planted shade agroforestry could enhance biodiversity intactness in degraded areas.
Importantly, the results highlight that cocoa planning seeking to achieve biodiversity benefits should consider the direction of land use and biodiversity transitions. We place our findings in a number of national contexts, discussing the modelling results with respect to the state of the cocoa industry in each location, the dominance of particular farming types, remaining forest cover and land use change pattern.

281 FEDA: A NEW TRANSDISCIPLINARY RESEARCH INITIATIVE TO REVERSE BIODIVERSITY LOSS

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Biodiversity is a central foundation of human life providing essential ecosystem services. However, biodiversity has declined massively over the past decades, as documented by many national and international reports and assessments. Despite considerable efforts, it is now clear that no trend reversal has yet been achieved with regard to biodiversity loss

and the most recent Global Biodiversity Outlook notes that none of the Aichi targets has been achieved. For Germany, the Ministry for Education and Research therefore launched a new "Research Initiative for the Conservation of Biodiversity" (FEdA) which consistently relies on a transdisciplinary research approach and thus aims to reverse the trend in biodiversity loss and to initiate a societal transformation. This research initiative focuses on three fields of activity: 1) to improve efficiency of biodiversity monitoring using innovative technologies, 2) to enhance the understanding of causes, dynamics and consequences of biodiversity changes and 3) to develop systemic solutions in cooperation with prospective users and decision makers to sustainably use and protect biodiversity, through active and transparent knowledge transfer. In line with the transdisciplinary approach, the research initiative with its 25 projects currently underway focuses on the analysis of indirect drivers of biodiversity loss in social-ecological systems. This promising strategy is explained by means of concrete project examples.

347 TOURISM CARRYING CAPACITY AND OPTIONS FOR THE SUNDARBANS ECOSYSTEM, BANGLADESH

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Tourism activities in the Sundarbans are growing rapidly, especially since the Sundarbans was certified as a UNESCO World Heritage Centre in 1997. Among the tourist areas of the Sundabans, Karamjal, Harberia, Kochikhali, Kotka, Dubla, Kolagachia and Nilkamal are the major sites that attract the largest numbers of visitors. Rapid but unplanned tourism activities have created various social and environmental concerns. This paper follows the methodology of Ceballos-Lascurain (1996) and Cifuentes (1999) in estimating the carrying capacity of 7 different sites in the Sundarbans. The carrying capacities of above mentioned 7 tourism sites are quantitatively evaluated as physical carrying capacity (PCC) real carrying capacity (RCC) and effective carrying capacity (ECC). Where PCC>RCC>ECC, maximum PCC was found in Karamjal (9450 visitors/day) and minimum was in Dubla (2400 visitors/day). In terms of RCC and ECC, Karamjal shows the highest (1908 visitors/day and 1146 visitors/day, respectively), and Nilkamal (Hironpoint Keora Shuti) shows the lowest (146 visitors/day, 86 visitors/day respectively). The management option could be a sectoral integration of all relevant sectors for promotion of ecotourism. Regarding this, the result of this research could be used as a preliminary benchmark for planning and future research in the Sundarbans ecosystem.

502 IMPACT OF RURAL TRANSFERMATION ON ECOSYSTEM SERVICES IN THREE "REAL LABS"

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China is undergoing rapid changes in rural areas where new opportunities linked to urbanization processes and rural revitalization. Rural transformation leads to a shift in land use which has had a major influence on vegetation and further impact on biodiversity which underlies all services provided by ecosystems that are crucial for human well-being. Though empirical research in three "real labs" in Huangyan-Taizhou, supported by remote sensing analyses and GIS tools, land use change, vegetation condition and ecosystem services were analyzed spatially and temporally from 1992 to 2020. Our findings indicate that, urban areas increase dramatically in Jianyang Wetland

Park with 595 % increase in the past 28 years, followed by Xinqian Smart Molding Town and Beiyang Town. Simultaneously, forest area in the three areas decreased by 49 %, 69 %, and 9 %. Although urban expansion has led to a loss of vegetated land in all three research areas during the past three decades. The biomass and density of vegetation, estimated through NDVI calculations, has slightly increased in Beiyang Town. Still, the values of mean and median NDVI are slightly decreasing in Xinqian Molding Town and Jianyang Wetland Park. The supply of ecosystem services in each research sites is developing downwards. The results and detected impacts of rural transformation on ecosystem services might be employed to improve sustainable development strategies, spatial planning and biodiversity conservation.

SES2 - Placing biodiversity research within a social-ecological context

316 BOTTOM-UP SYNTHESIS OF COFFEE AND CACAO AGROFORESTRY RESEARCH

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Agroforestry systems have the potential to combine agricultural production with high levels of ecosystem service provisioning and biodiversity, thereby representing an opportunity for attaining multiple sustainable development goals. This is especially the case for two important cash crops farmed predominantly by smallholder farmers in the Global South: coffee and cocoa. A growing set of studies has investigated determinants of yields, ecosystem services, and biodiversity in coffee and cocoa agroforests on the plot scale. However, management practices within agroforests are not considered in quantitative synthesis, despite a wide range of applied practices concerning shade trees, labour, and agrochemical inputs. These practices are likely to result in different outcomes, but no quantitative synthesis is available for coffee and cocoa agroforestry. Furthermore, synthesis research has yet to include land-use history – that is whether an agroforest was derived from forest or open land, as this can produce very different outcomes on the ecological, economic and social aspects of cocoa and coffee systems. These two aspects – synthesis of findings within agroforestry systems and the inclusion of land-use history – represent two key innovations of a recently started project at the University of Zurich aiming at synthesizing plot-level data. Here we present the conceptual framework of the project, collect feedback, and reach out to possible data contributors.

234 SCENARIOS FOR BIODIVERSITY TARGETS IN CHINA BASED ON NATURE FUTURES FRAMEWORK

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Biodiversity targets have significant implications for mankind to curb the biodiversity loss. Scenarios are considered as indispensable tools to make such science-based targets well established and implemented. They can facilitate to examine the impact of different pathways and policy choices of future human development on nature and nature's contribution to people. The scenarios and models task force of the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES) has developed the Nature Futures Framework (NFF) using an iterative and participatory scenario design

approach through co-production of visions with a diversity of stakeholders. The NFF framework puts human-nature relationships at its core, perceives the multiple values of nature, and explores effective pathways to reverse the biodiversity decline and enhance nature's contribution to people. To ensure the diversity and inclusiveness of future scenarios under the NFF framework, multi-level case studies should be urgently carried out at the regional or national scales. Here, we review the methodological process of developing scenario narratives, propose the key points for creating scenarios of biodiversity targets in China and establish three sets of positive scenarios for "Beautiful China", "Harmonious China", and "Smart China" based on the NFF framework.

SOI2 - Soil biodiversity and function scenarios

258 VEGETATION DIVERSITY BUFFERS MACROCLIMATE FLUCTUATIONS AND EXTREMES IN SOILS

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The frequency and intensity of extreme climatic events, such as heatwaves and droughts, are increasing with climate change, threatening humanity and other life on Earth. Especially, belowground communities and functions are known to be highly sensitive to changes in microclimatic conditions (e.g., temperature and humidity). Yet, vegetation was shown its potential to buffer macroclimatic fluctuations by providing a critical buffering layer between macro- and microclimatic conditions. Moreover, higher vegetation diversity increased primary productivity. Therefore, we would expect vegetation diversity to increase the macroclimate buffering effect, and thus protect belowground communities and functions from microclimatic extremes. Here, we tested the effect of vegetation diversity on macroclimatic buffering across ecosystems at the European scale using the SoilTemp database. Our results show that increasing vegetation diversity increases the buffering of extreme macroclimate temperature events by increasing low temperatures and reducing high temperatures. Therefore, our results suggest that the plant diversity-induced stabilization of ecosystem functions could be mediated by the stabilization of microclimatic conditions.

180 DOMAIN ONTOLOGIES TO EXPLORE AND MANAGE FUNCTIONAL SOIL-INVERTEBRATE DIVERSITY

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Due to their high structural and functional diversity, soil invertebrates are crucial for ecosystem functioning and its stability. This diversity is reflected not only in the multitude of quantitative and qualitative studies, but also in the range of existing vocabularies of characters and character states for functional soil biodiversity. Data mining and text mining are increasingly used to scour large data resources and

systematically extract relevant information in a machine-based manner. Controlled vocabularies play a central role in applying these methods to represent implicit and explicit knowledge in so-called knowledge graphs in a structured and machine- and human-readable way. The Specialized Information Service Biodiversity Research (BIOfid) aims at this method of data mobilization from Central European biodiversity literature. In cooperation with the European Soil-Biology Data Warehouse for Soil Protection (EUdaphobase), differing vocabularies on the taxonomy, anatomy, ecology and traits of soil invertebrates are currently being harmonized and mapped onto domain-specific ontologies. In addition to data extraction, these ontologies should also support the interoperable and sustainable management of pan-European soil biodiversity data.
This work is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), project number 326061700, and the European Cooperation in Science and Technology (COST), COST Action CA18237.

490 BOREAL FOREST SOIL MESOFAUNA RESPOND TO DECADAL CLIMATE FLUCTUATIONS

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Long term studies (1992-2012) of soil mesofauna response to climate warming were performed at three pine forest sites of different age (young, middle aged, and old) of the Latvia National LTER network. The rate of increase of positive temperature sums (PTS, > 4°C) differed during the two decades of the study period. In the first decade (1992-2002) PTS showed statistically significant increase (R^2=0.541, p<0.001) while in the second decade (2003-2012) no statistically significant trend in PTS was observed. We investigated whether these changes were reflected by soil mesofauna. NMS ordination of Collembola and predatory Mesostigmata mites showed that in the first decade the NMS axis 1 had significant correlation (r=0.735, p<0.001) with PTS, while in the second decade NMS axes only described the differences between microarthropod communities of forests of different age and had no correlation with PTS. Species richness of Collembola and Mesostigmata decreased significantly (r=0.410, p<0.05 and (r=0.608, p<0.001) over the whole study period in pine forests of all ages. Given the stand age difference, these changes should be considered as a regional phenomenon rather than an ecological succession. Changes in the density of enchytraeids were statistically significantly correlated with changes of soil moisture (r=0.352, p<0.01). NMS axes of the Oribatida data had no correlations with PTS and described only differences between mite communities of forests of different age.

473 MICROBIAL DYNAMICS IN TRADITIONAL ECO-KNOWLEDGE AGRI-AMENDMENT SYSTEMS

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In recent years, agroecosystem management strategies based on Traditional Ecological Knowledge have been receiving significant attention due to their better adaptability and sustainability. The inevitable environmental effects of chemical-based agri-inputs have raised enormous questions on their long-term use. The present study was an attempt to understand the impact of Traditional Ecological Knowledge (TEK) (A1) vis-à-vis conventional chemical-intensive integrated (A2) agriculture amendment systems in altering/modifying soil microbial dynamics and hence, their competence to achieve the overall goal of agricultural sustainability. The study explored the diversity of microorganisms with particular reference to Phosphate Solubilizing Microorganisms (PSM) in these two different agri-management systems. In order to understand the microbial

diversity perspectives in agricultural context, it is essential and useful to arrive at measures that can act as indicators of soil quality and crop productivity. The present study has provided evidence that TEK based organic systems had a bio-culturally rich and even soil environment, as explained by diversity indices. In addition, this dynamic state was explicitly maintained in the crucial mid-phase of flowering and fruiting. Seasonal data advocates that organic systems had stress resilience owing to microbial community composition that helps sustain stressors

VAL1 - An interdisciplinary discourse on biodiversity values

380 ON THE IMPORTANCE OF VALUES IN CONSERVATION SCIENCE

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There are several debates within the conservation literature (e.g., role of non-native species, importance of utilitarian arguments) that seem stagnant, in that positions seem increasingly entrenched and the exchanges virulent. We surmise that constructive dialogue around these debates is sometimes hindered not by the lack of data, but by conservationists being unaware of the diversity of values that exist within the field. To document this diversity, we conducted a literature review and identified papers that describe or compare values within the field of "conservation science". We then propose a taxonomy of conservation worldviews, which differ along three axes (dualism, acceptable human interventions, and a gradient of intrinsic-to-utilitarian values). We then illustrate how disputes can arise when worldviews are left unstated. Finally, we provide a series of questions that will help researchers self- identify the worldview closest to their beliefs. Making world-views explicit will not only help clarify potential synergies but also help separate the political from the scientific debates, both of which are necessary to implement conservation measures.

289 CRITERIA FOR SUCCESSFUL MARINE BIODIVERSITY CONSERVATION POLICY TARGETS

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Biodiversity change is one of most pressing planetary concerns. So much so that the Convention for Biological Diversity declared the 2010s the Biodiversity Decade. Yet, none of the 20 Aichi Biodiversity Targets that were set for 2020 as a result were achieved. Main reasons for their failure include the non-linear trajectories of biodiversity change, the focus on species extinction over immigration and emigration and using insufficient ways of measuring biodiversity. Moreover, targets are widely interpretable, vague and often set at the global scale whereas most conservation decisions are context-dependent and implemented at local scales.
In this paper, we evaluate marine biodiversity conservation policy of the past 10 years in a systematic review in order to determine relevant criteria that make effective policy

targets. Our review spans scientific as well as law and economic literature. Identified criteria are used to formulate revised targets for the conservation of marine biodiversity. Through in-depth discussion, our paper addresses biodiversity measures, global vs. local scales, marine protected areas, extinctions vs. immigration and emigration, functional diversity, and biodiversity as an insurance policy. We arrive at a set of targets for the conservation of marine biodiversity that are scientifically motivated, societally relevant and clearly communicable to enable effective governance.

38 AFRO-INDIANITY AND ENVIRONMENTAL JUSTICE: TOWARDS A "POLITICAL ECOSOPHY"

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The struggles in defense for the protection of Pachamama - Ilé Aiyé, for the defense of all forms of life and for the right to other possible worlds from the cosmopolitics of peoples in resistance, have been the engine of change of many of the socio-cultural processes in the world, especially in Most Affected People and Areas (MAPA) by climate change. The cyber-digital, hypercultural and post-human era presents itself as a new phase of the colonial civilizational project that threatens to destroy the socio-biodiversity of the Global South through the emergence of the systemic meta-crisis. This essay argues that: 1) Modernity and globalization are phase-states, waves or geodesic cycles of the exponential development of coloniality, which are born not only from the cyclical analysis of phases of scientific-technical development, but also from hauntological relations of inherence between the egos that co-constitute them; 2) this context reveals the limits of current social science theories to understand complex systems. 3) A political ecosophy from Afro-Indianity is proposed as a framework for analysis of the meta-crisis, post-development and socio-biodiversity in the context of the COVID-19 pandemic, the economic crisis, the collapse of civilization and the defense of other possible worlds.

150 FROM BIRD'S-EYE-VIEWS TO JOINT LANDSCAPE VISIONS

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How people see landscapes is strongly influenced by their land use needs in a nexus of water, energy, food and ecosystems. Compromise solutions between land use and biodiversity conservation require cooperation between actors with different viewpoints and backgrounds. We suggest videos and imagery, captured by drones flying over a landscape, to be boundary objects that create a common understanding in the way they illustrate connections in the landscape and spark the imagination of almost everybody. Affordable drone-based imagery can change people's perspectives by switching between vertical views from above (nadir) and angular views (oblique), thus creating an immediate link to human-nature interactions. We collected drone imagery of agricultural areas, forests, rivers and wetlands in Zambia. We then discussed the visual material with large- and small-scale farmers, governmental-, and non-governmental organizations. Across all groups, we found that people preferred and were able to identify more landscape elements on oblique drone images compared to more commonly used nadir images. People were able to contextualize themselves in the wider landscape and identify where differing interests conflict and align. While we highlight ethical concerns and technical limitations of drones, we suggest that conservation and environmental planning

can benefit from a critical use of these new types of imagery that are already reshaping the representation of landscapes in popular media.

OPEN SESSION - Open Poster Session without session allocation

48 THE HABITAT MAP OF SWITZERLAND

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Mapping the distribution of habitats is vital for successful conservation, management and monitoring of biodiversity. Within Switzerland, there is strong demand for a spatially explicit and area-wide habitat map from a wide variety of stakeholders for multiple purposes: i.e., informing field surveys, ecological research base data and ecological infrastructure projects. It is vital that the habitat map reflect not potential distribution of habitats but current distribution taking into account landscape management. We took advantage of Earth Observation data, machine learning, and image segmentation and classification methods to map habitats according to the classification of Delarze et al. (2015). Airborne ortho imagery (1m resolution) was segmented into 'image primitives' on the basis of reflectance in the RGB and NIR bands, particularly NDVI. Habitat distribution models were developed with machine learning approaches and used to assign habitat types to these segments in a rule-based approach. The models were trained with field data from large scale monitoring programmes, and spatially explicit predictors derived from Earth Observation data (Sentinel-1 and -2), climate, topography, and soil data. We undertook stakeholder consultation and workshops to ensure a fit for purpose result for the wide variety of end-users. The approach is semi-automated so that it can be re-applied with updates of the base data at specified time intervals, enabling use for monitoring purposes.

1 PROMOTING OPEN DATA FOR BIODIVERSITY CONSERVATION AMONG TARGET GROUPS

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Biodiversity is one of the core factors that help to push for socio-economic development and growth, which can contribute up to 40% of the world's economy and about 80% of the poor's needs are derived from biodiversity resources. Cambodia is one of Southeast Asia countries' richest biodiversity, with its forest cover still at a high level compared to all other countries in the region, which accounted for approximately 59% of the country in 2006. However, due to recent economic development, especially the Cambodian government's land development policy which allows companies to invest in large-scale economic land concession(ELC); this affects and threatens biodiversity. Lack of law enforcement and planning on natural resource management, increased human activities on forests, lack of proper land management with insecure land tenure, and lack of awareness on the importance of biodiversity among local communities are contributing factors to the loss of the country's rich biodiversity. There are concerns in term of recent biodiversity threats and its long-term sustainability. For Cambodia, the recent government reaction which suspended ELC is a good step to protected biodiversity which is under threatening. Open Development Cambodia's aim is to eventually build a

comprehensive national resource. Greater transparency through open data may over time lead to growing communication and understanding between the government, citizens, and the private sector, greater investment stability.

356 COUNTRYWIDE, HIGH-RESOLUTION CLASSIFICATION OF PERMANENT GRASSLAND HABITATS

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Grasslands host high species diversity, yet face strong declines in their extent and quality. Many European grasslands are listed as priority habitats in national and European conservation strategies. Countrywide, high spatial resolution maps of their distribution are often lacking, despite their pivotal importance for conservation purposes, i.e. to plan ecological networks.
We used a two-step approach to model the distribution of 20 grassland habitats at the level of phytosociological alliances across Switzerland at 10x10m resolution. We applied ensemble models to map the individual habitats using training data from field monitoring programs. Copernicus Sentinel-1 and -2 satellite imagery and variables describing climate, soil and topography were used as predictors. The individual maps were combined into maps of the most and second most likely habitat, respectively, using an expert-based weighting approach. The performance of the maps was assessed in several ways. Most individual maps had useful to excellent predictive performance. For the combined map of the most likely habitat, we found good agreement between the predicted and estimated proportions from field surveys. Omission errors occurred mainly between ecologically closely related habitats. A particular challenge remains in capturing the transition from nutrient-poor to nutrient-rich grasslands, which is highly important for biodiversity conservation. The combined map is integrated into the Habitat Map of Switzerland.

140 SUSTAINABILITY PRACTICES AT SECONDARY SCHOOL OF MYMENSINGH REGION, BANGLADESH

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SDG 4 refers to guaranteeing accessible and equitable quality education and promoting opportunities for lifelong learning for everyone, both of which are dependent on sustainable practices. An online survey with a structured questionnaire was conducted in secondary schools from six districts in the Mymensingh educational zone, Bangladesh, from March to June 2021 to determine how secondary schools in Bangladesh manage issues connected to sustainable development. A total of 346 teachers and principals from various secondary schools took part in the study. According to the data, the majority of respondents agreed that their schools adopt many policies for sustainability and dedication to a sustainable organization. They think their schools serve as life-changing environments and developers for a sustainable society, as well as information multipliers for long-term growth. The most common obstacle to implementing sustainability-related

projects (57.08 percent) was a lack of resources/materials. This finding could help policymakers and practitioners establish sustainable strategies in secondary schools in the near future to ensure high-quality education across the country.

420 MEASURING EQUALITY OF ACCESS TO INTACT BIODIVERSITY USING FINE-RESOLUTION DATA

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The Covid-19 pandemic has highlighted the importance of local biodiversity for physical and mental health. However, these benefits are most available to people with access to high-biodiversity areas, and barriers to access may disproportionately impact different sectors of society. We combine the PREDICTS database - a collation of biodiversity data from thousands of sites across the world - with annual, fine-resolution maps (~1km^2 at the equator) of land use and intensity to predict the state of local biodiversity (the Biodiversity Intactness Index) across the globe each year from 2000 to 2020. We then identify areas of particularly high and low biodiversity intactness using smoothing techniques. Using the UK as a demonstration case, we show how these fine-resolution maps of the status of local biodiversity can be combined with additional spatial layers, such as transportation networks and socio-economic and wellbeing data, in order to assess inequalities in access to areas of intact biodiversity. We have begun to work with a range of youth activist networks to identify additional barriers to access, including perceived barriers, rather than purely physical ones.

113 INTEGRATING CLIMATE CHANGE INTO MARINE PROTECTED AREA MANAGEMENT PLANS

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Marine Protected Areas (MPAs) are playing an increasingly valued role in achieving international commitments towards biodiversity protection. However, given the highly dynamic transformations and shifts in marine ecosystems due to climate change, the static nature of MPAs presents significant management challenges. These include contending with the increases in extreme weather events, loss of critical habitat, and the migration of species into and out of the protected area. While climate change projections can be incorporated into the design process for newly developed MPAs, adaptation is less clear for established MPAs which were often not designed with climate change impacts in mind. Therefore, it is crucial to understand the additional measures that can be taken by marine managers to anticipate, adapt to, and mitigate the consequences of climate change and ensure the continued effectiveness of their MPAs. Here we present an analysis that surveys the integration of climate change measures in existing MPA management plans, with the goal of developing an open-source reference database on actions and measures to help build climate resilience and adaptation in MPAs around the globe. This will enable MPA managers to access a 'tool-kit' of concrete actions, allowing them to explore management options and customize them in accordance with their specific climate vulnerabilities.