BOOK OF ABSTRACTS

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Forests in a Volatile World –
Global Collaboration to Sustain Forests and Their Societal Benefits

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INTRODUCTION

The sustainability of the ecosystem has been a global effort that involves collaboration of every sector, critical roles individuals, researchers, scientists and several organizations play on forest lands and its societal benefits cannot be left out of the discussion. The forest provides so many societal benefits and it also shares close relationships with human life. Forestry research is seeking to develop new technologies that will be implemented to support economic development programs aimed to improve human well-being, while protecting the natural resource base and the environment.

All – IUFRO Conference 2022 is addressing the critical roles of research on forest management, conservation and sustainability under dynamic economic, social and environmental conditions. Themes addressed by impressive number of submissions presented cut across several topics such as forest and human health which discussed the close relationship between forest and human health, bio-economy as a strategy to reduce dependence on fossil fuels by using woody biomass more efficiently, forest degradation and restoration which addressed successful and failed projects on forest productivity and rejuvenation, Gender (un) equal networking of IUFRO that discussed the gender roles and functions in forest research and IUFRO network, forest genetics resources for future resilient that addresses sustainable use and conservation of forest genetic resources, forest and water addressed three SDGs (SDG 1: No Poverty; SDG 6: Clean Water and Sanitation; and SDG 13: Climate Action) in terms of the impacts of forest management on water supplies and people, and likely co-benefits and trade-offs.

This event is jointly developed by IUFRO Divisions, Task Forces and Special Programs and Projects.

John Parrotta

President IUFRO

Alexander Buck

Executive Director, IUFRO

Vienna – Austria, September 2022

FORESTS AND HUMAN HEALTH SESSION

Towards a Quality-of-Life Approach to Valuing of the Benefits of Forests

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The concept of ecosystem services has been introduced to highlight that humans are dependent on ecosystems to provide them with certain services that are either required for or enhance their well-being. Within the ecosystem services approach, the thinking on ecosystem services (as provided by ecosystems) appears to be more systematic than that on the benefits of these services (when made use of by people). The Common International Classification of Ecosystem Services (CICES) offers a case in point, with only providing some examples of the benefits of the different ecosystem services. Moreover, valuation studies are usually limited to a few of the extensive lists of ecosystem services. Especially the value of cultural ecosystem services is often not included, such as that of the health benefits of contact with nature. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) argues that ecosystems and their benefits are too narrowly and too instrumentally defined within the ecosystem services approach. IPBES introduced the term nature's contributions to people (NCP), intended to be more encompassing, along with a new type of values, relational or eudaimonic values, that are also thought to be relevant for people's quality of life (QoL). Furthermore, IPBES argues for more pluralistic and holistic valuations of NCP. However, also within the IPBES framework it is unclear how precisely specific NCP led to specific benefits, and how important these benefits are for one's QoL. In this paper, we will present a valuation approach that starts with QoL (at the individual level) as endpoint and works its way back to ecosystems, such as forests, by answering the following questions: a) which determinants of QoL are distinguished in the social science literature, b) how important are the different determinants thought to be for one's QoL, c) which ecosystem services or NCP are likely to affect which determinants most and d) which ecosystems offer these services. Strengths and limitations of the proposed approach will be discussed.

Incidence of Haematological malignancies in French population living near forest areas: Pilot study

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Currently, the benefits of the forest on the ecosystem no longer need to be proven, but what about human health? The potential impact on the human health of populations living near forest areas is very little studied. For the first time, a pilot study will be performed in Gironde to estimate haematological malignancies (HM) risk in French population living near forest areas

and to assess whether this approach could be extended to others French areas covered by a population-based cancer registry. This pilot study has an ecological design, and will investigate HM incidence in population aged 15 and over, living near forest areas in Gironde department (South West France, 1,6 M inhabitants, 10,000 km2). It will focus on specific types of HM associated to forest areas. Numbers of HM cases will be obtained from the HM registry of Gironde at the "Commune" and "IRIS" level (the smallest French administrative unit) between 2006 and 2017. This study will use percentage of forest areas in the "Commune" and "IRIS" as a proxy of exposure. This exposure data will be obtained via Geographic Information System from the National Geographic Institute data. The statistical distribution of the number of cases observed around forest area will be compared to that obtained under hypothesis of a Poisson distribution, taking into account potential confounders and spatial autocorrelation. This study will examine HM risk for major subtypes by 5-years age groups, sex and calendar year. It will investigate whether there is an increase in HM in population living near forest areas. Such an ecological study will improve knowledge on the relationship between forests and human-health. However, it will not make it possible to conclude as to possible causal relationships. In addition, this pilot study will determine if technical challenges related to data collection or analysis can be resolved. Future collaborations with FRANCIM, SpF, INRAE, Atmo-Aquitaine will improve our results.

Human health benefits of walking forest trails – results from a field experiment in a nature park

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Green environments can affect human health, providing visitors restorative spaces. While many studies have revealed positive effects of green environments on human health compared to build environments, little is known about the health effects of different types of green on humans. Such information is necessary for the successful development of health-related offers such a health routes in forests. The community of Geras, located in the district of Horn, Lower Austria, is characterised by a nature park with fields, forests and ponds. A local actor group is working on a regional implementation of health-related offers. One option is the development of health routes within the nature park. To test the impact of routes in different park environments (deciduous forest, coniferous forest, open land with pond) on human health, probands (N = 27) walked three routes in the nature park while measuring health impacts on physiological level (pulse, blood pressure) and mental level (cognitive performance test) before, during and after the walk. The aim was to identify those routes, which provide the best health benefits. The study was supported by the European Union, province and country. The results of the standardized measurements showed positive effects on the health of the probands in all three landscape areas, both on a psychological and cognitive level as well as partially on a physical level. The deciduous forest route had positive effects on perceived well-being and stress reduction. Pulse reduction was high compared to the other two routes. The coniferous forest route showed the most positive effects on systolic and diastolic blood pressure and

concentration performance. In addition, the walk in the coniferous forest had positive effects on subjective well-being, perceived recreational effects, and stress reduction. The visit to the open area with a pond resulted in a significant improvement in perceived well-being, pulse reduction and concentration performance. As all of the landscape types had positive effects on health, they are also conceivable for the creation of health routes. The coniferous forest route seems to be slightly more restorative than the other two routes.

Traditional knowledge of wild mushrooms as ethnomedicine in primary health care among inhabitants of forest communities in Cameroon

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Mushrooms are widespread in nature, and they remain the earliest form of fungi known to mankind. Wild edible mushrooms are one of the important natural resources, on which the local people of all nationalities rely heavily, and these mushrooms certainly play a role in improving health and nutrition. Many communities in Cameroon depend on the forest resources for their livelihood, including the diverse use as ethnomedicine. With the increasing loss of forest due to exploitation and urbanization, they are liable to rapidly lose their indigenous knowledge of the forest resources, especially of mushrooms. An ethnomycological survey was conducted with the aim of documenting the indigenous knowledge of mushrooms as a prelude to conservation efforts and as usage in ethnomedicine in the communities. Ethnomedicinal uses was obtained through questionnaires, focus group discussions and pictorial presentation in the communities. In the Mount Cameroon communities, it was revealed that traditionally, mushrooms were used as food, medicine, for mythological purposes and for aesthetics uses. Species used for ethnomedicine were *Termitomyces*, *Auricularia, Agaricus, Daldinia, Dictyophora, Pleurotus, Russula, Trametes, Chlorophyllum,* and *Ganoderma*. Mushrooms were used as love charms, for dispelling evil spirits, and as part of cultural festivals. The indigenes of the Awing communities commonly use mushroom as food and medicine and in mythological beliefs. The most utilized species as food and medicine included *Termitomyces titanicus, Laetiporus sulphureus,* and *Ganoderma sp*. In the Bafut forest communities, polypores are used as food and medicine. *Microporus xanthopus* and *Microporus vernicipes* were used as food and medicine while all *Trametes* species were reported to be only medicinal. In the Kilum-Ijim forest communities, mushrooms were used as food and medicine, while the non-edible species were regarded as food from Satan. Eight species, *Polyporus tenuiculus, Termitomyces striatus, Termitomyces microcarpus Auricularia polytricha, Laetiporus sulphureus, Termitomyces sp.1, Termitomyces sp.2,* and *Polyporus dictyopus*, were reported as edible and *Auricularia polytricha, Daldinia concentrica, Ganoderma applanatum, Lentinus squarrosulus, Polyporus dictyopus, Termitomyces microcarpus, Trametes versicolor, Vascellum pretense* and *Xylaria sp*., were used as medicine in traditional health care. Local knowledge of medicinal mushrooms in the treatment of different illness still exists in all the communities surveyed. Elderly men and women appeared to play an important role in primary health care services in these communities. This survey underscores the need to preserve and document traditional

knowledge of the different medicinal mushrooms and the need for future scientific research on the mushrooms to determine their efficacy and safety.

The relationship of the population with its forest. Results from a long-term socio-cultural forest monitoring in Switzerland

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The relationship of the Swiss population to the forest has been investigated in surveys since 1978, and in 1997 for the first time as part of the so-called “Sociocultural Forest Monitoring” (German acronym: “WaMos “). This presentation describes the results of the 2020 WaMos3 national survey and relates these results to those of WaMos2 (2010). We used a Swiss-representative online-survey (LINK). Main results show that the self-assessed level of information on forest topics has declined (older people feeling better informed than younger people). Also, the level of knowledge regarding the increase in forest area in Switzerland and the management of mountain forests for protection against natural hazards is lower among younger people than among older ones. Today, the population attributes greater importance to most forest functions for society than in WaMos2. In particular, the ecological function, the production function and the recreational function have gained importance. Forest health has deteriorated, while the population perceives changes due to climate change. In terms of forest preferences, the population likes mixed forests best. The presence of a shrub layer is more preferred than in WaMos2 and the liking of deadwood is also increasing at a low level. However, recreational infrastructure is valued less and less. Forest characteristics such as visibility range, shrub layer cover and cover of berry bushes, stage of stand development, stand structure and the presence of deadwood have an influence forest preference. In order to get an impression of which forests are visited by people, we asked for their exact locations with PPGIS. Local recreation dominates; the densest point-cloud is found where Switzerland is most densely populated. Most people visit this preferred spot frequently. Activities in the forest are dominated by barbecues/bonfires/parties, jogging and sports in general. Satisfaction with forest visits has decreased at a high level compared to WaMos2. Forest attractiveness is rated lower, the visit to the forest is perceived as less restorative and the perceived disturbances are increasing. In sum, the Swiss population highly values the forest, as a recreational area, but also in particular as a habitat for plants and animals. Ecological awareness seems to have risen again in the last 10 years, and with it concerns about the state of the forest and biodiversity. On the other hand, satisfaction with forest recreation – at a high level – has somewhat declined.

Cycling in an urban and in a natural area. What is best for mental health?

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The practice of a physical activity is described as promoting physical and psychological well-being. However, little is known about these benefits when comparing activities in natural and

urban environments, especially involving cycling. This study aimed to examine psychological responses to stress and the well-being of cyclists in two environments: urban and natural areas. For that, two distinct groups of cyclists were followed in an urban ride (distance=23km, duration=1h:31´, temperature=21°C) and a protected area (14km, 1h:21´, 21°C). The two events took place in the metropolitan region of São Paulo – Brazil, respectively, in Guarulhos and the Juquery State Park. Before and after each activity, participants answered the World Health Organization- Five Well-Being Index (WHO-5) and Perceived Stress Scale 4 (PSS-4). In addition, sociodemographic information, cycling-related habits, and information about the activity performed were collected. The participants of the urban pedal (n=19; age= 47.2 sd 9.3; male= 63.2%, female =36.8%) and the pedal in a protected area (n=13; age= 48.8 sd 10.9; male= 84.6%, female=15.4%) self-reported, on a Likert scale (1 to 5), the same median for the degree of physical effort (3), thermal comfort (4) and satisfaction with the event (4). The median number of hours of cycling practice per week was also the same (20h) in both groups. Thus, the samples presented characteristics that could be compared. All scales presented Cronbach's alpha >0.75, indicating the high reliability of the instruments. PSS-4 in the urban pedal before/after had mean = 6.5 sd 3.2/ 5.4 sd 2.9, median = 7/6. Wilcoxon signed-rank test p=0.014, with an effect size r=0.56. In the protected area before/after average = 4.4 sd 3.2/ 3.3 sd 2.5, median = 4/3. p = 0.028, effect size r = 0.61. The WHO-5 in the urban pedal before/after had mean = 16.9 sd 6.0/ 19.5 sd 4.2, median = 16/20. p=0.092, with an effect size r=0.39. In protected area before/after mean = 18.2 sd 3.6/19.7 sd 3.6, median = 17/20, p=0.032, effect size r=0.59. These results corroborate the hypothesis that the practice of cycling brought psychological benefits. However, when performed in a protected natural area, there was a significant reduction in perceived stress and an increase in well-being. As for the practice in the urban environment, this occurred only with perceived stress. In addition, the effect size was larger in the natural environment. Thus, the importance of protected natural areas for human health and well-being is noted.

Effects and possibilities of Forest Therapy (FT) at local hospitals - Case studies utilized local abandoned artificial forest in Japan

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Forest Therapy (FT) aims to promote both the health of forest and human beings (Uehara 1999). FT can prevent illness, provide relaxation opportunities, rehabilitation & treatment environment, peaceful counseling space, and comfortable safe site (Uehara, 2003). There have been many case studies and attempts by FT all over the world. By experiencing forest activities for a long term and constantly, some clients with mental, psychological, and physical disabilities showed easing them and improvement of the abilities (Uehara 1996, 1997, 1998). Recently, some case studies of patients with dementia could recover their communication ability, too (Uehara, 2010). Trees also have great possibilities for healing. Some trees provide medicine, herb tea, and fragrance which have certain healing effects. However, although many scientific experiments have been attempted, real case studies of medical utilization have been still a few. Especially, hospitals have been lacking practicing FT yet. Therefore, this study shows some case studies at local hospitals that introduced and practiced FT in Japan. Especially, these case studies utilized local abandoned (untreated) artificial forests. The local hospitals attempted

walking, vocational works, counseling, recreational activities as FT. Some clients showed ease of their dementia disabilities by FT. Attempting to introduce and practice FT at the local hospitals made the forest environments recovered, too. The illumination at forest floor has been adjusted to the brightness by treating the forests and natural vegetation recovered the diversity. On human environment, the new team work has been born among the medical staff and new trusted relationship has been germinated between patients and medical staff. The forest environment could supply new healing places and FT programs for both of patients and medical staff. FT has created not only new spaces for occupational activities, but also relax and restorative places have been created near by the hospital buildings. Dementia is one of the important medical challenges all over the world. This study introduced that the patients could rehabilitate or treat their illness by practicing FT by utilizing local abandoned artificial forests. This is a model of promoting both health of forest and human beings.

How are outdoor leisure and recreational users coping with physical and mental health during the COVID-19 pandemic in Malaysia?

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The lockdowns during the COVID-19 pandemic or restrictions of using green spaces have some impact on physical and mental health of those leisure and outdoor recreational users. This has resulted in a decrease in all levels of physical activities and increase in daily sitting time as well as increase in unhealthy pattern of food consumption. This also applies to all Malaysians who were under a movement restriction called Movement Control Order (MCO). With this announcement, Malaysians were not allowed to get out of their houses except to get food, medical assistance, or other emergency cases. Malaysians are also prohibited from having mass gatherings including religious, sports, social and cultural activities. This even includes individual leisure and recreational activities in any public spaces including parks, recreational forest, green corridors, playgrounds, beaches and even at your own neighborhood. Therefore, an on-line study was conducted to investigate how the users were coping with their mental and physical health during the pandemic. The 606 users were selected from several social network platforms. Majority were disrupted (28.2%) and moderately disrupted (30.2%) in terms of their general health during the confinement period in Malaysia. Only about 18.8% felt not at all disrupted. This was further explained from the GHQ-12 items where respondents were moderately distressed from being self-isolation and quarantined. However, majority of the respondents were coping with varieties of physical and mental activities at home such as with household chores (85.5%) as their main physical activity as well as watching TV (71.3%) as part of their main mental activity. Though the respondents were coping with varieties of physical and mental activities, in long run this would not be sustainable. The government need to develop guideline to optimize the benefits of performing physical and mental activities at home and also try alternative ways of using the green spaces for the public during the pandemic.

Indigenous and conventional knowledge integration for restoring degraded rangelands in northern Kenya

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About 120 million pastoralists rely on rangelands for livestock production (*Rass, 2006*), as naturally rangelands are ecologically resilient and able to recover from livestock grazing (Ludwig et al. 2001). The resilience of rangelands has traditionally been supported by the rich indigenous knowledge and local pastoral governance systems. Pastoralists use herd mobility to opportunistically utilize seasonally and spatially variable pastures while resting degraded rangelands (*Niamir-Fuller, 2005*). This is made possible by enforcing rules and regulations that govern resource use through customary institutions (Agrawal and Benson 2011). Such institutions do not only help in managing grazing resource uses, but also useful in conflict resolutions and self- organization of pastoral societies at the time of difficulties (Ibid). The practice of resting degraded range units helps in restoring plant productivity, richness and diversity (*Yayneshet et al. 2009*) and as well as in enhancing soil fertility (*Damene et al. 2013*). Based on the indigenous knowledge of pastoralists in managing rangelands, pastoral livestock production systems are a highly reliable production system in dry lands (*Krätli and Schareika, 2010*). The climate of the pastoral residing regions are very harsh and undertaking normal afforestation processes is difficult due to scarcity of water and high rate of deforestation. Rangeland restoration through land resting for natural recovery as previously practiced by pastoralists is challenging considering the continuous and un-bated encroachment of other land uses into pastoral production systems which makes traditional flexible herd mobility difficult. The rate of uptake of conventional knowledge by the pastoralists is very minimal or low and there is a lot of deforestation but the only way to get their attention is through use of indigenous knowledge. This involves their knowledge of the trees that grow well in their areas, their location and how they protect them. Through the use of key informant interviews, focus group discussions and checklists and mapping extremely degraded sites in the rangeland for restoration we have managed to identify 27 trees, shrubs and 18 grasses in the vernacular Cushitic languages of Somali and Borana, the indigenous knowledge of marking old fodder trees especially *Acacia tortilis* trees where no one can cut to allow continued growth of the mother plants and natural regeneration to occur. Additionally, socio-cultural practices of the Muslim who live in extended family lifestyle in each household accommodating more than 5 persons allows to pray 5 times a day meaning taking ablution 5 times a day and watering the plants growing around the household. On the other hand, conventional restoration techniques including reseeding or over-sowing have been applied to enhance vegetation recovery process which used xai pits, transects.

Residents' Attitudes towards the Residential Urban Forest in Metropolitan City of Nepal

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It is evident that urbanization has replaced natural greenery in many parts of Nepal, deteriorating the quality of human life and the environment. Urban forests are a critical element in ameliorating urban habitats and building sustainable cities. Local residents are one of the key players in maintaining greenery in the city as they collectively own the majority of land in most cities. Therefore, they need to engage in planting and retaining trees on their properties in order to enhance canopy cover in urban areas. Purposive sampling was conducted to document the residents' attitudes towards residential trees. The project surveyed 200 local residents in Bharatpur Metropolitan City to examine their attitude towards trees on their property on the basis of 'Affective', 'Behavioral' and 'Cognitive' ABC model of attitude. The scores on the 5-point Likert scale where 'strongly disagree' was rated '1' and 'strongly agree' was ranked '5' were used as the input for the data on residents' cognitive intention towards trees. The data input for the reasons for tree planting, the effects of trees on respondents' properties and their feelings about it, the types of trees they want to add in the future, and the reason for the intention to remove existing trees was qualitative. Results show that majority of the residents have a positive attitude towards trees as they have high cognitive intention towards trees and showed willingness to retain the existing trees and add more in future. However, very few are cognizant of the environmental values of trees. The most common positive effects of trees in their property are food, shade and clean and fresh air. The most common negative effects are increases in bushes and weeds, wildlife hazards and risk of fall due to wind. Urban planners interested in influencing residents' decisions about residential trees need to work on public outreach. Residents need to be motivated and made aware of the long term and multifunctional benefits of trees for retaining the existing trees and planting more in their property. They should also, be made aware of the type of trees that are suitable for plantation on residential property in order to avoid the problems that can be created due to trees.

The marketing modelling of the mix of forest ecosystem services with the accent on cultural services under the conditions of the pandemic COVID-19

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Societal changes induced by the COVID-19 pandemic accelerated the demand on cultural ecosystem services, such as recreation and tourism, that have positive impacts on human mental health. The basic framework for the development of this area is granted by the EU´s biodiversity strategy for 2030 (COM (2020) 380). Well-functioning ecosystems are extremely important for improving the stability of human organism and extension of future diseases. Thus, the EU set the goal to invest into these areas, that will have essential importance for economic recovery of Europe, caused by COVID-19 pandemic. Starting from these considerations, the goal of the proposed project is marketing modelling of the mix of the forest

ecosystem services in chosen forest enterprises portfolios according to the three scenarios, specifically economic, ecological and the business as usual. The economic benefits for forest enterprises will be quantified according to predefined forest management system, that belongs to each scenario.

Importance of Trees outside forest (TOF) for people's livelihood and Chure conservation in Nepal

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While the diversity of forest-based care services provides a lot of potential business opportunities, the market is relatively young and not always fully recognized. The lack of a clear overview of the market development results in gaps regarding the understanding and full implementation of FBC. In this research, conducted within the framework of the Erasmus + GREEN4C project founded by European Union, we investigate and provide an overview of the FBC market to provide a better understanding of the advancement and the potential of this sector. We used an online survey (n=40), to obtain an overview of the FBC sector in Europe, and through focus group discussion and interviews with six experts in the field we explored success factors and challenges. Overall, the initiatives tend to be small and occasional activities without a regular income. The largest share of customers is the general public, while customers with health issues are difficult to reach due to the lack of formal rules and acceptance issues among health and social care sector. Cross-sectoral collaboration could facilitate the availability of private and public funding and increase the involvement of the public health care sector. Due to the fragmented nature of the market and the lack of a specific and widely recognised supply, a quality assurance system in the FBC activities is lacking. Our analysis identified three main research areas that could be developed: (i) defining the major benefits and the effectiveness of FBC initiatives compared to traditional treatments, (ii) investigating the cost reduction potential for the health sector and governments, (iii) monitoring and assessing certification schemes. To complement these research points, it is fundamental to implement a clear framing and a systematic approach in the communication and dissemination of the research findings.

The need and use of natural spaces for parents and caregivers of children during a pandemic-induced lockdown – insights from an international survey

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In the early and accelerated stages of the COVID-19 global pandemic, the rate of spread of the virus resulted in many governments imposing strict measures of movement restriction, "lockdown". Lockdown varied among countries and the experiences of lockdown were particularly pronounced in urban and peri-urban areas, where access to public natural spaces

such as urban forests were limited, sometimes entirely. Disruptions of daily routine, social distancing, lack of in-person contact, boredom, uncertainties and delays in tests, exams and graduation can increase perceived anxiety and stress, and be an increased risk of relapse for both children and adults with mental health history.
Recent studies suggest that access to parks in dense urban environments during the COVID-19 pandemic increased the odds of being physically active among adolescents and that maintaining contact with natural spaces had a buffer effects towards negative mood, depression and anxiety symptoms. To date, however, very little research has investigated the impact of lockdown measures on people´s perceived need and changing uses of public and domestic natural spaces and how this would have affected their ability to cope with this unprecedented measure. This study aims to understand whether the perceived need for and use of gardens and natural spaces changed during a lockdown and what type of nature-based activities parents/caregivers engaged in during lockdown. We distributed an online survey targeting guardians and caregivers of children aged between 0 and 12. We included questions on the level of lockdown, living environment, accessibility to gardens and natural spaces, the perceived need for and use of gardens and natural spaces and demographic data. We analyzed the answer of 231 people that experienced lockdowns with their children from 26 countries. Results suggest that the participants who had access to both gardens and natural spaces increased their use and enjoyment of gardens and natural spaces during lockdown. The three most increased uses of gardens were for didactic purposes (learning about nature), fresh air, and playing. For those without access to gardens and natural spaces, the majority answered that they believed that the lockdown would have been easier for the children in their care and themselves had they had access to a garden or natural space. The results can have implications for how to improve resilience to future public health crises that require lockdown or other movement restrictions, particularly for vulnerable groups such as children and their caregivers.

Influence of an urban forest on microclimate cooling in an Amazonian capital city

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It is known that thermal comfort is intrinsically related to human well-being, identified as a consequence of microclimate control: an important ecosystem service. This concept is related to the benefits derived from forested, aquatic, or terrestrial environments, which in addition to the effects of maintaining the quality of natural ecosystems, can satisfy human needs. However, the natural environment and rural landscapes are being rapidly transformed into urban and industrialized environments, considerably affecting human thermal comfort. In this sense, the goal of this research is to understand the importance of the typical Amazonian Forest ecosystem as a factor in maintaining the microclimate of an urban capital, located in the most populous region in northern Brazil, using the Thermal Comfort Index (TCI). The chosen environments encompass the area of an urban forest park, located in Belém, one of the main Amazonian capitals, and the urban area under its influence. The methodology used involved the use of a thermo-hygrometer equipment, with a HOBO U10 sensor for temperature (T°C) and

relative humidity (RH%), programmed in HOBOware® 3.7.22 software to record every 10 seconds. The sensor was attached to a meteorological shelter during all measurements, which occurred in a transect with a starting point inside the park and end point in an urban area, following the predominant wind direction. The measurements were performed by vehicle, at constant speed, twice a month, at five times a day, for one year. Data were also collected from meteorological stations near and far from the park. Interviews were applied to verify the thermal sensation and the attribute of monetary value given to the park by visitors. From the data collected, the TCI was calculated to correlate with visitors' level of thermal sensation, valuation, season, time of day, and presence or absence of vegetation. For this, the use of Bayesian Networks and Generalized Linear Models (GLM) is proposed to establish conditional relationships between the TCI of the CU and the urbanized proximity. The results are presented using tables and Bayesian inferences of partial questions such as: What is the minimum distance necessary for the implementation of urban parks in order to obtain the ideal thermal comfort? Or what would be the temperature near the park if the green area did not exist? It was found that the park significantly influences (p<0.05) the microclimate in its surroundings.

FOREST-BASED BIOECONOMY SESSION

The role of the forest sector in transition to a bio-based, circular economy

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The world's prevalent economic model, based on a 'take-make-use-dispose' approach, cannot maintain current standards of living without causing environmental degradation and incurring economic risks. Decoupling economic activities from the increasing demand for natural resources may be possible through bio-based, circular economy approaches leading to a regenerative growth model, allowing for lower environmental footprint on the planet. The forest sector, integrating natural cycles with industrial processes is well positioned to embrace such a bio-based, circular economic model. This study reveals that the forest sector is extremely efficient in using all material throughout the production process along its various value chains. In the time when we are looking at a green recovery and building inclusive and sustainable economies, such sustainable practices can trigger a transition towards circular bio-based systems in other strategic sectors, such as construction, furniture, paper industry, textiles and plastics, which today struggle with out-of-proportions environmental footprints. However, the replacing of fossil materials with forest-based products will also increase the demand for wood. This, when the regenerative capacities of forest ecosystems are threatened by climate change, landscape degradation, soil erosion, forest fires and pests, raises the question of whether fossil materials can really be replaced with wood as a fair and sustainable solution in the long term. The study emphasizes that forests and forest ecosystems can become a source of renewable and biodegradable products, which can substitute for finite and polluting materials in a larger scale than it is taking place today, only when they are given an opportunity to naturally restore the quality of their resources. That depends on sustainable, responsible forest management practices at the global scale, which are key to the natural cycle of forests' renewal and the sustainability of forest-based value chains. The study also provides evidence that not all circular approaches are sustainable under all circumstances. In some cases, the focus on circularity may cause environmental and socioeconomic externalities, in other cases, it may not guarantee economic viability. While the transition to a circular, bio-based economy can be facilitated by a legislator, the process will need to develop organically, based on the location of industries, proximity to available secondary resources and consumer preferences. Therefore, the study covers potential opportunities from going more circular in forest-based industries and lists concrete actions by business and consumers on how to accelerate the transition towards a bio-based, circular economy.

Implications of legalizing artisanal chainsaw milling on social welfare, income distribution and the economic performance of sawyers in Cameroon

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Cameroon has been at the centre of global concerns about illegal timber logging for several decades, much of which has been driven by the informal timber sector. While the formal timber sector generates nearly 40 billion FCFA per year, it has been estimated that the State loses nearly 7 billion FCFA each year from informal forest operations through unrecovered taxes. While the 1994 Forestry Law aims to reduce illegal deforestation and forest degradation in compliance with Cameroon's international commitments, these regulations are only poorly enforced in practice. Hence, this study was conducted with the objective to assess the benefits gained by different sawyer categories undertaking illegal timber logging and compare them to simulated legal benefits in order to envisage solutions to legalize the activity. To achieve this objective and by using the two-step cluster method, sawyers were categorized into four categories consisting of professional sawyers, semi-professional sawyers, upper survivalist sawyers and lower survivalist sawyers. The results demonstrate that under illegality, professional and semi-professional sawyers earn higher profit than the other groups because they exceed the legal quota limit (500 m^3 per year) and exploit the most valuable tree species ("precious red wood", "red wood"), many of which are protected by international conservation agreements. Survivalist sawyers cause significantly lower environmental externalities as they primarily extract the less valuable species ("white wood") not protected by the law and log below their annual logging permit capacity. Further results indicate that, enforcing the Forestry Law to legalize chainsaw milling (CSM) activities will increase private welfare through higher net profit, enhance the value added, reduce the negative externality from forest loss, and thus increase overall social welfare for all sawyer categories. Using the computed Gini coefficients, the study further proves that legalization of CSM is efficient in decreasing inequality among the different sawyer categories as well as at the societal level. Legalization of CSM can hence effectively contribute to reaching economic development, forest conservation and poverty reduction objectives in Cameroon. Hence, government should organize campaigns to sensitize stakeholders on the advantages of tax payments by demonstrating the use of tax revenues to improve the CSM sector; credit schemes that support the adaptation particularly of the survivalist sawyers to changing requirements; increasing cooperation among sawyer categories; fighting corruption at all levels of the public administration; severe penalties and sanctions for continued illegal logging; and requiring all public markets to buy timber only from legal sources.

Forest Bioeconomy in China: Policies and Markets

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China by far is the largest producing and consuming country on concrete and steel, coal, paper and paper board, fossil-based products like polyester fiber and plastic (PVC). Since 2000, by recognizing the importance of sustainable development and pollution control, China shifted to green economy development model with increased demand on bio-based technologies, materials and products. in 2007 first National Bioeconomy Strategy was published by Ministry of Science and Technology since then China kept exploring the bioeconomy development potentials in various areas include energy, medical etc. In May 2022, National Development and Reform Committee published the 14th Five Year Bioeconomy Development Plan reconfirmed the importance of bioeconomy in national development. Forest, as one of important renewable nature resource, can play curial role to replace fossil fuel based raw materials, and provide more climate friendly constructions, also was part of renewable energy solution. We first reviewed the policy evolution related to forest bioeconomy in China, and the forest bioeconomy market development in China both in traditional forest sector like wood manufacture, wood construction and new novel market like wood fiber-based textile and plastic, then use SWOT model analyze the strengthens, weaknesses, opportunities, and challenges to unlock the roles of forest sector in bioeconomy development in China. Based on SWOT analysis result, in the end, we provided the recommendations both from policy and market angles about how to better leverage forest bioeconomy development in China in next decade.

Collective action in Germany's forestry sector illustrating the potential impact of the transformation towards a forest-based circular economy

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The Charter for Wood 2.0 is a unique dialogue setting, involving the various stakeholders of the German forestry sector. Representatives are included from government, industry, diverse science disciplines, and civil society associations. The goal of this broad scale collaboration is to valorise forests and their multiple services (economic, environmental, social) in times of complex environmental and societal challenges. The initiative is working to create resilient forest eco- and economic systems, using forest resources sustainably, fostering forests' contribution to climate change mitigation. This boundary spanning initiative enables insights in the forestry sector across disciplines (forest management, wood use, social aspects, governance). To monitor progress, indicators were developed that broadly cover the three major aims of the charter: climate change mitigation, resource efficiency and value creation. So far, two indicator evaluations have taken place, one in 2019 and one in 2021.To support the

charter, a literature review on forest-based circular economy was performed with the scope of, focusing on review papers and excluding papers that were sector, product or country specific. The aim was to create a common understanding among all charter participants of the term's bioeconomy and circular economy in a forestry context. Comparing indicator values of the years 2017 and 2019 (common data years of the two evaluation reports) showed that the forestry sector in Germany suffered from climate change effects. Resource efficient value creation was challenged by high volumes of calamity wood. Using these indicators of the forestry sector in Germany, we illustrate how the transition towards a sustainable forest-based circular economy can create economic, social and environmental value by sustainable wood use. Fostering the transformation towards a sustainable forest-based circular economy will require system wide thinking crossing boundaries. This national initiative has the potential to find global resonance and to be replicated worldwide.

Towards monitoring and evaluation of a sustainable and circular forest-based bioeconomy: A material flow and life cycle assessment approach

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Shifting the existing fossil-based economy towards a more sustainable bioeconomy is considered, together with the concept of circular bioeconomy, an important part of the transformation of the economy. While bioeconomy is often associated with a range of benefits, the transition implies trade-offs as well as risks and opportunities. Whereas trade-offs and synergies between different sustainability objectives are unavoidable, it is important to identify them in order to be reduced or maximized. Therefore, the goal of evaluation should be to measure the development of bioeconomy per se and its sustainability. This includes the use of biomass in a sustainable way and the valorization of biomass resources efficiently. In this study we present a combined holistic Material Flow and Life Cycle Assessment approach to assess and monitor the sustainability and circularity of the forest-based bioeconomy. This approach provides information about the total amount of bio-based materials produced, used, and recycled as well as associated sustainability effects. As prove of applicability we use the example of Uruguay, one of the few countries in the world that has its forestry development exclusively on the production of forestry plantations. Particularly Eucalyptus pulp is the second most exported product of the country and is expected to consolidate Uruguay as the second world largest producer of short-fiber pulp in the near future. We provide the first systematic assessment of the forest biomass flows in Uruguay and assess sustainability and circularity using a comprehensive set of indicators (e.g. cascading use, GHG emissions and substitution effects, biodiversity conservation, employment, value added, among others) at the country and value chain level. Our results highlight the need to include additional sustainability impacts beyond economy to capture the overall picture of the system. Based on our results recommendations are drawn on how to enhance forest statistics, having monitoring and evaluation of the bioeconomy as a goal.

What is the problem of gender inequality represented to be in the Swedish forest sector?

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Gender equality in natural resource management is a matter of sustainability and democracy for Sweden's government, however the country's forest remains a highly gender-segregated sector. We examine how gender inequality is problematized within Swedish forest and rural policy documents using the What's the problem represented to be? (WPR) approach. We build on previous efforts to investigate gender inequality in the forest sector by expanding the critical analysis to rural development policy. We conduct interviews with forest experts, owners, and practitioners to shed light on where there are gaps within the policy representations and uncover alternative policy options that are presented. Our findings corroborate that gender inequality is represented to be a technical problem, with policy measures aiming to increase the number of women within a forest sector that continues to maintain rigid conceptions about forestry production values. While there are claims of success in the increase of women within the sector in aggregate, there is little change in the numbers of women in decision-making positions. Forest policy relies upon women to bring growth and sustainability to the forest industry, while rural policy expects women to halt rural population decline. Our findings suggest that merely trying to fit more women into a mold that has been shaped for and by inflexible forestry and masculine values is an impediment not only to gender equality but also to the inclusion of other social groups and ideas in the changing rural landscapes of Sweden.

National timber harvest projections under the EU Green Deal and 2030 biodiversity strategy

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Currently, 24% of EU27 forests are protected and 5% are strictly protected. The 2030 EU biodiversity strategy was launched with the objective of protecting 30% of EU27 land and strictly protect 10% of it. Furthermore, the European Commissions "Fit For 55" climate package has increased the mitigation demand from the EU27 forests, for reaching EU27 climate neutrality by 2050. The fulfillment of the protection and mitigation demands from the two policies would require the European countries to adapt their current forest management according to the expected future objectives. Within this context, the objective our study was to project future timber harvest levels until the year 2100 for Europe (EU27+UK) and analyzing the spatial allocation of harvest areas at national level and leakages outside Europe, under scenarios integrating the 2030 biodiversity strategy and increasing the climate mitigation objectives. Under these scenarios, we have applied the Global Biosphere Management

(GLOBIOM) economic land use model for optimizing allocation of forest harvest across Europe. In addition, we considered alternatives as to how the European protection targets may be reached and countries contributions to the fulfillment of the overarching targets. Our results shows that the implementation of the biodiversity strategy would lead to a 7-12% reduction in overall EU harvest levels in 2050 compared to a baseline, depending on the implementation of the biodiversity strategy objective at EU, country, or at a finer scale resembling the development of the EU Green Infrastructure. The fulfillment of the target would generally reduce EU wood-based products competitiveness, but the EU would remain a net exporter of wood and semifinished products. However, a stricter interpretation of the "closer to nature" forest management in the protected areas would further impact the harvest levels and EU would become a net importer. Hence, it would be relevant for policy makers to consider our optimization results for allocating future protection areas in a way that will not impact on EU forest sector competitiveness in the bioeconomy and limit the leakages outside Europe.

How does an established pulp and paper business field transform towards sustainable circular bioeconomy?

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Change drivers, such as environmental challenges and the sustainability megatrend, are immensely affecting the global business environment and initiating a sustainability transition away from a linear fossil resource-based economy to a circular bioeconomy. The transition will influence established business fields and companies, catalysing them to alter their value creation logic and consider sustainability holistically where economic, social and environmental dimensions are in balance. Despite the forest-based sector is largely referred to as being in the core of bioeconomy, its sustainability has been contested: the economic benefits have been highlighted leaving social and environmental dimensions in a minor role. This case study investigated a practically interesting phenomenon, the transformation of an established pulp and paper business field towards sustainable circular bioeconomy, through a theoretical framework of business environment transformation. A theory-framed qualitative analysis was conducted by focusing on academic and non-academic documents (approx. 130) discussing the transition of the traditional forest-based business field to a circular forest-based bioeconomy. Furthermore, three globally influential Finnish-based pulp and paper companies are presented as case companies to investigate how the business field-specific value creation logic has been altered to respond to sustainability challenges. Thus, the case companies' external communication was investigated. The findings suggest that the pulp and paper business field has started to transform as it is exploring new sustainable path-breaking innovations and creating a common development agenda. The case companies have done incremental adaptations in their value creation logic by increasing cross-sectoral collaboration in research and development leading to new pulp-based products. However, the business field's narrative

of already being sustainable has hindered their contribution to holistic sustainability. Therefore, sustainability adaptations have not been stabilised as the social and environmental dimensions are not sufficiently implemented. Thus, the business field seems to be going through a business renewal, rather than a transformation. Sustainability transition requires a shift to holistically sustainable collaborative and regenerative value creation logic where ecosystems are seen also as natural capital and not only as providing resources. If the reconfigured value creation logic wants to be stabilised and implemented properly, a business field with strong influencing power needs to create a truly common sustainable development agenda by engaging different cross-sectoral stakeholders and considering their perspectives. In addition, business fields and companies need to construct a sustainable and cross-sectoral value-creating system that is agile to respond to changing demands and markets, and thus strengthens their competitive advantage and future resilience.

The use of hybrid indicators in the assessment of the impacts of technology on forest sustainability

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Developing indicators that can measure the impact of technology on agriculture and forested areas is directly linked to sustainability goals; that are of major interest to the global and green growth initiatives. The key technological areas targeted in this investigation are of those of relevance to high volume and high impact in agriculture and forestry, hence the focus on biotechnology. Identifying current, and proposing new, indicators linked to technology in sustainability domains is key to help capture impacts in a measurable, and meaningful manner that in turn can promote better research, science, technology, investments and ultimately the quality of life. With this context in mind, this presentation discusses available technology impact indicators in agriculture and forestry. It explains relevant indicators and proposes a novel framework to evaluate the unknown impacts of biotechnology on sustainability.

An assessment of the policy and legislative frameworks for commercial forestry management in Kenya

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Population growth is driving demand for wood products in Kenya, which is facing a wood deficit of 10 million m3. The country is only able to meet 70% of its demand through sustainable supply, and this has caused small and medium –sized enterprises to operate below capacity. One of the reasons for this deficit is poor forest plantation management. To resolve this, commercial forestry has been suggested as a solution whereby private actors can be involved in the management of public plantation forests through forest concessions and other joint management arrangements. Public-private partnerships could provide access to private sector financial capital as well as benefits from the transfer of technological and operational efficiencies from the private sector into public forest management. It could also boost

employment, income generation, and alleviate poverty. This paper explores the policy and legislative framework for commercial forestry in Kenya that includes: the Public-Private Partnership (PPP) policy, law and regulations, and sustainable forest management approaches like forest management certification and chain of custody certification for forest products. The main study approaches used in the development of this paper include literature review and content analysis of reports, government documents, strategies, and publications related to commercial forestry. The aim is to provide a critical assessment that highlights gaps and opportunities to be addressed in future policy formulation and implementation of commercial forestry in Kenya. The paper demonstrates that the Forest Management and Coordination Act (FMCA) 2016 contains most of the requirements outlined in the FAO Voluntary guidelines on forest concessions, though there is need to address some gaps such as: the harvesting value of an area, forest revenue collection, management of rescinded concessions, evaluation of the concession process, the mode of bidding, gender inclusion and independent observation. With regards to certification, although the socio-economic and environmental benefits of certification are sometimes not clear, it has played a major role in the adoption of sustainable forest management practices in forest concessions. In conclusion, to promote willingness to invest in a long-term venture such as commercial forestry, there is need for secure land tenure, respect for private ownership, reliable economic guidelines and standards, transparent governance, effective measures for tackling corruption, and efficient conflict resolution mechanism.

Evidence-based and emotional arguments about forests in the Baltic region: a comparison of mediatization and polarization in hybrid media systems

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In the global push to mitigate climate change, the competition between different users and uses of the forest is hardening. Conflicts often become entrenched and little agreement can be found between groups of actors. This battle over forests is a discursive struggle regarding what is framed as problems and solutions. The bioeconomy as a discourse is an integral part of this struggle, as well as the question what is considered valid and relevant science. The polarization observed in the debate is often explained by mediatization, social media, and powerful stakeholders' involvement. The process leading to polarization is however little researched. It remains unclear if more or less nuances can be found in different media formats.
The aim of this paper is to analyze how forests are framed in news and social media. We will analyze two main newspapers and selected data from Facebook and Twitter in three EU countries (Estonia, Germany and Sweden) in order to better understand the role of the media in framing forests and the process generating polarization. Our main method is a framing analysis and we will study the year 2018, a period when the forest issue became more salient in the Estonian, German and Swedish media. The overarching research questions are: How are the problems and solutions in the forestry debate framed? Theoretically we draw on the concepts of hybrid media systems and framing. The hybrid media system refers to the ongoing mutual

adaptation in structures, norms, logics and practices of the legacy media with those of digital-native media, social media, and digital platforms. Media are key actors when it comes to framing problems and solutions on environmental issues, and the notion of "framing contests" has been used to direct attention to the power aspects of media frames. The comparative analysis enables us to track how stakeholders use different media outlets and arguments to further their positions in media formats and contexts.

Enhancing resilience across the forest-based value chains: Identification and mapping of most relevant policy aspects within a European bio economy

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In the context of forestry related resilience research, for the last decades, "resilience" has been broadly understood in terms of recovery periods after disturbance events (*e.g., Holling 1973*). Since then, a lot has been written on different technical functions of engineering and the persistence of systems for ecological resilience. Most recently, discussions on so-called socio-ecological resilience have emerged (*see Nikinmaa et al. 2020*), calling for a more holistic view on resilience mechanisms which also should include societal and economic aspects, ideally going beyond mere technical understanding of forest ecosystems. From a methodological point of view, such endeavours are not easy to fulfil and only few scholarly efforts exist so far trying to tackle the burning issue of resilience with the holistic aim to take into account also societal aspects. The poster sets out to map the current policy steering capacities and related policy efforts that aim at increasing the resilience of forest-based value chains in a bio economy. The research uses the CICES classification (common classification of ecosystem services), covering the different steps along the entire forestry-related wood value chain. The policies outlined in the mapping range from forest management related policies along the lines of other uses and services of forests, ending up with the recycling phase in a circular bioeconomy. The involved policy measures cover the related environmental, energy, climate, research-related as well as timber and industry-related measures. Based on document analysis and expert interviews, the poster presents (i) the results of the policy mapping in form of a visual tool, it (ii) outlines the single policy documents along the value chain in form of a table and it (iii) draws inferences on related diverging policy objectives when it comes to the goal of strengthening resilience. The results identify those diverging strategies within some of the policy goals outlined in the mapping: Some biodiversity related goals are contradicting with the goals outlined in the bio economy strategy. These policy efforts take place under the umbrella of the most recent European Green Deal. The poster presentation will identify the differences in sectoral divisions

along the value chain, including some of the inherent trade-offs as one important factor for such diverging policy objectives. In conclusion, it will provide some recommendations for balancing these trade-offs by way of synergies.

Reconciling timber harvesting systems with forest structure data to assess the harvesting options of European forests

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The establishment of a bioeconomy to reduce greenhouse gas emission from the combustion of fossil fuels is seen as an important step for mitigating climate change effects. Wood as a renewable material is used to substitute other non-renewable and emission-intensive materials and this will likely increase the demand for wood and wood products. Forests provide important ecosystems services and not all forests in Europe are available for harvesting due to legal restriction but also due to high harvesting costs. The aim of this study is to assess the harvesting situation within European forests by reconciling forest structure and other European spatial data with different harvesting systems. The analysis considers the protection status of forests as well as the technical and, to a lesser degree, economical limitations for harvesting. The assessment is carried out on a 500 m x 500 m grid using consistent methodology all over Europe. It builds on an extensive forest structure data set based on 350.489 point sampled National Forest Inventory data from 16 European countries which provides forest information at 8 km resolution. Our results suggest that around 75 % of the European forest area can potentially be harvested under the current economic and technical harvesting conditions. The results encourage the use of fully mechanized harvesting systems such as `Harvester and Forwarder´ and `Winch-assisted Harvester and Winch-assisted Forwarder´ which can potentially be used on 80 % of the harvestable forest area in Europe. A shift to more mechanized harvesting is desirable to increase productivity and work safety. Finally, the age class distribution of “forest available for wood supply”, showed that around 6.627 Mill. m³ of the stocking timber is older than 80 years. Depending on the rotation length of these forests they should be available for harvesting in the near future.

National policy frameworks for implementation of EUTR requirements in the Western Balkans: a comparative analysis of Slovenia, Croatia, and Serbia

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Although the European Union Timber Regulation (EUTR) entered into force nine years ago, its implementation is uneven among EU member states. In addition, some Western Balkan countries are still characterized by weak legality monitoring which increases the risk of trade in illegally harvested timber both originating from the region and from other sources. Regardless of this, research on the policy frameworks for the implementation of EUTR in the Balkan countries is limited. Our study aims to contribute to filling this gap by deepening the analysis of policy frameworks for the EUTR implementation in the Western Balkan countries (Slovenia, Croatia, and Serbia). Qualitative content analysis was conducted on 22 policy documents from the three countries. Documents were coded deductively, using coding categories derived from EUTR. Targeted countries do not have policies directly addressing illegal logging or the prevention of illegal activities and show differences with reference to how EUTR requirements are embodied within national legislation. As EU member states, Slovenia and Croatia implemented EUTR through laws, however, while the Slovenian Forest Act addresses all EUTR obligations, the Croatian Law on EUTR Implementation does not directly address the obligation of legality. This obligation is addressed by the Croatian Law on Forests. As Serbia is not an EU member, it did not implement EUTR, nevertheless, Serbian Law on Forests addresses all EUTR obligations yet has some discrepancies regarding traceability obligations. Our findings indicate that the reporting quality of Competent Authorities in Slovenia and Croatia should also be improved, which is in line with the findings of existing grey literature and technical reports, such as WWF (2019), the European Commission (2020), and ClientEarth (2020). With ongoing discourses on Green Deal policies, the increasing focus on “deforestation-free” commodities, and the emerging of an EU taxonomy for environmentally sustainable economic activities, stricter implementation of EUTR (or EUTR-like) requirements might be expected at the EU level. Western Balkan countries will be no exception, and decision-makers, forestry professionals, as well as operators and traders, will face new challenges. To successfully implement EUTR, an increased number of checks, as well as stricter fines, will be needed along with improvements in the forest governance and policy: targeted countries will need to become more transparent and responsible concerning information availability.

On potentials, challenges and missing links regarding substitution effects of wood-based products for a circular bioeconomy

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The 2015 Paris Agreement aims to ensure that the global average temperature increase remains below 2 ˚C above pre-industrial levels and pursues further efforts to limit the temperature increase to 1.5 °C. Achieving these goals requires major societal and economic reforms to significantly reduce anthropogenic greenhouse gas (GHG) emissions and increase carbon sinks. Forests and forestry play an essential role, as they provide natural carbon sinks, provide products that store carbon over their life cycle, as well as substitute more emissions-intensive materials, thereby reducing emissions. In this regard, forests products are an integral part of a bioeconomy, aiming to replace fossil-based resources with bio-based raw materials in as many areas and applications as possible. Bioeconomy strives to create economic value and prosperity while offering solutions for environmental and climate-related issues through low-carbon intensive and renewable materials. However, substitution benefits of harvested wood products (HWP) cannot be attributed directly to the land use, land-use change and forestry sector (LULUCF) under the current national reporting of GHG emissions established by the United Nations Framework Convention on Climate Change (UNFCCC), as the emission reductions through the use of HWP will be captured in other sectors and potentially in other countries. This contributes to a very prominently perceived trade-off in climate-related policies between carbon storage in forests to conserve and enhance carbon sinks and wood use to reduce overall emissions. This poster provides an overview of the role of the forest-based sector in carbon management, focusing on material substitution of more emissions-intensive materials through wood-based products. Based on a literature review, the poster presents i) state of the art estimations on present substitution potentials of wood-based commodities, ii) describe challenges and uncertainties associated with the calculations of substitution factors and iii) showcase the importance of calculating and reporting substitution effects to foster climate-effective policies for the forestry and forest-based sector. The results identify promising applications for wood-based products with high substitution potentials, note uncertainties in the calculation of substitution effects and highlight risks pertaining to climate effective policies associated with the failing to include substitutions effects of wood-based products to the LULUCF sector. In conclusion, the poster will provide some recommendations on ways forward to recognise climate-smart, wood-based value chains and their contribution to GHG-mitigation efforts.

Evidence-based and emotional arguments about forests in the Baltic region: a comparison of mediatization and polarization in hybrid media systems

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In the global push to mitigate climate change, the competition between different users and uses of the forest is hardening. Conflicts often become entrenched and little agreement can be found between groups of actors. This battle over forests is a discursive struggle regarding what is framed as problems and solutions. The bioeconomy as a discourse is an integral part of this struggle, as well as the question what is considered valid and relevant science. The polarization observed in the debate is often explained by mediatization, social media, and powerful stakeholders' involvement. The process leading to polarization is however little researched. It remains unclear if more or less nuances can be found in different media formats. The aim of this paper is to analyze how forests are framed in relation to climate change in news and social media. We will analyze two main newspapers and selected data from Facebook and Twitter in three EU countries (Estonia, Germany and Sweden) in order to better understand the role of the media in framing forests and the process generating polarization. Our main method is a framing analysis and we will study the year 2018, a period when the forest-climate issue became more salient and polarized in the Estonian, German and Swedish media. The overarching research questions are: How are the problems and solutions in the forestry-climate debate framed? What kind of argumentation (emotional or evidence-based) is prevalent in these frames and successful in terms of reach? Theoretically we draw on the concepts of hybrid media systems and framing. Media are key actors when it comes to framing problems and solutions on environmental issues, and the notion of “framing contests” has been used to direct attention to the power aspects of media frames. The hybrid media system refers to the ongoing mutual adaptation in structures, norms, logics and practices of the legacy media with those of digital-native media, social media, and digital platforms. The comparative analysis enables us to track how stakeholders mobilize evidence-based and emotional arguments to further their positions in media formats and contexts. Expected results reveal the emotional turn in seemingly evidence-based experts’ argumentation. The (lack of) diversity of actors and arguments in all three countries indicates what are the dominant influences on the forest and climate change related debates in different media formats.

FOREST DEGRADATION AND RESTORATION SESSION

How dry is too dry? A retrospective analysis on how global change-type droughts are driving mortality in European forests

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European forests are an important source for timber production, human welfare, income, protection and biodiversity. During the last two decades, Europe has experienced a number of droughts which were exceptionally within the last 500 years both in terms of duration and intensity and these droughts seem to leave remarkable imprints in the mortality dynamics of European forests. However, systematic observations on tree decline with emphasis on single species together with high-resolution drought data has been scarce so far so that our understanding of mortality dynamics in the context of drought occurrence is still limited at continental scale. Here we make use of the ICP Forest crown defoliation dataset (ICP level I), permitting us to retrospectively monitor tree mortality for four major conifers, two major broadleaves as well as a pooled dataset of nearly all minor tree species in Europe. In total, we analysed more than 3 million observations gathered during the last 25 years and employed a high-resolution drought index which can assess soil moisture anomaly based on a hydrological water-balance and runoff model every ten days across the continent. We found significant overall and species-specific increasing trends in mortality rates accompanied by decreasing soil moisture. Previous-year soil moisture anomaly had a stronger influence on mortality rates than current-year soil moisture, suggesting that legacy effects (either physiological or caused by secondary biotic agents) play a key role in actual forest decline. Remarkable peaks in mortality occurred simultaneously in Norway spruce and Scots pine (2004, 2018, 2019), but were largely asynchronous in broadleaves. Mortality rates in Norway spruce and Scots pine have increased by 60% and 40%, respectively (period 2010-2020 compared to 1995-2009). Oak (*Quercus robur and Q. petraea*) as well as Silver-fir (Abies alba) showed lower mortality and only a moderate upward trend. We conclude that mortality patterns in European forests are currently reaching a concerning upward trend which could be further accelerated by the occurrence of future global change-type droughts.

Large-scale detection of bark-beetle outbreaks in Norway spruce forests

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There are efforts towards forest and landscape restoration to recuperate the ecosystem and enhance human well-being in deforested and degraded areas in Uganda. The study explores numerous challenges and success factors experienced in a bid to restore forest landscape in the

country. Data from a global online survey was used to ascertain common barriers and success factors for the delivery of forest restoration. Common challenges to forest restoration highlighted were a lack of local stakeholder engagement, participation, and involvement in forest landscape restoration programs, along with environmental, anthropogenic, and technical barriers to tree regeneration. Lack of synchronized synergies between local community needs, expectations and priorities compromises forest landscape restoration processes. Observing key principles of forest and landscape restoration can galvanize community participation and support, with the potential to overcome barriers to forest regeneration and motivate communities' protection, management, and monitoring of the restored forests in a more sustainable manner. Research is needed to gain a better understanding of the perception of local communities towards restoration activities.

Forest related nature-based approaches. Review of implementing forest related nature-based approaches - from afforestation to forest landscape restoration

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The term 'Nature-Based Solution' is relatively new, but the concept of managing land for changing climate, biodiversity and sustainability using natural processes is not new in forest management. We explored seven related terms used in the scientific literature to clarify their use in forest landscape restoration (FLR) implementation. Terms were Nature-Based Solution (NBS), Ecosystem (Based) Adaptation (EBA), Integrated Land(scape) Management (ILM), Forest Restoration (FR), Forest Landscape Restoration (FLR), Afforestation (AFF), and Rewilding (REW). Using a systematic approach, 11,165 articles were retrieved from Web of Science (WoS) and analysed bibliometrically. Ten systematic reviewers recruited from the IUFRO Task Force 'Transforming Forest Landscapes for Future Climates and Human Well-Being' then extracted partial data from 700 of these articles, using random sets of 100 articles for each of the seven terms, and identified articles that provided clear definitions of terms. The resulting 122 articles were extracted for a full range of data, including scale and location of the study, land use context, and focus on sustainability, nature-based concepts, and sustainable development goals. There were temporal and geographic trends in usage of these concepts and differences in interpretation across scientific disciplines. The terms AFF and FR appeared first in the literature indexed in WoS (*1903 and 1970s, respectively*), followed by ILM and EBA (1992), REW (1999), FLR (2002), and NBS (2009). Forests and rural land uses dominated the context of publications,

except for NBS, which emerged primarily from an urban/city context. There was a clear geographic divide: FLR from the global South while the other terms came either from the global North or from the economically developed countries plus emerging economies in Africa, Asia, and South America. Of all the terms, FLR was the most cognizant of sustainability concepts. The lack of definitions of terms or clear explanations of how research interventions would achieve the aims embodied in standard definitions of these terms, supports the suspicion such terms are often used as 'buzz words' to attract funding or notice. We conclude that adherence to a specific definition of a nature-based approach is less important than emphasising expected outcomes for improving the quality of the targeted socio-ecological system. Following the principles and standards of NBS approaches should improve the amount and quality of vegetation cover, secure ecosystem services of clean water, soil and biodiversity protection, and production of products from the forest (wood volumes to be harvested, non-timber forest products, food security), and improve livelihoods.

RFFL – Science-practice interactions through long-term demonstration, research and monitoring experiments at operational scale in Central Asia

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Mountains forests in Central Asia are threatened by overgrazing, illegal logging, wildfire, and climate change. The resulting soil erosion and faster runoff causes downstream flooding and contributes to mudflows and landslides. The Resilient Future Forests Laboratory (RFFL) initiative is establishing demonstration, research, and monitoring (DRM) locations in Uzbekistan and the Kyrgyz Republic. RFFL is focusing on developing disaster-resilient landscapes through improved watershed management and innovative forest regeneration systems. The DRM sites serve to facilitate the transfer of information and innovation to stakeholders, focusing on advantages and disadvantages of a range of management alternatives. This approach is expected to uncover conflicts and synergies with other sustainable development targets (e.g., biodiversity, economic and social benefits). Innovative solutions for the future are only feasible if local stakeholders are engaged in their development and thus become convinced that they benefit from land use changes. Site conditions can be challenging due to harsh microclimate, low precipitation, and infertile soils and, in some places, degraded conditions. The goals of mountain afforestation are to reduce and stop soil erosion, decrease mudflows, an increase the even seasonal flow rate of rivers. Our strategy follows three principles: Afforest small catchments on slopes, choose appropriate trees for specific locations, and evaluate economic benefits of environmental services. DRM sites are established at operational scale with a simple design initially, including mixed crop species using combined methods including container vs. bareroot seedlings, rows with and without sacrificial nurse species to protect the crop species, amendments to improve soil moisture (hydrogel and/or biochar and/or mulching with cut plant material, and temporary fencing of part of the plots to show the effects of grazing. A micro-nursery system will produce the container seedlings (initially using Jiffy-7, 200 cm3 pellets). At

landscape scale, climate and hydrological modeling will illustrate the effects of alternative land use changes.

Innovating public incentives for nature-based solutions: moving from bottlenecks to opportunities and blended finance to restore degraded lands in Latin America

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Public economic incentives for Forest and Landscape Restoration (FLR) are policy instruments from governments encourage landholders and landowners to implement actions in the ground. Incentives come in the form of direct payments, tax reliefs of grants to farmers interested to implement changes to the status quo and revert degradation on their lands. There are many incentives in Latin America available for famers, but several bottlenecks remain impeding the implementation at scale. In this presentation we will address the following questions: How are governments improving accessibility of payment for ecosystem services to marginalized groups? how could carbon taxes accelerate or impede land restoration in forest and agricultural landscapes; and how can we achieve a balance between agricultural and environmental incentives to produce, protect, conserve and restore? The analysis was done with six countries in Latin America thought the Policy accelerator Program. The Restoration Policy Accelerator (PA) is a peer-to-peer, innovation program for career government officials and policymakers looking to improve the implementation of existing public incentives or design new policy instruments to promote landscape restoration as a Nature-based Solution. Drawing on two years of experience leading the PA program in Latin America, this presentation will focus on the in the policy bottlenecks identified in Mexico, El Salvador, Chile, Brazil, and Guatemala on how innovative solutions are being addressed and how they can unlock the flow of public financial resources to implementers.

Co-benefits of restoring mangrove ecosystems and livelihoods for the poor - Case study in Myanmar's Ayeyarwady Delta

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Mangroves are important for people’s livelihoods, well-being and resilience in tropical coastal regions but are strongly subjected to deforestation and forest degradation. In Myanmar’s Ayeyarwady Delta, large areas have been converted to paddy fields, but have become unproductive after frequent saltwater intrusion. Several efforts have been done in the past thirty years to restore these degraded lands and plant mangrove trees as part of the country’s community forestry program with the goal to enhance ecosystem services and livelihoods for the rural population. However, few studies have analysed the contribution of community forests, especially mangroves to the livelihoods of different households within a community, including the poorest and those not participating in official community forestry user groups. To

address this gap, we compared livelihood strategies and the use of restored mangrove community forests by different community members in the Ayeyarwady Delta. Applying a sustainable livelihoods approach, data were collected through a household survey (n = 110) and various participatory tools applied in four villages. The significance of mangroves for people's livelihoods and well-being was clearly demonstrated, with as many as 91% of households depending on forest products to varying degrees. Commercial products include mainly crab and nipa palm, whereas nipa palm has particular importance for women's income. Substantial differences in the contribution of restored mangroves to total income were related to community forestry membership ($p = 0.004$) and wealth ($p = 0.022$). The poorest households had the highest income shares (36%) from community forests whereas richer households get most of their income from home gardens. There is no clear link between membership and wealth. However, non-members benefit mostly through subsistence products including fuelwood and a range of other non-timber forest products. A strong support for mangrove restoration and recognition of its importance for well-being and resilience against climate extremes was observed across villages and households. In terms of success factors for mangrove restoration, we therefore believe that actively involving and giving rights and responsibilities to local stakeholders, including the poorest households and those that do not participate in community forestry user groups, is key for sustainable restoration outcomes. This is particularly important considering the many challenges that forest dependent communities in Myanmar and beyond face linked to the climate emergency, cost of living crises and COVID-19 after effects. We conclude that transformative restoration efforts depend on the co-benefits provided to ecosystems and people.

Restoration of the Atlantic Forest in Brazil: motivations and barriers from the perspective of rural landowners

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The Atlantic Forest is considered a conservation and restoration hotspot. Due to Brazil's historical settlement, land use and the high population density, the remaining Atlantic Forest is largely restricted to small fragments. One of the restoration challenges in conserving and connecting these forest patches. With rural landowners owning over half of these forests, they play an essential role in ecological restoration (ER). However, one of the bottlenecks of expanding ER is the resistance of rural landowners to restore native forests on their properties. Moreover, there is a scarcity of research involving landowners' perspectives on ER in the Atlantic Forest in Brazil. This study aims to understand the motivations and social characteristics of two groups of rural landowners: those who have restored their forest with the support of ecological restoration projects (S) and those who did not receive this support (NS). Using a case study approach with qualitative content analysis, we focused on the southeast of Brazil in the operation area of a local NGO, in which 68 landowners were interviewed (36 supported and 32 not supported). Preliminary results indicate that 91% of the interviewed, even the landowners without project

support, reported having restored at least a small patch of their forest. For most of the landowners of the S group, rural production is not the primary income (86%). They used row planting as the main restoration technique. In contrast, 69% of NS consider themselves rural producers and use natural regeneration as a technique. The results also demonstrate different perceptions related to the barriers. Restoration cost and difficulties associated with implementation dominated the S group's responses, whereas in the NS group, no respondents reported difficulties in implementing ER and rather mentioned high restoration costs and losses of productive areas. The NS group used areas unsuitable for crop production for natural regeneration of native vegetation. Challenges regarding the establishment, management, and restoration expense were much higher in the case of afforestation through planting than in natural regeneration. Regarding the motivations, the three most cited were idealistic reasons, water protection, and biodiversity. Yet, 25% of the NS landowners reported that they are not motivated to restore. These results indicate the different motivations, barriers, and potentials that can be used to better engage the diverse groups of landowners in ecological restoration. In addition, they provide a foundation for ER mobilization strategies for local institutions and may guide restoration policies in the Atlantic Forest.

Brazilian policy instruments for social innovative forest and landscape restoration: exploring complexity

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In 2012, the Brazilian Forest Code underwent reforms that reduced the obligation to protect native vegetation on private lands by 60%, while introduced instruments to support landowners to restore an estimated deficit of 20 million hectares. The complexity and contestations about these instruments' implementation resulted in the state environmental system adaptations that, after 10 years, still could not fully put them into practice. Together, de-regulation and implementation gap slowed down FLR achievement in Brazil and pushed the restoration chain organisations to share knowledge and organise collective actions, finding new ideas and governance arrangements to overpass the new risks and challenges derived from the reform, thus undertaking Social Innovation (SI) processes. SI are processes and results where people share ideas, knowledge and take collective actions to overcome a common challenge. Typically, large-scale FLR initiatives led by governments or markets have faced difficulties in engaging stakeholders and the needed capital with efficiency, transparency and responsiveness to restore degraded landscapes and enhance people’s wellbeing, the FLR dual goal. Alternatively, organised farmers, women and youth can leverage a bottom-up FLR process by leading or actively participating in the design, implementation and evaluation of innovative small-scale social-ecological restoration practices and processes. This can be supported by government and markets but points to a distinctive approach, the Socially Innovative Forest and Landscape Restoration (SI-FLR). Through an inductive method and applying content analysis techniques in 50 national policy documents of four policy domains (environment, agriculture, regional

development and science, technology & innovation) we the map governance structures and identify policy instruments likely supporting social innovators in implementing landscape restoration initiatives in Brazil. On the basis of which, we identify gaps between policy (written words) and politics (the implementation process) and made recommendations on to foster SI-FLR in Brasil. We found that while the current governance structures and policy instruments seem well designed for being supportive of SI-FLR, the effectiveness of the implementation still suffer of lack of a real politics support and administrative constraints. Policy instruments willing to support SI-FLR should assume a landscape approach, by decentralising land use design, implementation and evaluation, and encouraging experimentation by local dwellers at the landscape level.

Forest landscape restoration improves tree coverage in Bangladesh's Kutupalong Rohingya refugee camps

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The 2017s settlement of 700 hundred Rohingya refugees from neighboring Myanmar has resulted in approximately 4000 acres of degraded forests in Bangladesh's southeastern region. To restore the degraded landscape, different governmental and non-governmental organizations launched plantation programs using native trees and non-woody plant species. To this end, we conduct a multi-temporal satellite image analyses from 2017 to 2022 to determine how the restoration initiative has affected the degraded forest landscape, as well as a random field sampling approach with 45 plots (size: 10m×10m) to determine the current state of tree diversity and regeneration in the Kutupalong camps. Our findings indicate that forest covers in Kutupalong camps had increased by 60% between 2017 and 2022 whereas, during the same period, degraded forest was decreased by 38%, implying that plantation efforts provide positive feedback to forest expansion. Our land use change analyses also indicated rapid expansion of agricultural lands (136 Ha) in that timeframe. However, the dominant land cover type was settlement areas, which was due to the gradual rising of housing needs for camp's inhabitants. In the sampled plots, we found that 19 tree species were used in the plantation operations, with a 75% survival rate. Furthermore, regeneration of 32 different tree species was documented in the restoration sites, with an overall Shannon and Simpson indexes of 2.99 and 0.07, respectively. Regeneration from seed and coppice were the most common in the study area. Our findings indicate that a higher number of tree species were present in these forests prior to the Rohingya settlement in Kutupalong, as evidenced by nearly 60% higher numbers of regenerating tree species compared to plantation tree species, and we suggest that these tree species must be considered in future plantation operations. The main threats to the survival of planted trees and seedlings include landslides, land degradation, and the presence of invasive species in the study area. The ecosystem will be restored to its previous state if tree diversity and vegetation covers continue to improve, enhancing ecosystem services for the human and biodiversity living in the camp environment.

Climate change and severity of crown dieback in Brant's oak trees; some recommendations to mitigate the tree mortality

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Persistent drought and warming are prominent outcomes of climate change in pure stands of Brant's oak (*Quercus brantii*) in the southern Zagros Forests. With the continuation of drought conditions, crown dieback has become a challenge for these Brant's oaks. We have monitored 400 Brant's oaks for four years to assess the severity of crown dieback. We examined 100 healthy individuals from an unaffected stand of north aspect, 100 healthy individuals from an unaffected stand of south aspect, 100 dieback individuals of varying severity from an affected stand of north aspect, and 100 dieback individuals of varying severity from an affected stand of south aspect. In addition, we monitored tree mortality, changing crown dieback severity, changing nutrient uptake, and some soil physicochemical variables beneath the trees. At the end of the period, there was no natural tree mortality other than some trees that were cut by rural people to provide fuel. Thus, some dieback trees were able to recover, possibly because of genetic differentiation and its impact on tree resistance. On the other hand, we have seen that dieback severity in some individuals is progressive. The point to consider is that minor cutting of some drying branches of dieback trees by rural communities might boost the ability of the trees to recover while extensive and irregular cutting of drying branches might kill the trees. The content of soil P, Zn, and Fe nutrients plays a prominent role in induction of the tree resistance; the dieback trees always presented the lowest concentrations of P and Zn, while the Fe content was higher in the drying trees. Furthermore, soil humidity and P content of soils beneath healthy trees were greater than those affected by crown dieback. In conclusion, some silvicultural activities such as minor brushing treatment or cutting of drying branches under the supervision of forest pathologists and fertilization of Brant's oak stands with P and Zn might improve the resistance of these valuable trees, countering the effects of climate change.

Forest restoration on a former industrial land of Sulphur quarry in Ukraine

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This paper adds to the evidence base in the scientific discussion to what extent woodland development can be a means to restoring the land affected by natural resource mining. We investigate the formation of vegetation communities in sites of a former Sulphur quarry in the Roztochya district of the Lviv oblast (province) in Ukraine to answer the research questions: How the formation of vegetation cover can affect the disturbed sites and what knowledge can be used in restoration practices elsewhere. We perform an experiment examining which types of vegetation are suitable for woodlands restoration, and we explore the influence that restored vegetation and re-emerged woodlands have had on the process of soil rehabilitation

and the increasing organic substance in it. We examine the impact of various combinations of vegetation on land rehabilitation. Explaining the degree of colonization of waste land by various types of vegetation helps us to reveal the trends of regenerative processes and identify the most promising for restoration tree species in affiliation with the ground vegetation. The results can assist decision-makers in choosing compatibility alliances of vegetation to sustain regeneration processes. Although this research is location specific, the knowledge developed can to a degree be applied to similar places, in the temperate zone, elsewhere. Moreover, the war in Ukraine has shown, as never before, the necessity to build the resilience of socio-ecological systems to be able to tackle anthropogenic disturbances, and even of what the UN General Secretary, António Guterres described, a global 'triple food, energy and financial crisis'. Thus, indeed, there is a need of having powerful and valuable tools and strategies for designing, developing, and diffusing of solutions to multifaceted disturbances and crises, requiring societal or behavioural shifts towards more sustainable choices in environmental policy and management.

Barriers and good practices to promote forest landscape restoration programmes

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There are efforts towards forest and landscape restoration to recuperate the ecosystem and enhance human well-being in deforested and degraded areas in Uganda. The study explores numerous challenges and success factors experienced in a bid to restore forest landscape in the country. Data from a global online survey was used to ascertain common barriers and success factors for the delivery of forest restoration. Common challenges to forest restoration highlighted were a lack of local stakeholder engagement, participation, and involvement in forest landscape restoration programmes, along with environmental, anthropogenic, and technical barriers to tree regeneration. Lack of synchronized synergies between local community needs, expectations and priorities compromises forest landscape restoration processes. Observing key principles of forest and landscape restoration can galvanize community participation and support, with the potential to overcome barriers to forest regeneration and motivate communities' protection, management, and monitoring of the restored forests in a more sustainable manner. Research is needed to gain a better understanding of the perception of local communities towards restoration activities.

The potential of bamboo for the reclamation of forestland degraded by surface mining activities in Southern Ghana

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Artisanal and small-scale mining activities have been rife in Ghana for several years. The methods used result in significant environmental damage, including land and forest degradation, air pollution and pollution of water bodies in the mining communities by mercury and other toxic substances. This has contributed to the incidence of floods and irreversible damage to aquatic and terrestrial ecological systems. In addition, air pollution from dust and other harmful substances poses health hazards to communities where such activities take place.

Currently, efforts are being made to restore forest reserves and lands degraded by unregulated mining activities in Ghana by planting trees and other vegetative cover. Bamboo is abundant in Ghana and is known to be useful for soil erosion control, carbon sequestration and restoration of degraded land. However, its potential for land restoration has not been fully assessed in the country. This study therefore sought to explore the potentials of bamboo for reclaiming degraded mined land and to identify suitable bamboo species for this purpose. Plots measuring 825 m2 were demarcated on un-mined, reclaimed mined and un-reclaimed mined sites located in the moist semi-deciduous forest in Ghana. Seedlings of seven bamboo species were planted at 2 m x 2 m matrix in blocks on each plot and the seedlings were assessed for survival rate, shoot production rate, height growth and qualitative phenotypic characteristics. The results indicated 97% survival of seedlings of all the species on all the plots and 70% of seedlings developed new shoots on the un-mined and reclaimed sites one month after planting while the un-reclaimed site recorded 50%. Mean shoot production for reclaimed-, un-mined-, and un-reclaimed mined sites were 3.0, 2.0 and 1.0 shoots per clump, respectively with corresponding mean height growth of approximately 173 cm, 113 cm and 63 cm after three months. By the tenth month, the bamboo had formed an impenetrable barricade on the reclaimed and un-mined sites. *Dendrocalamus membranaceus, Oxytenanthera abyssinica, and Bambusa vulgaris var. vittata* performed well on all sites in terms of foliage accumulation. Being abundant locally in Ghana, *Bambusa vulgaris* is recommended for rapid reclamation of degraded mined lands in southern Ghana where much of the reclamation in most needed. This will contribute significantly to Ghana's commitment to restore 2 million hectares of degraded forest landscapes under the Bonn Challenge and other restoration initiatives, and to Targets 3, 4 and 5 of SDG 15.

War-induced degradation of forest ecosystems and losses of their services in Ukraine

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The ongoing hostilities in Ukraine induced by the Russian Federation's open military aggression have already led to a major disruption of civil infrastructure, natural ecosystems, and their services. We hereby present the preliminary assessment of the inflicted damage and losses to the civil objects and natural ecosystems of Ukraine's forest sector. It is necessary to note that in the combat zone there were 10 regional administrations, 45 state forestry enterprises, 386 forest management sub-units, 603 objects of real estate (structures), and 3236 units of movable property. The area of the occupied forest lands is 1391 thousand hectares. First, we highlight the losses caused to the objects of civil infrastructure within the forest sector. Real estate worth EUR 28.7 million was destroyed. Damaged real estate is worth EUR 20.2 million. Movable property worth EUR 9,9 million was destroyed. Damaged movable property worth EUR 3.3 million. The destroyed office property is worth EUR 3.3 million. Devices and mechanisms worth EUR 4.3 million were damaged. The direct damage to the forest ecosystem is estimated at the level of EUR 127.4 million, at the affected forested area of 2907 thousand hectares, with the expected amount of damaged growing stock of 588 million cubic meters. Indirect (deferred) damage to forest ecosystems is expected at the level of EUR 50,4 million, with a decrease in the annual increment of wood by 10 %. Damage to ecosystem services provided by forests is assessed at EUR 173,9 million. The expenditures associated with the return of forest ecosystems to safe forest management (demining, clearing of military equipment, etc.) are expected to approximate EUR 4.7 million. Total losses according to this assessment are expected to amount to EUR 453.1 million. The research presents the results of preliminary calculations, which may be subject to increase depending on the development of the situation. It is therefore a joint task for the world to stop the military action in Ukraine as soon as possible by all the acceptable means.

A goal-orientated approach to Forest Landscape Restoration in West African Burkina Faso

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West African Burkina Faso is facing continuous deforestation. Since 1986 forest area has been reduced by more than 85%. At the same time the majority of the local population is involved in subsistence farming and thereby also depending on trees, shrubs, and lianas for their livelihood. Various restoration efforts with different goals and methods are already taking place all over the country. When planting, however, it is important to focus on selecting appropriate species. In a collaboration between the project Restool and Diversity For Restoration (D4R) a decision support tool (DST) was created to facilitate finding an appropriate woody species to plant according to site conditions, actual and future climate, and the aims of the user. By

literature research and interviews conducted with experts, information on different characteristics and uses of various woody species native to and naturalized in Burkina Faso was compiled, and knowledge was identified, evaluated, generated, stored, and transferred to the freely available DST D4R, so anyone interested in restoration activities could use it. Eventually 75 woody species were included and information for 84 different species traits and uses was compiled to cover all three climatic zones of the country and offer options for species selection for the four main objectives of the decision support tool (agroforestry and commercial uses, biodiversity conservation, regulating ecosystem services, and traditional uses). The D4R tool further integrates (a) species habitat suitability maps under current and future climatic conditions; (b) analysis of functional trait data, local ecological knowledge and other species characteristics to score how well species match the restoration site conditions and restoration objectives; (c) optimization of species combinations and abundance considering functional trait diversity or phylogenetic diversity, to foster complementarity between species and to ensure ecosystem multifunctionality and stability; and (d) development of seed zone maps to guide sourcing of planting material adapted to present and predicted future environmental conditions. With this tool the ambitious goals of forest landscape restoration projects in Burkina Faso can be supported in leading to multiple win-win-situations as carbon sequestration, halting deforestation, and enhancing livelihoods can go hand in hand.

Uncertain future of Chernobyl forests: regeneration or degradation under fire and military risks?

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The Chernobyl nuclear disaster (1986) entailed a strict limitation of human access and silvicultural interventions in the forests within 2600 km2 area of radioactively contaminated lands. Additionally, local croplands were abandoned due to a prohibition of agricultural activities. Subsequent natural succession on these formerly open landscapes accelerated two contradicting processes: net forest cover gain and altering natural disturbance risks. New complex mosaic of grassland, young tree vegetation and homogeneous even-aged coniferous forests appeared to be a suitable environment for severe wildfires. Conventional approaches to regenerate burned or cleared forest area by planting Scots pine (Pinus sylvestris L.) seedlings were once again applied after a severe 1992 wildfire in the Chernobyl Exclusion Zone (CEZ). Low ecosystem resilience of CEZ forests under climate change impact and building fuel stocks due to highly limited silvicultural interventions facilitated the spread of catastrophic wildfires in 2015 and 2020. Poorly developed infrastructure and lack of fire-suppression capacity contributed as well. CEZ has faced new emerging cascading risks with an escalation of Russian-Ukrainian war after full-scale Russian military invasion on 24 February 2022. CEZ was returned under Ukrainian control in April 2022, but this area continues to be severely contaminated by landmines. It limits both monitoring of natural ecosystems in CEZ and fire-suppression capacity. New severe wildfire happened in May 2022 and killed Scots pine vegetation planted on the

sites burned in 1992. Lack of field data continues to limit recent efforts to simulate future wildfires and enhance decision making. That is, the main effort should be launching a new aerial survey program over CEZ. Stereophotogrammetric and LIDAR acquisitions can substitute on ground visitations in landmine- and radioactively contaminated forests aiming to estimate forest attributes. While the forest cover has increased up to 59% (1.5 times net increase since 1986 based on Landsat temporal segmentation), substantially burned areas require measures to reduce fuel stocks and plan efficient regeneration efforts. We suggest using coupled dense time series of Landsat, Sentinel-1 and Sentinel-2 data with ancillary data. Our Sentinel-based machine learning model derived carbon estimates with 40% relative root mean square error and thus is eligible for assessing carbon loss due to wildfires. As well, Sentinel products robustly captured a degradation of forest cover through fragmentation after this disturbance (mean forest cover patch size decreased twice, to 3.1 ha). Building of spatially explicit information system is crucial to ensure a comprehensive forest management in such a unique and important area as CEZ.

Joint Forest Management: A Potential Option for Restoring Degraded Forest Reserves in Nigeria

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The Nigerian Forest estate has been shrinking due to a variety of drivers of deforestation and degradation. Forest encroachment for agricultural expansion is the root of gradual loss of forest resources, besides firewood and timber cutting. These forest reserves are part of the forest estate which are solely managed by the state governments, which state lacks the capacity to effectively manage and protect these forests properly. With few experiences existing in Nigeria, it is important to look at possible option that can fully integrate at local level those who drive forest degradation and deforestation into options to maintain and restore forests, under a joint land and forest management scheme. In this study, we identified potential success factors that will aid the adoption of joint forest management (JFM) for restoring degraded forest reserves in the study area. The study was carried out in Cross River South (CRS) and Ikrigon Forest Reserves, Cross River State, Nigeria. Three forest communities used were: Alok in Ikrigon Forest Reserve, Isabang and Odonget in CRS Forest Reserve. Key informant interviews (KIIs), Focus Group Discussions (FGDs) and household survey were used for data collection. The result showed that presence of traditional rules and norms guiding the people, consensus on forest importance and people's willingness to be involved in restoring and managing these degraded forest reserves were the factors that can aid the adoption and success of JFM. The incentives identified by the local communities that would trigger their interest and full engagement to participate in JFM schemes include equitable benefit sharing, employment of local work force from the villages and provision of basic amenities. JFM can be a viable option for restoring degraded forest reserves.

Assessment of restored riparian forest functioning in tropical streams

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Tropical streams have great importance due to their biodiversity, provision of essential ecosystem services for humans, but also because they are considered one of the ecosystems most threatened by land use changes. The riparian forest is an important component for the structure and functioning of streams ecosystems, maintaining their ecosystem processes and providing shade and organic matter to the stream. Riparian forests restoration has been considered as a tool of stream restoration in Brazil, without evidence of its effectiveness for the functioning of the stream ecosystems, once the maturity of the forest is longstanding and not always reached, making their shading and large wood provision ineffective. This study aims to evaluate the restored riparian forests in providing organic matter and shade to streams, according to the time of restoration (3-13 years, 23-33 years and 43-43 years), in 15 catchments (third to fifth order), all located in the southeastern region of Brazil. 150m stream reach, per catchment, were used to collect the total number of large wood present inside the channel and their respective volume, considering large wood with length greater than or equal to 1 meter and circumference greater than or equal to 30 cm. The measurement of the shading of the restored riparian forests, according to the restoration time, was measured using a concave densiometer in three points along the 150m stream reach, in the dry and rainy seasons. The basal area of the riparian forest was also measured, using transect plots (25m x 10m) installed across the stream in each of the 15 catchments. Large wood abundance and volume was higher in older restored riparian areas (34-;43 years) compared to younger riparian areas (3-13 years). The basal area was also higher in the older restored areas. Shading was higher in younger restored riparian areas, demonstrating that in terms of stream shading, young forests are already capable to provide this ecosystem function. Preliminary results showed that age and structure of riparian forests are strongly linked to shading and large wood abundance and volume, demonstrating the importance of restoration and conservation of riparian forests for the structure of tropical streams.

Past development, present status, and likely futures of Norway spruce in Western Ukraine and South-West Germany

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At present, Norway spruce forests are distributed far beyond their assumed natural range in many parts of Europe. While in the northern and eastern parts of Europe, most Norway spruce occurs within its natural range. In Western Ukraine and even more in Southwest Germany it reaches far beyond its assumed natural range. Due to environmental changes and changes in management aims, forest tree species composition is already changing. These changes will have an impact on wood production as well as on carbon sequestration; nutrient cycling; biodiversity; and resistance against storm, snow, drought, fires, insects and fungi. Associated compositional, structural and functional changes of forests will affect almost all goods and services provided by forests, including secondary effects on income of forest owners and on the climate change mitigation potential of these forests. In Central and Eastern Europe, Norway spruce is currently facing unprecedented severe threats by multiple abiotic and biotic stressors. The current forest health crisis underpins the vulnerability to climate warming and gives reason to question the magnitude of the climate change mitigation potential of the future forests. In this poster, we will highlight the past development, current status and expected future projections of Norway spruce in Western Ukraine and South-West Germany. Our analyses are based on forest management and forest inventory data as well as on projections made using the forest growth model EFISCEN. We gathered data about forest area of Norway spruce stands (i.e., 80 % of stand area), including growing stock, mean annual volume increment and real and allowable harvest for the past 40 years in the study areas. We also collected data about the amount of damaged wood and damaging factors threatening Norway spruce forests (e.g., forest fires, wind, drought, insects, diseases). Based on the current state of the Norway spruce stands, we project future development with EFISCEN to quantify changes in volume stock and increment. Our analyses show that Norway spruce forests face several challenges and threats that reduce round wood potential and carbon storage in South-West Germany. Especially, storm and insects are main drivers of change promoting forest conversion, leading to reduction in area and volume stock. In Western Ukraine forest areas of Norway spruce stands declined, while at the same time growing stock remained stable. Beside area losses, forests are mainly threatened by drought and diseases. Results from EFISCEN simulations will be presented showing likely futures of Norway spruce stands.

Emission Reductions Program for Addressing Drivers of Deforestation and Forest Degradation: An Insight from the Terai Arc Landscape in Southern Nepal

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As part of the REDD+ program, for the past decade, Nepal has been working with the World Bank's Forest Carbon Partnership Facility on its Emission Reductions Program (ER-Program). The ER-Program was designed for a program area covering 13 districts in the Terai Arc Landscape. Approved in 2018, the Emission Reductions Program Document (ERPD) identified six major drivers of deforestation and forest degradation in the program area: unsustainable and illegal harvesting of timber and fuelwood; overgrazing; forest fires; encroachment and conversion of forest land for other land uses; resettlement; and infrastructure development. The ER-Program aims to address these drivers and help the conservation and enhancement of existing forest carbon stock through the sustainable management of forest resources. To do so, seven program interventions have been designed, ranging from localized and improved community-based forest management, through private sector engagement in the forestry sector and alternative energy promotion, to integrated land-use planning. The February 2021 Emission Reductions Payment Agreement (ERPA) between the Government of Nepal and the World Bank has paved the way for official implementation of these interventions on the ground. These interventions unlock the potentiality of up to USD 45 million in results-based payments for emission reductions of up to nine million tons of carbon dioxide equivalent by 2025. Accordingly, the ER-Program is expected to address the drivers of emissions-causing deforestation and forest degradation and enhance forest carbon stock, ultimately paving the way for results-based payments for future emissions reductions.

GENDER (UN-)EQUAL NETWORKING OF IUFRO SESSION

Creating new spaces for gender balance in the wood value chain: women in leadership and management

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Much of the classics in literature and research on gender balance in the forest sector has been based on models of economic rationality presumed to be universal and "a-gendered". Our research starts from the assumption that economic processes are not "neutral" and we aim to produce insights on the efficiency of means and tools for achieving gender balance. By some scholarly literature, goals such as increasing resilience and robustness of the forest-based value chains will depend on the abilities to respond to current economic and societal transformation processes, seen by some even as multiple crisis. The question remains, in how far inclusion, the fostering of diversity and gender balance can influence resilience? This poster will present the results from a study funded by the Austrian Ministry of Agriculture, Regions and Tourism. It will, amongst other, illustrate the results from a survey amongst the Austrian participatory stakeholder platform "Walddialog" and other principal forestry related institutions and agencies [1]. The Walddialog (Austrian Forest Dialogue) is an internationally well-acknowledged process with the aim to promote a cross-sectoral consolidation of existing forest-relevant as well as forest-policy discussions and instruments at the federal and state levels. It has around 800 participants and the survey reached a response rate of n=206. Focus was on the connection between the attributed importance to gender and the perceptions of robustness towards crisis in sector-related enterprises. The poster will present a resulting "innovation sum index" for forestry sector enterprises and agencies. As regards the findings on a correlation between attributed importance of gender balance and perceptions of strengthening innovation and resilience, these cannot be confirmed by the data. However, respondents ranked employment status and gender as most important for diversity. Only the enterprises that ranked ethnic diversity with highest importance had also highest outcomes in the innovation sum index.

The role of women in forest bureaucracies: a gender perspective analysis from the representatives of conservation and production interests in Argentina

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Forestlands have become spaces of negotiation between conservation and production interests among state and non-state actors across the world. In this context, the role of women in forestlands has mainly been studied at local levels, showing that while women are associated to conservation activities, land distribution is concentrated in men. However, no studies have so far analyzed the role of women in forest bureaucracies. In Argentina, although women have

been gaining positions within specific activities of the forest sector, the number remains significantly small compared to men positions, resulting in a predominantly male dominant sector. Hence, this study aimed at analysing the role of women in forest bureaucracies and explaining the connections between their positions and the decision-making process of land use in forestlands, using the case of Argentina. To answer these questions, we analysed the staff working for the forest bureaucracies in charge of the main forest legal instrument in the country: the national forest conservation law. As a federal country, the provinces of Argentina have the power over the natural resources inside their territory resulting in a wide range of land use management scenarios according to the economic activities and political interests of the provinces. By means of the law, the national government gives a budget to the provinces to conserve forestlands and to develop a land-use planning of their forestlands. We interviewed representatives of the production and conservation forest bureaucracies of different provinces working in the application of the law and, additionally, we support our data, with information provided in the official bureaucracy web pages. Our data base was processed in a multivariate analysis to determinate the connection between the variables. We found a small percentage of women in the higher positions of forest bureaucracies compared to men and the women in these positions express to adopt a rigid posture on their decisions to gain respect among men. We observed women representatives mainly in activities that are against economic interests of the provinces or remain insignificant as conservation tasks, we discussed this could be intentionally as local people have more respect to the male image in authorities. Even if Argentina is a country where women rights are discussed and women representation in forest bureaucracies is aimed in strategic projects, they still do not play an important role in the decision-making process.

“Gender-specific barriers in forestry: How do Austrian female leaders perceive barriers and what are their strategies to overcome them?

Barbara Öllerer, *University of Natural Resources and Life Sciences, Vienna (BOKU), Vienna, Austria*

Forestry is an almost entirely male-dominated sector (Larasatie, Barnett and Hansen, 2020; Ringblom and Johansson, 2019; Andersson and Lidestav, 2016). The existing data shows an underrepresentation of women in forestry, especially in leadership. This underrepresentation, disproportionate to the share of women in the total population, causes gender imbalance and low representation of a considerable share of the population among actors in the forestry sector. This is also true for the Austrian sector which, despite efforts to increase the number of women, remains largely male-dominated. These conditions point to the existence of remaining gender-specific barriers that prevent women from progressing at the same speed, being fully included in the workplace culture and attaining the same level of recognition. Studies (*Böhling et al., 2021; Larasatie, Barnett and Hansen, 2020; Baublyte et al., 2019*) confirm the existence of barriers. The study aims to depict gender-specific barriers in forestry and strategies to overcome them by looking at how female leaders in the Austrian forestry sector perceived the barriers they encountered in their careers, and the strategies they used to overcome them, thereby going beyond mere numbers to measure gender equality (Follo et al., 2017). Following

literature and document research, a series of in-depth, semi-structured qualitative interviews was conducted with eight of the most prominent female leaders in the Austrian forestry sector about their personal experiences and their general perceptions of barriers and strategies. The findings of this research confirm the existence of gender-specific barriers in the Austrian forestry sector. The results suggest that external barriers such as structural settings are by far more numerous and impactful than internal barriers such as occurrences of own underestimation of capabilities. The poster outlines the list of identified barriers with several graphs. These are enriched with selected (anonymised) statements from the women in concern. The results further demonstrate that the personal strategies applied by the interviewees are strongly context-dependent and include, among others, working hard in order to be better and looking for outside support. The research concludes that changing the circumstances is crucial to overcome gender-specific barriers in the forestry workplace and names examples identified by the interviewees such as the support by those in charge of hiring or already working in the field, the availability of mentorship programmes and coaching, adapted forest education, the introduction of new working models, more women and parents in leadership and equal recognition of women's performance.

Training professionals in gender equality & diversity in forestry – the development of a massive open online course (MOOC)

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Gender and diversity aspects are crucial elements of sustainability transitions. Sustainable Development Goal no. 5 demands gender equality in terms of empowerment of women, equal access to resources, and benefit distribution. The IUFRO Task Force on Gender Equality in Forestry was created to address gender and diversity aspects as a cross-cutting issue for all five IUFRO themes. One sector that we regard as highly relevant for our efforts within the task force is education. Despite the rising importance, gender equality and diversity competence training are lacking in forestry curricula in many parts of the world (UN International Conference on Forest Education 2021). The absence of locally available trainers is the main barrier to integrating gender and diversity issues in forestry higher-education institutions (HEIs) curricula, leading to professionals without competencies in gender equality and diversity issues, working in forest-related domains (e.g., climate change, bioeconomy, rural development). In order to close this gap, we embark on developing a Massive Open Online Course (MOOC), involving several IUFRO partner institutions and researchers with expertise in the area. A MOOC on Gender Equality & Diversity in Forestry (Forest GEDI) enables making the best available competencies accessible to a worldwide audience of forest students and professionals. In the format of a MOOC, Forest GEDI knowledge and skills training can be easily adapted and integrated into any HEIs curricula. Educators can also adapt the materials into courses for vocational education and training (VET). The MOOC on Forest GEDI aims to explain and promote gender equality and diversity as it relates to forests – their use, management, and research practices. The preliminary syllabus is divided into three parts:

- Introduction of basic concepts in gender studies (facilitation of access to the scholarship on gender and diversity)
- Provision of examples of best practices including case studies at operational levels (e.g, companies, organizations, networks)
- Implementation of practical tools (e.g., as takeaway lists, guides, lessons learned, etc).

The MOOC will connect leading organizations worldwide and contribute to the aims of the IUFRO Task Force on Gender Equality in Forestry. By building on the research and competencies available among the task force members the MOOC will also contribute to the spreading of IUFRO research. Most importantly by supporting the MOOC, IUFRO will address a gap in forestry-related education and facilitate professional capacities that take gender and diversity aspects of forestry into account and contribute to achieving Sustainable Development Goal 5.

Conditions for gender awareness in forest research and beyond – the IUFRO research network experiences

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Gender inequality in networking have been cited as one of the main reasons for gaps in gender career development and promotion - academic networks have shown to be no exception. Based on a study of the International Union of Forest Research Organizations (IUFRO), the analysis of diversity and leadership across the functions and positions at different organizational levels within IUFRO shows a substantial lower representation of women, and a high dominance of men, on all levels. There is also an uneven representation of women across the different Divisions and Task Forces - which make up most of the research network. Women's engagement varies across thematic divisions, with men dominating traditional forestry divisions, and women dominating in social forestry divisions. In Division 3, which brings together researchers dealing with forest operations, engineering and management, only one out of seven officeholders is a woman. In contrast, more than half of the officeholders in the division that focus on the social aspects of forests and forestry, i.e., Division 6, are women. Further, key informant interviews and surveys among IUFRO officeholders provide insights on how women and men experience and perceive gender (in)equalities in the network. Our analysis points at two patterns. First, the network manifests gender gaps in terms of diversity and leadership across functions and positions. Second, gender norms and patterns are also reflected across the type of work done within forest science. These patterns are likely to have an impact on the knowledge it generates, and how it is communicated and disseminated, e.g. in global forest science conferences.

10 years of gender equality on the agenda – gendered conditions of Swedish forest section at a change?

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It is now just over ten years since the national gender equality strategy for the Swedish forest sector, including its background report on the working life, was launched. This has contributed to placing gender equality higher up on the forest agenda and initiated a number of initiatives at both sector and organizational level. But what has really happened and how has it affected the gendered and segregated forest labor market that the study from 2011 showed? This follow-up study explores the potential effects of ten years of gender equality efforts for men and women with a university degree in forest sciences and their experiences of their carriers, labor market, education and the overall working conditions. The study is based on a survey to all women with a Swedish forestry degree and a mirror group of men (of similar age, education and examen year). In total, the sample consist of 1624 individuals, with a response rate of 53% (n: 860). The survey follows-up two similar studies from 1999 and 2011 and their form enables more longitudinal analysis of the development of the labor market, its conditions etc. from a gender perspective. The results of the studies indicate both changes and stability in the gendered patterns of the forest labor market, with lower degree of segregation and improved career paths for women. This is something has been in focus of many forestry organizations' gender equality work, which also has had consequences for men's experience of the sector's gender equality work. However, although Swedish forestry's own #Metoo of women's testimonies of sexual harassment, this is still present in the sector at a relatively high level. The results also highlight other specific challenges that remain and calls for future attention in the strive for a gender equal forest sector.

Same but different: How female forestry professionals experience their careers in countries of the Danube Region

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The issue of gendered career paths in male-dominated sectors, including forestry, mining and construction, attracts growing attention. In forestry, women tend to work in administration and accounting, training and consultancy, as well as nature conservation, while men are frequent in fields of work that are more closely associated with wood production. Moreover, women are rare in leadership positions at higher management levels. Gender segregation in forestry hampers the sector's attractiveness and innovativeness and poses serious challenges for equality in work life. The suggested contribution to the IUFRO conference in Vienna aims at showing how female professionals perceive of their careers and the challenges they are faced with. It also reveals success factors for female careers in forestry. The contribution is based on a quantitative survey that was conducted in 10 countries of the Danube Region in March 2021

(n=663) and the preliminary findings of qualitative interviews with female role models in forestry (n=30). The Danube Region covers a vast region in central and south-eastern Europe including, among others, Austria, Bavaria, Bosnia & Herzegovina, Czech Republic, Romania and Slovenia. To date, there is sparse research on female forestry professionals in this region. The cross-country analysis shows overlaps and differences in women's experiences of careers in forestry. Stereotypical thinking, work-life issues, and lack of supportive environments affect their careers. But differences between countries apply. Insights from the qualitative interviews with role models are used to reveal how sectoral characteristics impact on female careers in the forestry sectors of the different countries involved.

Can we mobilise women farmers to restore landscapes? A Case of Sanga and Kavuzi women farmers.

Tonthoza Unganja, *Bangor University, Bangor, UK; Vanessa Simwela, Sustainable Farming Solutions, Lilongwe, Malawi*

In the last two years, the context in which farmers must manage their land has changed rapidly and without warning. COVID-19 has had a dramatic effect on the pricing of certain agricultural commodities. There have been extreme climate events, a shift to more organically produced food crops, the revision of land and forest policies, and the launch of new Agendas (2063 Agenda in Malawi) regarding the consequences of the climate crisis, creating uncertainty regarding future threats and potentials. A one-sided view on efficient restoration efforts is no longer enough in such turbulent times. Farmers need to cope with new tensions and adopt new technologies while dealing with social and environmental issues within their communities. They also need to find a balance between efficiency and adaptability by adopting farming practices that are not just low cost but provide for a restorative/regenerative culture in a changing climate. Rural women farmers in Malawi earn a third of what their male counterparts gain even though they constitute more than 51% of the farming labor. Women's access to advanced agricultural tools and technologies in Malawi is limited, resulting in lower productivity of their farms and communities. With agriculture accounting for about one-third of the country's GDP, gender inequality holds Malawi back. This study forms part of a broader project on utilizing small-scale farms to restore landscapes, implemented by Sustainable Farming Solutions (Malawi). The study is being conducted in Kavuzi and Sanga in Nkhatabay. The study aims to identify approaches that strengthen the adaptive capacity of women farmers to restore high biodiversity hot-spots and reduce the pressure exerted on the same, learning through experimenting and monitoring of outcomes; ensuring flexible revenue streams to increase the options for new activities; and diversifying to spread risks and creating buffers while reducing the workload of women farmers. We registered a total of 200 farmers starting July 2020 and funded 54 women and are in the process of funding more. Similarly, we created 3 women groups starting with the establishment of a village savings and loan group so they can grow and self-fund the production and marketing of indigenous tree seedlings, honey and mushrooms for sustained livelihoods. We found that if implemented strategically, women farmer groups enable them to maneuver and identify possible transitions, giving them access to better markets and allowing them to pivot accordingly considering the pressure exerted by their day-

to-day lives. We managed to record a 30% increase in revenue from their initial state and can see the possibility to increase those revenue streams even more. We further managed to put 270 hectares under farmer managed natural regeneration. The success of women groups for community success depends on the group's organization, the condition of the landscape, the women's ability to mobilize external resources, and their capability to engage in collective action. In this case, when change occurs it no longer becomes a threat to livelihoods but rather a catalyst for mobilization of resources and a system reboot for landscape practices. Implementing these approaches comes at a cost; however, possibilities exist. The key is building community structures that allow women in rural communities to tackle the inevitable trade-offs between social issues and the need for efficient conservation and restoration efforts. Nevertheless, unless women farmers master the challenge of collective action, they cannot ensure the adaptability of the landscapes to climate shock nor the profitability of their landscapes.

FOREST GENETIC RESOURCES SESSION

Inventory and Assessment of Superior Mother Trees of Mangrove Species in Pagbilao Mangrove Experimental Forest, Quezon, Philippines

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Mangrove forests are declining at an alarming rate. The wide array of benefits provided by mangrove leads man to continuously cause the unabated degradation of this ecosystems. Hence, there is a need to reforest the denuded mangrove to sustain not just its productivity but also the genetic resources. However, the lack of knowledge regarding the phenology and distribution of superior mother trees is a problem here in the Philippines. This is a major obstacle in increasing the production of high-quality mangrove seedlings. Moreover, seedling growers and seed suppliers has little knowledge on the ideal qualities of outstanding mother trees, which led them to collect germplasm from low quality sources. There are many studies being conducted in quality mother trees of indigenous timber tree species but for mangrove species there are limited information about it. Hence, an inventory survey of mangrove Mother/Individual Plus Trees (IPTs) and geo-tagging activity were carried out in the Pagbilao Mangrove Experimental Forest in Pagbilao, Quezon, Philippines. Phenotypic qualities and phenology of the potential IPTs were monitored. Phenotypic quality was assessed using the method developed by the Department of Environment and Natural Resources. A total of 115 mangrove Individual Plus Trees (IPTs) belonging to 10 Families comprising of 24 species were identified and geo-tagged. These established IPTs serves now as sources of quality germplasm of the 24 mangrove species. They are free from defects, no sign of attack from insects, pest and diseases, prolific flowering and fruiting, vigor, and dominant were among their characteristics. Quarterly,3,000 quality germplasm was collected in these IPTs. The produce planting stock where then raised and tended in the nursery. Having these superior mother trees ensures that there is a continuous production of quality planting stocks of different mangrove which is vital in the protection and conservation of the mangrove genetic resources. In order to enhance the collection and utilization of high-quality germplasm, there is a need for Information, Education, and Communication (IEC) campaign on the value of germplasm quality and capacity building to persuade seedling producers to do so. To increase the accessibility of high-quality germplasm from a diverse species basis, it is also necessary to develop an effective germplasm collection and distribution mechanism.

Using genomics to improve predictions of population responses of forest trees in the face of climate change

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Predicting future population responses of forest trees is challenging, as it involves extrapolating information from a moderate number of provenances tested in only a few common gardens

(environments) to the full distribution range of a species. Nevertheless, accurate predictions of future tree population responses to climate change are necessary to adequately manage and use forest genetic resources. In this talk, we provide insights on the use of genomics to improve power of predictive models, as well as a case study in maritime pine where multiple models were tested for accuracy of predictions, focusing on methods combining information from common gardens via genotype-phenotype association (i.e. polygenic scores and/or counts of positive-effect alleles, PEAs, as identified by GWAS) and extensive genotyping of natural populations. Models including genomic data provided better predictions outside the range of the provenances tested in common gardens. In addition, models based on gene-environment association and genomic offset, although not without caveats, provided insights on the future response of maritime pine populations in the face of climate change. Future challenges and common flaws of this approach will also be highlighted.

Genomic selection for improved growth in Sitka spruce

Ronan Cashell, *Forestry Dev elopement Department, National University of Ireland Galway, Galway, Ireland; Stephen Byrne, Crop Science Department, Teagasc, Carlow, Ireland; Charles Spillane, Plant and AgriBiosciences Research Centre, National University of Ireland Galway, Galway, Ireland; Niall Farrelly, Forestry* Development Department, Teagasc, Athenry, Ireland

Genomic selection (GS) is an increasingly prevalent aspect of forest tree breeding, given the proven capacity of GS to predict for traits of interest over conventional, pedigree-based selection models. We are examining the potential for GS to be implemented in a population of Sitka spruce *(Picea Sitchensis* (Bong.) Carr.) used to establish the Irish Sitka spruce breeding program, a relatively nascent program at the point of establishing its second generation. Genotype-by-sequencing (GbS) was used to generate data of a suitable quantity for GS, while phenotypic data concerning juvenile height and early diameter at breast height (DBH) was taken from stands of half-sibling families generated from and corresponding to each of the genotyped individuals. The potential for GS to provide predict accurately, as well as a comparison of the accuracy several models (G-BLUP, rrBLUP, BayesCpi & RKHS) was examined for each of the traits of interest. Multi-trait modelling using all available phenotype data is also being generated to evaluate the possibility of accurately predicting for improvement in overall tree volume. Also being undertaken is modelling using Kinship using GbS with Depth adjustment (KGD) as a potential method of improving estimations of the genomic relationship between genotyped individuals. Current results show positive moderate correlation between predictions and observed breeding values, though predictions for juvenile height displays greater accuracy that those of early DBH. Our expectations for multi-trait predictions are thusly that predictive accuracy will be small, but that they and uni-trait predictions could be improved in future breeding endeavours. Results from models utilising KGD should provide insight as to whether GbS, rather than whole-genome sequencing, may be a viable alternative for providing the necessary depth of genomic information required for sufficiently accurate GS models. Our hope is that improvement of wood production output with the limited land available for forestry would promote future security of timber supply and allow for land forest stands of other species for the purposes of promoting biodiversity.

Linking conservation of forest genetic resources to species restoration in Western Himalayas

Manisha Thapliyal, *Sheeshram Dangwal, Forest Tree Seed Laboratory, Forest Research Institute, Dehradun, India*

The Himalayas are rich repositories of biodiversity and provide ecosystem goods and services to the communities of the region. However, many ecologically and socio-economically important species of the Himalayan region are threatened due to their utilization, deforestation, degradation and climate change. These threaten the sustainability of forest genetic resources and highlight the importance of conservation and sustainable management of these resources. A research programme on conservation of Forest Genetic Resources (FGRs) with special focus on the exploration of FGRs of North-West Himalayas has been undertaken with the support from Environment and Forest Ministry of India. Under the programme major activities undertaken are documentation of species populations, their characterization and germplasm storage. The population of the prioritized species are being explored, populations geo-tagged, phenological observations and species associations recorded. Their seeds are collected at maturity, processed, tested for quality and desiccated to safe moisture levels for storage. The seed storage physiology of important Himalayan species like spruce, fir, *Acer sp*p., *Carpinus*, *Buxus*, Fraxinus*, pines, rhododendrons*, walnut, *Corylus, Hippophae*, medicinal shrubs/trees, etc. are being studied for chalking out a long-term ex situ conservation program. Seeds of most of these species have orthodox seeds which after slow desiccation to lowest safe moisture levels are vacuum sealed and stored in seed bank at -180C for periodic regeneration. Field germplasm banks of several species have also been established under the program. The material will be multiplied for producing planting stock of these species. Thus, ex situ conservation becomes the focal point of gene conservation program of FGRs of Himalayan Region. Conservation units of species, in nature, that maintain vital genetic diversity for the species survival and adaptive capacity for their sustenance are important. Utilizing the knowledge and information from long-term FGR conservation programmes for chalking out robust species restoration strategies, will only script the success stories in forest management and species conservation programmes.

PLANTEDFORESTS.ORG : Help us to shape a resources centre on planted forests for stakeholders

Christophe Orazio, *IEFC, Cestas, France*

Forest plantations initially aiming at wood production are more and more promoted in restoration scheme after megafires or massive diebacks induced by drought and bark beetle, but also for carbon sequestration scheme (Bonn challenge, EU 3 billion planted trees target). Plantations are based on human choices about the species, provenances and/or improved material to plant, the site preparation in an uncertain context where drought and heatwaves are more frequent; In addition, there is a new interest in mix plantations supposed to be more resilient to pest and diseases, making design and choices more complex for the forest managers. The aim of this paper is to stimulate feedbacks and needs expressed from many countries to target and prioritize knowledge and tools of interest that should be developed at

international level to support all historical and emerging bodies involved in tree planting. The plantedforest.org platform objectives and ambition will be presented; a first version of the webpage design and structuration will be proposed. The survey opened to collect feedbacks will also be introduced to design the best tool of resources collection serving best stakeholders involved in the topic. The activity in in line with taskforce concept as the emphasis will go on results facilitating action and decision making by manager rather than scientific excellence. It will be closely connected to the task force Resilient planted forests serving society and bioeconomy.

Molecular characterisation of *Balanites aegyptiaca* (L.) Del populations in Northern Nigeria"

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Uncovering the molecular variability of different populations of *Balanites aegyptiaca* (L.) Del, also known as desert date, as well as their relatedness at the inter- and intra-population levels is important for conservation of its genetic resource base and ensuring the resilience of the existing populations of this indigenous fruit tree species of Nigeria and other Africa's dryland environments valued for its nutritional and medicinal usages. In this experiment, we extracted DNA samples from young healthy leaves of *Balanites aegyptiaca* growing in eight natural populations- Gamawa, Buratai, Guri, Kirikasama, Baure, Mashi, Dumsai and Gashua in Northern Nigeria using modified CTAB protocol. The extracted DNA were tested for amplification using a pair of MatK primers. The amplified products were visualized in a 1.2% resolution agarose gel and photographed for further analysis. Sequences were aligned to draw a phylogenetic tree using Neighbor-Joining method while bootstrap consensus tree was inferred from 150 replicates. Pairwise distance, haplotype diversity (Hd), nucleotide diversity (Pi), number of variables sites, parsimony-informative sites, average number of nucleotide difference (k) and Tajima's D Test were determined. Phylogenetic tree revealed two clades among population of *Balanites aegyptiaca i*n Nigeria. Samples from Buratai, Guri, Gamawa and Kirikasama formed a clade with a bootstrap value of 4. Mashi, Baure, Gashua and Dumsai samples also formed another clade with 0 bootstrap. Phylogenetic tree cluster indicated similarities implying populations in the same clade share similar genetic characteristics. *Balanites aegyptiaca* trees in Baure and Mashi formed a monophyletic clade with a very high bootstrap value (100), while Gashua, Baure and Mashi had a bootstrap value of 73. *Balanites aegyptiaca* populations in Nigeria were 98.6% similar to those in Kenya. Highest nucleotide distance, 0.12 was between Baure and Guri. Haplotype diversity ranged from 1 – 4 with Baure, Gashua, Guri, Kirikasama and Mashi having 4 each, while Dumsai had the least. Mashi had highest nucleotide diversity (0.264±0.136) while Dumsai was least diverse (0.002±0.001). Mashi had many variables sites (302) while Dumsai had only 3. Only Gashua (-1.202) and Kirikasama (-1.217) had significant negative D. Population of *Balanites aegyptiaca* from each monophyletic clade have same parent or originated from the same parent. The high bootstrap values attached to both monophyletic clades indicate high confidence or certainty supporting their relationship as siblings. *Baure* and *Mashi* population seems to form a different ecotype from the others

suggesting that they could be prioritized during domestication/conservation, breeding and/or improvement programme.

Assessing local community opinions towards management regimes for balancing human needs and conservation goals in Pendjari Biosphere Reserve, Benin

Esther Kpodo, *West African Biodiversity and Ecosystem Services (WABES), University Felix Houphouet-Boigny, Côte d'Ivoire, Haramaya, Ethiopia; Jan Henning Sommer, Center for Development Research (ZEF), University of Bonn, Germany*

Conservation success is often depended on local commitment for conservation that is strongly linked on opinions of local communities on existing management regime. Sustaining good governance is essential for the acceptability and future effectiveness of protected areas. Since 2017, in Pendjari Biosphere Reserve of Benin, African Park Network, an international private management regime has been designated to safeguard the park's flora and fauna; and build a constituency for sustainable conservation with the local communities. This study assessed a broad range of positive and negative social, economic and cultural impacts of existing management regime (African Park Network "APN") and the former management regime (National Center of Wildlife Management "CENAGREF"). Based on community opinions, 345 local people in 23 communities were interviewed towards private vs public governance in Pendjari Biosphere Reserve using semi-structured questionnaire. We differentiated variables that had the greatest importance to prefer or not the existing management regime using descriptive statistics and Excel. Only 34% of local community prefers the current private management regime in contrast to public former management regime (66%). Participants' perception of management regime was highly linked to locally perceived advantages. The decision to prohibit encroachments because of agricultural activities reinforced the negative opinions on the existing management regime. Interview participants have also expressed dissatisfaction with restrictions on access to sacred cultural sites, agricultural lands, collection of non-timber forest products (NTFPs), lack of participatory management, increased human-wildlife conflicts and limited safari benefits under the APN management. However, they applaud APN for increased environmental awareness and job opportunities. Therefore, policy measures are advocated for mainstreaming the needs of local communities into environmental policies to safeguard protected areas.

Climate change and provenance regions for the main tree species in Romania: Implications for forest management

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The most recent climate change scenarios show that Southern and Eastern Europe will be affected by a significant increase in temperature and drought frequency by the end of this century, which will have a serious impact on forest growth and adaptation, and important

consequences for forest management. Considering that successful forest management requires suitable species and high-quality reproductive material for reforestation, delimitation of the provenance regions is the basic step towards the selection, usage and transfer of forest reproductive material, conservation and improvement of forest genetic resources. The system of provenance regions according to EU directive was thought to encourage the use of the local seed sources, under the concept 'local is the best'. But climate is changing faster than some populations can adapt or migrate, which will raise some uncertainties with respect to the future performance of local populations. In Romania, as in other countries, the delimitation of provenance regions is based on geographical, ecological and vegetation criteria. The climatic variables that underlie the current provenance regions were determined 70 years ago. Therefore, the aim of this study was to evaluate: 1) the climate change that has occurred at the level of the provenance regions; 2) which regions will be most vulnerable to climate change; 3) which forest types will be the most vulnerable in a certain region; 4) changes in the species climatic envelope; and 5) re-delimitation of provenance regions according to climatic criteria and genetic variation within-species. Four climatic parameters and ecoclimatic index have been calculated and analyzed at the level of provenance sub-regions and ecological sectors (forest types), during the period 1951–2020. The results highlight a general shift towards warmer and drier conditions in the last 30 years. The values of the De Martonne aridity index for the vegetation season show that 86% of the ecological sectors fell into the arid and semi-arid categories, which indicates a very high degree of vulnerability for forest species. The forest steppe climatic conditions occurred in all pure or mixed pedunculate oaks forests, thermophile oak species, meadow forests, poplar and willow, and Turkey oak and Hungarian oak forests. The Ellenberg coefficient highlights that the warming process is more evident along the altitude and the degree of vulnerability increase at lower altitude or at the edge of species distribution. The climate envelopes of many forest species have already shifted to another ecosystem's climate. New approaches regarding the delineation of provenance regions according to species climate envelope, future climate projections and intraspecific genetic variation are required.

Drought adaptation of Italian silver fir genotypes in a climate change perspective

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Susceptibility of forest ecosystems to climate change is closely linked to their ability to adapt to drought and increasingly extreme temperatures. In this study, we analyse silver fir (*Abies alba*) populations in the Tuscan-Emilian Apennines National Park, with a view to the conservation and sustainable management of forest resources. In a climate change context, it is essential to understand the effect of the environment and the climate on silver fir growth, in order to define management guidelines that consider the adaptation performance at local level. In this study, we propose the comparative analysis of the drought adaptability of silver fir in natural (i) and artificial (ii) population, analysing at the same time the growth of three main provenances of this species in Italy: (a) Piedmont - (b) Northern Apennines (local) - (c) Southern Apennines.

Methods include dendrochronological analysis on tree rings and the study of individual competition and environmental effect on tree growth. Dendrochronological analyses include the study of climate-growth relationships, drought 'resilience indices' based on tree ring width, and the estimation of water use efficiency (iWUE) by isotopic analyses on wood samples. Drought years of interest and their severity are defined through the Standardised Precipitation-Evapotranspiration Index (SPEI). Moreover, the study includes the use of modelling techniques to predict forest dynamics under different climate scenarios. We used FORMIND, an individual-scale dynamic vegetation model that simulates forest growth under two climate scenarios (R.C.P. 4.5 and 8.5). Our results reveal higher mean growth (BAI) of artificial forests compared to natural forests (BAIart= 16.4, BAInat= 13.2), also showing higher resilience during severe droughts (p<0.01) and higher recovery during severe and extreme droughts (p<0.01 in both cases). At the same time, we found a slight significant difference in BAI values of the silver fir provenances under consideration (BAIa= 17.5, BAIb= 19.0, BAIc=22.8), higher in the southern provenance followed by the local and Piedmontese provenance. The same trend across provenances is shown by the recovery and resilience indices during moderate (p<0.01 for both indices) and extreme drought years (p=0.01 for both indices). These results provide important information on the adaptive response of silver fir under climate change, underlying the importance of managing natural populations and how southern provenances are actually more adaptable to drought conditions. Thanks to the collaboration with the National Park and local forest managers, there are wide applicative possibilities of the results in active land management.

Influence of *Cupressus lusitanica* cones and seed characterization on germination in Kenya

Alice Onyango, Peter Angaine, Stephen Ndungú, Kenya Forestry Research Institute, Londiani and Nairobi, Kenya; Shadrack Inoti, Egerton University, Egerton, Kenya; Jesse Owino, Kenya Forestry Research Institute, Londiani, Kenya

Cupressus lusitanica also known as Mexican cypress was introduced in the tropics to increase diversity of plantation species suitable for commercial forestry. In Kenya, *C. lusitanica* is the most widely planted commercial species comprising about 55% of forest plantation area. This species has wide used mainly for timber, plywood, fuel wood, poles production and live hedges. Due to the many uses associated with this species, there has been increase in demand for seed. This species is a conifer that produces cones, which are collected for seed extraction. There are variations in seed collection and handling which compromise quality. Few studies focus on cone morphometry and seed characterization, thereby causing a gap in quality improvement through packaging and subsequent germination. Thirty trees that were heavily seeding were randomly selected from a 14-year-old *Cupressus lusitanica* seed orchard. From each tree, fifty mature cones were collected totaling to 1,500 cones. Cones were sorted by sieving using a 20mm sieve. Cones that were more than 20mm were categorized as large cones (CB) and those that were less than 20mm as small cones (CS). The cones were placed in glass petri dishes and subjected to artificial heating for seed extraction at 650C for 48 hours in an oven. Seeds from each of the two categories (CB and CS) were then sieved in a standard 2mm sieve. Seeds that were more

than 2mm were categorized as big seed from both the large and small cones (CBBS and CSBS) while those that were less than 2mm were categorized as small seeds from the large and small cones (CBSS and CSSS). Thirty seeds were randomly selected from each of the four categories (CBBS, CBSS, CSBS and CSSS) and individually weighed. Seeds from each of the four categories were subsequently subjected to floating test for 5 minutes where they were further separated into floaters (CBBSFF, CBSSFF, CSBSFF and CSSSFF) and sinkers (CBBSFS, CBSSFS, CSBSFS and CSSSFS) resulting to eight categories. Germination tests each of the eight categories were conducted in a cultivation chamber under controlled conditions at 270C and 70%RH. The results showed that seed size and density heavily impacted on germination and thereby showing that sorting through sieving and floatation would provide a low-cost technique for seed quality improvement. The technique in the present study improved germination from 25% to 50%, and also reduced the number of seeds per kilogram from 290,000 to 105,000.

Phenotypic characteristics of *Parkia biglobosa* fruits and seeds indigenous to West Africa

Idowu Ademola, *Forestry Research Institute of Nigeria, Ibadan, Nigeria; Mattew Oyun, Federal University of Technology, Akure, Nigeria; Johnson Olusola, Federal College of Agriculture, Akure, Nigeria; Olufinks Gelpy, Forestry Research Institute of Nigeria, Ibadan, Nigeria*

Parkia biglobosa, indigenous to West Africa, produces fruits which are used as a condiment in most African dishes. The seed which is rich in protein is used to produce African locust beans. Its distribution across the West Africa savannah belt tends to exhibit variations in physiology. Information from provenance studies has great practical use in the improvement of forest stands. The most obvious and most important use at present is to assure sources of seed that produce well-adapted, productive trees in reforestation and afforestation. Hence, there is need to study the observable characteristics of this tree for tree improvement purpose. The fruit and the seeds morphological characteristics were assessed from the germplasm of *Parkia biglobosa* at Wasangare, Saki, Oyo State. Eight provenances of *Parkia biglobosa* represented in the germplasm include Nigeria, Mali, Senegal, Burkina Faso, Cameroun, Benin, Guinea and Ghana. Selective sampling method was adopted in the selection of the trees from a particular provenance investigated. Variation in fruits of *Parkia biglobosa* from different provenances were assessed through optical observation, vernier caliper, electronic top bar balance. The data obtained were subjected to analysis of variance using Completely Randomized Design (CRD). The result obtained showed thatthe pod size from the west provenance to the east provenance varied from small to big along the West Africa gradient. (Senegal to Cameroun). Variation in length thickness and width of seed ranges from western to eastern provenances, seeds become flatter, larger, longer, and heavier. The fruit from Burkina Faso has the highest pod length, pod width and pod weight as follow 22.73cm, 2.08cm, and 17.48g, respectively. The fruit from Benin Republic has the least pod length, pod width and number of seeds per pod which are 16.72cm, 1.76cm, and 10.33g, respectively. Mali and Senegal fruits have the highest number of seeds per pod and seed weight respectively. The yield variables measured showed that fruits from Nigeria are significantly different from other provenances. The study revealed that there is variation the physiological characteristics of the seeds and pods of *Parkia biglobosa* from the eight-

provenance investigated. This could be an indicator that there might be variation in the genetic composition of the fruits of *Parkia biglobosa* from different provenances.

Incorporating intraspecific variation into ecological niche modeling suggests local adaptation of a wide-spread West African species (*Pterocarpus erinaceus, Fabaceae*)

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Climate change pronouncedly affects species distribution worldwide. These effects are evident in the range shifts of many taxa due to annual global temperatures rising. However, several studies have demonstrated significant powerful of species distribution models (SDM) to assess the climate change impact on species. But it is often used without considering intraspecific variation across the environmental variability for guiding conservation policies. For this study, we use two SDM approaches (whole species and separate population) for *P. erinaceus* in Benin using the maximum entropy (MaxEnt) algorithm based on presence-absence data were employed to predict the distribution pattern and changes of its present (1970-2000) and future (2050 and 2090) potential suitable region in Benin under multiple climate scenarios (SSP1-2.6, SSP2-4.5 and SSP5-8.5). A niche conservatism test was also performed among ecologically distinct species populations. The models predicted the potential distribution of *P. erinaceus* with area under the receiver operating characteristic curve (AUC) higher than 0.8 during training and testing. In general, the two modelling approaches worked nearly as well when predicting the current distributions. However, under future climate change, suitable habitat projections quality for *P. erinceus* have diverged. The whole species models show, in contrast to the separate population model, an intense decline in suitable *P. erinaceus* habitats under climate change. The Sudano-Guinean zone populations shift to the Guinean zone under the climate change effect. Furthermore, the Guinean zone populations will extend towards the Sudano-Guinean zone. The Sudanian zone populations have simply experienced a decrease in suitable areas. Besides the methodological challenges, it also is apparent that each population of *P. erinaceus* occupies a different climate niche that could induce a local adaptation or a phenotypic plasticity that experimental studies of urgent transplantation can nuance for a more informed the conservation planning in Benin.

Assessing local community opinions towards management regimes for balancing human needs and conservation goals in Pendjari Biosphere Reserve, Benin

Esther Kpodo, West African Biodiversity and Ecosystem Services (WABES), University Felix Houphouet-Boigny, Côte d'Ivoire, Haramaya, Ethiopia; Jan Hemming Sommer, Center for Development Research (ZEF), University of Bonn, Bonn, Germany

Conservation success is often dependent on local commitment to conservation that is strongly linked to opinions of local communities on existing management regimes. Sustaining good

governance is essential for the acceptability and future effectiveness of protected areas. Since 2017, in Pendjari Biosphere Reserve of Benin, African Park Network, an international private management regime has been designated to safeguard the park's flora and fauna; and build a constituency for sustainable conservation with the local communities. This study assessed a broad range of positive and negative social, economic, and cultural impacts of existing management regime (African Park Network "APN") and the former management regime (National Center of Wildlife Management "CENAGREF"). Based on community opinions, 345 local people in 23 communities were interviewed regarding private vs public governance in Pendjari Biosphere Reserve using a semi-structured questionnaire. We differentiated variables that had the greatest importance for preferences of the existing management regime using descriptive statistics and Excel. Only 34% of the local community residents prefers the current private management regime in contrast to public former management regime (66%). Participants' perceptions of the management regime were highly linked to locally perceived advantages. The decision to prohibit encroachments because of agricultural activities reinforced the negative opinions on the existing management regime. Interview participants also expressed dissatisfaction with restrictions on access to sacred cultural sites, agricultural lands, collection of non-timber forest products (NTFPs), lack of participatory management, increased human-wildlife conflicts and limited safari benefits under the APN management. However, they applaud APN for increased environmental awareness and job opportunities. Therefore, policy measures are advocated for mainstreaming the needs of local communities into environmental policies to safeguard protected areas.

FORESTS AND WATER SESSION

Forest-water and its contributions to global water security

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Forests are key to the provision of the world's freshwater resources. About 30% of the planet's land area is covered with forests, which influence both downstream and downwind waters. Large-scale forestation (reforestation, afforestation) efforts that focus on forests as nature-based climate solutions for storing carbon are altering how forests transmit water downstream and downwind. These large-scale efforts are "replumbing" the water cycle, and this replumbing of the water cycle may have consequences for atmospheric, surface and groundwater supplies. Tension over freshwater resources is rising, especially in transboundary water systems in water-scarce regions of the planet. Science and technologies are urgently needed to advance understanding of the global connections between forests and water. Governance frameworks are also urgently needed - that consider all relevant scales (from local to global, from drivers to impact) of these forest-influenced transboundary water issues. A call-to-action for international agreements, regional organizations, and national governments that focus on the role of forests for water (not just forests for carbon) and that embrace inclusive (diverse stakeholders, rights-holders, elders, youth), integrated (local to global) diplomatic tools to facilitate the incorporation of science and governments into decisions and actions is presented.

Accessing tropical forest restoration contribution for water supply: insights from Atlantic Forest

Silvio Ferraz, *Bruna Lopes, Matheus Ogasawara, University of São Paulo, Piracicaba, Brazil*

Following Brazilian restoration goals, more than 1 million hectares will be restored at Atlantic Forest biome. Many Sustainable Development Goals (SDG) are highly linked to forest restoration including its potential benefits in the provision and regulation of water, as there is an association between native forest cover and availability of clean water. Considering this context, it is necessary to increase the understanding of the effects of forest restoration on ecohydrological processes and, consequently, on water resources and the aquatic environment in tropical region. Regional satellite data were used to understand hydrological responsiveness and sensitivity to changing forest cover in ecoregions. We used field data obtained by experimental catchments (streamflow) and plots (interception, transpiration, infiltration and soil recharge) to understand effects of forest restoration in the Atlantic Forest region. The effects of conversion to forest on hydrological dynamics vary according to geographic region and local aspects such as soils condition and land-use history, tree species composition and relative position of the forest on topographic position. The establishment of forest cover is not directly linked to recovery of hydrological processes, and the time lag depends on ecological condition of the new forest, historical land-use and local natural physical characteristics. In addition to benefits for water quality, positive effects of forest restoration on hydrological

regime are expected in the medium and long term, when streamflow regulation is achieved, offsetting the short-term effect of flow reduction. A framework of effects of forest restoration on water resources at catchment scale is proposed and discussed.

Forest and water an overview

Lars Högbom, *Forestry Research Institute of Sweden, Uppsala, Sweden*

Forest and water are forming a co-dependency; what is happening to the forests affect waters and what is happening to the water influence the trees. The connection of between forests and waters is a multi-facetted issue involving both temporal and special scale considerations as well as geographical differences including differences in climate and land use. The talk will cover several aspects on forest and forest management on water quality; help reducing diffuse pollution, improve drinking water quality, forest management issues, how to convey scientific results to general public, landowners, forest managers and decision makers. The presentation will focus on how trees, woodlands, and forests can provide a natural based solution for addressing both water quality and quantity issues. Water leaving forested ecosystems is usually of high quality, and forests and woodlands are important for providing drinking water. Tree planting is sometimes used to protect drinking water supplies. Planting trees along watercourses has been shown to be effective to reduce diffuse pollution from agriculture. How these should be planned, designed and maintained depends on site characteristics. Here new concepts like payment for ecosystem services (PES) might be useful. I will also give example on how forest management strategies and forest operation methods to reduce negative impacts from forestry on water quality and yield. Logging operations cause hydrological changes by altering run-off patterns, change transpiration and evaporation, and also tree species effect. For example, by improved planning of forest operations terrain transport could be reduced and driving on sensitive areas could be avoided. To further reduce negative impact on water and to protect soils during forest operations by using brash mats or corduroy bridges could reduce erosion. Riparian forests are a key feature in the forested landscape, since much on the run-off water quality is formed here and riparian forests are usually considered as ecological hot spots connecting land and water ecosystems. Leaving functional buffers could help reduce nutrient load to surface waters and also add to ecosystem connectivity and green infrastructure. There is a need for better exchange of knowledge between the scientific community to stakeholders and decision makers at all levels. In addition, knowledge exchange among different scientific specialities is needed to meet our Sustainability Development Goals.

Evidence integration for coherent policy: perspectives on managing soil-forest-water-climate interactions

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The United Nations and its member states increasingly seek nature-based solutions to support sustainable development. Forests provide many ecosystem services to meet our needs for timber and food while supporting critical ecologic functions that include but are not limited to fixing carbon, supplying drinkable and clean water, controlling soil erosion and reversing land degradation, and conserving biodiversity. Global initiatives, such as the Bonn Challenge and the New York Declaration on Forests call for restoring 350 million hectares of forestland worldwide by 2030. Rewilding and forestation are good intentions to support achieving SDGs, requiring large public funds and private investments. Therefore, their sustainability must be evaluated against co-benefits and trade-offs by considering resource interactions, natural constraints, and regional priorities. We use a case study in China to show how co-benefits and trade-offs of ecosystem services result from forestation. Our process-based observations at forested sites and natural grassland showed that forestation had altered the water cycle and rainfall partitioning into green and blue water fluxes. Planted forests deplete subsoil water during the main growing season due to water loss through enhanced evapotranspiration, preventing groundwater recharge through seepage in water-limited areas. Forestation in non-humid climate consumes an amount of water close to (in average rainfall years) and is likely to exceed (in drier years) the annual precipitation, presenting a trade-off in water supply services. This explains the findings of significant observed declines in streamflow of rivers, in which forestation made a considerable contribution. On the other hand, forestation protects soil from erosion, improves physical health, and promotes carbon storage in aboveground biomass and underground soil. Our measurements showed that in addition to the extra carbon stored in tree biomass, the forest soil organic carbon content (within one meter) reaches a comparable level as natural grassland after 30 years, which will have a net gain beyond this time horizon. We argue that with climate change resulting in more frequent and prolonged droughts over larger areas, global greening efforts in water-limited regions require careful integrative evaluation and sustainability assessment. It should pay attention to integrating evidence of synergies and trade-offs across resources that is vital for effective carbon fixation and land-based production while achieving water security in a changing environment. It concludes that monitoring data, consolidating process-based knowledge, and translating evidence into coherent practices and policy could assist to manage and balance ecosystem services to ensure a successful forest development.

Protection and maintenance of water resources through implementing the sustainable forestry initiative in the Southeastern US

Jami Nettles, *Brent Hawks, Weyerhaeuser Company, USA*

The Sustainable Forestry Initiative (SFI) has released enhancements in the 2022 Forest Management Standard, including Objective 3. Protection and Maintenance of Water Resources. In addition to protection to water quality and water resources (water, wetlands and buffers), a new performance measure was added to address water quantity during all phases of forest management. SFI released guidance to direct a programmatic approach to water quantity management and protection. The guidance states "The intent of including water quantity in the Forest Management Standard Objective 3 is to increase the awareness of watershed features and forest management activities that may influence water quantity and to promote implementation of practices, appropriate to the size and scale of the Certified Organization, that help to maintain a natural range of variation while avoiding or minimizing negative effects."
In the Southeastern US, forest management predominantly falls under state approved Best Management Practices (BMPs) with some regulatory restrictions. To maintain SFI certification, companies are audited against the BMPs and regulations. To prepare for the new SFI standards, SFI Objective 3.2 guidance was compared to current BMPs and research into their protective capacity and implementation rates. Common forest management practices, from the site to landscape level, were matched to the desired water quantity protection objective and ranked for the probability of effectiveness. Practices that protect water quality – the basis of BMPs – also protect water quantity, but there is a need to ensure current practices are adequate, add tools to the forestry management toolkit to identify and resolve where they need improvement, and consider the effects of a changing climate in decision making.

Changes in Ecosystem services in riparian forests amidst Climate Change: A case of the Densu River Basin

Theodora Akweley Asiamah, *Albert Nii-Moe Allotey, Andrew Manoba Limantol, Edward Debrah Wiafe, University of Environment and Sustainable Development, Somanya, Ghana*

Riparian forests play a significant role in water supply for agricultural activities, domestic and industrial use for surrounding communities. The forests in the catchments also provide functions such as water purification, regulating water flows and facilitating the availability of water resources in the catchments. The forests also provide livelihood opportunities for inhabitants of the communities within the catchment through cropping activities and game. The water in the catchment also serves as habitats for fish and other aquatic species that provide livelihood opportunities in accordance with SDG 1. Consequently, the management of the water and forest resources in forested catchments is very important for attaining SDGs 6, 14 and 15. Over the years, these functions are compromised as a result of direct human activities on the forest and water resources as well as the impact of climate change. The study employed a multi approach which consists of geospatial and social-ecological methods to assess the changes in ecosystem

functions of the Densu River Catchment over a period of 30 years and establish the underlying causes of the changes. A quantitative survey was made in which 450 residents in the catchment were interviewed. Descriptive statistics and chi-square analyses were made. In addition, Landsat images of 1991, 2002 and 2021 were analysed to complement the social-ecological survey. Findings from both the satellite images and the survey indicate an increase in built-up areas of the catchment and a decline in forest land and farmland over a period of 30 years. We also found a significant difference in the use of the riparian forest for food provisioning between current times and 30 years ago. The study recommends the adoption of urban forestry in town planning by urban planning authorities and the enforcement of buffer zone policies to protect the water body and aquatic species.

The effects of thinning on hydrological processes: a global meta-analysis

Antonio del Campo, *UPV-Spain, Valencia, Spain; Kyoichi Otsuki; Yusuf Serengil, Adam Wei*

Forest thinning can significantly affect hydrological processes. However, these effects largely vary with forest types, climate, thinning intensity, and hydrological variables of interest. Understanding these effects and their variations can significantly support thinning treatments' design and selection to ensure desired hydrological benefits. In this global-level review paper, we report the first comprehensive meta-analysis on the effects of thinning on major hydrological processes with an emphasis on rainfall partitioning, soil moisture and evapotranspiration processes. The synthesized and reviewed studies encompass different biophysical conditions (climate and forest ecosystems), silvicultural systems, and time scales (from weeks to decades) across continents. The results showed a significant increase in net precipitation, soil moisture and tree-level water use after thinning (the effect sizes are 1.19, 1.14 and 1.56 relative to the value of the control, respectively), while decreases in stemflow and transpiration (the effect sizes of 0.42 and 0.6 relative to the value of the control, respectively). Thinning intensity of about 50% of the stand density is determined as the threshold at or over which hydrological processes are significantly affected. The duration of thinning effect can be set between 2.6 - 4.3 (throughfall) and 3.1 - 8.6 years (soil moisture and transpiration), asking for repeated thinning in order to effectively sustain these effects. These global averages can serve as benchmarks for assessment and comparisons, but the effects of thinning depend on local biophysical conditions and thinning treatments. The literature review on the rest of the studied hydrological variables suggests that thinning generally enhance runoff to increase water yield and groundwater recharge. Thinning can also have a positive or limited role in water use efficiency (WUE), but it mitigates the effects of drought through increasing WUE. Moderate adverse effects on water quality can be prevented by adequate forest managements to prevent soil degradation. Nevertheless, more research at relatively less studied regions is needed to support a more robust analysis of these reviewed hydrological variables. The management implications of the synthesized and reviewed results are suggested and discussed within the context of climate change.

Key success factors of restoration on forested peatlands in Europe

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In the European Union, Biodiversity Strategy 2030, Water Framework Directive, LULUCF directive, and most recently, Nature Restoration Law constitute evidence of ambitious policy targets that relate to the management of forested peatlands. Restoration of wet- and peatlands is considered to carry a remarkable potential to contribute to the carbon and biodiversity objectives as well as to the resilience of ecosystems. However, practical solutions are currently often fragmented and remain small-scale with scant learning across cases and contexts. To tackle this challenge, the EU Horizon 2020 Green Deal project WaterLANDS (2022–2026) operates in 14 European countries and aims at upscaled and impactful wetland restoration. In WaterLANDS, scientific and practical learnings from 15 knowledge sites, located in 12 countries in different parts of Europe, are serving as a source of learning and insights towards successful and scalable wet- and peatlands restoration, tested and further adapted in 6 living-lab action sites and beyond. But what kind of success factors are behind the achievements of restoration showcases? To shed light on the possible key characteristics in the socio-ecological system that make wetland restoration successful, a desktop study on the 15 WaterLANDS knowledge sites was conducted. Publicly available information on the forested knowledge sites was gathered from the project's website (waterlands.eu) and qualitatively categorised in the main achievement categories, which were thereafter interpreted and classified as key success factors. The co-occurrence of the identified success factors varied across the forested knowledge sites. The success factor types identified were: 1) ecological features of the site, which is typically a unique area with valuable species and ecosystems present; 2) spatial features of the site, either sufficiently large and/or recognisable in the region, or a network of connected sites; 3) triggering, typically international and long-lasting policies, such as Natura 2000 conservation or INTERREG funding; 4) effective actors, networks, and collaborations in place, such as NGOs, local communities, international collaboration, and science-policy interface; and 5) cultural significance of the site exhibited as legends, traditions, events, etc., fostering positive public attitudes. It is evident that this desktop study has only touched the surface of various successes, which cannot be imported but can only develop contextually in each place. The categories found can nevertheless inform governance design and restoration upscaling efforts.

Analysis of forest-specific ecosystem services with regard to water balance components

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Water-related regulative and provisioning ecosystem services (ES) were assessed based on a holistic approach, aiming at runoff regime and groundwater recharge in the Palatinate Forest Biosphere Reserve in south-western Germany with hydrological modelling using the Soil and Water Assessment Tool (SWAT+). As potential risk factors for the degradation of water-related ES in the forest, soil compaction due to driving with heavy machinery, rejuvenation, as well as a changing climate were analyzed with regard to their impact on hydrological processes. For each

of those influencing factors, separate SWAT+ model scenarios were created. The high infiltration capacity of dominating Red Sandstone soil substrates, and the mitigation effect of forest canopy cover on runoff generation indicated favorable conditions for groundwater formation and a pronounced retention potential in the catchment. Nevertheless, elevated amounts of precipitation were found to result in pronounced surface runoff peaks. BIAS-adjusted REKLIES and EURO-CORDEX regional climate models (RCM) simulated a decline in the provisioning ES groundwater formation due to water deficits by the middle of the century and promoted surface runoff with elevated precipitation by the end of the century. The simulation of soil compaction showed a clear influence of soil type on hydrological responses on skid trails, with the susceptibility for soil deterioration to increase with higher percentage of silt and clay soil particles. The pathway system was found effective in the contribution to elevated surface runoff at high precipitation inputs. Rejuvenation was simulated based on an artificial model, comparing juvenile stocks (3 to 10 years) to mature stocks (30 to 80 years) regarding selected water balance components. Losses in the water flow retarding effect of canopy cover resulted in promoted overland flow generation, and slightly higher leaching on juvenile stocks. The simulations indicated that with higher evaporative demand, but scarce water inputs to the system, the hydrological impact of rejuvenated stocking structures compared to mature was the most pronounced the less developed the canopy cover. The results suggest that enhancement measures for regulative (decentralized flood control) and provisioning (drinking water supply) ES of the forest should focus on critical source areas for runoff generation, and the preservation and reestablishment of the hydrological continuity in forest stands.

Tree water use and climate – emerging trends and drivers

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Forests greatly affect and modify the global water cycle. Understanding the effects of climate, management, air pollution and changes therein are impaired by data limitations, since measurements of water use at whole tree and stand scales are costly and widely available only for the last few decades. Well known technologies include sap flow measurements, eddy covariance measurements, lysimeter and growth measurements. Another source of water use information is the concentration of carbon isotopes in tree rings. A global meta-analysis collated available data (n trees +400, n observations +11,000) on intrinsic water use efficiency (iWUE) of a wide range of species and geographic locations (Adams et al. 2021). iWUE can be calculated from the ratios of 13C and 12C isotopes in tree ring wood and atmospheric concentrations of CO2 (ca). We linked iWUE with two gridded climate datasets and nitogren deposition data. We found that iWUE has a non-linear relationship with the widely used Aridity Index (AI), an indicator for water availability. After AI, variation in iWUE was due to ca and to nitrogen (N) deposition. Regionally, differences emerge with the southern hemisphere exhibiting the greatest effect of N deposition despite mostly unpolluted atmospheric conditions. Dry conditions (low AI), increasing ca and high N deposition all contributed to

greater iWUE. Water use of trees has numerous and sometimes counter-acting drivers and accurate model-assisted assessments have to incorporate such effects. Quantifying actual water use (liters water per tree or per square meter) requires information on tree growth and/or sap flow. In the SAPFLUXNET global database there are about 2,700 trees with sapflow data (Poyatos et al. 2021. Sapwood area is an important scalar of sapflow. Sapwood area data are more widely available than sapflow data due to costs of measurement. Preliminary analysis of North and South American sapwood data (n = +11,000 trees) suggest that wood anatomy and tree species are more important drivers of sapwood area than climate. Tree diameter explains most variation in sapwood area. Linking tree dimensions with robust sapwood area models can help quantify hydraulic transport and storage capacity of trees and help further explorations of the causes of changes in water use by trees.

The role of hydrological research and modelling for designing resilient forest landscapes in Central Asian Mountain regions

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Mountains are the source of water for the rivers of Uzbekistan and the Kyrgyz Republic and mountain forests are threatened by overgrazing, illegal logging, drought, and wildfires. The result is accelerated soil erosion, mudflows landslides, and downstream flooding. Climate change already is altering the distribution of some mountain forests. The Resilient Future Forests Lab (RFFL) is establishing demonstration and research locations to document the benefits of mountain forests and explore innovative approaches to sustainable future landscapes through improved watershed management and forest regeneration systems. Climate modeling supporting the RFFL uses the Weather Research and Forecasting (WRF) model to investigate the atmospheric response to changing land cover. The WRF model has demonstrated reasonable skill in downscaling local climate in Central Asia. Future climate scenarios from WRF will drive the Soil & Water Assessment Tool (SWAT) model to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change. SWAT is widely used in assessing soil erosion prevention and control, non-point source pollution control and regional management in watersheds. Initial regional WRF simulations across the entire domain comparing current forest to non-forest (savanna) cover showed accumulated precipitation and accumulated snow and ice were higher in the forested vs. savanna runs. Previous research with the SWAT model of a mountain basin in the USA found significant differences in annual precipitation, runoff, water yield, ET, and discharge between past and future climates. The SWAT model is being applied to the Aktash basin in Uzbekistan, comparing a watershed afforested over 100 years ago to an adjacent non-forested watershed. Next steps are to expand the climate model to include more of Central Asia, extend the length of the simulation period, compare effects of different land

use change scenarios, and assess the effects of a warming climate on forest mountain hydrology. The hydrologic modeling will be expanded to the entire Tian Shan basin.

How does land use cover change affect hydrological response in the Atlantic Forest? Implications for ecological restoration

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Water availability in watersheds is influenced by climate conditions and physical characteristics such as topography, soil type, and land-use and cover. The Atlantic Forest has a long deforestation history and presents a climatic and environmental gradient that reflects natural vegetation diversity driven mainly by water availability and local conditions. These characteristics can be estimated by the equation developed by Zhou et al. (2015), based on the Budyko hypothesis, and represented by the parameter m. The parameter m can be considered a proxy for the water responsiveness of the site. Hence, it is expected that Atlantic Forest ecoregions present a natural variability of water responses and different hydrological effects caused by land-use cover change. In this study, we compared the hydrological response among 11 Atlantic Forest ecoregions in areas of native vegetation and pasture, using CHIRPS rainfall data, evapotranspiration by the MOD16A2 product of the MODIS satellite and water surplus calculated by the 19-year mass balance for 712 sampling points. The parameter m was calculated by equations based on the Budyko framework and varied between 1.2 and 3.6 in the biome. In 10 of the 11 ecoregions, the parameter m in native vegetation was statistically higher than the pasture, and in the REST, ECOT, SEMI, STEP and PARK ecoregions this difference was more pronounced. For all ecoregions, the R/P (water yield) ratio was inversely proportional to the parameter m, however, there were different levels of variation among them. In wetter and drier areas, there is less variation in the water surplus, while the greatest variations occurred in areas where the PET/P (dryness index) ratio is 1.5. In conclusion, the parameter m of native vegetation and pasture varies in different Atlantic Forest ecoregions. Understanding each regions natural water availability and how changes in the removal of natural vegetation or restoration can affect the water performance of watersheds is essential for planning conservation and ecological restoration actions.

ECHYZON: A tool integrating soil-plant-atmosphere components for ecohydrological zoning based on remote sensing and cloud computing

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Ecohydrological zoning is a key element in sustainable forest management and planning. The European Green Deal proposes a new strategy to protect and restore the European Union's forests, with the priority objective of planting 3 billion trees by 2030. This will promote a multitude of reforestation projects in this decade with different species that will spread across different climates. Mediterranean areas and especially those with a semi-arid climate will face

the greatest challenges, as they are severely exposed to adverse climatic conditions. Furthermore, these areas do not have a primarily productive vocation, but rather a protective one, which is why a combination of different species is normally used in reforestation. This means that the selection of species for each site is essential to ensure the survival of the reforestation. However, this selection is often done by traditional methodologies developed in previous socio-ecological contexts from the last century, that do not consider new satellite information and databases. Reforestation success is to a great extent due to optimal ecological zoning and site-species matching. To avoid the failure of future reforestation efforts, a decision support tool has been developed on the Google Earth Engine (GEE) platform that allows managers to accurately zone the area to be reforested based on the water which is in the system (soil, plant, atmosphere). This tool is called ECHYZON (Eco-hydrological zoning for Precision Forestry) and what it does is to calculate the TVMDI (Temperature-Vegetation-Moisture Drought Index) with Landsat 8 satellite images to see the water content in each pixel of the study area. This allows the user to subsequently divide the project area into a certain number of categories or classes and to be able to match the forest species to be used in reforestation according to their water needs. In this way, it is possible to identify different potentialities for areas having different drought index and hence designing patchy landscapes in the reforestation program (from no-planting to more complex designs in areas with a higher water content that would allow for more water-demanding species or mixtures to be planted). The purpose of the development of this tool is to create an initial module for zoning and species matching in the reforestation (productive or protective) that will later be used to quantify and optimise the ecosystem services derived from forest management, using the CAFE (Carbon, Aqua, Fire and Eco-Resilience) tool developed in the LIFE RESILIENT FOREST project.

Have heavy impact of the local forest stands on water crisis in Hungarian sandy drylands?

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The decrease of the available water resources is a global concern. Groundwater depletion in the Hungarian Great Plain has been significant since the mid-1970s, especially at the Kiskunság Sand Ridge. This phenomenon has been a constant focus for researchers from a variety of fields such as forestry, hydrology, and nature conversation, but also for farmers. Some of the factors behind this process are climate change, river regulation; groundwater pumping for industrial, agricultural, and domestic water demand, changes in land use and in settlement structure and hydrocarbon extraction. The issue usually becomes a subject of professional and public debate when one or more of the highlighted factors are considered the main causes behind this process. The regional water balance is a result of the complex interaction of the groundwater-soil-vegetation-atmosphere system. Achieving an adequate investigation necessitates the monitoring of the basic elements of these four sub-systems. Since 1999, the University of Sopron Forest Research Institute has been performing complex hydrometeorological and soil moisture measurements at a grassland, a black locust (*Robinia pseudoacacia*) stand, and a black pine (*Pinus nigra*) forest stand in Kecskemét. Our results indicate the soil moisture content is lower below forest stands than on the control site (grassland) during the growing season. In

contrast, this difference cannot be an indicator of the “underground deserts” in Kiskunság Sand Ridge, knowing the soil moisture values are 0.7-1.64% higher below the grassland in the upper 80 cm layer of soil. The groundwater level is constantly declining at our study site near Kecskemét. The level has declined nearly two meters since 2018. This phenomenon cannot be connected directly to the impact of the local forests stands. According to our own measurements: the annual average temperature increases of 1.8 C occurred between 1999 and 2021. That increases the potential evaporation (PET), which has a negative effect on the overall hydrologic balance of the area as there is no increase in the precipitation. The local forest stands may also have additional positive water balance effects: the interception of temperate forests significantly cools the environment in summer, reducing evaporation, evapotranspiration, and erosion. In the near future, the monitoring will be expanded with satellite imagery based on weather datasets, vegetation and water indices showing the water content of forest stands.

Flood Modelling and Water Pollution Analysis of Cagayan De Oro City, Philippines

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In the Philippines, densely populated areas are mostly located in coastal areas that are either valley plains or floodplains. Two of the most pressing and worsening environmental issues in these areas are flooding and pollution of rivers and waterways. Cagayan de Oro is one of these areas experiencing these problems. The study therefore aims to assess hazards of flooding and pollution loading of waterways in highly dense urban areas like Cagayan De Oro. Flood modelling was conducted in the five major watersheds that transect the City using terrain analysis. Terrain analysis involves the geomorphological and spatial assessment of a watershed in terms of watershed shape, relief features and channel morphology. Hydrological parameters used included circulatory and bifurcation ratios, stream densities and frequencies and relief ratio. Results show that Cagayan De Oro and Iponan are the most flood prone watershed in Cagayan de Oro City. The critical parameters in the flood modelling are the bifurcation and circulatory ratios. Critical areas to flooding were also determined by spatially delineating low lying areas in the deposition zones with 1-5 meters masl as the most critical to flooding, followed by 5-10 masl and 10-15 masl elevations. A buffering system of the two flood prone rivers was formulated based on the result of the flood modelling to determine areas that need riverbank stabilization. Reforestation is recommended for steep slopes 30 percent and above, and strict protection measures are needed in the remaining close canopy forests. Protection should be instituted through land use planning and local ordinances. Land use change favoring sprawling subdivisions should also be regulated in steep sloping areas. Land use activities were spatially studied to determine the relationship between the land use and activities to the type of pollution in drainage and waterways. Iponan and Bigaan are the most polluted in terms of hard metal and sedimentation. The land use activities related to this pollution are mining and sand and gravel extraction. It is recommended that an environmentally sensible mining measure be implemented in these areas. The Iponan and Umalag River systems are the most polluted in terms of nitrate and phosphate loading. This type of pollution is linked to industrial and residential land uses.

Management of hemiboreal forest riparian fixed-width buffers for the increased value of ecosystem services

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Riparian buffer zones represent valuable areas for the biodiversity of both forest and water ecosystems. Simultaneously these areas are also important for the increasingly more common nature-based cultural activities. The size and means of management of riparian buffer zones vary widely between countries. In hemiboreal forests, Latvia strict protection of fixed-width buffers adjacent to streams had been implemented since 1997. We compared the provision of different ecosystem services in this zone (0–50 m from the bank) with the one in adjacent unprotected areas (51–200 m from the bank). We also modeled the potential management and its usefulness in increasing the value of ecosystem services. The case study was based on four small-to-medium-sized rivers. In total, six different indicators of ecosystem services were estimated, based on data from the National Forest Inventory and the European Soil Data Centre. A novel methodology was developed to assess the value of services “Potential for the presence of medicinal plants” and “Potential for the presence of nectar plants”. Bayesian ordinal regression was employed to assess the differences. Our results showed that the majority of assessed ecosystem service indicators were of higher quality in the adjacent (0–50 m) buffer. Only one indicator (Flora with phytoremediation potential) had significantly higher values in the distant buffer strips (estimate 0.24, CI: [0.11, 0.38]). The observed distribution of quality classes showed that, only for the indicator Potential of medicinal plants, the highest quality class was the most common (>60%), for other indicators dominated average quality class estimations. Current protection of riparian forest buffers has facilitated sustaining the provision of several cultural and regulation & maintenance ecosystem services. However, modeled development showed a notable decline in the total value of these services over the next 50 years. This decline can be prevented, and the situation can even be improved with targeted management interventions. Practical implications of the findings and their importance also for the water ecosystem will be discussed.