Effects of fertilisation and understory removal on aboveground and belowground carbon stocks in wet and dry moorlands in south-western France

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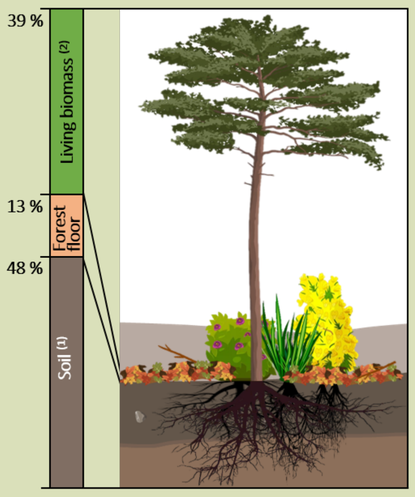
INTRODUCTION

Figure 1 *Percentage of carbon stored in three forest compartments [1]. (1) Soil estimates are based on 1 meter depth. (2) Living biomass estimates include aboveground and belowground biomass.*



These estimates are means for temperate forests.

◈ Forests provide valuable ecosystem services, e.g. biomass production or carbon (C) storage, that are increasingly threatened by global changes such as droughts and depletion of non-renewable nutrients (e.g. phosphorus).

◈ Fertilisation and understory removal are two practices commonly set up in south-western french moorlands to improve tree growth as the understory vegetation strongly influences water availability, and P fertilisation influences soil phosphate availability [2].

◈ Little is known about the effects of these practices on soil functioning and carbon pools at the ecosystem scale.

◈ **In this study, the main objective was to investigate the effects of understory removal and fertilisation on C stocks in the living biomass as well as in the underlying soil.**

MATERIALS AND METHODS

2 sites located in wet and dry moorlands in southwestern France, with the same crossed 2 factors: P supply (-P / +P) and understory management (-U / +U), meaning 4 treatments total:

◈ **Understory characteristics:**
Wet moorland: dominated by herbaceous species, gorse and ericaceous shrubs, but also sparce ferns and woody plants.
Dry moorland: largely dominated by ericaceous species and mosses, with small patches of other woody plants.

◈ **Field work:**
Forest floor: rectangles of 10 * 20 cm collected in all plots in spring 2021.
Soil: 3 soil cores collected at 3 depths in all plots in spring 2021.
Trees: height and circumference.
Understory: estimation of the aboveground biomass in furrows in summer 2021.

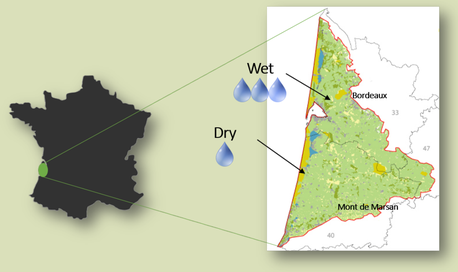
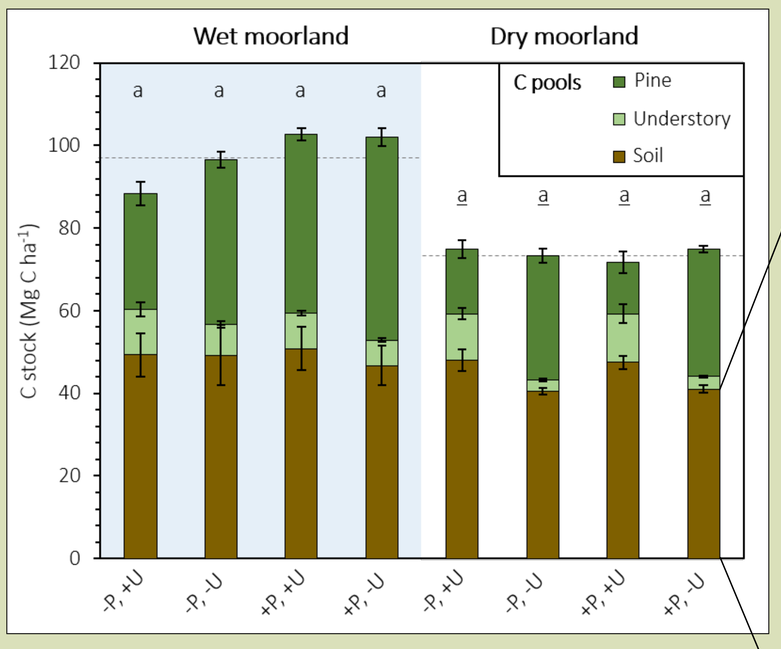


Figure 2 *Pictures of plots with and without understory in the dry moorland*

RESULTS & DISCUSSION

Figure 3 *Interactive effects of fertilisation and understory removal on carbon pools in wet and dry moorlands. Pine and understory C stocks consider both aboveground and belowground C stocks. The dotted lines represent the mean total C stocks in wet and dry moorlands.*
Treatments: -P = unfertilised; +P = fertilised; +U = understory preserved; -U = understory removed.



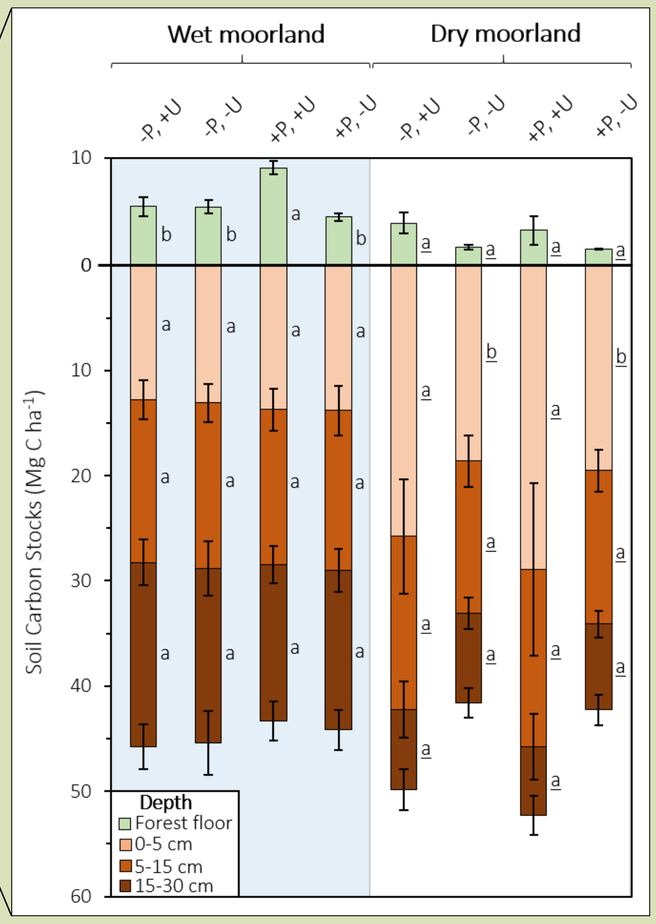
Effects of fertilisation and understory removal on ecosystem C pools

◈ The treatments did not affect significantly C pools at the ecosystem level.

◈ In the wet moorland: fertilisation tended to increase the overall C budget at the ecosystem-level (not significant), led by an increase in pine biomass only, suggesting that a longer time period may be needed to fully assess the advantage of fertilisation on the overall C budget.

◈ In the dry moorland: a strong trade-off took place between the C stored in the biomass and the C stored in the soil, leading to a relatively stable C budget when the understory was removed.

Figure 4 *Interactive effects of fertilisation and understory removal on soil organic carbon (SOC) stocks in wet and dry moorlands. Bar plots represent means of SOC stocks for each soil layer and error bars represent standard errors of the mean.*
Treatments: -P = unfertilised; +P = fertilised; +U = understory preserved; -U = understory removed.



Légende

- P = unfertilised
+P = fertilised
- U = understory removed
+U = understory present

Effect of fertilisation and understory removal on soil C stocks

◈ In the wet moorland: fertilisation only affected soil C stocks of the forest floor in the P-fertilised plots where the understory vegetation was left untouched.

◈ In the dry moorland: understory removal strongly decreased soil C stocks, particularly in the horizon 0-5 cm.
This may be due to the presence of ericaceous shrubs that lock up carbon and nutrients in the organic matter through the production of highly recalcitrant litter. Furthermore, these plants are commonly associated with ericoid fungi, that may hamper saprotrophic decomposition by inducing competition, and store C in their melanised fungal necromass.

Take home message

◈ These results indicate that a "win-win" scenario, i.e., optimising simultaneously tree biomass and soil C storage, was not achieved in our study system.

◈ The composition of the understory layer was important when looking at soil processes in our sites.

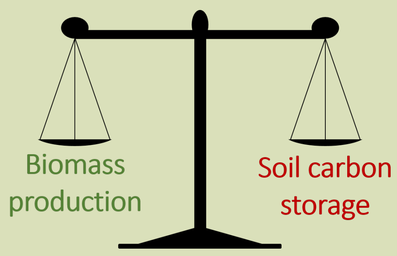
◈ The effects of the treatments are site-dependent, suggesting that it is necessary to adapt forest management practices to the environmental context.

CONCLUSION

◈ This study demonstrated that the impact of silvicultural practices on tree growth and soil C stocks depends closely on the environmental context.

◈ It is not always possible to improve C storage in both tree aboveground biomass and the soil.

◈ It is necessary to assess the relative importance of different resources such as water and nutrients if we aim at optimising tree growth and soil C stocks at the ecosystem scale.



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[1] Pan et al. (2011) - doi: 10.1126/science.1201609 ; [2] Balandier et al. (2006) - doi:10.1093/forestry/cpi056