“Managing forests in the 21st century“

BOOK OF ABSTRACTS

Conference at the Potsdam Institute for Climate Impact Research

Telegrafenberg, 14473 Potsdam, Germany

3rd - 5th March 2020

Forest ecosystems, their products and services play an important role in achieving ambitious climate change mitigation objectives at the same time requiring profound adaptation to climate change. Forest management schemes to support climate action have to be developed within their regional context but also have to be aligned with national or EU-level climate, forest and sustainability policies.

The conference on “Managing forests in the 21st century” is the final conference of the FORMASAM, REFORCE and FOREXCLIM research projects. The conference brings together scientific experts on forest management from all over Europe facing very specific management challenges. The aim is to discuss and improve the understanding the role of forests and forest management in the context of climate change. The conference addresses climate change impacts, as well as needs for mitigation and adaptation especially with regard to the following scientific questions:

1. What are the impacts of climate extremes and disturbances?
2. What are the management challenges (and options) for resilient forests?
3. What can we do to increase the contribution of forest management to climate change mitigation?

Conference Organizing Team:

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03.03.2020

13:30-15:00, A56 Conference Room

Plenary: Overview of the conference themes

Speaker: Nadine Rühr, Karlsruhe Institute of Technology, Germany

"Tree and forest functioning in a changing world"

The climate of the 21st is rapidly changing marked by a consistent trend of increasing temperatures and altering precipitation patterns. Large areas of Europe have recently been facing extraordinary long drought spells alongside record high temperatures. The impacts on forests are manifold and wide-spread tree mortality has been reported. Following the record drought of 2018 and 2019 in central Europe, several million trees have died in Germany alone causing tremendous financial losses to forest owners. This clearly displays the urgent need to improve the resilience of European forests to future climate change through adaptive forest management.

During my talk I want to address if our functional understanding of tree and forest responses to extreme events is sufficient to provide the urgently needed management recommendations? Along this line I will present i) physiological insights into the ability of trees to withstand drought, ii) the importance of stress recovery in determining tree resilience to future conditions, and iii) tree mortality as a consequence of extreme climatic conditions. I provide reasoning that management recommendations should be based on a rigorous ecological and physiological understanding of tree and forest responses to changing environmental conditions. To achieve this, uncertainties need to be identified and open research questions addressed, ideally in a close dialogue between scientists and forest managers.

Speaker: Harald Bugmann, ETH Zurich, Switzerland

„The need for a paradigm shift in forest management to cope with global change"

The Anthropocene provides numerous challenges for resource management and society in general. In this contribution, I reflect on the historical and climatic basis of current forest management, and I derive the implications for future forest management in the face of increasing uncertainties induced by globalization processes as well as climate change. I argue that, similar to the fact that agriculture became possible only after the stabilization of climate at a certain level and particularly the reduction of interannual climatic variability, forestry was developed between the late 16th to the early 20th century, coinciding largely with the Little Ice Age, i.e. temperature conditions well below those even of the 1961-1990 period, let alone what one could consider "current climate" (e.g., 1981-2010). For a number of reasons, the historical approach to forestry emphasises control over the forest (e.g., "Normalwaldmodell" developed by von Carlowitz). However, taking into account the current challenges, such as those arising from enhanced disturbance regimes including the drought of 2018, and anticipated future challenges, we need to emphasise the fact that nature cannot be "commanded" (Sir Francis Bacon), but forest management needs to define a new role as a contributor to, rather than a governor of, forest dynamics. If we accept this, multiple implications arise for the provisioning of ecosystem services and the relationships between forests, forest management, and society at large.

Speaker: Galina Churkina, Potsdam Institute for Climate Impact Research, Germany

„Buildings as global carbon sink“

The anticipated growth and urbanization of global population over the next several decades will create a vast demand for the construction of new housing, commercial buildings, and accompanying infrastructure. The production of cement, steel, and other building materials associated with this wave of construction will become a major source of greenhouse gas emissions. Might it be possible to transform this potential threat to the global climate system into a powerful means to mitigate climate change? To answer this provocative question, we explore the potential of midrise urban buildings designed with engineered timber to provide long-term storage of carbon and to avoid the carbon-intensive production of mineral-based construction materials.

15:30-17:00, A56 Conference Room

Parallel session 1: Management Modelling 1

Speaker: Thomas Kainz, University of Natural Resources and Life Sciences, Vienna, Austria

„Simulated effects of tree species diversity and species pattern on biomass production at stand level“

Recent synthesis in functional biology suggests that across a variety of systems and for a number of ecological processes, diverse communities often outperform the ones which are species-poor. Tree species diversity therefore has important implications for forest management practices. For instance, diverse forests sequester and store a greater amount of carbon compared to monocultures (e.g., Paquette & Messier 2011) and may show increased biomass productivity (Zhang et al. 2012). However, experiments and observational studies revealed that there is no general overarching diversity – ecosystem functioning relationship, but that diversity effects may vary across sites, densities and species compositions, and may be due to true complementarity or species identity effects. Tree-based forest ecosystem models offer the opportunity to explore diversity–functioning relationships. In this contribution we employ the 3D hybrid forest model PICUS v1.6 to simulate the behaviour of various species mixtures to shed light on diversity and species identity effects on biomass productivity. In total, we consider eight tree species (Picea abies, Abies alba, Pinus sylvestris, Larix decidua, Fagus sylvatica, Quercus petraea, Acer pseudoplatanus, Betula pendula) along a mixture gradient (species number, species shares) where species are either randomly distributed in space or intermixed in patches of various size (100m2, 400m2 and 900m2 patch size). Simulated output is analysed for diversity–functioning effects related to biomass production. Results will inform about management options for resilient forests.

Speaker: Mats Mahnken, Potsdam Institute for Climate Impact Research, Germany

„Locally adapted stand-scale forest management alternatives for the 21st century“

Understanding the implications of large-scale forest management objectives, associated strategies and the linked stand-scale silvicultural actions under climate change is crucial for decision making because of the long-term nature of strategic forest management planning and pronounced lag effects in forest dynamics. Here, specific locally adapted stand-scale silvicultural management schemes (planting, thinning, harvesting regimes) related to different management strategies (business-as-usual, bioenergy for mitigation, harvested wood products for mitigation, multifunctional-adapted) are imple-mented in a simulation experiment for multiple potential climate change pathways. Using a process-based forest growth model, different forest management alternatives are investigated on eight distinct forest stands across Europe to study the potential management effect on forest dynamics, climate change mitigation potential and ecosystem services provisioning in the 21st century.

Speaker: Andrey Lessa Derci Augustynczik, University of Freiburg, Germany

„Socially optimal forest management and biodiversity conservation in temperate forests under climate change“

Forest biodiversity underpins social welfare by preserving ecosystem multifunctionality and the provision of ecosystem goods and services. Still, the social value of biodiversity is not adequately incorporated into forest management and decision support models. This study proposes a novel approach for defining socially optimal biodiversity levels, wood supply and taxation schemes under climate change. We developed a partial equilibrium model to maximize consumers' and producers' surplus until the end of the century, including climate change impacts as productivity shocks in a coupled ecological-economic framework. In our model, we consider a first-best and a second-best taxation scheme to internalize the value of forest biodiversity into forest planning. The framework developed here was applied to a temperate forest landscape in southwestern Germany, where biodiversity has a high social value. Our results indicate an increasing consumption of wood and supply of biodiversity (up to 38.4 %) until the end of the century. Moreover, climate change may affect forest productivity, optimal harvesting rates and taxation schemes. Crucially, current management is unable to capture the adequate social value of biodiversity and is inefficient under climate change. Policy mechanisms are therefore required to correct biodiversity provision in temperate forest landscapes.

Speaker: Rüdiger Grote, Karlsruhe Institute of Technology, Germany

„How to consider forest regeneration in process-based models? Interaction of physiology, environment and management“

Disturbances of forest ecosystems are expected to increase in frequency and intensity due to increasingly severe storms, drought periods, fires, or insect attacks, which all are triggered by climate warming. In addition, the transformation of current forests with the intention to increase resistance to these threats will also require to carry out extensive shelterwood cuts. A successful establishment of multiple species under partly or fully removed coverage is a major challenge for forest management, in particular since increasingly stressful conditions will also affect regeneration.

Process-based models are needed to capture climate-change impacts and to investigate possible stress-mitigating effects of management. However, they are generally not designed to address specific problems related to regeneration such as the competition of ground vegetation and the responses of allometry to quickly changing environmental conditions. In fact, horizontal crown expansion, the change in height/diameter ratio, or the development of relative branch- and coarse root biomass can be decisive for the question if the establishment of a particular species will be successful.

In order to address the multiple feedbacks between allometry and physiology, it is suggested to implement dynamic allometric ratios that depend primarily on neighborhood competition into a physiology-based ecosystem model. Since different species and tree size groups are treated as cohorts in the model, asymmetric competition is considered by explicit simulation of resource acquisition and depletion per canopy layer. The new implementation has been tested on two sites in Germany. The further potential and eventual pitfalls of the approach are discussed.

Speaker: Anu Akujärvi, Finnish Environment Institute SYKE, Finland

“The carbon balance of boreal old-growth forests”

Boreal old-growth forests safeguard the resilience of forests through protecting biodiversity and storing large amounts of carbon in the biomass, litter and soil pools. Recent studies have suggested a continuing carbon sink of old-growth forests questioning the hypothesis of a steady-state system. The carbon sink capacity of boreal old-growth forests is, however, poorly known due to lack of knowledge about the spatiotemporal patterns of growth, mortality and regeneration. The impacts of climate change on the carbon balance of old-growth forests can be predicted using process-based models. The objectives of this study were, first, to modify the forest carbon balance and growth model PREBAS to be applicable also in unmanaged and old-growth forests, and second, to quantify the carbon balance of old-growth forests in Finland under present-day and changing climate conditions. The validity of the simulated forest growth and carbon balance estimates was tested against a time-series of tree measurements in natural forests from the 1990s to 2019. Here we present preliminary results on the potential responses of a boreal forested landscape to changing climate in southern Finland. Unmanaged, old-growth forests had a higher biomass carbon stock, somewhat lower soil carbon stock and a lower carbon uptake rate than managed forests. The differences were related to patterns in stand growth, age structure and litter production. The model will be applied to country-wide projections of different forest management options later. The results can be applied to identify areas where biodiversity conservation and climate change mitigation through carbon sequestration could be best reconciled.

Speaker: Michael Duhr, Ministry of Agriculture, Environment and Climate Protection (MLUK), Germany

"Forests and woodland in Brandenburg"

Brandenburg is located in north-eastern Germany, characterised by a temperate continental climate. Mean annual temperatures range between 7.8°C in the north and 9.5°C in the southeast. The average annual precipitation is between 450–550 mm. Brandenburg is characterised by mostly sandy soils with generally moderate to low nutrient content and water retention capacity.

More than one million hectares are covered with forest in Brandenburg (thirty-seven per cent of the landscape). Sixty percent of the state´s forests are privately owned. Landesbetrieb Forst Brandenburg, the state forestry operation, manages the state-owned-forest, which makes up on quarter of the forested area. Community and other forest owners own Fifteen percent of the forest in Brandenburg.

Brandenburg features a wide range of deciduous and coniferous tree species as part of its potential natural vegetation. However, Scots pine (*Pinus sylvestris*) is currently the most common tree species. The pine dominated forests are mostly even-aged single-story stands, which are susceptible to abiotic and biotic damage. In particular, the forests and woodland are currently threatened by winter storms, summer drought, forest fire and insect outbreaks. Therefore the conversion of even-aged pine forests to more site-adapted near-natural mixed woodland has been one of the most important objectives of forest policy in Brandenburg throughout the last two decades. Due to the generally high game density in Brandenburg, however, the establishment of regeneration of tree species other than pine or birch is often associated with costly protection measures. A reduction of game density is thus required to facilitate forest conversion, and to take full advantage of the benefits of natural regeneration.

The integration of forest ecosystem processes into forest management resulted in the formulation of the 'nearnatural forest management' paradigm, which is the essential guideline for forest management in Brandenburg. The steadily increasing demand for timber for material and energetic use is constantly increasing the utilisation pressure on Brandenburg's forests.

Due to the already dry climatic conditions, negative effects of climate change can be already observed in Brandenburg like

- moderate increase of mean annual temperatures of 1.8-2.3°C, with decreasing number of frost-days and increasing number of heat-days
- slightly decreasing total precipitation; 10 per cent increase in winter precipitation; 18-22 per cent decrease in summer precipitation
- increasingly negative climatic water balance, ground water recharge, and ground water and river levels
- increasing probability of extreme weather events (e.g., storm, hail, heavy rainfall, etc.)

The introduction of more drought-resistant varieties of native tree species such as pine, birch or oak is thus likely a more successful approach to maintaining forest functionality.

15:30-17:00, A56 Telepresence Room:

Parallel session 1: Resilience

Speaker: Kirsten Thonicke, Potsdam Institute for Climate Impact Research, Germany

„How to better understand the adaptive capacity of Social-Ecological Systems to absorb climate extremes“

Enhancing the capacity of social-ecological systems to adapt to climate change is of crucial importance. While gradual climate change impacts have been the focus of much recent research, large research gaps in our understanding exist with regards to how social-ecological systems (SES) are impacted by climate extremes and how they adapt. Here, based on an advanced conceptualisation of social-ecological resilience, we outline three major challenges for operationalizing the resilience concept with particular focus on climate extremes. First, we discuss the necessary steps to identify and measure the relevant variables to identify the full response spectrum of the coupled social and ecological components of SES. Second, we examine how climate extreme impacts on coupling flows in SES can be quantified by learning from past societal transitions or adaptations to climate extremes and resulting ecosystem services trade-offs and bundles. Lastly, we explore how to identify management options to maintain and enhance social-ecological resilience under a changing regime of climate extremes. We conclude that multiple pathways within adaptation and mitigation strategies for enhancing the adaptive capacity of SES to absorb climate extremes will open the way towards a sustainable future.

Speaker: Elena Cantarello, Bournemouth University, UK

„Resilience of multiple ecosystem services and biodiversity in a temperate forest“

Resilience is increasingly being considered as a new paradigm of forest management among scientists, practitioners, and policymakers. However, metrics of resilience to environmental change are lacking. Faced with novel disturbances, forests may be able to sustain existing ecosystem services and biodiversity by exhibiting resilience, or alternatively these attributes may undergo either a linear or nonlinear decline. The talk will present a novel quantitative approach for assessing forest resilience that focuses on three components of resilience, namely resistance, recovery, and net change, using a spatially explicit model of forest dynamics. Two main sets of scenarios were developed to explore the impact of increasing disturbance on the provisioning of ecosystem services and biodiversity: “pulse” and “pulse+press” sets. Nine ecosystem services and four biodiversity measures were selected: aboveground biomass, aesthetic value, commercially harvested fungi richness, net nitrogen mineralization absorbed to ionic resins, recreation value, soil nitrogen stock, soil respiration rate, timber volume, total carbon stock and species richness of ectomycorrhizal fungi, ground flora, epiphytic lichens, and trees. The approach presented will illustrate how the multidimensionality of stability research in ecology can be addressed and how forest resilience can be estimated in practice. Managers should adopt specific management actions to support each of the three components of resilience separately, as these may respond differently to disturbance. In addition, management interventions aiming to deliver resilience should incorporate an assessment of both pulse and press disturbances to ensure detection of threshold responses to disturbance, so that appropriate management interventions can be identified.

Speaker: Dominik Thom, Technical University of Munich, Germany

„Directing structural development can improve the functional response diversity of forests to climate change in northeastern North America“

The functional diversity (FD) of an ecosystem defines its range of possible responses to environmental change. It has been suggested to include the concept of FD in management plans to cope with climate change. However, incomplete scientific knowledge and difficulties to understand the concept of FD hinder the implementation of FD-based management approaches. In our study we (i) mapped the current distribution, (ii) analyzed the drivers, and (iii) tested the sensitivity of FD to projected increases in temperature and precipitation to facilitate the development of adapted management approaches in northeastern North America.

We combined a literature and database review of 44 traits for 43 tree species with terrestrial inventory data of 48,426 plots spanning an environmental gradient from northern boreal to temperate biomes. Employing an ensemble approach consisting of multiple non-parametric models, we evaluated the statistical influence of 25 covariates on FD. Subsequently, we conducted a climate sensitivity analysis.

Temperate forests and the boreal-temperate ecotone east and northeast of the Great Lakes were identified as FD hotspots. The response of FD was most strongly driven by forest stand structure. Climate change elevated FD in boreal, but lowered FD in temperate forests.

Forest management can increase FD when specifically designed to promote structural complexity. Moreover, mixing species from functionally different groups can enhance the response diversity of forests to an uncertain future.

Speaker: Boris Sakschewski, Potsdam Institute for Climate Impact Research, Germany

„Variable rooting strategies stabilize biome productivity“

Tree water access via roots is crucial for forest functioning and therefore a vast variety of rooting strategies have evolved in the global forest systems. Especially, the distribution of roots within the soil column is important for buffering temporal shortages of precipitation. However, dynamic global vegetation models (DGVMs) often condense this variety into biome scale averages, potentially overestimating the dependence of forest functioning on short term precipitation. Here we present first results of implementing variable root systems into a DGVM (LPJmL 4.0) applied to Central- and South-America. We show how variable root systems constrained by soil & sediment thickness enable a better reproduction of state variables like forest cover or biomass pattern as well as intra-annual variability of e.g. evapotranspiration. We find that trade-offs between water accessibility and below ground carbon investment explain local diversity and co-existence of rooting strategies. We present mean rooting depth maps and below ground carbon investment maps based on our modelling results. Conclusively, we propose a stabilizing effect of realized rooting depth on ecosystem productivity.

Speaker: Hao-wei Wey, Max Planck Institute for Meteorology, Germany

„Drought responses of Amazon forests under climate change: The contrasting roles of soil moisture and canopy responses“

The Amazon forests are one of the largest ecosystem carbon pools on Earth. While more frequent and prolonged droughts have been predicted under future climate change here, the vulnerability of Amazon forests to drought has yet remained largely uncertain, as previous studies have shown that few land surface models succeeded in capturing the vegetation responses to drought. In this study, we present an improved version of the land surface model JSBACH, which incorporates new formulations of leaf phenology and litter production based on intensive field measurement from the artificial drought experiments in the Amazon. Coupling the new JSBACH with the atmospheric model ECHAM, we investigate the drought responses of the Amazon forests and the resulting feedbacks under RCP8.5 scenario. The climatic effects resulted from (1) declining soil moisture and (2) soil moisture-induced canopy responses are separated to give more insights, as the latter was poorly simulated. Preliminary results show that soil moisture and canopy response have contrasting effects on net ecosystem production, which is negative for soil moisture, but positive to neutral for canopy responses. In addition, declining soil moisture enhances rainfall in Northern Amazon and suppresses rainfall in the south, while canopy responses have less effects on rainfall. Based on our findings, we suggest cautious interpretation of results from previous studies. To address this uncertainty, better strategy in modeling leaf phenology such as implemented in this study should be adopted.

17:30-19:10, A56 Conference Room

Plenary: What are the impacts of climate extremes & disturbances?

Speaker: Maxime Cailleret, IRSTEA, France

„Short- and long-term impacts of drought on tree primary and secondary growth and on mortality risk“

Drought is the main factor limiting individual growth of adult trees worldwide. It primarily impacts cell growth and tissue formation, and then photosynthesis due to stomatal closure.

A large number of studies have been carried out to better understand and predict their consequences on tree structure and functions and on population dynamics, but important research gaps still remain.

Among others, (1) the drought impacts on primary growth (including shoot elongation, number of ramifications, leaf size) and on the production of reproductive organs are largely understudied, and (2) the short- and long-term effects of extreme droughts on tree mortality risk are not yet well quantified, although these processes are key drivers of tree crown structure and forest dynamics.

In this presentation, we will address these issues by analyzing multi-species tree-ring width networks and long-term measurements from the experimental site of Font-Blanche, France, where Aleppo pine trees have been monitored in rainfall exclusion, irrigation, and controlled plots for more than 10 years.

Speaker: Georges Kunstler, IRSTEA, France

„Demographic performance of European tree species at their hot and cold climatic edges“

1. Species range limits are thought to result from a decline in demographic performance at range edges. However, recent studies reporting contradictory patterns in species demographic performance at their edges cast doubt on our ability to predict climate change demographic impacts. To understand these inconsistent demographic responses at the edges, we need to shift the focus from geographic to climatic edges and analyse how species responses vary with climatic constraints at the edge and species' ecological strategy.
2. Here we parameterised integral projection models with climate and competition effects for 27 tree species using forest inventory data from over 90,000 plots across Europe. Our models estimate size-dependent climatic responses and evaluate their effects on two life trajectory metrics: lifespan and passage time – the time to grow to a large size. Then we first predicted growth, survival, lifespan, and passage time at the hot and dry or cold and wet edges and compared them to their values at the species climatic centre to derive indices of demographic response at the edge. In a second step, we estimated climate response of 10cm dbh trees recruitment and developed density-dependence IPMs for monospecific populations. Then we evaluated the population equilibrium size, its demographic variance and the time to extinction at the edges and at the climatic centre. Using these indices, we investigated whether we found a general pattern in species demographic response at hot and cold edges. Then we analysed if species differences could be explained by their position along the climate gradient and functional traits related to their climate stress tolerance.
3. We found that at cold and wet edges of European tree species, growth and passage time were constrained, whereas at their hot and dry edges, survival and lifespan were constrained. We also found that despite having a larger basal area at equilibrium the hot edges populations had shorter time to extinction than the climatic centre. Demographic constraints at the edge were stronger for species occurring in extreme conditions, i.e. in hot edges of hot-distributed species and cold edges of cold-distributed species. Species leaf nitrogen content was strongly linked to their demographic responses at the edge. In contrast we found only weak links with wood density, leaf size, and xylem vulnerability to embolism.
4. Our study presents a more complicated picture than previously thought with demographic responses that differ between hot and cold edges. In particular, the hot edge is experiencing higher mortality and a shorter time to quasi-extinction. Predictions of climate change impacts should be refined to include edge and species characteristics.

Speaker: Rupert Seidl, Technical University of Munich, Germany

„Insights on the current and future resilience of Central European forests to bark beetle disturbances“

Bark beetle disturbances have strongly increased in Central European forest ecosystems in recent years. Synchronized waves of bark beetle mortality at the subcontinental scale are increasingly challenging forest management and raise questions of the ecological resilience to the currently observed disturbance levels. Here we address two questions of key relevance for ecological resilience, (1) how well are forests recovering from recent bark beetle outbreaks, and (2) are current bark beetle outbreaks amplifying (because of a synchronization in forest age structure) or dampening (because of increased structural and compositional diversity) the risk of future disturbances? We used remote sensing approaches (Lidar + Landsat) in combination with landscape-scale simulation modeling (iLand) to address these questions. We focused our work on the Bavarian Forest National Park and the surrounding managed forests, as these areas contain the single largest high severity bark beetle disturbance patch recorded in recent history in Europe. Using Lidar data we show that >50% of bark-beetle disturbed forests have structurally recovered 30 years after the disturbance, regardless of whether they were actively managed or not. Active forest management increased the speed of recovery, but at the same time reduced the disturbance-induced variation in forest structure. Our simulations show that the increasing compositional and structural diversity emerging naturally after disturbance is able to effectively dampen future bark beetle outbreak. We conclude that the forests of Central Europe have considerable ecological resilience to bark beetle outbreaks, and that disturbance-induced increases in diversity should be harnessed (rather than eradicated) by forest management.

Speaker: Janet Maringer, Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Switzerland

„General assumption: Beech forests do not burn. Evidence from recent years: Yes they do!“

There is a general assumption among European scientists and forest managers that beech forests do not burn due to their inherent poor flammability. Tall and closed stands prevent a biomass-rich understory in managed high-stem beech forests, and the compact, moisture litter layer hardly ignites or sustain fire spread.

Evidence from recent years shows, however, that beech forests burn! In case of long-lasting heat waves beech forests become prone to fires. In the light of global change-related drought effects this raises questions on the fire resilience of beech forests and best post-fire measures to ensure continued provision of ecosystem services, particularly in forests that protect against natural hazards. Recent studies on post-fire dynamics over 40 years allowed us to conclude that:

• Fire-injured beeches experience delayed mortality lasting over 20 years depending on fire intensity, tree size, growth habit (mono- vs. multi-stems), and fungi infestation.

• Regeneration window for beech opens immediately after fire and is mostly successful within the first 15 years when supported by mast events.

• The protection capacity is critical in moderate und severe burnt beech stands within 5 and 30 years post-fire.

We conclude that beech forests are resilient to surface fire. Post-fire management should focus on the resulting burn severity and leave, whenever possible, dying trees and dead wood within the burnt area in order to enhance beech regeneration. In case of silvicultural interventions, treatments should take place after a mast year. Special attention should be paid to the protection function in high severity burns on steep slopes.

04.03.2020

09:00-10:30, A56 Conference Room

Plenary: What are the management challenges (and options) for resilient forests?

Speaker: Klaus Puettmann, Oregon State University, USA

„Court Jester is chasing the Red Queen: Adaptation as a key feature of future forest management“

Current trends suggest that the speed of global change will keep increasing in the future. Thus, rather than adapting forests and forestry to a novel set of conditions, adaptation efforts need to focus on preparation for a future where conditions are not only continuously changing, but changing at a faster and faster rate. In this context, this presentation provides a more detailed look at adaptation. For example, I describe how natural adaptation mechanisms can be aligned along organizational scales, how such mechanisms can differ as a function of the degree of uncertainty and turnover time (i.e., life span of individuals). Next, I explore how this understanding of natural adaptation mechanisms can be useful for development of forest management strategies. I conclude with ideas what a multi-scale adaptation strategy that acknowledges continuous change at increasing rates could look like.

Speaker: Carola Paul, University of Göttingen, Germany

Forest enterprises trapped between desperation and resignation – how ecological-economic modelling may contribute to supporting management decisions in a changing climate

Forest owners have always been faced with high uncertainties. Natural disturbance events but also the changing demands for different wood products are key considerations in forest management. Yet, climate change adds further uncertainties and an unprecedented magnitude of forest damages. But what are possible adaptation strategies for forest enterprises? Despite increasing scientific evidence on the potential consequences of climate change on forests, strategies to maintain economic sustainability of forest enterprises are yet to be identified.

Given the inherent uncertainties of future developments and the long-term nature of forestry, there is single-best solution. However, modern ecological-economic modelling may provide important insights to support management decisions. Using the example of species selection, some recent experiences with bio-economic and multi-criteria modelling are presented. They combine updated estimates on survival probabilities with Modern Portfolio Theory and robust optimization modelling. Results show that incorporating uncertainties in ecological-economic modelling is methodologically challenging but crucial for supporting management decisions. Instead of comparing fixed management scenarios, framing the question into “at what magnitude do conditions need to change to severely affect my desired outcome and management strategy” may help to mitigate desperation, while also demonstrating the need for changing practices. The talk shares experiences on how to implement such analysis using extensive sensitivity analysis in normative modelling approaches.

As conclusion, some recommendations, such as diversifying tree species appear robust against a wide set of uncertain futures. Yet, other specific management recommendations remain highly sensitive to classic economic drivers, such as planting costs and wood prices, even when accounting for economic consequences of climate change. This shows that, despite the urgent need for ecological adaptation strategies, resilient forests need to account for classic economic decision variables to path a way between desperation and resignation for forest managers.

11:00-12:30, A56 Conference Room

Parallel session 2: Empirical Management

Speaker: Daniele Castagneri, Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Switzerland

„Does competition influence tree response to drought?“

Improved knowledge on forest responses to drought is needed to drive forest management adaptation to climate change. In the past years, several studies have investigated stand-level competition influence on growth responses to water stress. Most argued that competition exacerbates drought influence on growth, still results are very variable, and sometimes contradictory. This raises doubts on the general suitability of thinning to increase tree growth resistance and resilience. Here, we performed a statistical meta-analysis on literature investigating stand-level competition influence on different descriptors of response to drought. Our results demonstrate that competition mostly reduces growth resistance. Among several parameters descriptive of stand, species, and climate, only drought intensity during the event significantly affected competition influence on resistance. Differing from most previous studies, our analysis did not show negative influence of competition on growth recovery and resilience. We conclude that thinning is generally effective in improving growth resistance, but not resilience. However, studies considering forest stand peculiarities at the local level are necessary to identify the best management strategies to improve forest response to drought.

Speaker: Hernán Serrano-León, EFIPLANT

„The REINFFORCE infrastructure network for monitoring and adapting Atlantic forests under a changing climate. First empirical evidences on the potential adaptive performance of alternative species."

As the long-term performance of current productive tree species is increasingly threated by climate change impacts, the resilience and mitigation capacity of our productive forests might only be sustained by diversifying the number of available species with better-adapted provenances.

It is crucial to provide forest managers with empirical evidences to help the selection of adapted material under a future climate that will differ from the present conditions.

With this aim, the REINFFORCE network (reinfforce.iefc.net) was established in 2011-2013 as a unique transnational infrastructure of 38 Arboreta with common genetic material to test the field adaptation performance of current and alternative reproduction material under present and future climates.

Distributed along 4 countries of the European Atlantic arc (Portugal, Spain, France, United Kingdom), the network latitudinal gradient (37° - 58° N) allows assessing the response of 33 different tree species and 176 provenances along a large diversity of climate and soil conditions outside their current distribution range.

We present the first field performance results of 33 alternative tree species under the wide gradient of climatic conditions covered by the arboreta network. We identified the climate drivers that better explain the growth and survival performance of the different species. These early-stage results allowed us to predict the risk on the species performance under different climate change scenarios.

These results provide evidences on recommended plantation material for forest managers aiming to increase the adaptation of productive forests facing future climate uncertainty.

Speaker: Pierre Ibisch, Eberswalde University for Sustainable Development, Germany

„Forests and landscape temperature management"

Urban heat island effects have long been the subject of research and are increasingly being taken into account for urban planning and adaptation to climate change. However, the control of surface temperature by different vegetation properties, more specifically biomass, in a regional context has so far been less investigated. As corresponding metrics are easy to create and the required remote sensing data of surface temperature is globally available, planners and ecosystem managers could be provided with meaningful tools to assess vulnerability and quantify ecosystem services, e.g., related to cooling. As a case study, we investigated the surface temperature of different land cover and forest types for different seasons and different temperature ranges in northern Brandenburg, Germany. The analysis is based on daily MODIS data from 2002-2018 as well as habitat mapping. We focus on cooling capacities of various forest types and how they change with higher temperatures. Our results quantify the relation between cooling capacities and the ratio of pine forest and deciduous forest over different temperature ranges. In comparison to deciduous forests, the cooling capacity of pine forest drastically decreases at higher temperatures. This highlights the importance of future landscape design to preserve ecosystems services beyond extraction-based use, create cold-air corridors and reservoirs to avoid regional heat islands effects, and actually embrace the need for a landscape temperature management.

Speaker: Jeanette Blumroeder, Eberswalde University for Sustainable Development, Germany

„Forest microclimate and management under climate change: insights from forests and plantation in north-eastern Germany“

Forest management can substantially contribute to the loss of ecosystem functions including microclimate regulation. At 102 sample plots in the state of Brandenburg, Germany, we assessed surface and ground temperature as well as forest properties such as biomass or structure. Cooling capacity and buffering of extreme temperatures are regulated by crown coverage, the volume of dead and living biomass as well as tree species composition. On the hottest days, mean maximum temperatures in dense beech forests was 8°C cooler than in more open and biomass-poor pine plantations. The conversion of single layered monocultures into multi-layered forests supports shading and substantially contributes to microclimate cooling. Under conditions of extreme heatwaves and drought, microclimate regulation must become an explicit forest management target. Ecosystem-based forest management strategies are needed to reduce the vulnerability and to increase forest resilience.

Speaker: Jonas Schmeddes, University of Greifswald, Germany

„Phenotypic plasticity and local adaptation of Fagus sylvatica and its implications for assisted migration“

Fagus sylvatica is one of the most dominant tree species in Europe. Yet, it is expected to suffer from climate change due to its high drought sensitivity and low seed dispersal capacity. A widely discussed approach to mitigate the impact of climatic change on tree species and forestry is the assisted migration; i.e. the plantation of seeds that originate from provenances that are expected to have a better adaptation to the future climate. However, the applicability of this measure depends on the genotypic and phenotypic variation of the species and local site conditions and is still scarcely investigated.

We conducted a fully reciprocal transplantation experiment across a Europe-wide gradient, reaching from the dry (Spain) to the cold distribution edge (Sweden) of F. sylvatica. At 12 different sites inside and outside of the natural distribution range, we planted in total over 12.000 beechnuts collected from known mother trees. We sampled morphological, fitness- and stress-related traits during the year of establishment and the subsequent years. We compared different potential sources of phenotypic plasticity in F. sylvatica seedlings, namely within single mother trees, within single stands or provenances, and across different provenances under the contrasting climates of the translocation sites.

For specific leaf area (SLA) we found that the full phenotypic variation was already present within each mother tree. This finding implies surprisingly high phenotypic plasticity per mother tree and, hence, indicates high potential to respond to climate change. Based on these results, assisted migration of presumably better adapted southern provenances appears superfluous.

Speaker: Victor Fririon, INRAE, France

„To what extent can silviculture drive adaptability to changes in disturbance regimes? Integrating disturbance impact regimes in a demo-genetic simulation approach“

Climate change, with its uncertainties and the complexity of the systems it affects, will have partly unpredictable consequences. Therefore, assuming the limits of our knowledge, evolution-oriented forest management highlights the need to maintain genetic diversity over the long term while ensuring local adaptation in the short term.

The changes in disturbance regimes associated with the complex interactions between the different biotic and abiotic risks are likely to cause dieback and eventually collapses in terms of demography (if mortality exceeds regeneration) and genetic diversity (if selection pressure turns into genetic erosion). Silviculture, by influencing the demographic process (growth, reproduction and survival), indirectly affects the genetic structure and therefore the susceptibility to hazards of stands. Conversely, interacting with environmental conditions, genetic structure influences demography and thus silviculture.

As part of a multi-risk approach, here we propose a demo-genetic simulation approach aiming to quantify the ability of silviculture to influence the resilience and evolutionary capacity of forests facing natural disturbances. To do so, we develop a common framework to represent different types of disturbances through their impacts regime, defined by hazard occurrence, spatial pattern and intensity measured in terms of impact on the demographic process (growth, reproduction, survival), as well as by factors of vulnerability to these demographic impacts at stand and tree levels. Today restricted to climatic hazards, the method aims to integrate other types of abiotic and biotic hazards in demo-genetic forestry models in the future.

11:00-12:30, A31 Big Cupola

Parallel session 2: Empirical Impacts 1

Speaker: Daniel Nadal-Sala, Karlsruhe Institute of Technology, Germany

„Seasonal changes in the most limiting factor for Gross Primary Production in a semi-arid forest“
Forest growth in semi-arid regions is known to be strongly limited by water availability. However, also other environmental drivers can be limiting factors, with varying seasonally. We investigated changes in the main limiting factor of GPP from 4 years of eddy covariance flux measurements in the Yatir forest, an Aleppo pine (Pinus halepensis Mill.) plantation in Israel with low annual precipitation (<290 mm). Daily-integrated GPP data was used to calibrate and validate a Random Forest (RF) algorithm, relating GPP to four environmental drivers: soil water content (SWC), vapor pressure deficit (D), photosynthetic active radiation (PAR) and air temperature (Tair). After validation, RF regression allowed us to identify the environmental conditions maximizing GPP. From those modeled optimal environmental conditions, we evaluated changes in observed GPP versus its maximum by running the RF model for one driver at a time. Thereby we could derive the potential degree of GPP limitation per environmental driver. Afterwards, we applied an optimization algorithm to calculate the most limiting factor on a daily basis for observed GPP, when all limitations where accounted together.

Speaker: Jarosław Socha, University of Agriculture in Krakow, Poland

„Changes in site productivity as one of the factors increasing the forest dieback risk“

Changes in forest site productivity affect forest ecosystems services such as the production of wood and biomass, carbon storage and others. Disturbances related to climate and environmental changes observed on an unprecedented scale in recent years are connected with changes in forest site productivity. A decline in the stability and resistance of stands is observed first in fast-growing stands which are particularly exposed to drought stress and become less resistant to attacks by insects and secondary pathogens. Simulations of site productivity changes allow indicating sites and species particularly exposed to negative effects of climate condition, reducing the risk of disturbances and are critically important for carbon and biomass estimation. Change detection using remote sensing becomes a new source of data for forest growth and site productivity estimation. Modelling of the long-term changes in site productivity using Airborne LiDAR scanning (ALS) has become an efficient and precise tool employed in forest inventories by providing the capability to accurately estimate the forest growth and site productivity. Multitemporal ALS observations could be used as a substitute for permanent sample plot data traditionally used to date for the TH growth modelling. In the presented research, we developed a new approach that allows for the practical application of repeated LIDAR data for the calibration of site index models that are applicable in site productivity estimation. We demonstrated how wall-to-wall ALS data could be also used for the detailed mapping of the forest site productivity. Information concerning site productivity together with selected forest stand characteristics, which affect the probability of forest dieback were used to develop the forest dieback risk model for selected test sites in Poland.

Speaker: Dejan Stojanović, University of Novi Sad, Serbia

„Relations between radial growth of European beech and remotely sensed indices across Europe“

Studies that used tree-ring data and remotely sensed indices, temperature and precipitation across wider scale (e.g. continent) are not abundant. We provide new findings that relate to the radial growth of European beech (EUMIXFOR dataset with 32 plots) and remotely sensed indices (NDVI, EVI and soil moisture) temperature and precipitation (eobs database) across European continent. After application of bootstrepped correlation analysis significant correlations between time-series of remotely sensed indices and climate variables (for available periods) and growth have been found for most of the localities. Variables from different parts of the season were differently related to the growth of European beech. Most of the stands were positively related to the summer precipitation. Generally high temperatures were related to poor growth and vice versa. Remotely sensed indices were often significantly related to growth, but without clear patterns among 32 sites. Acquired results give contribution to better understanding of climate-growth phenomena and observation of forest growth from satellites.

Speaker: Negar Rezaei, CREA, Italy

„Frost and drought: effects of extreme weather events on Stem Carbon dynamic in a Mediterranean beech forest“

Extreme weather events affect tree functioning, which needs to be deeply investigated. Being european beech one of the most sensible species to late frost and water shortage, we investigate the intra-annual C dynamics in stems under such conditions.

Wood formation and stem CO2 efflux were monitored in a Mediterranean beech forest for three years, including a late frost (2016) and a summer drought (2017).

The late frost reduced radial growth and consequently the amount of carbon fixed in the stem biomass by 80%. Stem carbon efflux in 2016 was reduced by 25%, which can be attributed to the reduction of effluxes due to growth respiration. Counter to our expectations, we found no effects of the 2017 summer drought on radial growth and stem carbon efflux.

Speaker: Julen Astigarraga, University of Alcalá, Spain

„Anthropogenic land-use legacies underlie Mediterranean forest vulnerability to climate change“

A generalised abandonment in agricultural and forest management activities coupled with increased climate change impacts may decrease forest resilience. Understanding the role of anthropogenic legacies on forest dynamics is thus essential for the management of natural resources. However, it is largely unknown whether different anthropogenic legacies of past land-use can modify forest responses to specific hazards. To address this question, we conducted a meta-analysis of published studies that quantified forest responses to climate change under the major types of legacy and vegetation in the Mediterranean region. We found that forest responses depend on forest composition and structural characteristics linked to legacy-type resulting in contingent dynamics that can strongly depend on initial conditions. Our results suggest that past land-use determine current forest structure and thus, future forest community responses to climate change. This study may help us to further understand likely forest system trajectories under climate change and forest abandonment and, therefore, assist forest managers and policy-makers to develop forests adaptation strategies.

15:00-16:30, A56 Conference Room

Parallel session 3: Management Modelling 2

Speaker: Laura Dobor, Czech University of Life Sciences, Czech Republic

„Efficiency of bark beetle management threatened by climate change“

Recent bark beetle outbreaks have reached supranational scales and challenged the traditional ways of outbreak management. Bark beetle outbreaks are climate sensitive processes, what makes the efficiency of tactics used for their management highly uncertain under climate change. We here used the process-based forest landscape and disturbance model iLand to study the complex interplay between management, climate, bark beetle populations, and host trees in a Central European forest landscape. In particular, we studied the effects of (i) different intensities of sanitation removal of windfelled trees, and of (ii) different silvicultural practices such as changed species composition and harvesting regimes. We found that that more than 80% of windfelled trees need to be removed in order to prevent the outbreak, while intensities reachable under operational conditions had almost no effect. Moreover, long-term outbreak prevention increased forest vulnerability to wind and partly weakened the effect of sanitation logging. A reduced rotation period reduced both bark beetle and wind disturbance (total disturbed volume reduced by 17 % under reference climate but only by 8% under climate change) though the short-term effects, such as reduced carbon stocks and increased harvests, were severe. The efficiency of all measures was substantially lower under climate change. We conclude that bark beetle outbreaks amplified by climate change are increasingly hard to control by forest management and this fact should be increasingly considered in forestry practice. Ecosystem models, which include mechanistic implementation of forest disturbances, have indispensable role in informing present-day disturbance management.

Speaker: Juha Honkaniemi, Natural Resources Institute Finland (LUKE), Finland

„The effect of landscape structure on the climate resilience of lowland Norway spruce forests“

Forest management can strongly alter the tree species composition in landscapes by favoring species with high economic value. In Central Europe, lowland landscapes naturally dominated by beech (Fagus sylvatica) have widely been converted to Norway spruce-dominated stands to support timber production. However, natural disturbances (i.e. wind and bark beetles) are increasingly impacting these forests, and their resilience under climate change has been called into question recently. The aim of this study was to quantify the resilience of Norway spruce to climate change at the warm edge of its distribution. Specifically, we asked whether resilience can be influenced by manipulating the landscape structure, i.e. spatial configuration of stands and proportion of Norway spruce. We simulated the dynamics of a 9,183 ha forest landscape in Eastern Austria over 190 years with iLand, the individual-based forest landscape and disturbance model. We quantified the climate resilience of Norway spruce by comparing mortality and recovery rates to a baseline scenario with historic climate. Different landscape configuration and composition scenarios were simulated to analyze their effect on Norway spruce resilience. Placing Norway spruce in mixed stands over the whole landscape resulted in the highest level of climate resilience (on average 2.7 times more resilient than monospecific configurations). However, small patches of monospecific stands were able to dilute bark beetle outbreaks the best. Natural disturbances increased under climate change on average by 58.5% in all scenarios compared to historic climate. We conclude that focusing on landscape structure could provide means to foster Norway spruce resilience.

Speaker: Isabella Hallberg-Sramek, Swedish University of Agricultural Sciences, Sweden

„Thinking new about forest management - A reflexive collaboration process to adapt local forests to climate change“

In this study we explored if it was possible to think new about forest management when framing it in a climate change context. To do this, we carried out a collaboration process with local actors from four Swedish municipalities aiming at developing pathways for local adaptation to climate change.

The actors represented different ways of thinking, knowing and doing to enable a creative and reflexive process. This in line with theories of reflexive forestry. In the process, we introduced the actors to multiple forest management systems and let them identify which of them that were more preferable for their future communities in a climate change context, and how these might be changed or altered in order to fit better with their local communities and conditions.

Speaker: Marco Mina, Université du Québec à Montréal (UQAM), Canada

„ Seeing forest landscapes as functional complex networks: a way to enhance resilience to climate change and disturbances“

Uncertainty due to global changes makes planning for forest management exceptionally difficult. An integrated landscape management approach can ensure that individual decisions are aligned in a territorial strategy aimed at maintaining ecosystem services and maximizing resilience. This is particularly relevant in landscapes where forests are fragmented by intensive land use and where connectivity is poor. In such cases, it is key to prioritize interventions in stands and area contributing the most to functional diversity and resilience at the landscape level. We combined forest simulation modelling with network theory to explore how functional diversity and connectivity within and across forest stands respond to climate change and disturbances. We applied a multi-scale, ecophysiologically based forest landscape model (LANDIS-II with PnET-Succession) to a large fragmented forested landscape in Southern Canada to evaluate future trajectories under global changes. We simulated forest landscape dynamics over 100 years under multiple climate, disturbances and management scenarios and analyzing the landscape as an interconnected and functionally diverse spatial network of forest patches. Model projections show that climate change will increase net primary productivity and forest biomass but changing climate and increasing disturbances will promote a shift in species composition and loss of functional response diversity and connectivity at landscape scale. Current management is not proactive enough in coping with such expected changes. The analysis of the landscape as a functional network allowed identifying stands contributing the most to connectivity and requiring functional traits diversification to be targeted with strategic management interventions.

Speaker: Pekka Lauri, International Institute for Applied Systems Analysis (IIASA), Austria

„Transition to multifunctional forest management in EU28 – Transition costs and implications to forest sector“

Natural distortions like storms, wild fires and insect invasions are expected to increase due to climate change. Multifunctional forest management (MFF) can be considered as adaptation strategy against climate change, because it increases the tolerance of forests against natural distortions. However, forest owners do not want switch to MFF voluntary, because they maximize production value of forests and underestimate climate change damages. In this study, we investigate a transition to MFF in EU28 scale by using partial equilibrium forest and agricultural sector model GLOBIOM. The transition costs of MFF are estimated by considering a shadow price of forced MFF transition path. It turns out that forest owners require about 100 euro/ha/yr compensation of MFF in the low mitigation scenario (SSP2 RCPref) and about 200 euro/ha/yr compensation in the high mitigation scenario (SSP2 RCP2p6). MFF transition decreases availability of coniferous biomass and logging residues, demand for which is expected to increase in the future. The adaptation to lower availability of coniferous biomass and logging residues in EU28 happens through intensification of forest management in the remaining production forests and through trade. MFF transition is expected to increase import of coniferous biomass and pellets from USA, Canada and Russia to EU28 significantly.

Speaker: Sebastian Karaytug, Karlsruhe Institute of Technology, Germany

„Modelling the potential of Douglas-fir in future European forests using LPJ-GUESS“

Climate change will require silvicultural responses in regions where currently commercially important tree species will be negatively impacted by rising temperatures, droughts, storms and insect outbreaks. Today the coastal variety of Douglas fir (Pseudotsuga menziesii (Mirb.) Franco var. menziesii), native to the northern west of North America, is already widely planted in Europe. It has shown high growth rates and carbon sequestration potential as well as relatively large drought resistance, which implies it to be a potential resilient, commercially interesting conifer species under climate change.

We modelled productivity and potential future European habitats of Douglas fir under different climate scenarios using the dynamic global vegetation model ‘LPJ-GUESS’. We implemented Douglas fir into the model with parameters based on bioclimatic limits, reported literature values and calibration to measured productivity from sites in Europe and its native habitat. We expect that Douglas fir will outperform Norway spruce in primary production, carbon sequestration and yield in many regions, especially under more extreme climate scenarios. Our results will help stakeholders in forest and land-use management to decide where afforestation with Douglas fir is commercially viable. Ecological consequences associated with the use of foreign tree species are not taken into account in the simulation study.

15:00-16:30, A31 Big Cupola

Parallel session 3: Management Challenges

Speaker: Rasoul Yousefpour, University of Freiburg, Germany

"Uncertainty of Carbon Forestry"

Forest growth predictions are used to build expectations about the future performance of management decisions. Faustmann land expectation value (LEV) is a widely used criterion in forestry to evaluate a diversity of decision parameters, such as rotation age and thinning regimes incorporating time preferences for money. Most of the predictions and, consequently, expectations are based on emperical knowledge, assuming a steady state in climate and a deterministic forest growth pattern. However, the climate may change to potentially different degrees in the coming decades, causing a dynamic and uncertain forest growth and carbon allocation. Moreover, ”climate smart forestry”, aims for efficient allocation of forest mitigation actions, and can hardly be analysed using empirical models and calls for process-based forest biomass production models. These models include numerous parameters and processes that embody some degree of uncertainty. The uncertainty of these parameters and climate state propagates over time to the final decision about carbon budget and optimal management solutions. Here we quantify this uncertainty using Bayesian inference and apply different climate change scenarios and discount rates in the contexts of European forestry. The results show a strong influence of the model’s parameters uncertainty on the final decisions about timber and carbon economy. The uncertainty triples if different climate change scenarios are applied as a source of deep uncertanty where no probability can be assigned to any scenario. To deal with deep uncertainty, a robust decison-making approach has been applied to find solutions with minimum regret or maximum value at risk regarding all scenarios.

Speaker: María-Luisa Chas-Amil, Universidade de Santiago de Compostela, Spain

„Economic Impact of climate change on forestry: An analysis at European scale“

We build a Dynamic Integrated Forestry (DIF) model to assess the economic impact of forestry disturbances on a continental (European) scale. DIF is a modified economic growth model with a form of natural capital added: the stock of forest (area). Disturbances (fire, bark beetles and wind) have negative implications for economic output through their influence on mortality harvesting. The DIF model is estimated via country-based data using Bayesian methods. We use an impulse-response function and posteriors disturbances distributions to compute the economic impact of climate changes on disturbances.

Speaker: Hannes Böttcher, Öko-Institut e.V., Germany

„The CO2 storage balance – a method for more comprehensively assessing GHG implications of wood use“

Wood harvest reduces the forest carbon stock. Partly the harvested wood is transferred to product pools that temporarily retain the carbon. Wood products can replace fossil carbon in materials or energy products (substitution). Total net greenhouse gas (GHG) effects of wood use are thus the result of complex processes. GHG assessments calculate the climate impact of wood use and allow a compari-son with fossil products.

Extraction of biomass from forests has also implications on the forest's ability to further sequester car-bon (storage capacity). Changes in the storage capacity in forests resulting from wood removals are typically not taken into account in GHG assessments. This accounting error leads to wrong conclusions on net GHG effects of wood use.

We present a method for integrating changes in forest carbon storage capacity (CO2 storage balance). It can be assessed by means of two forest management scenarios applying different harvest intensities. The CO2 storage balance compares the storage capacity of the two alternative scenarios and puts it in relation to the amount of harvested wood. We review forest management modeling studies that estimate carbon storage capacity and wood harvest under different harvest intensities. We find that the CO2 storage balance varies across forest types and management scenarios. An important influencing factor is also the time period covered by the scenarios. We conclude that effects on the total GHG balance of wood use are significant when the CO2 storage balance is considered. it needs to be included in GHG assessments used for planning mitigation options involving wood use.

Speaker: Jean-Luc Peyron, ECOFOR, France

„Forest challenges under climate change with technical, scientific, social, economic and political options“

Forest challenges under climate change with technical, scientific, social, economic and political options.Climate change influences forests in many ways (growth, health, composition, regeneration, risks...) and is influenced by them through carbon, water and energy cycles. Although much uncertainty remains about the severity of future climate change, most analysts expect that mitigation of climate change will not be enough in order to avoid significant impacts: adaptation is a necessity. For forestry and due to the long life-cycle of trees, adaptive management has to be urgently and progressively implemented. It must be set up not only for timber production but also for climate change mitigation and the maintenance of all forest ecosystem services.

The presentation will discuss the challenges that include taking into account uncertainties related to the future climate scenario, in terms of crises to be overcome as well as trends to accompany, considering the various ecosystem services provided by forests, in particular the forest contribution to mitigation of climate change, interlocking different temporalities and different spatial scales, managing scientifically the complexity and the interdisciplinarity of these issues, developing an economic analysis making it possible to inform the choices to be made, raising the political level at which these issues are dealt with, discussing continuously with the different components of civil society.

Speaker: Sven Herzog, Technische Universität Dresden, Germany

„Adaptedness versus adaptability: Forest genetic management as a tool to mitigate climate change effect on forests“

We have actually good evidence of severe impacts of recent –at least partially anthropogenic- climate change on Central European forests. This ist partly due to wrong decisions on species and genotypes in the past. However, actually we cannot forecast environmental situations of the ongoing lifetime of the just regenerating forest stands. The present paper deals with the question as to how we can increase not only adaptedness but also genetic adaptability to changing environmental conditions by an active management of forest genetic resources.

It is demonstrated based on the actual state of evidence that for some taxa how forest management measures are influencing genetic adaptedness, but also genetic adaptability.

Thus, if we would like to increase the contribution of forest management to climate change mitigation, we need integrated concepts of silviculture, forest protection and management of forest genetic resources. This would allow to use the broad spectrum of former adaptation of forest trees, especially native Central European species, to grow optimally prepared forest stands in the future.

Speaker: Yelena Gordeeva, UCLouvain, Belgium

„Types of Uncertainties and Possible Legal Responses in GI Strategy (e.g. Adaptive Forest Management, USA)“

The working title of the presentation is “Adaptive Management as a Legal Tool for Connectivity Conservation in EU Green Infrastructure (based on the experience for forest projects in the USA and Canada)”. The presentation is a part of the interdisciplinary research project on landscape connectivity for forest species “WOODNET”: “Connectivity patterns and processes along a gradient of European Landscapes with Woody Vegetation and Spatial Heterogenity”, co-funded by the European Commission (BiodivERsA).

The objective of the presentation is to address some legal challenges raised by connectivity conservation, which is at the heart of the EU strategy for green infrastructure (GI). The presentation, first, discusses the process of building legal standards for the protection of ecological continuity on sound science: e.g. What are the knowledge needs in EU GI design and implementation? What are the types of scientific uncertainties? What are the tools to address uncertainties in connectivity science through law and policy instruments (e.g. including precautionary approach, evidence-based and adaptive management)? Second, the presentation investigates the application of “adaptive management” tool to forest projects in the USA and Canada. What are the challenges? To which extent law makes the process of adapting the conservation policies to new scientific data and ecological dynamics effective? What can we learn from the experience in the USA and Canada? Third, the presentation discusses, whether adaptive governance is compatible with legal principles like legal certainty? Finally, the presentation concludes with suggesting adaptive management as a strategy to manage uncertainty in EU GI policy making.

17:00-18:40, A56 Conference Room

Plenary: What are the management challenges (and options) for resilient forests?

Speaker: Julius Sebald, University of Natural Ressources and Life Sciences (BOKU), Austria

„The role of alpha and beta diversity in buffering the effects of intensifying disturbance regimes under climate change“

Forests are strongly affected by climatic changes, but impacts vary between tree species and prevailing site conditions. A number of studies suggest that increasing tree species diversity is an potent management strategy to decrease climate change impacts in general, and increase the resilience of forest ecosystems to changing disturbance regimes. However, most studies to date have focused on stand-level diversity in tree species (alpha diversity), which is often difficult to implement in operational forest management. Inter-species competition requires frequent management interventions to maintain species mixture and complicates the production of highquality stemwood An alternative option to increasing alpha diversity is to increase tree species diversity between forest stands (beta diversity). Here we quantify the effects of alpha and beta diversity on the impact of forest disturbances under climate change. We conducted a simulation experiment applying two forest landscape models (i.e. iLand and LandClim) in two landscapes of with strongly contrasting environmental conditions in Central Europe. Simulations investigate different levels of tree species diversity (no diversity, low diversity and high diversity) in different spatial arrangements (alpha diversity, beta diversity). Subsequently a standard forest management regime and a series of prescribed disturbances are applied over 200 years. By analyzing biomass values relative to a no-disturbance run, variation in biomass over time and the number of trees > 30 cm dbh per hectare, we isolate the effect of tree species diversity on the resistance of forests to disturbances.

Speaker: Hans Verkerk, European Forest Institute

„The atlas of forest management practices in Europe“

Forest management practices can provide an important contribution to climate change mitigation. Unfortunately, current forest management practices are generally poorly documented. The aim of our study was to fill this gap by developing an atlas of forest management practices in Europe.

We compiled the atlas based on information collected through a literature and database search and by compiling country narratives on management practices since 1990 by involving national experts. We structured all information by using an existing classification of forest management approaches, which characterizes forest management based on a set of 11 major forest management decisions.

Coniferous species have been favoured for centuries, but a shift towards more broadleaved species can be observed, especially in Central Europe. Most of today's forests have been established by natural regeneration or natural expansion, but regional practices differ. Clear-cutting has been the dominant harvest system in Europe in the past, but there is a trend to move towards other harvesting systems in which the tree canopy is only partially removed to develop more structurally rich forests. We also provide insight in other decisions such as machine operation, use of fertilizers and chemical agents and soil cultivation, for which existing information is limited.

Despite three decades of experience with indicators on sustainable forest management, current reporting focuses on the state of Europe's forests rather than on sustainable forest management. Our atlas helps to understand how forests are managed. Such understanding is indispensable for targeting climate change mitigation and adaptation efforts in the European forest-based sector.

Speaker: Laura Nikinmaa, European Forest Institute

„Assessing forest resilience - how engineering, ecological and social-ecological resilience are used in forest sciences“

In forestry, resilience is vital to deal with an uncertain future and it receives increasing attention from both research and practice. However, a common understanding of what resilience means in a forestry context, and how to operationalize it is lacking. There is a pressing need to understand the breadth of approaches and to identify key concepts used in the literature. Here, we conducted a systematic review of the recent forest science literature on forest resilience, synthesizing how resilience is defined and assessed.

Based on a detailed review of 255 studies focusing on forest resilience, we identified that forest resilience has a variety of meanings, essentially adhering to three different concepts, being engineering resilience, ecological resilience, and social-ecological resilience. A clear majority of the studies addressing resilience in forests adheres to the concept of engineering resilience, quantifying resilience as the recovery time after a disturbance. The two most used indicators for engineering resilience were basal area increment and vegetation cover; for ecological resilience they were tree physiology indicators and vegetation cover; whereas for social-ecological resilience the indicators were socio-economic diversity and stock of natural resources.

We found that choosing the most appropriate resilience concept for management can be challenging. Based on our analysis we provide guidance on deciding which resilience concept is the most suitable for management and research situations and how it could be assessed. We finally provide suggestions for a further operationalization of the concept for enhancing resilience in forests under impacts of climate change and disturbances.

Speaker: Marcus Lindner, European Forest Institute

„Enhancing forest sector resilience through pro-active disaster risk management“

Recent events have provided evidence that business as usual management might not be the best strategy to deal with ever increasing extreme events and disturbances in forests. The project SURE - Sustaining and Enhancing Resilience of European Forests is introduced, outlining the importance of management responses that look beyond the response to disturbances. In order to enhance the resilience of forests to better cope with climate change and disturbances, new strategies are needed that change the focus from reaction to increased efforts related to prevention and preparedness. Active management interventions that increase forest resilience are suggested to provide indeed a new type of guidance that may allow a more effective way of handling the challenges posed by climate change. The SURE project compiles best practices in disturbance risk management related to wind storms, wildfires, and biotic threats and documents them in a web-based knowledge platform to access tools and measures for the different phases in disaster risk management at different levels from management unit to the enterprise and societal/policy level. The vision of a European forest risk facility is presented which would support such pro-active management approaches through trans-border collaboration in disturbance risk management, science-based best practice guidance, exchanges of experts, training workshops and engagement in public relations and media outreach. SURE tested the functioning of a European forest risk facility and advocates for the implementation under the umbrella of the Forest Europe process.

05.03.2020

09:00-10:45, A56 Conference Room

Plenary: What can we do to increase the contribution of forest manament to climate change mitigation?

Speaker: Julia Pongratz, Ludwig Maximilian University of Munich, Germany

„Forests as key drivers of local, regional and global climate“

Roughly half of the world's forest cover has been cleared for agriculture and most of the remainder is used by humans in one way or the other. Strong further changes are expected for the future, because reforestation, afforestation and forest management have been assigned prime roles in the effort to limit global warming to 2 degrees. Understanding and quantifying the effects of forests on local, regional and global climate in the past and in future scenarios is thus of high importance, yet accompanied by diverging, sometimes contradicting, results in the literature. The potential of reforestation and afforestation to take up and store CO2 may have been overestimated in some studies by neglecting socioeconomic constraints, but may still reach on the order of 2 PgC/year, making it one of the negative emission technologies with large potential. Global mitigation aspects, however, may be dwarfed by effects forest and forest management changes have on local climate via biogeophysical pathways, where temperatures may be altered by several degrees. This could turn reforestation, afforestation and forest management into important tools for adaptation to climate change. Studies disagree, however, which surface property is responsible for the local response. Earlier modeling studies suggested afforesting dark boreal forest may warm climate due to the albedo decrease, though more recent observation-based studies suggest that in fact effects from the higher roughness (i.e. more energy transfer away from the surface) may dominate, with a cooling. Here, I try to resolve some of the discrepancies and set the frame for discussing how to increase the contribution of forests and forest management to mitigating and to adapting to anthropogenic climate change.

Speaker: Georgy Safonov, Center for Environmental Economics, National Research University Higher School of Economics (HSE), Russian Federation

„What is needed to reduce emissions to mitigate climate change and the potential contribution by the forest sector to deep decarbonization in Russia“

Russian forestry plays an important role in the national carbon budget and perspective decarbonization of national economy. Being a substantial source of carbon sequestration of 650-700 MtCO2 per annum in recent years, Russian forest is also a huge source of biomass that can be used for expansion of bioeconomy and substitution of carbon-intensive products. Though Russia has no official low-carbon development strategy and its GHG emission targets under the Paris Climate Agreement by 2030 are weak (25-30% below 1990 level), the recent economic modeling provides sound evidence of enormous potential for decarbonization in all key sectors of national economy. The scenario analysis reveals numerous opportunities for deep emission reduction of 80-87% below 1990 level by 2050, which corresponds to the “well below 20C target”. Different kinds of biofuels (wood pellets and briquettes, energetic biochar, liquid and gaseous biofuels) can provide 96-190 Mtoe of energy supply to substitute fossil fuels (12% of estimated final energy consumption in 2050). The role of other timber products in decarbonization still needs to be evaluated, but is potentially high in residential and commercial buildings sector (wooden houses, windows, construction materials), chemicals and bioplastics, and textiles. Transition of Russian economy toward decarbonization will require much stronger engagement of forest sector to reduce emissions and enhance sequestration of greenhouse gases. It will be especially important with respect to strengthening climate change impacts, such as losses of forest due to wildfires, expansion of diseases, extreme weather events, and at the same time growing demand for climate-neutral energy resources and products.

Speaker: Mart-Jan Schelhaas, Wageningen University & Research, the Netherlands

„Short and long term mitigation effects of setting forests aside“

Cessation of harvesting in forests is one of the measures that is proposed to increase the contribution of forests to climate change mitigation. While this is an easy to understand measure for policy makers and the general public with tangible short-term results, there are trade-offs with carbon storage and substitution effects in wood products, as well as concerns about its long-term efficiency. We coupled the EFISCEN Space forest model with the YASSO15 soil model and a simple wood products model to assess the long-term effects of this measure. We applied this model system to a set of forest stands that were taken out of production in the late 1980s as part of the Dutch Forest Reserves Network. We validated the model outcomes with regular forest inventories done since, as well as to soil carbon measurements done in and outside the reserves.

Speaker: Annikki Mäkelä, University of Helsinki, Finland

„Forest NPP and volume growth in Finland inferred from climate and satellite data“

Forest inventories support forest policies by delivering data to assess key issues such as sustainable harvest levels or climate change mitigation. Satellite-based data streams are now being widely adopted to complement ground-based inventory measurements. While progress has already been demonstrated on variables such land cover, species distribution and above-ground biomass, less work has been conducted on monitoring the dynamic inventory variables, current forest volume increment and harvested volume. Volume increment can be regarded as a result of carbon acquisition through photosynthesis and its allocation to respiration and biomass component growth. We recently demonstrated that combining light use efficiency with a simple carbon allocation scheme yielded reliable estimates of regional stem volume increment distribution in Finland when initialised with forest inventory data. Here we demonstrate the same approach using satellite data as input. We use data from two different satellite sources over Finland, Suomi NPP with 500 m resolution, and Sentinel 2 with 10 m resolution. We develop methods to interpret the satellite data to describe the state of the forest in terms of species composition, site type, height, mean diameter and volume. We also use information about leaf area index and absorbed radiation. The state of the forest is used as the initial state for the model, which predicts the subsequent growth driven by climate data. The estimated state of the stand is validated against field data, and the model predictions at regional scale are compared with national statistics and predictions utilizing ground-based data for initialization

11:00-12:30, A56 Conference Room

Parallel session 4: Mitigation Modelling

Speaker: Daniela Dalmonech, Independent Scientist

Gina Marano, University of Naples Federico II, Italy

„Little leeway to increase Northern European forests climate change mitigation capacity through alternative management“

Forests are expected to respond differently to climate change and to management. Indeed, forest modelling can be used as a dynamic tool to predict the effect of climate change and increasing CO2 on C stocks and fluxes in the forest ecosystem and to plan the most appropriate management under future climate change. In particular, adaptive forest management has been proposed to enhance the provision of forest ecosystem goods and services under climate change. To test this hypothesis and in order to quantify whether alternative management options would lead to changes in plant carbon sequestration potential and stocks, when compared to Business As Usual (BAU) scenario, we used the biogeochemical forest growth model 3D-CMCC-BGC. The simulations have been applied to three even-aged European forests at sites of the Fluxnet network included within the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP, https://www.isimip.org) and PROFOUND database: the Danish temperate European beech (Fagus sylvatica L.) forest of Sorø, the Norway spruce (Picea abies (L.) H. Karst) stand of Bílý Kříž in Czech Republic, and the Finnish boreal Scots pine (Pinus sylvestris L.) forest of Hyytiälä. The modeling protocol has been designed in order to consider different age classes for the three considered species. As our preliminary results suggest, BAU is still confirmed to be a better option in any of the RCPs analyzed, across different local climate, for all of the forest structure and age classes considered, rather than the ‘no management’. In conclusion, there seems to be little leeway to increase forest climate change mitigation capacity for northern Europe through a more intensive management.

Speaker: Tuomo Kalliokoski, University of Helsinki, Finland

„Ensemble of forest impact models for analysing the variability of carbon sink projections“

Finnish forest's are under intensive management and the system has not been optimized from the mitigation perspective. Different forest management strategies can have significant impacts on forest carbon sink and storage, and thus varying impact on climate change mitigation. Comprehensive accounting of uncertainties in the scenario projections and realization of improved forest management in specific region calls for reliable tools for projecting the impact. In this study we investigated the projections of five forest carbon models. This comparison include pure empirical forest carbon models (EFISCEN, MELA, MONSU), semi-empirical FORMIT model, and more process oriented ecosystem flux model PREBAS. We tested these models for Finnish forests under three different harvest scenarios, LOW (40 Mm3 year-1), POLICY (80 Mm3 year-1), and MAX (> 85 Mm3 year-1), and analyzed how the choice of forest impact model influences the projected harvest impact in terms of medium and long-term forest carbon sink. The LOW scenario had the highest mean annual carbon sink in all models at least until year 2065. The impact of harvests on the forest carbon sink ranged from 1.96 to 0.74 tnCO2 per removed m3. The harvest level of MAX scenario obtained from MELA proved to be too high for other models causing abrupt decreases in harvests in different phases of the simulation period. In light of our results, it is essential to provide uncertainty ranges around forest model projections, something which is not common practice in forest mitigation studies.

Speaker: Katarina Merganicova, Technical University Zvolen, Slovakia

„Searching for an optimal harvest-regeneration system using multi-criteria analysis“

Climate change is one of the most important factors currently affecting forest management. Its impact is particularly evident in secondary ecosystems that are composed of tree species occurring outside the borders of their ecological distribution. In our study we focused on testing the impact of future climate and different management scenarios on environmental, ecological and production forest functions represented by specific quantitative indicators. The indicators were derived from standard outputs of SIBYLA forest growth simulator that represents the prognostic component of the system. For the multi-criteria optimisation of fulfilling different forest functions, we developed a software called OPTIMUS, which enables the application of several methods of multi-criteria analysis including different approaches of weight calculation. In our study we show that the presented approach of combining these tools allows forest managers to select forest management most suitable for climate change mitigation.

Speaker: Andreas Krause, Technical University of Munich, Germany

„A regional assessment of land-based carbon mitigation potentials: bioenergy, BECCS, reforestation, and forest management“

Land-based solutions are indispensable features of most climate mitigation scenarios. We conduct a novel cross-sectoral assessment of regional carbon mitigation potential by running an ecosystem model (LPJ-GUESS) with an explicit representation of forest structure, tree competition and climate impacts for Bavaria (Germany) as a case study. We drive LPJ-GUESS with high-resolution climate projections (EURO-CORDEX) and present-day land-cover from three satellite-derived datasets (CORINE, ESA-CCI, MODIS) and identify total carbon mitigation potential by not only accounting for carbon storage but also material and energy substitution effects.

LPJ-GUESS represents the current state in Bavaria adequately, with a simulated forest biomass 13% lower than observed. Future land-use changes according to two ambitious Land-Use Harmonization (LUH2) scenarios (SSP1xRCP2.6, SSP4xRCP3.4) achieve a mitigation of 206 and 247 MtC (2015-2100 period) via reforestation and the cultivation and burning of dedicated bioenergy crops, partly combined with carbon capture and storage (BECCS). Sensitivity simulations suggest that converting croplands or pastures to bioenergy plantations could deliver a carbon mitigation of ~40 kgC m-2, respectively, if used to replace carbon-intensive energy systems and combined with CCS. However, under less optimistic assumptions, only ~15 kgC m-2 are mitigated and reforestation might be the better option (~20.0 kgC m-2). Mitigation potential in existing forests is limited (converting coniferous into mixed forests, nitrogen fertilization) or even negative (suspending wood harvest) due to decreased carbon storage i n product pools and associated substitution effects.

Speaker: Abhijeet Mishra, Potsdam Institute for Climate Impact Research, Germany

„Forest management options for timber production and carbon sequestration: Insights from a land-use model“

Sustainable forest management can meet increasing global timber demand while limiting land-use change emissions. Within this context, the interaction of forestry and agricultural land-use change, as well as the role of foresight in long-term decision making is a particular challenge to modeling forest management. Existing literature predominantly covers forest management systems where interactions with other land-use types are not extensively analyzed, especially in inter-temporal optimization models. Here, we introduce forest management to the existing recursive-dynamic MAgPIE (Model of Agricultural Production and its Impact on the Environment) modeling framework.

Our results indicate that an optional extension of rotation lengths in commercial plantations could result in lower land-use change emissions while keeping a stable demand for cropland towards the end of this century along with a stable food-price index. Extension of rotation lengths however also results in a loss of about 30Mha of forests by 2100 when compared against a baseline scenario. While ensuring sustainable timber production, the model results show that improved forest management could sequester an amount equivalent to 2.5% of the remaining carbon budget for the 2-degree target, while still producing the same amount of timber. By extension, CO2 prices on emissions from land-use change could sequester around 350Gt of additional CO2 from the atmosphere and may decrease harvested areas for timber in the future.

Speaker: Christine Herschlein, Karlsruhe Institute of Technology, Germany

„ Impact of simulated present and historic management regimes on forest carbon cycling in Europe“

The potential of forest management for carbon (C) storage and forest adaptation to climate change is of increasing importance. We explored the effect of historic and current management practices and intensities on carbon pools in Europe's forests by applying the widely used Dynamic Global Vegetation Model (DGVM) LPJ-GUESS. We compare clear-cut versus selective harvest versus unmanaged and mixed forests versus monoculture plantations. Historic and current forest management was simulated based on estimated timber demand, species distributions and harvest fractions from forest inventory data. Preliminary results showed that harvest and species selection reduced the C storage of European forests to 70% compared to unmanaged forests . Carbon in the vegetation pool (CVeg) was decreased to 30% and in the litter pool to about 60%. The reduction in CVeg was found to be caused not only by wood removal (40%), but also tree species selection contributed to a large extend (30%). The observed trend in inventory data of in increasing CVeg in the recent years was reproduced and found to be solely an effect of better growth conditions due to e.g. CO2 and N-fertilization as well as climate, but not of changed management. First results show also that the soil carbon pool (CSoil) is neither affected by wood removal nor by species selection. Our results will help to understand the effects of past forest management on carbon pools. This is a precondition for investigating effects of future management options, which play an increasing role in climate change mitigation policy.

11:00-12:30, A31 Big Cupola

Parallel session 4: Empirical Impacts 2

Speaker: Tomáš Hlásny, Czech University of Life Sciences in Prague, Czech Republic

„A new Multiscale Framework for assessing impacts of climate change on Central European forests: MuFfin“

Ecosystem models are potent means for assessing impacts of climate change as well as for testing performance of diverse adaptation strategies. We present here a new framework developed to study the climate change-driven forest dynamics in Central Europe, including elements cycles and forest disturbances. The framework consists of a network of forest plots and landscapes that cover substantial ecological and management gradients, and two ecosystem models calibrated using these data. The stand-scale component covers Croatia, Hungary, Slovakia, the Czech Republic and Poland. The experimental data include site and stand data from the ICP monitoring network, long-term silvicultural experiments supervised by different national agencies and several highly-instrumented sites (with eddy-covariance-based measurements). These data were used to derive a new set of ecophysiological parameters for main tree species of Central Europe in the model Biome-BGCMuSo, an advanced version of the notorious Biome-BGC model. The landscape-scale component includes two forest landscapes in Slovakia and the Czech Republic (16 000 and 30 000 ha), and the forest landscape and disturbance model iLand, which was thoroughly tested for use in these landscapes. We present here main elements of this framework, including its performance in reproducing observed forest dynamics in Central Europe, and its potential for integrative climate change research in the region. Finally, we present practical use of the framework using several studies on the impact of climate change, wind and bark beetles on the regional forests.

Speaker: Allan Buras, Technical University of Munich, Germany

„Quantifying impacts of the drought 2018 on European ecosystems in comparison to 2003“

In the context of assessing impacts of global change type droughts on forests, the European heatwave of 2018 may be considered a key event. We assessed anomalies of atmospheric circulation patterns, maximum temperature, and climatic water balance and quantify ecosystem response to drought using MODIS vegetation indices (VI). To place the drought of 2018 within a climatological context, we compare its climatic features and remotely sensed ecosystem response with the extreme hot drought of 2003. Analysing ecosystem response of five dominant land-cover classes, we found significant positive effects of climatic water balance on ecosystem VI response. Negative drought impacts appeared to affect a 1.5 times larger area and to be significantly stronger in July 2018 compared to August 2003, i.e. at the respective peak of drought. Moreover, we found a significantly higher sensitivity of pastures and arable land to climatic water b alance compared to forests in both years. The stronger coupling and higher sensitivity of ecosystem response in 2018 we explain by the prevailing climatic dipole: while the generally water-limited ecosystems of the Mediterranean experienced above-average climatic water balance, the less drought-adapted ecosystems of Central and Northern Europe experienced a record hot drought. In conclusion, our assessment quantifies the drought of 2018 as a yet unprecedented event, outlines hotspots of drought-impacted areas in 2018 which should be given particular attention in follow-up studies, and provides valuable insights into the heterogeneous responses of the dominant European ecosystems to hotter drought.

Speaker: Mikko Peltoniemi, Natural Resources Institute Finland (LUKE), Finland

„Environmental and climate controls of Pine sawfly outbreaks“

Expected increase in forest disturbances requires that climate and environmental controls of biotic disturbance agents are understood. Here, we study an important endemic defoliator European Pine Sawfly (Neodiprion sertifer) in Finland, which can cause widespread growth losses in Scots pine forests. Extreme winters limit the outbreaks, but under climate change, extreme winter conditions are become rarer. It has been hypothesized that drought plays role in triggering and exacerbating damage, which could mean that outbreaks become more frequent in future. In this study, we reconstructed a wide and long data series of Pine Sawfly damage observations throughout Finland, consisting of observations made at municipality level and in forest inventory plots. We investigated and quantified the roles of environmental conditions and weather in driving Pine Sawfly damage occurrences. The damage probabilities were higher in poor than on fertile growing sites, and contrary to our expectation, highest on pine mires, which are relatively poor and wet growing sites. No clear associations with drought were found. Cold winters reduced the damage probability of the following summer, as expected. Based on climate associations of Pine Sawfly damage alone, we expect that outbreaks will become more frequent under climate change, and cause more chronic growth and carbon balance losses.

Speaker: Arnaud Guyennon, IRSTEA, France

„Colonization and extinction dynamics match the distribution of European trees at continental scale“

Processes driving current tree species distribution are still largely debated, and large uncertainties about processes and scales at play remain. Attempts to relate environmental factors and population related metrics have shown mixed results, and the link between tree species range and their population dynamics are unclear. In this context, we would like to test the hypotheses that metapopulation processes drive range limits. Harmonized national forest inventories across Europe, that includes several censuses, were used to calibrate a dynamic patch occupancy model based on the probability of presence derived from Species Distribution Models. Results show for most species that colonization probabilities increased with increasing probability of presence, and conversely extinction probabilities decreased. Using these results, we evaluated whether the equilibrium probability of presence derived form the patch occupancy model match the observed species distribution.

Speaker: Santiago Sabaté, University of Barcelona, Spain

„A five-step model calibration-validation procedure allows to anticipate water-demanding eucalypt tree species' responses to changes in environmental drivers"

Fast-growing water-demanding eucalypt tree species are being planted worldwide for paper pulp extraction and biomass production. One of such eucalypt species, the Sydney blue gum (Eucalyptus saligna Sm.), was planted during 2007 in the Hawkesbury Institute for Environment experimental fields, in Richmond NSW, Australia. Trees of this plantation were then exposed to different treatments, such as elevated CO2 conditions, artificially induced soil dry-down for five consecutive months. One of the main findings from those experiments was that E. saligna was less sensitive to unsaturated soil water depletion than expected, due to its ability to obtain water from deep soil water resources. In addition, it was found that this tree species' net carbon uptake and transpiration was also highly sensitive to changes in atmospheric vapor pressure deficit (D).

Here we used photosynthesis data, gas exchange data measured in trees growing in Whole Tree Chambers (WTC), and stem growth data to calibrate and then validate GOTILWA+ model in a five-steps calibration-validation procedure. We started characterizing photosynthesis under two CO2 treatments to account for photosynthesis down-regulation at elevated CO2 conditions. Then we added photosynthesis limitation due to reduced unsaturated soil water availability to our calibration. Additionally, we modeled deep soil water uptake and its importance for E. saligna processes. Finally, we used gas exchange data and stem growth data to validate GOTILWA+ outputs at stand level. After this five-step procedure, and with the calibrated and validated model, we analyzed the sensitivity of E. saligna to changes in three main environmental drivers, i.e. rising CO2, increasing D and reducing precipitation (P), both alone and combined.

Our results suggest that, even after accounting for photosynthesis down-regulation, the most important environmental driver for E. saligna productivity is rising atmospheric CO2. Our results suggest that the fertilizing effect of rising CO2 alone would increase E. salinga's productivity up to a 60%. However, D increases and P reductions would limit this effect down to a half (~35% increase). Furthermore, D increases were found to limit productivity at the same magnitude as P reductions. These results highlight the limiting effect that D may have for sub-humid forests productivity, even in well-watered stands, and how changes in this essential environmental driver should be properly accounted in simulation models, both at local and regional level.

Poster sessions

Poster session 1: What are the impacts of climate extremes and disturbances?

Speaker: Cosmin Cosofret, Stefan cel Mare University of Suceava, Romania

„Assessing the protective value of forest included in soil protection category. A study case in forest district Rasca, Romania“

The demand for ecosystem services from a single parcel of mountain forest is manifold which includes protection from natural hazards, timber production, and landscape aesthetics. The provisioning of these services will be affected by climate change.

The assessment of soil protection against gravitational hazards can be made through several indicators: density, percentage of vegetation cover, slope steepness, tree species diversity, stand type, root type, wind or soil type and texture. There are few studies which analyze how will evolve the protective value of forest included in soil protection category in the next 100 years.

Our study aims to assess the protective value of forest included in soil protection category under different management types and climate scenarios. We address three research questions: (i) How accurately can predict forest protective value using LandClim simulation results, proxy indicators and forest management plan data? (ii) Which is the protective value of forest included in soil protection category? (iii) What is the influence of climate scenarios and management strategies on protective value of forest included in soil protection category?

We conducted simulation experiments with 6 management scenarios (three adaptive management strategies, BAUC – low intensity cuttings, no management and BAUR – regular cuttings) and created an index to assess the protective value of forests, using LandClim simulation results, proxy indicators and forest management plan data.

The preliminary results show that management strategies do not differentiate among them regarding protective value of forest, excepting regular cuttings, and that the disturbances modify the index value in conservation.

Speaker: Jonathan Holder, University of Helsinki, Finland

„Carbon sequestration and economic impacts of wind, snow and root rot disturbances in Finland under climate change“

In climate change (CC) mitigation, forests can be utilised to remove carbon from the atmosphere and store it in the long term. However, the intensity of natural disturbances has increased in recent years, a trend which is expected to continue under CC; the carbon sink function of forests is therefore potentially at risk. In this context, it is vital to quantify the effects of disturbances on the carbon balance and growth of forests to evaluate forest management options and their potential in CC mitigation.

Forest simulators applicable to Finland as a whole currently do not assess the role of disturbances; the objective of this project is therefore to quantify the effects of disturbances on the ability of Finnish forests to sequester and store carbon in the future.

As a modelling framework, we employ the regional, semi-empirical growth simulator PREBAS; it considers effects of both management and CC, and has been successfully applied at a national scale in Finland. We will develop disturbance modules for the agents wind, snow, and root rot, based on empirical risk models currently under development at the Natural Resources Institute Finland, and complement these with process-based wind and root rot models to better assess effects of CC on disturbance prevalence and intensity. We will implement feedbacks between individual disturbance modules as well as with the growth simulator. In a large-scale scenario analysis, we will asses the effects of disturbances in response to CC and management regimes, both from carbon balance and economic perspectives.

Speaker: Thomas Ovenden, University of Stirling, UK

„Revisiting forest resilience assessment“

Large scale, drought-induced forest die-off events and losses in productivity are now being documented in forest biomes globally. With climate change set to increase the frequency, severity and duration of future drought and other extreme weather events, it has never been more critical to understand how and why forests respond to environmental stresses, and how we can increase the resilience of these systems to such events. Resilience concepts have become a key focus in applied forest research. However, current methods for assessing forest resistance, recovery and resilience to extreme events don’t incorporate sufficient detail on key physiological processes, account for the influence of pre-drought growth or post-drought recovery conditions, or differentiate between different types of drought. We aimed to develop existing approaches to address some of these issues and incorporate greater realism into forest resilience assessments. Here we present the results of this work, applied in the context of a common forestry system where exposure to drought and flood events is expected to increase. By including greater detail of how pre-drought conditions interact with species specific physiologies to influence drought year performance, we hope to increase our understanding of patterns in drought resistance. Equally, by attempting to identify biological indicators of drought onset, and accounting for how post drought climate sets the context for recovery, we hope similar clarity can be achieved in interpreting alternative recovery trajectories.

Speaker: Robin Bourke, University of Freiburg, Germany

„Managing wind storm risk in mixed stands through climate robust strategies“

We investigate the implications of adaptive management measures to wind damage risk in southwestern forests in Germany. We simulate forest growth considering European beech (Fagus sylvatica), Douglas fir (Pseudotsuga menziesii), Scot's pine (Pinus sylvestris) and Norway spruce (Picea abies) using the hybrid process-based/empirical forest growth model 3-PG-Mix (Forrester & Tang 2016). We couple 3-PG-Mix with the extreme wind storm model Lothar (Schmidt 2006) and validate the simulations using individual tree plot data provided by the ICP Forests database. In the case of storm damage probability, we validate the model from damage data provided by ForstBW. We consider a no climate change scenario and the RCP scenarios 4.5 and 8.5, as well as varying future storm frequencies, to simulate future forest conditions. We investigate which management scenario, primarily considering species selection and thinning timing/intensity, allows for the greatest minimisation of storm risk in mixed species and monocultures, as well as even and uneven aged stands. We consider the performance of some forest development types, as well as strategies which have been developed in the course of this study. Following from this, we recommend the adaptation strategies which would be the most robust to future climate and meteorological risk, while also choosing the option which can generate the best possible economic outcome and maintains forest functions and services.

Speaker: Matija Klopčič, University of Ljubljana, Slovenia

„Did thermophilic tree species extend their distribution range due to climate change? Experiences from Slovenia“

Climate change may considerably alter demographic structure of tree species. Many projections based on bioclimatic scenarios show dramatic shifts in tree species distribution poleward and upwards in the next decades. Thermophilic species are supposed to significantly extend their distribution range. However, there is a lack of empirical evidence of the actual changes in tree species distribution ranges during the recent decades when climate warming was significant. Comparison of the distribution of juvenile and mature stage of the same tree species may reveal early signals in shifting of tree species' distribution, since seedlings grow in environment that likely changed from the time when mature trees regenerated. The objective of the study is to compare distribution of saplings (up to 150 cm tall), recruits (trees crossing the measurement threshold of 10 cm dbh) and mature trees for selected thermophilic tree species in forests of Slovenia (12,000 km2) that occupy strong gradient of elevation (10-1830 m), mean annual temperature (1.5-13.5°C) and mean annual precipitation (780-3800 mm). The research is based on ≈102,000 plots for mature trees and recruits, and ≈2100 plots for saplings. Differences between life stages in the mean values, extremes and variability of distributions of mean annual temperature, mean annual precipitation and elevation per tree species are evaluated. Preliminary results indicate changes in the distribution range of some thermophilic tree species. Main results are discussed and advantages and disadvantages of the methodological approach are exposed.

Speaker: Nikica Ogris, Slovenian Forestry Institute, Ljubljana, Slovenia

„An on-line tool for detecting large-scale disturbances in forests using MODIS satellite time series“

We developed a web application for detecting large-scale disturbances in forests using NDVI time series. The NDVI time series were derived from MODIS time series from 2003 to 2018 for the whole of Europe with a spatial resolution of 500 × 500 m and a time resolution of one month. The on-line tool works as an interactive web map in which the user can make point queries for the analysis of the time series. The results are shown in two graphs: (1) the annual averages of NDVI of the selected raster cell; (2) the monthly averages of NDVI of the selected raster cell. Significant deviations from the overall averages depicts extreme weather events or large-scale disturbances. Additionally, standard deviation and autocorrelation values of vegetation index time series, two time series stability metrics, are shown for the selected point in the table.

The web application is result of the REFORCE project and available at:
https://www.zdravgozd.si/projekti/reforce/

Speaker: Werner Rammer, Technical University of Munich, Germany

„Projecting regeneration failure under future climate and fire regimes for Greater Yellowstone“

Multiple drivers are expected to accelerate environmental change in the 21st century, but the resilience of landscapes to these drivers remains uncertain. We asked if expected changes in climate and fire regimes can lead to widespread regeneration failure of forest types currently dominating the Greater Yellowstone Ecosystem (GYE) in the western USA. We applied SVD (Scaling Vegetation Dynamics), a novel tool based on Deep Learning, to predict regeneration success for the three main forest types for the whole region under varying climate and fire scenarios. The deep neural network at the core of SVD was trained on post-fire regeneration success simulated by a detailed process based forest model (iLand). Dynamic SVD simulations were initiated from the current distribution of forest types in the GYE and driven by spatially explicit fire perimeters derived via statistical projections of climate and fire dynamics. The probability of postfire regeneration success was predicted based on forest type, climate, and the current distance to adult seed trees at a spatial grain of 1 ha. The model predicted regeneration failure between 8% and 21% (depending on fire and climate scenarios) of the total area at the end of the 21st century. Moreover, Douglas-fir and subalpine spruce/fir forests showed regeneration failure on up to 38% of the burned area and were less resilient to fire disturbance than lodgepole pine forests (up to 15%). We conclude that future climate and fire regime may lead to significant loss of forested area in the Greater Yellowstone Ecosystem.

Poster session 2: What are the impacts of climate extremes and disturbances?

Speaker: Zoran Galic, University of Novi Sad, Serbia

„Microclimate Conditions in July in Clima Zonal Vegetation in Serbia“

In Serbia climate zones vegetation types are represented by typical association of Quercetum frainetto-cerris on cambisol. The paper will show data of microclimate conditions in this forest (temperature and relative humidity) for past period of 10 years in July.

In past period the mean monthly temperature in July was increased according to equation y=0.0878x - 155.05 with standard deviation of y =-0.1261x + 257.57. In this month the mean minimal monthly temperature was increased to (according to equation y = 0.3046x - 598.68). Deviation of mean monthly temperature in past period was increased, and it is defined according to equation of y = 0.1066x - 205.96, with decreased standard deviation defined by equation y=-0.0937x + 191.04.

Mean monthly relative humidity was slightly decreased according to equation y=-0.1259x+324.33, with standard deviation defined by equation y=-0.8048x + 1630.6. As in in case of temperature in July the mean minimal monthly relative humidity was increased to (according to equation y=0.9472x - 1853). Deviation of mean relative humidity in past period was slightly increased, and it is defined according to equation of y = 0.1742x - 319.44, with slightly decreased standard deviation defined by equation y = -0.1135x + 237.45.

Based on this data we have trend of increasing of deviation of mean monthly temperature and mean monthly relative humidity in typical association of Quercetum frainetto-cerris on cambisol.

Speaker: Margot Verhulst, KU Leuven, Belgium

„Mapping forest resilience using remote sensing time series“

Forests cover about one third of the Earth’s land surface and provide significant ecological, economic, and social benefits to humanity. They moreover have a strong regulating function on global biogeochemical cycles and the climate system. However, climate and global change put many ecosystem function and services at risk. Understanding how forests cope with perturbations (resilience) is therefore crucial for the development of sound forest conservation and management strategies. Yet, the quantification of forest resilience requires a long-term record of forest state variables, which are difficult to obtain over large spatial scales using in-situ measurements. Satellite remote sensing may offer a solution to this problem as it provides data over large spatial and temporal scales related to the state of the forest. For example, time series of canopy greenness can be related to forest biomass dynamics and is a key variable in forest functioning. Here, a variety of methodologies have been explored for monitoring forest dynamics and resilience using time series of optical satellite imagery. These include the quantification of the recovery speed after a perturbation, temporal variability and slowness of the forest response and highlight both the potential and remaining challenges of satellite remote sensing for mapping forest resilience.

Speaker: Vasilije Trifković, University of Ljubljana, Slovenia

„Factors influencing the diameter growth of beech, spruce and fir in uneven-aged forests in Dinaric Mountains, Slovenia under weak to moderate disturbances“

The dynamics of uneven-aged forests can be described by regeneration, ingrowth, growth and mortality. Models are needed to predict the development of uneven-aged forests. However, extreme weather events may significantly change stand structure, composition and life processes. We quantified the uneven-aged structure by the diameter diversity indices (Gini, Shannon and Coefficient of variation) to be able to discern between even-aged and uneven-aged forests and to control for the possible influence of the stand diameter structure (dbh) on the diameter growth. The objective of this study is to find which factors influence the diameter growth of European beech, Norway spruce and silver fir in Dinaric fir-beech forests, Slovenia under weak to moderate disturbances. The data from permanent sampling plots (n = 6,848) with consecutive measurements of trees (n = 104,930) before the large ice-storm in 2014 were used for the analysis. The diameter growth was modeled with selected tree (e.g. dbh), stand (e.g. basal area, Ddom, Gini index, tree species diversity), site (e.g. site index, altitude) and climate (temperature, precipitation) variables. Multivariate non-linear regression models were used.

Speaker: Xianglin Tian, University of Helsinki, Finland

„Diagnosis of environmental restrictions across various forest types using the ecosystem flux model PRELES“

The response of canopy photosynthetic production to environmental factors, including light intensity, temperature, vapour pressure deficit (VPD), and soil water status, can be generalised and quantified using the light-use-efficiency (LUE) model PRELES. By partitioning the variability of canopy photosynthetic production, the effect of each environmental stress was respectively detected. We analysed the global variation and seasonal pattern of each environmental restriction, by applying PRELES to forests in tropical, subtropical, temperate, and boreal regions. Besides, Water limitations and drought events were assessed based on both PRELES and meteorological indices on daily, monthly and annual time scales. The results showed that the intensities of restrictions varied with the forest-climate types. Similar seasonal patterns were found for most sites in light saturation, temperature acclimation, and the VPD stress. Limitation from soil water occurred more irregularly. Annual meteorological drought indices strongly correlated with each other, and insufficiently described drought conditions across biomes. For the monthly indicators, in comparison to SPI (standardized precipitation Index), SPEI (standardized precipitation evapotranspiration index) showed a higher correlation with the water restriction modifiers in PRELES. The LUE-based model illustrated that those forests only reached 26% (SD±12%) of the potential productivity, while 56% (SD±17%) of the potential productivity was unachieved due to light saturation, 21% (±13%) was temperature limitation, 12% (SD ±10%) was soil water stress, and 9% (±9%) was VPD stress.

Speaker: María-Luisa Chas-Amil, Universidade de Santiago de Compostela, Spain

„Social vulnerability to wildfires"

Wildfires constitute a recurring natural risk, with greater consequences on the population of areas with human settlements in contact with the vegetation, Wildland Urban-Interface (WUI). The number of people living in these areas has increased dramatically in recent years raising wildfire risk and a growing concern, both for the environmental damages caused by fires, as well as for endangering properties and human lives. Scientific research indicates that the actions taken by the population for their protection reduce firefighting expenditures. It is essential, therefore, to have greater knowledge of the affected population and the factors that influence the potential impacts on it. The overall objective of this work is to spatially identify the vulnerability of the population to forest fires. As a case study, we select the autonomous region of Galicia because it registers the highest occurrence of fires in Spain (40% of the total) and where the consequences can be very important for the population. We use socioeconomic, demographic and territorial variables at the municipal level. Relevant variables will be selected for the construction of a spatial social vulnerability index (Cutter et al. 2006) in order to identify the most vulnerable areas to wildfire impacts. This information can spatially define the impact on local communities potentially affected by fires, showing those areas where it is necessary to improve preparedness and capacity to response by local communities, in order to increase social resilience to natural risks.

Speaker: Natalia Kowalska, Global Change Research Institute, Czech Academy of Sciences, Czech Republic

„Analysis of floodplain forest sensitivity to drought"

Floodplain forests are very complex, productive and dynamic ecosystems, which are able to store huge amount of soil carbon and nowadays, under more often occurring extreme events, are among the most threatened ecosystems. Main goal of our study was to assess the productivity of the floodplain forest located in Lanžhot (LNZ) in Czech Republic, from two perspectives - carbon sequestration (using eddy covariance (EC) method) and stem increments (using dendrometry). We aimed to find out which conditions allow for high ecosystem production and what role plays drought in reducing such production potential. In addition, our interest was determination of the relative SWC (rSWC) threshold indicating the onset and duration of this event. We hypothesized that summer drought in 2018 have the most significant negative effects on the overall annual carbon and water budgets but species differences on the study site between oak, hornbeam and narrow-leaved ash exist. However, the exceptionally warm spring 2018 caused positive gross primary production (GPP) and evapotranspiration (ET) anomaly which consequently led in 2018 to the highest GPP and ET seasonal total from all of the investigated years. Results showed that the most drought resistant species is narrow-leaved ash. Relative SWC threshold ~ 0.45 was determined to indicate the onset of drought events.

Speaker: Dušan Roženbergar, University of Ljubljana, Slovenia

„Resistance and resilience of forests prone to ice damage“

The provision of ecosystem services depends upon forest structure and its function, both of which are essentially defined by different natural disturbances. Ice-storms are common disturbance agents in temperate forests across much of the northern hemisphere. For example in February 2014, a major ice-storm damaged forests across a large part of Slovenia. In this research different ice storm effects were analyzed including damage rates, tree mortality and sprouting. Reduction of the susceptibility of individual trees and stands with various silvicultural tools can increase their resistance and mitigate the negative effects of severe disturbances. As storms increase in intensity (e.g. ice load more than 8 cm thick) they become non-selective and forests get heavily damaged with no regard to their resistance. In such circumstances forest management should take into consideration the concept of resilience, which refers to the capacity of a forest ecosystem to recover from a disturbance. Resistance improvement measures include promotion of less susceptible tree species and symmetrical crown architecture, improvement of height diameter ratio of dominant trees, regular thinning of young stands and increasing of diversity of stand structure and age (using selection or irregular shelterwood system). The latter is also important for enhancing forest resilience, which is also increased with systematic promotion of understory structures, like advanced regeneration and understory trees, natural or artificial regeneration, increase of tree species diversity and regular silvicultural treatment of newly established young forest aiming at high structural and species diversity and appropriate number of strong dominant trees with symmetrical crown architecture.

Poster session 3: What are the management challenges (and options) for resilient forests?

Speaker: Matteo Cerioni, University of Ljubljana, Slovenia

„Are Slovenian forests resilient to large and severe windthrows? - A decade of natural recovery dynamics“

European temperate forests are considered to be resilient to their current disturbance regime, which consists mainly of small gap-scale and periodic moderate severity events. Coupled with aging forests, there is concern that climate change may lead to larger are more severe disturbances. However, few studies in the temperate region of Europe have focused on forest recovery following large and severe events. In western North America, recent evidence indicates regeneration failures after large and severe disturbances under current environmental conditions (e.g. frequent incidence of drought). Here we present some preliminary results of regeneration dynamics in three Slovenian sites (Črnivec, Bohor, Trnovski gozd) that were affected by large and severe windthrow events in 2008. Inventories were carried out in permanent plots in 2012, 2014 and 2019, providing valuable insight into the first 10 years of forest recovery. Data collection involved regeneration characteristics (species, height, and DBH), herb cover, and browsing effects. The presence of both early and late-seral species was observed at all sites, but preliminary results indicate that one of the sites has experienced a regeneration failure over a large part of the windthrow, presumably due to herb competition, lack of advance regeneration, and lack of seed sources. Structural parameters indicative of resilience will be assessed for each site. In order to understand if European temperate forests are resilient to large disturbances or need some form of active management, we intend to develop a network with other partners that are studying forest recovery dynamics after large and severe disturbances.

Speaker: Thomas Cordonnier, IRSTEA, France

„I-Maestro project : Innovative forest MAnagEment STrategies for a Resilient biOeconomy under climate change and disturbances“

Disturbance intensification and its interactions with climate change (CC) question the ability of forest ecosystems to achieve the bioeconomy objectives of the EU, i.e. obtaining sustainable resource use while preserving the provision of other ecosystem services (ES). In this context, forest resilience can play a major role in limiting degradation of ES. The main aim of the I-Maestro project (ERANET ForestValue, 2019-2022) is to improve the scientific basis for developing management strategies that increase resilience of the bioeconomy to future natural disturbances and CC, maintain high level of wood production, biodiversity conservation and carbon storage. It will specifically address the value of developing management strategies fostering structural complexity. I-Maestro will meet these objectives by using forest dynamics models and evidence-based studies while considering different spatial and temporal scales.

Speaker: Ekaterina Podolskaia, Center for Forest Ecology and Productivity of the Russian Academy of Sciences (CEPF RAS), Russian Federation

„Comparison of data sources on transport infrastructure for the regional forest fire management“

Purpose of present research is to give a transport data sources comparison for the ground access to the forest fires. We consider transport infrastructural digital data as a key element in the forest fire fighting decision making when there a need to ensure the access to the forest fires sites with a minimum time spent.

Comparison of Russian datasets is done based on the main characteristics of road networks, such as: their presence, length, density and seasonality of roads, as well as roads configuration, geographical and economic features of the region (topography, population).

On the example of the Irkutsk region of Russia as region with a long fire hazard season (its duration is more than 5 months per year), an analysis of the available data sets, their geometry and attributes is presented.

Dataset of 1: 200 000 scale (Former Soviet Union roads map) is compared to the open source OSM (Open Street Map, OpenStreetMap Foundation). One of the comparison results is that the total length of all roads and forest clearings of 1: 200 000 scale is greater than OSM dataset of the same extent. Dataset of 1:200 000 was chosen as a base to create a forest fire transport model of ground access for Irkutsk region.

Transport datasets assessment can be used for the annual preparation of fire hazard season in the forestry departments of Russian Federation and for the development of regional programs such as “Forestry Development” and Forest Plans (Forest Plan of Irkutsk Region, 2019).

Speaker: Anamika Menon, University of Freiburg, Germany

„Retention forestry as an option for climate-resilient forests in Central Europe“

As climate change now poses a considerable challenge to foresters, adaptive measures like modifying existing traditional forestry practices are required in order to produce more resilient forests.

Retention forestry is “an approach to forest management based on the long-term retention of structures and organisms, such as live and dead trees and small areas of intact forests, at the time of harvest” (Gustafsson et al. 2012). This helps to maintain the continuity of structural and compositional diversity as an alternative to clearcutting. Retention forestry requires managers to mimic natural forests whereby the amount of structures (deadwood and habitat trees) which are naturally occurring in undisturbed forests have to be retained in managed forests. These amounts vary across different forest types and habitats.

In this study, the natural amounts of structures are recorded across the different undisturbed or old-growth forests of Central Europe. The parameters studied include- the type of forests, altitude, major tree species, age and size of trees to be retained and the amount of dead wood to be left. The forests are also categorized based on the “degree of disturbance (biotic and abiotic)”.

Adapting forest management to build resilient forests is the need of the hour and old-growth forests are set as a bench-mark to do this in a scientific manner. It is possible to increase the climate benefits from managed forests and also create synergies with other needs related to forests, by implementing Climate-Smart Forestry practices like retention forestry.

Speaker: María-Luisa Chas-Amil, Universidade de Santiago de Compostela, Spain

„Paying landowners and resilience in forest ecosystems"

Paying landowners to conserve forests is a promising strategy to protect biodiversity and ecosystem services. In this paper we focus on the resilience properties of this strategy in risky environments where forests are affected by disturbances. We show that the recovery of the forestry after a disturbance shock is faster when we use strategies based on paying landowners to protect biodiversity. Therefore, despite that, in an ex-ante perspective the payment is suboptimal as it promotes overcapitalization, it can be welfare increasing in an ex-post point of view as it helps a faster recovery of the forest when affected by a negative shock.

Speaker: Mats Lindeskog, Lund University, Sweden

„Modelling future forest management options in the dynamic vegetation model LPJ-GUESS"

Changing climatic conditions with increasing temperatures, more variable precipitation patterns and more frequently occuring climate extreme events pose challenges for managing forests in Europe. The dynamic global vegetation model LPJ-GUESS is well adapted to modelling vegetation under future climate, CO_2 and nitrogen deposition scenarios and has now been extended to explicitly simulate forest management. The new model version can successfully reproduce current stand age and species composition of Europe's forests by combining various available continent-wide data-bases as input to the model. Forestry modelling options include detailed tree species and harvesting method selection as well as automated harvest methods. The impact of future forest management scenarios like changing to needle-leaf or to broad-leaf species, higher or lower harvest intensity and nitrogen fertilisation can be explored with respect to productivity, carbon storage, evapotranspiration, nitrogen leaching and age/species structural diversity. We use CMIP5 IPSL climate/CO_2/N-deposition RCP 4.5 and 8.5 scenarios as well as stylised storm frequency scenarios at the 0.5^o gridcell resolution.

Speaker: Joanna Horemans, University of Antwerp, Belgium

„Forests in an uncertain context: comparing contrasting strategies of risk management at the local and regional scales“

Under the increasing uncertainties of forest management conditions, this project aims to test the hypothesis that managing diversity and functional redundancy at landscape-level maximizes the resilience and multi-functionality of forests. This hypothesis will be confronted, in particular, to an adaptation strategy using a limited number of genotypes, chosen according to some expected climate changes. Based on local and regional simulations, a first axis will evaluate the response of two forest regions (in Quebec and Wallonia) to these distinct strategies for adapting to climate change, taking into account the uncertainties in climate projections and in modelling the response of forests to global changes. A second axis will identify the socio-economic constraints limiting the implementation of these strategies, through a detailed analysis of governance at different scales.
The results of this research will allow to understand the mechanisms involved in the resilience of forests to global changes, and to identify the best combinations of forest management and policies for contrasting scenarios of climate and global change.

Poster session 4: What can we do to increase the contribution of forest management to climate change mitigation?

Speaker: Sophie Labonne, Grenoble Alps University, INRAE, France

„Decision-making behavior of forest managers and owners in adapting forest management to climate change“

Missing knowledge about the individual decision-making behavior of forest managers and owners on adaptation measures in forest management is a limiting factor in the adaptation of forests to climate change. In order to analyze the willingness to adapt of decision makers in Austria and France, personal interviews were conducted in three different case study regions along an East-West gradient in Austria and two regions in France along a North-South gradient. In total 94 interviews (74 in Austria) were conducted. Results show that the willingness to adapt differs between regions. For instance, in Austria in the more alpine Western region it is significantly lower than in the sub-montane East. Sources of information and extent to which decision makers use information about forest management and climate change is one of the few factors that can partly contribute to explain future willingness to adapt. Surprisingly, in Austria, the experience of damage caused by disturbances in the recent past did not have a significant effect on willingness to adapt. In contrast to other studies, the expectation of severe disturbances did not have a generally significant effect on a greater willingness to adapt across the regions. In France, expectations of severe future droughts and heat events appear to trigger adaptation actions. The result underlines the importance of effective communication of climate change information regarding existing risks and adaptation options. An important step is also the involvement of reliable experts who are engaged in extension services with forest decision makers.

Speaker: Jasper Fuchs, University of Göttingen, Germany

„Adaptation Strategies for Spruce Sites –

Climate-sensitive Modelling of the Economic Influences of Bark Beetle Management and Cultivation of Alternative Tree Species“

The selection of tree species is a fundamental decision in strategic forest planning. Climate change influences the suitability of species regarding growth potentials and natural risks. This leads to expectations of high economic losses in European Forests. In Germany, high shares of Norway spruce have been cultivated in suitable growing areas. This species is particularly vulnerable to climate-driven risks such as storms or bark beetles. Frequently studied mitigation strategies for risk-averse forest owners are a reduction of rotation periods and a diversification of the tree species portfolio. However, studies on the economic impact of forest protection measures are rare. Our study seeks to analyze the economic consequences of intensified bark beetle monitoring with sanitation fellings as a future strategy in typical growing areas of spruce. The underlying simulation model integrates empirical survival time models and a bark beetle model into the mean variance portfolio method to derive rational species mixtures. In this framework, we show under which conditions it is advantageous to reduce the infestation risk of bark beetles for spruce by investing in intensive protection measures. As an alternative to bark beetle monitoring, we analyze which characteristics an additional tree species should have to compensate for the higher risks of spruce. The results indicate that, compared to increased shares of beech, forest protection measures and alternative tree species might be able to compensate for considerably more climate-driven economic losses.

Speaker: Ilié Storms, KU Leuven, Belgium

„Scaling factors to adjust yield tables with mechanistic forest growth modelling: predicting wood availability under climate change“

To maximize climate change mitigation strategies, forest resources should get a more prominent role in the circular bio-economy. To evaluate the mitigation potential of forests and forest products, accurate predictions of future growth and standing stocks are necessary. Current predictions of wood availability in Europe are often based on yield tables. These empirical growth curves still predict current forest growth quite accurately, but fail to take into account the effects of climate change or alternative management strategies. Process-based models form a climate and management sensitive alternative but often lack the accuracy necessary to make economic planning and evaluation. Therefore, the use of hybrid models, which combine both empirical and process-based models, have been suggested as an approach to predict future wood availability in a climate and management sensitive manner. In our research, we define species and soil specific scaling factors for Flanders, Belgium, describing growth changes predicted using the mechanistic forest growth model 4C (FORESEE). The obtained scaling factors can easily be incorporated in any empirical model describing forest growth to increase their sensitivity to different climate scenarios. Our results highlight the importance of combining mechanistic with empirical forest growth models, as well as pinpoint drought stress sensitivity as one of the most important points of improvement for mechanistic modelling techniques to ensure further adoption of these forest management tools in forest resources planning and decision support.

Speaker: Quentin Lejeune, Climate Analytics, Germany

„Contribution of forest management to climate mitigation and adaptation – A multi Earth System Model perspective“

World’s forests constitute a large carbon sink, and are expected to play an important role for mitigation under the Paris Agreement. Moreover, reforestation and changes in forest management practices can lead to a local cooling offsetting the impact of historical carbon emissions – thereby highlighting the forests’ potential for adaptation.

Within the LAMACLIMA project (LAnd MAnagement for CLImate Mitigation and Adaptation), three Earth System Models will conduct coordinated idealized experiments to uncover the impacts of the deployment of three land-use change options (including af/reforestation and wood harvest) on climate, crop yields and water availability through their effects on the carbon and water cycles, as well as energy fluxes. These impacts will be integrated into a Computable General Equilibrium model (GRACE) and a land-use allocation model (MAgPIE), which will enable to conduct more detailed cost-benefit analyses of af/reforestation and wood harvesting.

These relationships will then be summarized in a lightweight emulator, which will especially allow the exploration of the local potentials of af/reforestation and wood harvesting for carbon sequestration and the dampening of the impacts of global warming. It shall serve as a tool to support land-use decision-making, including by forest policy experts. It will notably be used during a workshop gathering scientists and land-use stakeholders to design land-use scenarios that help achieve mitigation and adaptation while considering other sustainability boundaries.

Speaker: Claudia Chreptun, Technical University of Munich, Germany

„Acceptable forest landscape composition for all – optimizing for multiple ecosystem services with different stakeholder groups“

Modeling the composition of a forested landscape and its associated ecosystem services is challenging because the solutions must unite the different needs and management ideas of all forest stakeholders.

Here, we present robust compromise solutions, which maximize the overall contribution of a forest landscape to several ecosystem services.

Our multi-objective optimization approach includes uncertainty in data and future conditions and produces solutions which are, to a certain extent, robust against changes in input data.

As input data we use survey data from 2019. It shows the valuation of nearly 650 people in Germany and 130 in Slovenia regarding eight forest types and their provision to five ecosystem services. For further analysis the participants were grouped according to their forest context, e.g. forest owner or forester in a state forest.

Due to our multi-objective approach, all resulting forest landscape portfolios consist of at least two forest types. The higher the presumed uncertainty range, the more diversified the portfolios. The solutions of the German dataset show a preference for forest types with uneven age structure and native tree species. In the Slovenian portfolios the unmanaged forest type has a bigger share. In the comparison of the optimization results for the group analysis we see similarities between forest owners, foresters in state forests and foresters in public forests. The group nature conservationist is the most dissimilar to the other groups.

Our results illustrate that diversified forested landscapes contribute the best to multiple ecosystem services under uncertainty in data and future conditions. Our optimization approach is beneficial because it doesn’t require knowing every opinion of each individual stakeholder for every ecosystem service. By using simple statistical values and a convincing selection of ecosystem services, we achieve robust solutions which reflect the multiple demands on forests and serve as compromise for all stakeholders.

Speaker: Atte Kumpu, University of Helsinki, Finland

„Biomass and structure of uneven-aged Norway spruce stands in southern Finland“

Tree biomass models are increasingly needed for the estimation of carbon storage and for testing and parameterizing process-based growth models, but most biomass models have been estimated using data from even-aged stands. Here we took measurements from individual Norway spruce trees grown in uneven-aged stands in Southern Finland to characterize tree structure and to estimate the biomasses of tree parts. Using the data, we tested various structural biomass equations developed for even-aged stands for their suitability to uneven-aged stands and compared our measurements to data from previous studies on even-aged stands, to test the hypothesis of structural differences in individual trees and stands between the two management practices.
The test trees had longer crowns than usually found in an even-aged Norway spruce stand, ranging from 55 to 85% of total tree height. The average proportion of total biomass in branches and foliage was 13.8 % and 7.0 %, respectively. The average wood density of the test trees was slightly higher than that reported for Norway spruce trees of comparable size.
The structural relationships found in trees under even-aged management were applicable to trees growing in uneven-aged stands but required re-parameterization. In particular, the trees had higher branch and stem biomass than trees of same stem and crown dimensions on average in even-aged stands. The relationship of crown ratio and the slenderness index on an uneven-aged stands also differed from those reported in even-aged stands. These results can inform individual-tree biomass model development for uneven-aged stands.

Speaker: Jonathan Holder, University of Helsinki, Finland

„Modelling carbon sequestration in Finnish forests: A climate and harvest level scenario case study“

In Finland, forests currently sequester about half of anthropogenic CO_2 emissions. Most current climate change (CC) mitigation policies focus on increasing forest utilisation to substitute fossil resources; however, higher harvest levels might impair the function of forests as carbon sinks, as they commonly reduce growth potential. This study analyses how forest utilisation and CC affect the carbon balance of Finnish forests at a national scale during 2015–2100. The semi-empirical growth simulator FORMIT-M estimates biomass carbon stocks and fluxes, and is coupled with the Yasso15 soil carbon model. Carbon stored in harvested wood products is estimated by applying decay functions to harvested timber assortments. We analysed four harvest scenarios (40 – 87 million m3 a-1) under current, RCP2.6 and RCP8.5 climate scenarios.
Our results confirm earlier research, indicating that higher harvest levels decrease the total carbon sink. Under CC, carbon sinks generally increase, and the relative effect of harvests is reduced, but management remains the most influential factor. The reduction in carbon sink per unit of additionally harvested carbon increases with harvest levels. At high harvest levels, managed forests act as carbon sources in the near future; the total forest area remains a net carbon sink only due to carbon sequestration in preservation areas.
The results suggest that, from a CC mitigation perspective, a reduction of harvests is favourable, even when avoided emissions are considered in a rough estimation of substitution effects.
Future applications of FORMIT-M should consider disturbances and additional limitations to growth under CC.