POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

P I K

*"We find a mostly positive trend of net primary productivity (NPP) in Northern Europe in response to 21st century climate change scenarios. In Central Europe, NPP trends diverge locally, indicating the importance of other, local factors such as soil and management effects upon NPP trends. In the Mediterranean positive trends were found but few sites and strong $CO_2$-effects blurr the picture. Please note, that we are considering physiological effects of global change and not the effects of other factors such as disturbances."*

# Model-based analysis of forest productivity and carbon stock shifts in Europe under global change

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## Introduction

Understanding and predicting trends in forest productivity and carbon stocks, their uncertainty under different global change scenarios and their spatial extent is crucial for understanding forest carbon cycling under changing environmental conditions and for adapting forest management to climate change. Comparing the results of different process-based models under different global change scenarios allows to assess uncertainties in model structure and in productivity and carbon stocks. We present synthesis information from a literature review on future productivity and carbon stock shifts as simulated with process-based models at the stand scale and a scenario analysis of productivity changes at 132 forest sites in Europe with the process-based forest model 4C (Fig. 1).

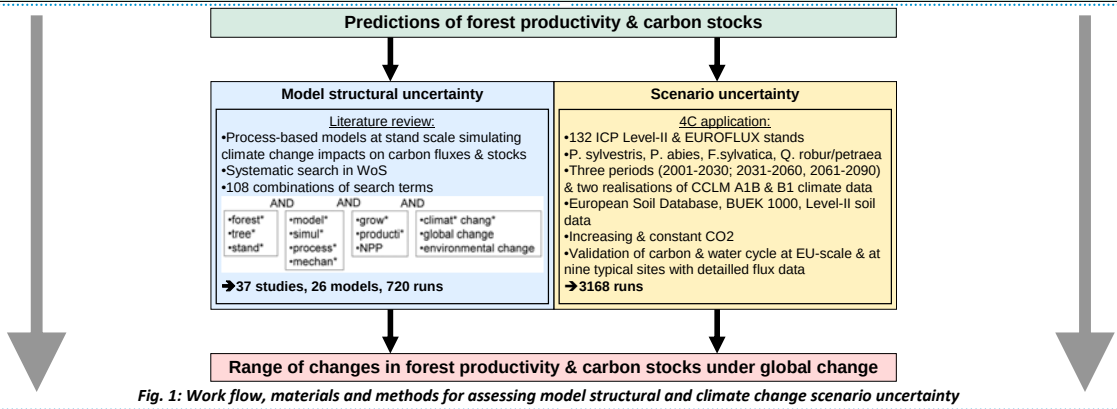


***Fig. 1: Work flow, materials and methods for assessing model structural and climate change scenario uncertainty***

## Results: Literature Review

- Most of the simulations revealed **positive** changes of forest productivity and carbon stocks (**81%**) under climate change, increasing $CO_2$ and their combination while **17%** showed **negative** directions of change (Fig. 2).
- Climate change impacts alone led in **34%** of the simulations to **negative** responses. Under increasing $CO_2$ **no negative** responses were simulated.
- The widespread positive effects of $CO_2$ on productivity and carbon stocks ($CO_2$-fertilization, water-use efficiency) persist when climate change and increasing $CO_2$ are combined. Here, **13%** of the simulations results in **negative** and **85%** in **positive** productivity and carbon stock changes.

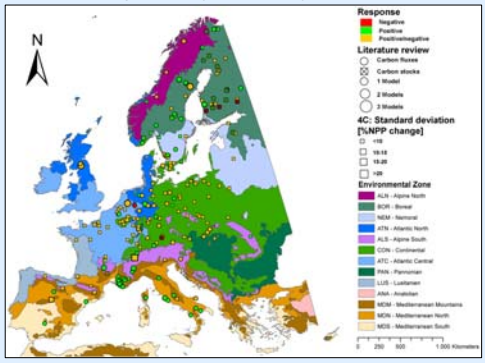


***Fig. 2: Synthesis map of forest productivity and carbon stock changes under global change scenarios found in the literature review and the 4C application. Environmental zones after Metzger et al. 2005.***

## Results: 4C Application

- 4C showed good correspondence of simulated NPP with published data at the European scale and of simulated carbon and water fluxes at nine sites where detailed measurements were available.
- When driven by different climate change scenarios and realizations as well as increasing $CO_2$, 4C mostly simulated increasing NPP in comparison to the historic climate (Fig. 3).
- Under the assumption that trees acclimate to increasing levels of atmospheric $CO_2$, the increase in NPP is much lower and often even negative (Fig. 3).

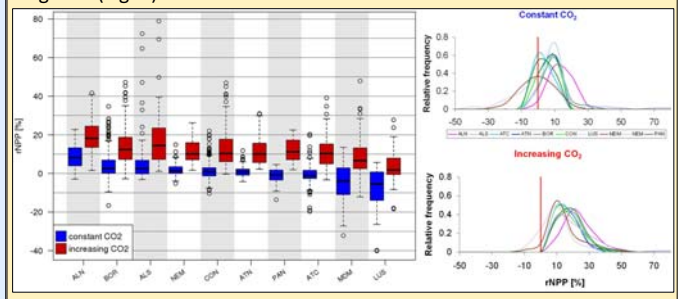


***Fig. 3: Boxplots of NPP changes (rNPP) as simulated with 4C in ten different environmental zones (after Metzger et al. 2005, see Fig. 2) under two realisations of the A1B and B1 scenarios respectively with increasing and constant $CO_2$ (i.e. full acclimation to rising $CO_2$-levels) for three different time periods (2001-2030, 2031-2060, 2061-2090) in comparison to the historic climate. The graphs on the right show the corresponding probability density functions.***

## Discussion & Conclusion

- Most studies in northern Europe zone show productivity increases and higher carbon stocks under global change scenarios.
- The response to global change is positive and negative in Central Europe.
- In the Mediterranean, the response depends strongly on $CO_2$. However, only a limited number of sub-regions and tree species are covered.
- We only consider physiological changes and ignore other impacts of global change (e.g. disturbances or management).
- The degree of acclimation to higher $CO_2$-levels is crucial.
- The carbon sink strength depends also on the response of respiration to global change.

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