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Net Ecosystem Productivity of a mature temperate deciduous oak forest: reconciling flux and biometric estimates

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Introduction

Net Ecosystem Productivity (NEP) can be quantified using flux measurements (Eddy Covariance, EC) and a biometric approach, e.g. based on consecutive inventories of ecosystem carbon stocks.

Both the EC and biometric approach agree generally well in temperate forests [1] but usually omit variations of the soil organic carbon (SOC) stock.

Objectives

We aimed at comparing NEP values derived from the EC and the biometric method in a mature temperate deciduous oak forest.

Site description

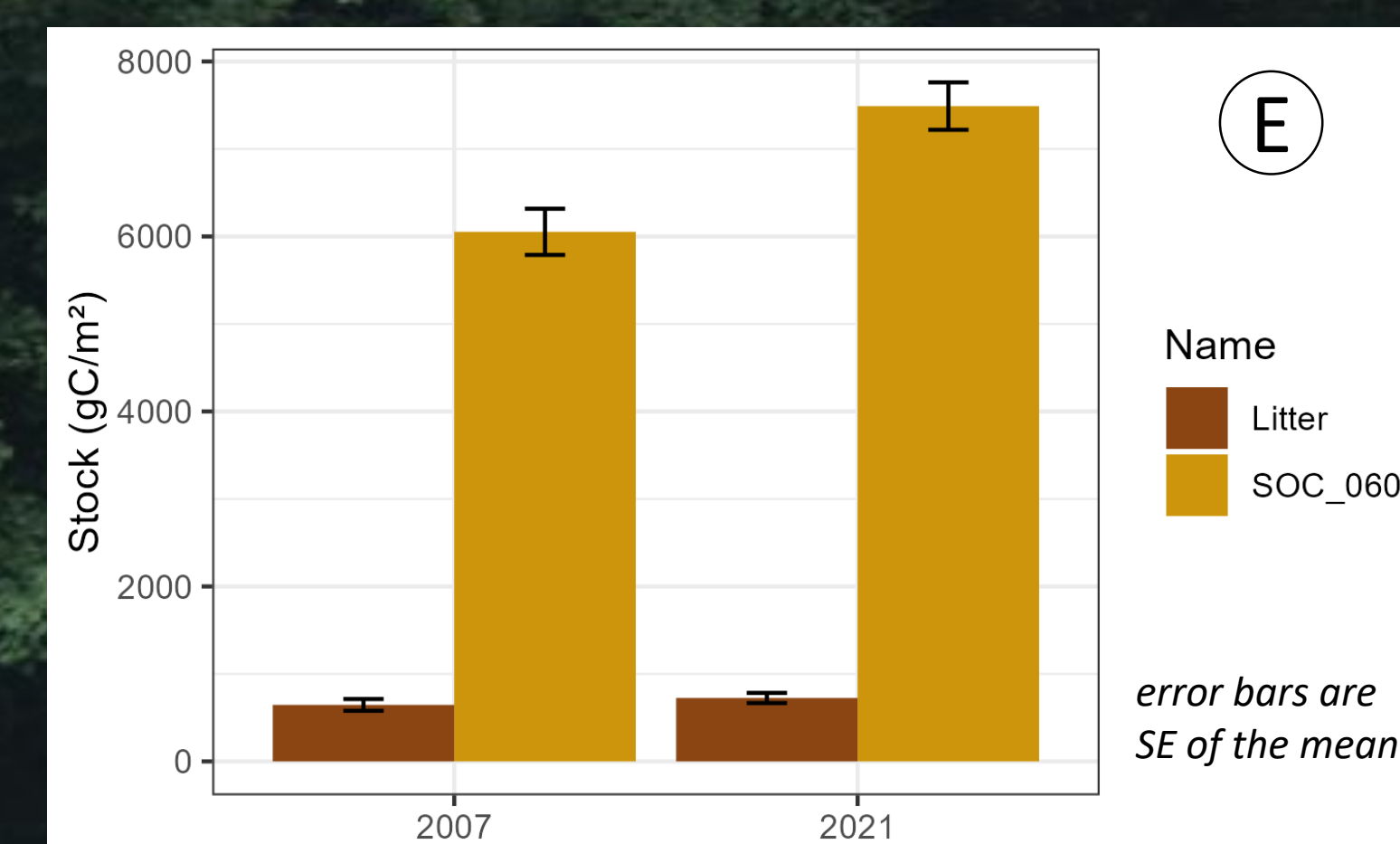
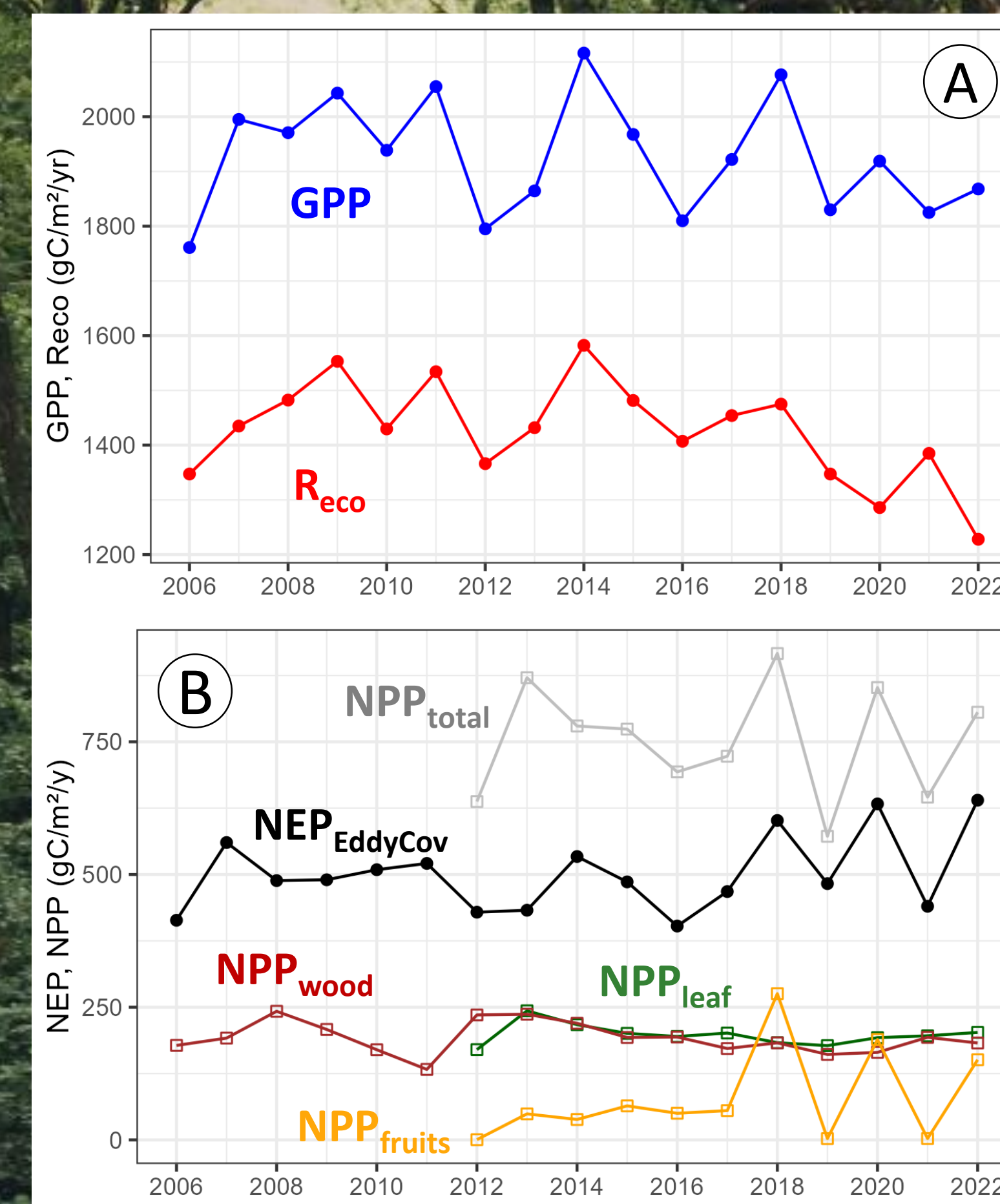
The study was conducted in the Fontainebleau-Barbeau forest (ICOS FR-Fon, MAT = 11.7°C, MAP = 657 mm), which is populated by sessile oak (*Quercus petraea*, max. 130-yr old, 79% of the basal area) and hornbeam (*Carpinus betulus*, max. 70-yr, 18% of b. a.). The forest stands on an endostagnic luvisol. Trees develop deep roots (down to 5-m), accessing deep soil water [2, 3].



Methods

We quantified NEP at the annual scale through flux (EC) and biometric approaches conducted over 14 years (2007-2021), encompassing the time interval between two SOC measurements campaigns.

Flux	Method	Type	Resolution	Period
NEP _{EC}	eddy covariance	flux meas.	hourly	2005-ongoing
NPP _{leaves}	litter traps	biometric	weekly	2012-ongoing
NPP _{fruits}	litter traps	biometric	weekly	2012-ongoing
NPP _{wood}	inventory + dendrometers (n=90)	biometric	weekly	2006-ongoing
NPP _{roots}	allometry (wrt wood and leaves)	allometric	annual	2006-ongoing
ΔSOC	soil coring	biometric	pluri-annual	2007 and 2021



Forest is a strong carbon sink

FR-Fon had an average annual NEP_{EC} of +502 gC/m²/y (Fig. B), that resulted from a GPP of 1927 gC/m²/y and Reco of 1425 gC/m²/y (Fig. A).

NEP_{EC} was higher than the average for mature temperate deciduous forests [4], in spite of a normal GPP, due to a lower Reco (Fig. C).

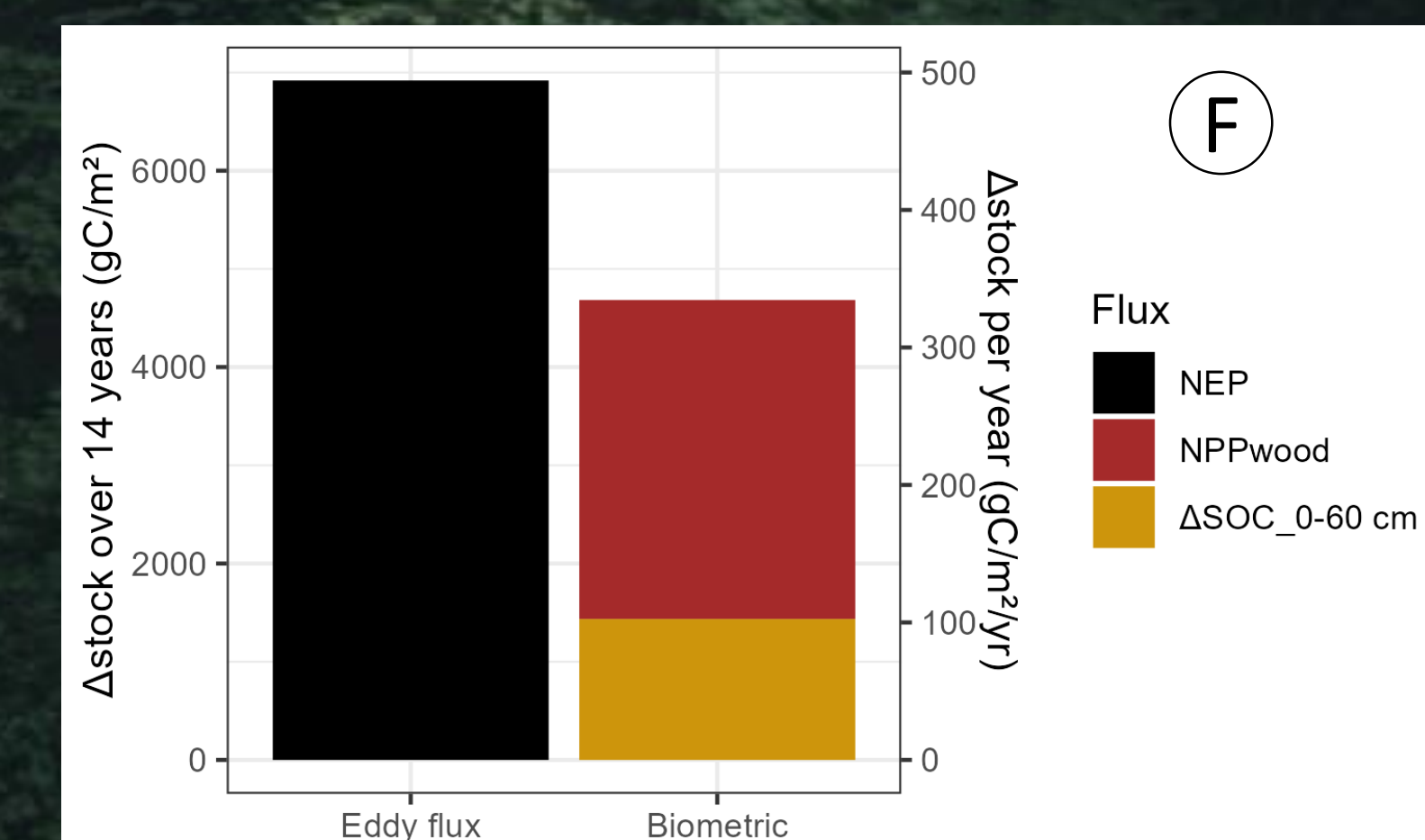
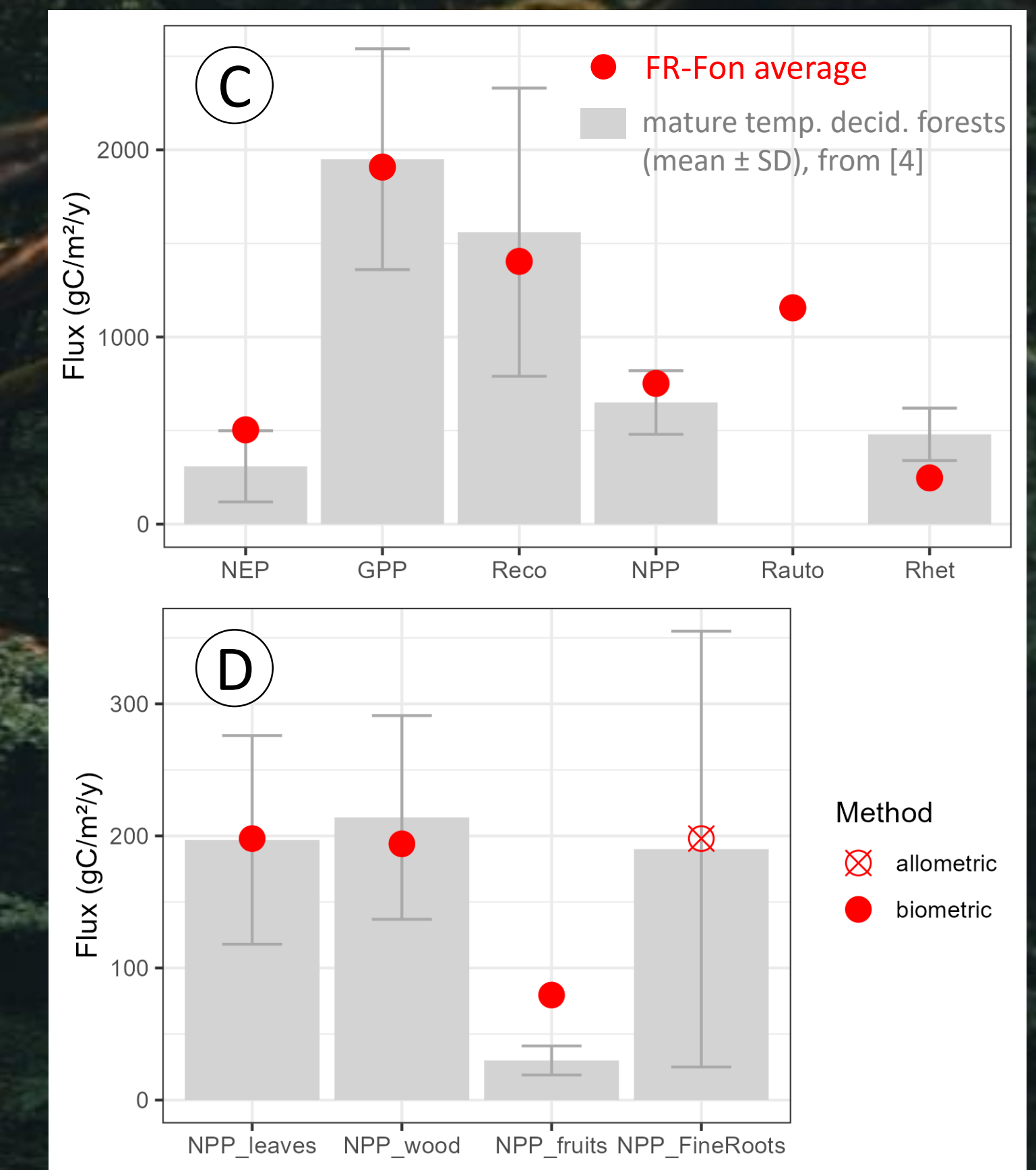
NPP/GPP ratio (average = 0.39, not shown) and calculated heterotrophic respiration (R_{het} = NPP_{total} - NEP_{EC}, Fig. C) suggested that some components of NPP (e.g. fine roots, Fig. D) have been underestimated or that NEP_{EC} has been overestimated.

Carbon accumulation in wood and soil

In temperate deciduous forests, shedding all leaves and fruits annually, carbon accumulation occurs in pools of slow turnover, i.e. wood, soil and litter.

Over 2007-2021, the stock of litter did not change at FR-Fon (but note that logs and coarse woody debris have not been measured), but SOC measured over 0-60 cm increased (Fig. E). This increase is considerable (+102 gC/m²/yr) and represents 30% of the forest perennial C stock increase (wood is the other 70%, with +232 gC/m²/yr) (Fig. F).

However the biometric estimate of NEP (ΔSOC + NPP_{wood}) misses 33% of the carbon accumulation measured by eddy covariance (Fig. F)



Conclusions

- Both the eddy flux and the biometric approach show that FR-Fon forest is a net carbon sink, accumulating carbon in the form of wood and organic matter in the soil.
- NEP_{EC} is probably overestimated due to air drainage of nighttime fluxes, as shown by comparison of the above-canopy eddy flux measurements with soil respiration and below-canopy eddy flux.
- Changes in the stock of roots has not been considered and might contribute to increase in the C stock.
- Increase in SOC is remarkable, in the high range of what has been reported in other French forests [5] and deserves further investigation.

References

[1] Campioli, M., Malhi, Y., Vicca, S., Luysaert, S., Papale, D., Peñuelas, J., ... & Janssens, I. A. (2016). Evaluating the convergence between eddy-covariance and biometric methods for assessing carbon budgets of forests. *Nature communications*, 7(1), 13717.

[2] Delpierre, N., Berveiller, D., Granda, E., & Dufrene, E. (2016). Wood phenology, not carbon input, controls the interannual variability of wood growth in a temperate oak forest. *New Phytologist*, 210(2), 459-470.

[3] Maysonave, J., Delpierre, N., François, C., Jourdan, M., Cornut, I., Bazot, S., ... & Berveiller, D. (2022). Contribution of deep soil layers to the transpiration of a temperate deciduous forest: Implications for the modelling of productivity. *Science of the Total Environment*, 838, 155981.

[4] Anderson-Teixeira, K. J., Herrmann, V., Morgan, R. B., Bond-Lamberty, B., Cook-Patton, S. C., Ferson, A. E., ... & Wang, M. M. (2021). Carbon cycling in mature and regrowth forests globally. *Environmental Research Letters*, 16(5), 053009.

[5] Jonard, M., Nicolas, M., Coomes, D. A., Caignet, I., Saenger, A., & Ponette, Q. (2017). Forest soils in France are sequestering substantial amounts of carbon. *Science of the Total Environment*, 574, 616-628.