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European Forest Management Portfolios Optimized for Uncertain Future Climate

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Forests are considered a major player in climate change mitigation since they influence local and global climate through biogeochemical and biogeophysical feedbacks. However, they are themselves vulnerable to future environmental changes. Thus, forest management needs to focus on both mitigation and adaptation. The special challenge is that decisions on management strategies must be taken today while still a broad range of emission pathways is possible, and a good decision regarding one assumed pathway might turn out to be a bad decision when a different one materializes.

With our study we try to aid this decision-making process by finding management portfolios that provide relevant ecosystem functions such as local and global climate regulation, water availability, flood protection, and timber production for a wide range of future climate scenarios. To simulate according ecosystem processes and functions, we run the dynamic vegetation model LPJ-GUESS for the most relevant forest types across Europe for four different RCPs and five different management options. We analyze our simulation outputs using robust optimization techniques to determine optimal forest management portfolios for each 0.5° grid cell in Europe that ensure a balanced provision of all considered ecosystem functions in the future under any of the four RCPs.

Generally, our simulations and optimizations show that diversified management portfolios are most suitable to provide the set of considered ecosystem functions in all climate scenarios everywhere in Europe. While the portfolios show different compositions in different regions, they are quite similar in adjacent grid cells. The suggested future forest composition in Europe tends to be fairly close to present day values except for Northern Europe where a much higher proportion of deciduous types is proposed.

Management as high forest (trees emerging from seeds) remains the most important form of management. The proposed share of coppice management is much higher in Central and Northern Europe (~20%) than in Southern Europe, where its disadvantages (e.g., high water consumption and its non-suitability to provide long-lived wood products) are more pronounced.

A succession of ~30% of managed forest to natural forest is proposed by the optimization as it provides highest carbon storage and surface roughness values. However, this infeasibly high share is reduced if the provision of wood harvest is valued higher in the optimization compared to the other ecosystem functions.

Current public focus on forests lies often on their potential for carbon sequestration, but future forest management must also address the other services that they provide. This work gives insights on how this may be done.