The role of alpha and beta diversity in buffering the effects of intensifying natural disturbance regimes

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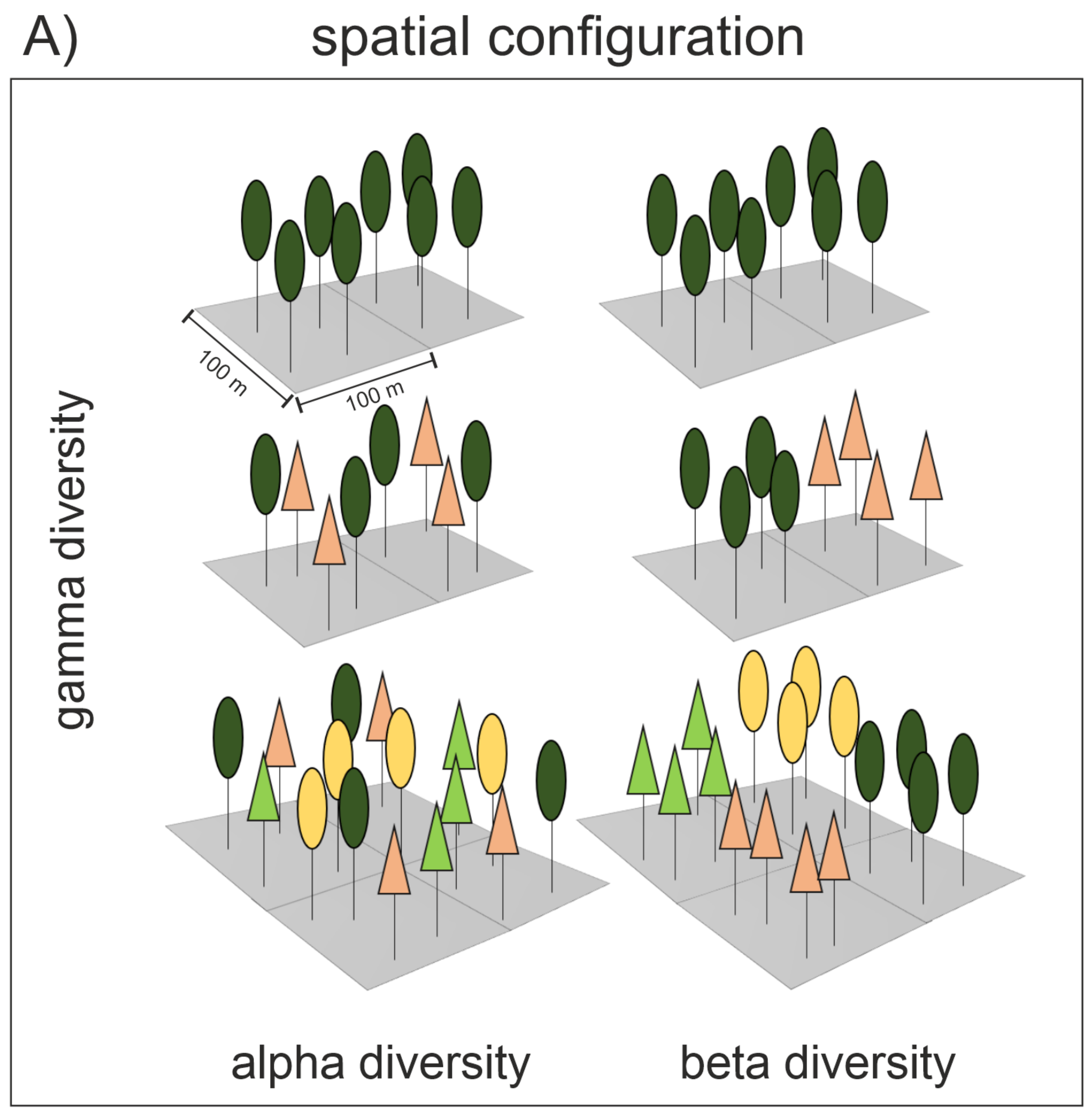
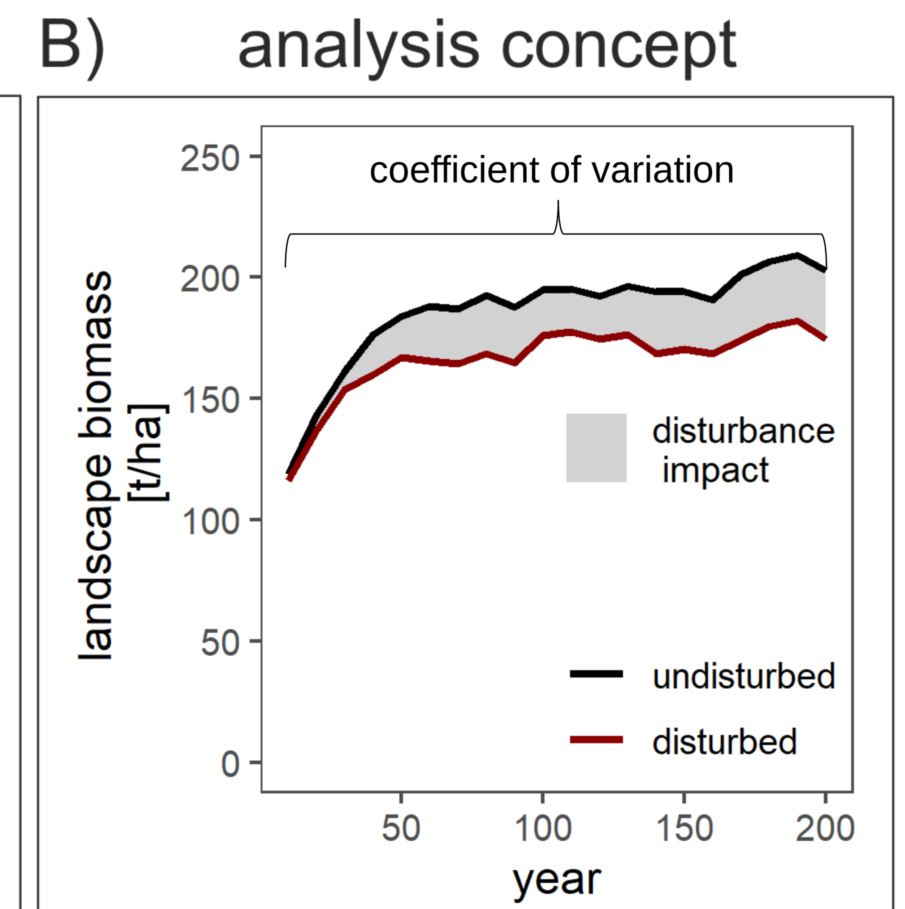
Idea

Europe`s forest are changing, with intensifying forest disturbances and changing environmental conditions

Increasing tree species diversity has been shown to be an effective measure to adapt forests to changing climate and disturbance regimes.

Yet, the ***spatial grain of mixture*** to obtain these positive effects is unknown.





C) simulated combinations

2 study landscapes	x	2 simulation models
x		x
3 climate scenarios	x	2 disturbance scenarios

Conceptual visualization of our study design: we study effects of tree species diversity and spatial configuration on the landscape scale with a computer simulation experiment. We set up a standardized 1-hectare stand grid and initialized three levels of tree species diversity in two spatial configurations (A). Subsequently, we exposed these initial states to a series of forest disturbances over a 200 year simulation period and calculated disturbance impacts by comparing landscape values of biomass stocks and forest structure to an undisturbed simulation run (reference). Further, we analyzed temporal variation of biomass stocks and forest structure by calculating the coefficient of variation over the 200 yrs simulation period (B). To broaden our analysis we conducted the simulation experiment in two contrasting forest landscapes (Dischma, Rosalia),with two process-based landscape models (iLand, LandClim) under three different climate scenarios (historic, RCP45, RCP85) and under two different disturbance scenarios (200 and 400 yrs disturbance rotation period).

Research questions

Does it make a difference for *the impact of disturbances* on forest landscapes if tree species are mixed within stands (alpha diverstiy) or between stands (beta diversity)?

Does tree speces diversity (gamma diversity) increase *temporal stability* of biomass stocks and forest structure under climate change?

Results

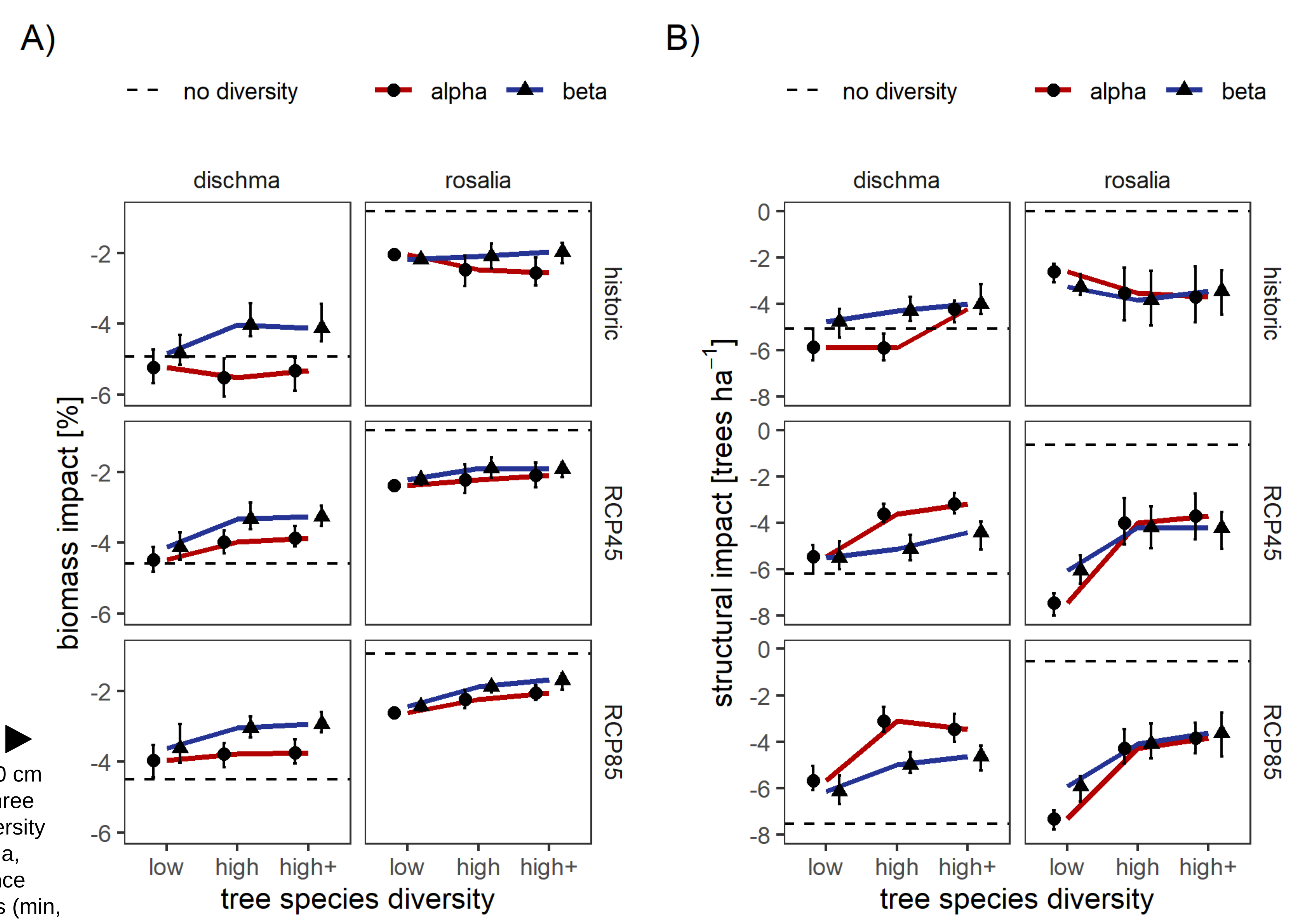
Does it make a difference for the impact of disturbances on forest landscapes if tree species are mixed within stands (alpha diversity) or between stands (beta diversity)?

Beta and alpha diversity show similar patterns, reducing disturbance impacts on landscape biomass stocks between 2 and 6 %.

Our results thus suggest that mixing tree species between forest stands reduces disturbance impacts, while taking advantage of other positive effects of beta diversity (ecosystem service provisioning, biodiversity).

Positive effects of tree species diversity were stronger under climate change.

Our results thus confirm findings from previous studies indicating that increasing tree species diversity is a potent management strategy to adapt forests to future conditions.



Disturbance impact on biomass stocks (A) and forest structure (trees > 30 cm dbh ha⁻¹, B) for the two study landscapes (Dischma and Rosalia) under three different climate scenarios and for four different levels of tree species diversity (no, low, high, high+). Colors indicate different spatial configurations (alpha, beta). Values are averaged over two simulation models and two disturbance scenarios. Whiskers show variation between 20 replicated simulation runs (min, max).

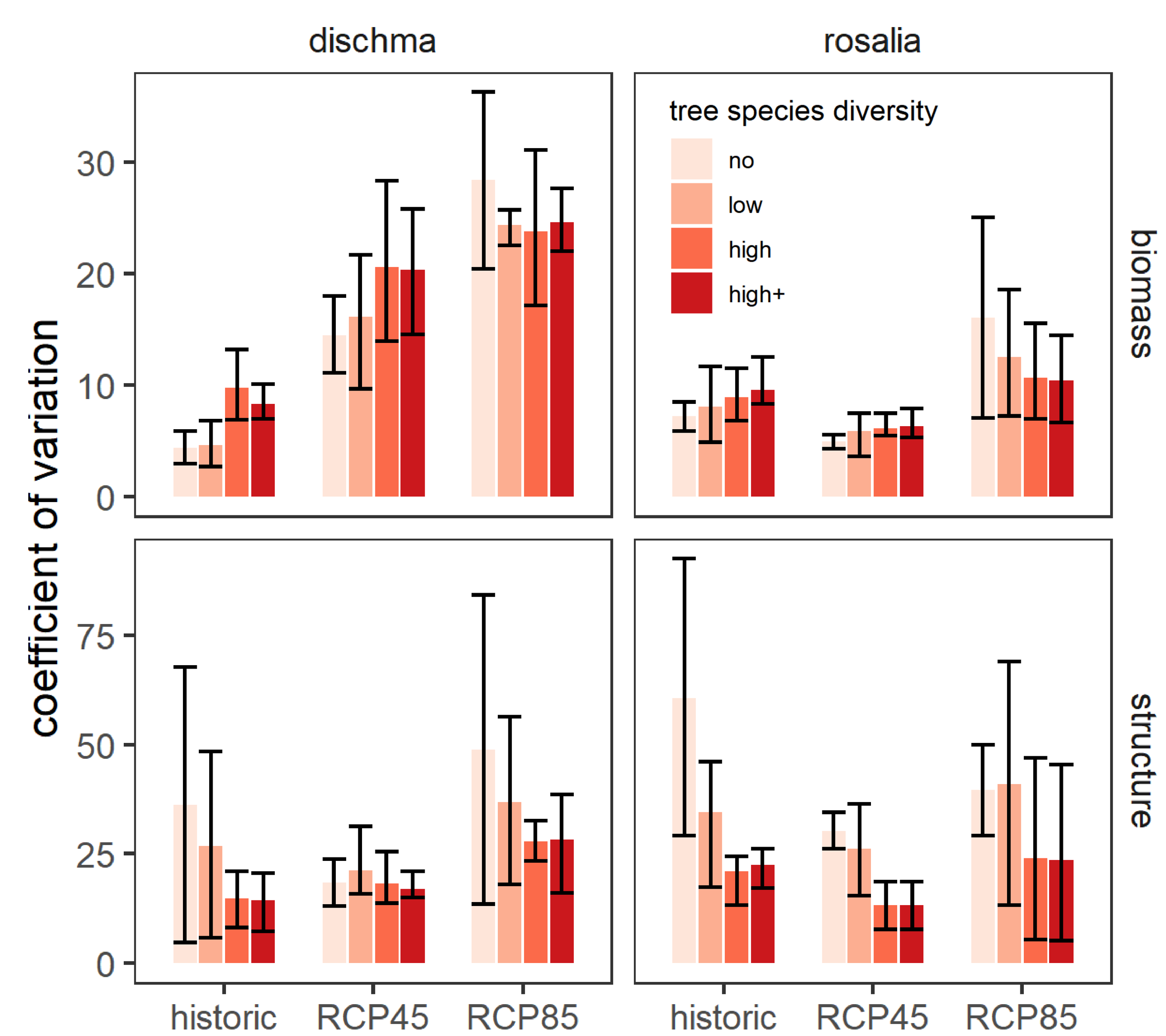
Does tree species diversity (gamma diversity) increase temporal stability of biomass stocks and forest structure under climate change?

Climate change increased temporal variation of biomass stocks and forest structure for all levels of tree species diversity.

However, variation increased most strongly in single species scenarios, indicating that these systems might turn from stable to highly volatile conditions due to climate change.

High levels of tree species diversity buffered increasing temporal variation of biomass stocks and forest structure.

Under future climate, biomass stocks and forest structure were most stable (lowest temporal variation) under high levels of tree species diversity.



Temporal variation $(coefficient\ of\ variation\ (x) = \frac{standard\ deviation\ (x)}{mean\ (x)} \times 100)$ in biomass stocks and forest structure on the landscape scale for three climate conditions and four levels of tree species diversity. To isolate climate induced variation from disturbance induced variation, this figure shows only data of simulation runs without disturbances. The bars show mean values of variation, the whiskers minimum and maximum variation over two models (iLand, LandClim), two spatial configurations (alpha, beta) and 20 replicates. Temporal variation was calculated over 20 time steps during the 200 years simulation period.

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