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LONG-TERM DYNAMICS OF CO_2 FLUXES OVER A MANAGED AND AN UNMANAGED BEECH FOREST

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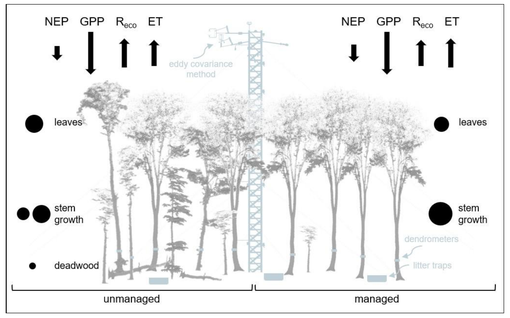


Comparison of flux exchange and storages between the unmanaged and managed forest site.

NEP: net primary productivity
GPP: gross primary productivity
R_{eco}: ecosystem respiration
ET: evapotranspiration
WUE: water use efficiency
DBH: diameter at breast height
(scanned trees by Marius Heidenreich)

I. Introduction

Forests are important natural carbon sinks and can help mitigate climate change. The **drought and heat waves** of recent years have severely affected forests in Germany, resulting in reduced **net CO_2 uptake**. How **forest management**, **age** and **species composition** moderate the negative impacts of weather extremes on net CO_2 uptake or its recovery is still unknown.

Here, we compare around 25 years of **stem growth** and flux data obtained with the **eddy covariance method** at two differing forest sites in Thuringia, Germany:

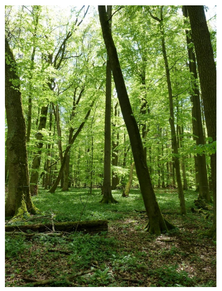
- DE-Hai: unmanaged, uneven-aged and mixed beech stand in the Hainich National Park
- DE-Lnf: managed, even-aged and pure beech stand near Leinefelde

Based on these long-term measurements, we address following questions:

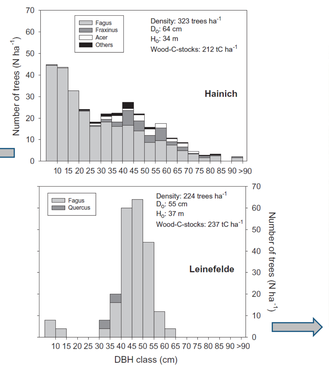
1) How did the long-term dynamics of CO_2 fluxes of the two structurally different forest systems differ?
2) What influence did recent drought years (2018, 2019, 2022) have on the CO_2 sink strength?
3) How did drought events affect tree growth?

II. Study Sites

Hainich (DE-Hai)



unmanaged

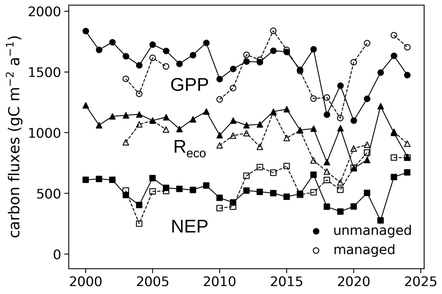


Leinefelde (DE-Lnf)

managed

Herbst et al. 2015, doi:10.1016/j.foreco.2015.05.034

III. Long-term CO_2 Sink Strength and Influence of Droughts

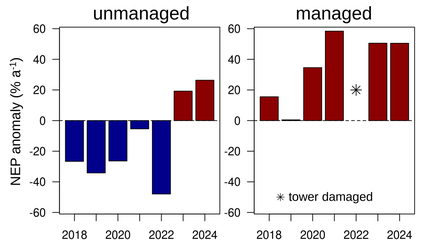


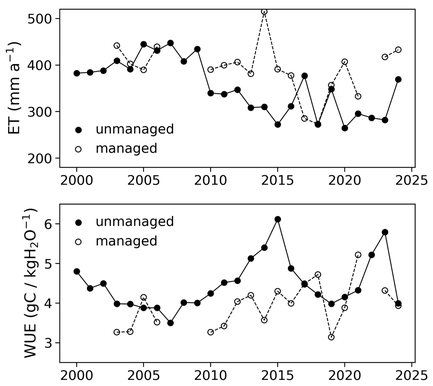
CO_2 sink strength

- stable GPP in unmanaged forest until 2017, in managed forest higher variation
- R_{eco} was slightly larger in unmanaged than managed forest due to more deadwood
- both forests show a high NEP – also during drought years

NEP anomalies since 2018

- NEP was reduced in the unmanaged and increased in managed forest during drought years
- in both forests NEP was smaller in 2019 than in 2018
- unmanaged forest shows positive NEP anomaly since 2023

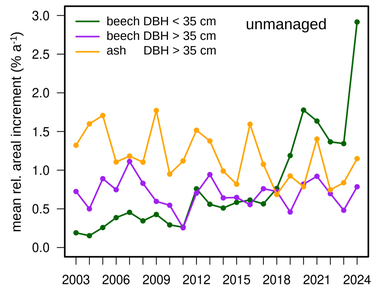


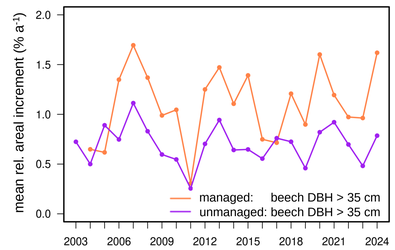


ET and WUE

- unmanaged forest shows lower ET and higher WUE than managed forest
- in both forests ET was decreased during drought years
- WUE shows no clear response

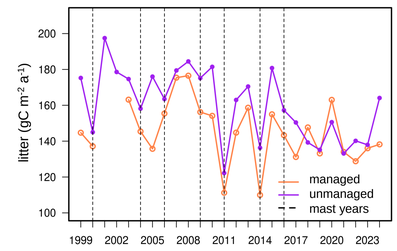
IV. Tree Growth





Tree growth

- in unmanaged forest, growth of older trees (DBH > 35 cm) stagnated; growth of younger beech trees (DBH < 35 cm) increased
- higher tree growth, but less litter in managed than unmanaged forest
- in both forests, growth of beech trees reduced in 2019 and 2023, but recovery thereafter



- in both forests, reduced leaf litter after drought events

V. Conclusions

- both forest sites with high CO_2 uptake
- unmanaged forest shows reduced CO_2 uptake due to drought events
- unmanaged forest in natural transformation process: older beech trees grew less or died, younger beech trees grew more, managed forest in optimal phase with high CO_2 uptake
- reduced growth in managed and unmanaged forests in the year following the drought event → legacy effects (see Yu et al. 2022, doi: 10.5194/bg-19-4315-2022)

Acknowledgements

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