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The dynamic of annual carbon allocation to wood in european forests is consistent with a combined source-sink limitation of growth: Implications on growth simulations in a terrestrial biosphere model

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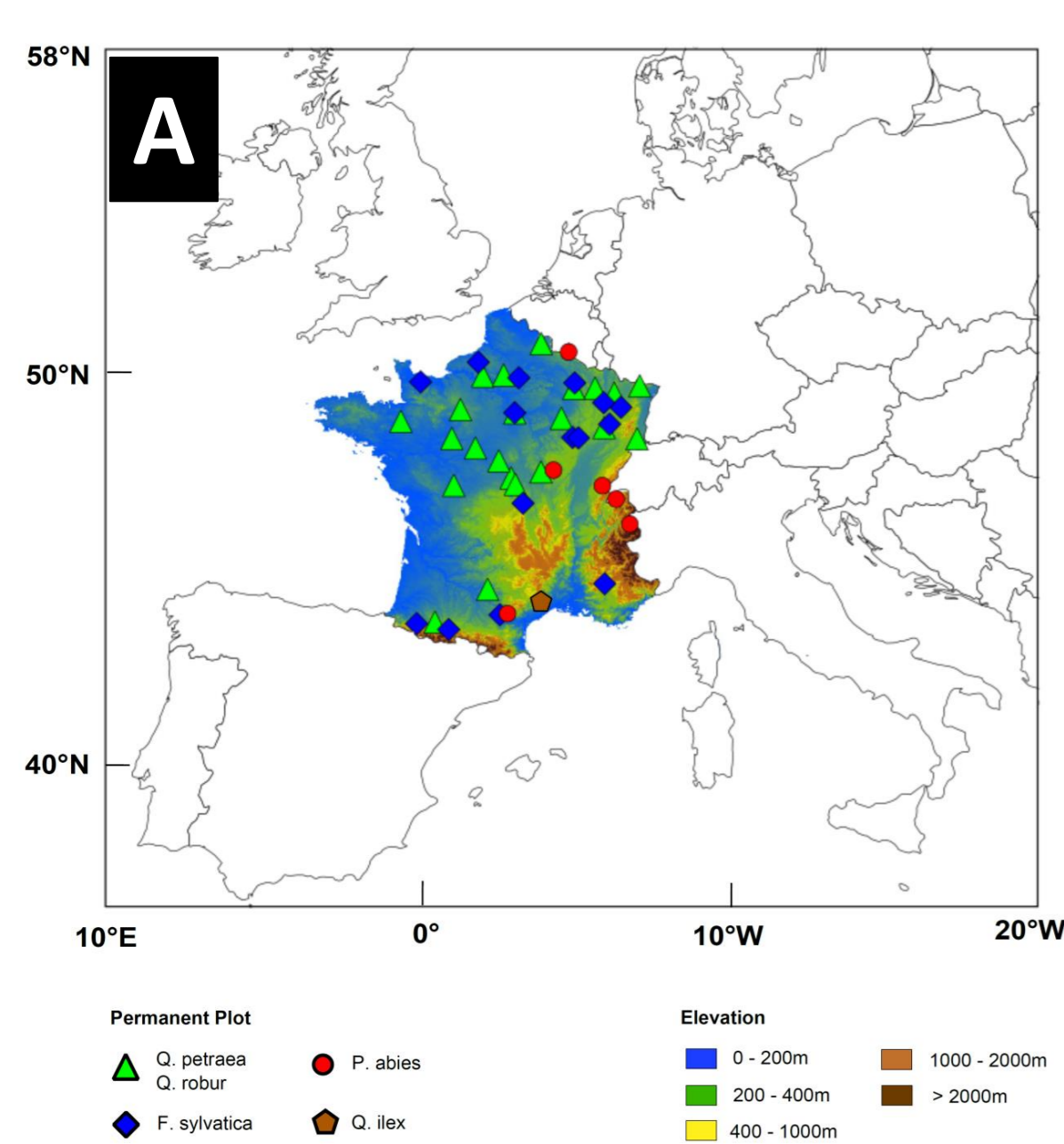
Introduction

- ❑ The physiological processes underlying the limitation of forest growth are still under debate. A number of recent local investigations challenge the historical view of a strict carbon (C) limitation of growth that is the basis of the C allocation rules of most terrestrial biosphere models (TBMs).
- ❑ The extent to which forest growth is under a C source- or a sink- control is of paramount importance to predict how trees will respond to global changes, especially with regards to the potential fertility effect of rising atmospheric CO₂.

Objectives

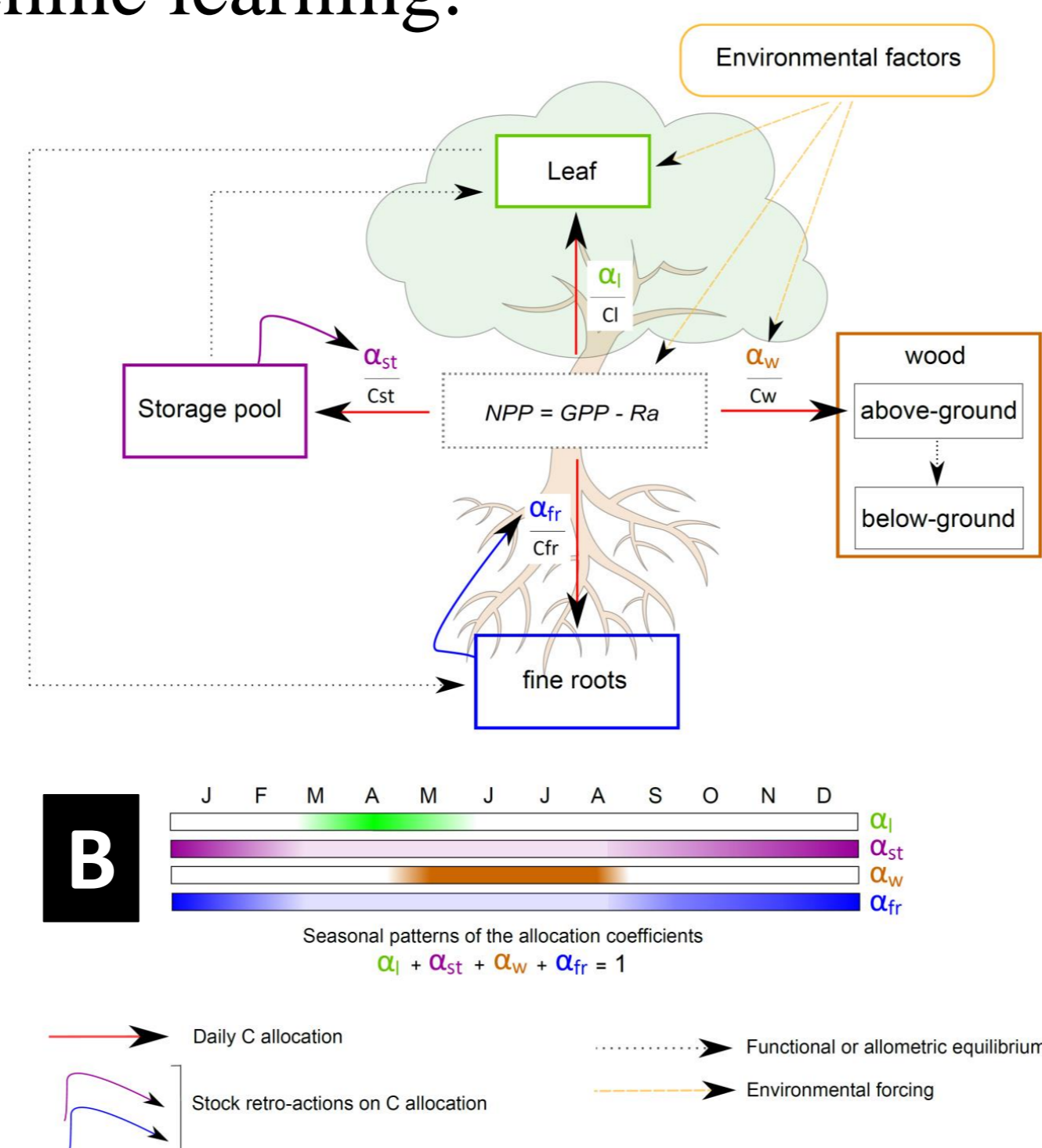
- ❑ To evaluate the dynamics of annual C allocation to wood along regional gradients in 5 major European tree species (in relation to environment and C budget)
- ❑ To implement the revealed C allocation rules within the CASTANEA TBM and evaluate the simulated wood productivity at regional scale
- ❑ To evaluate the implications of our new allocation scheme for the productivity of French forests along the 21st century

Material and Methods



- 4 species from sites representative of the main European biomes.
- C allocation to wood inferred from growth measurements (RENECOFOR permanent plots [A]) and simulated GPP and NPP.
- Assessment of inter-site and inter-year drivers using a Random Forest machine learning.

- C allocation scheme in CASTANEA: 4 compartments in semi-competition for C supply ([B, 1]).
- Simulated growth results from both source- and sink-limitations (direct effects of water and temp. stresses on growth).

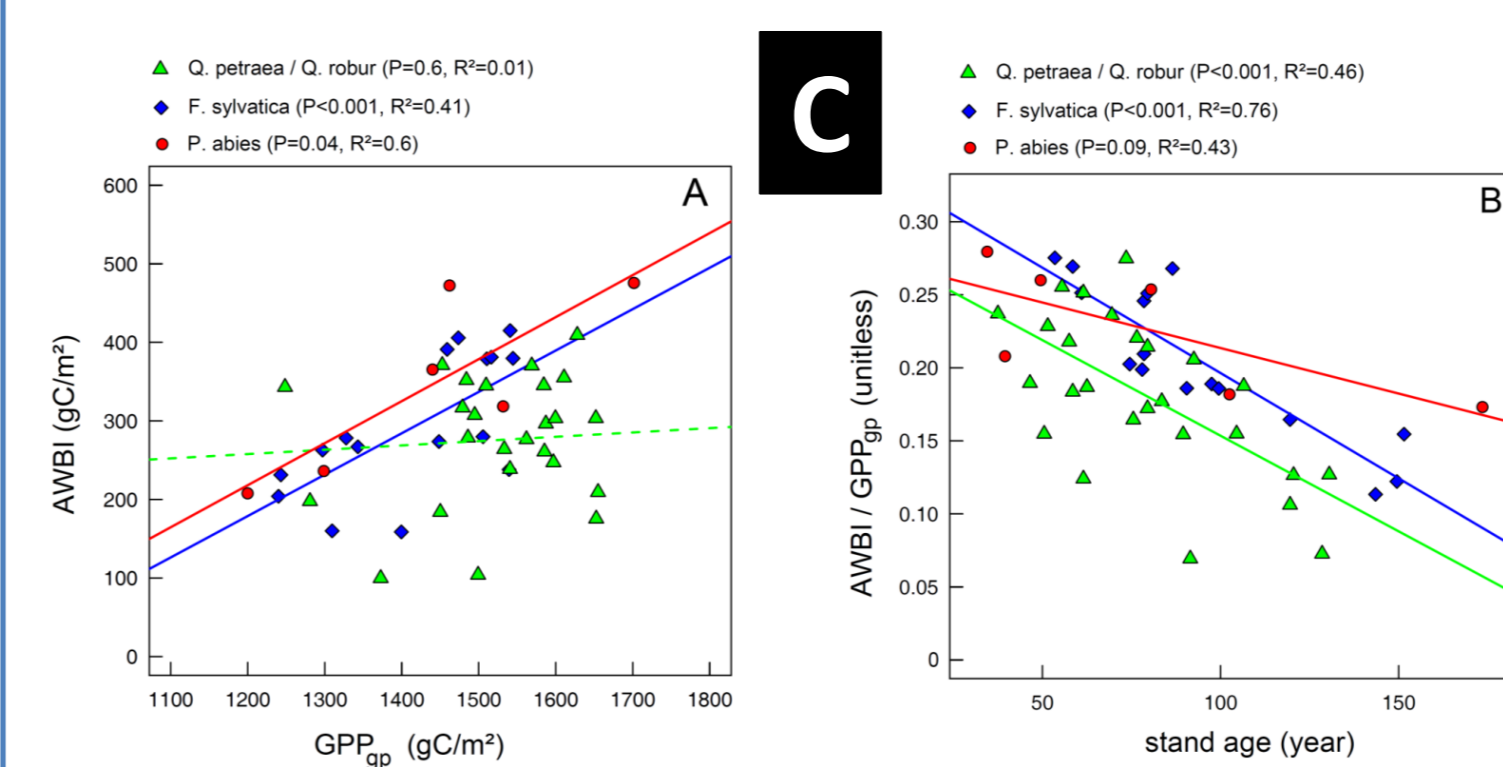


- Performance evaluation was based on the French forest national inventory (5 years of stand biomass increments on >10000 sites).
- Parameters of the allocation scheme were adjusted using a Bayesian optimization (6 param.) and validated on an independent subsample.
- Projections were based on the IPCC AIB scenario [2].

Conclusion

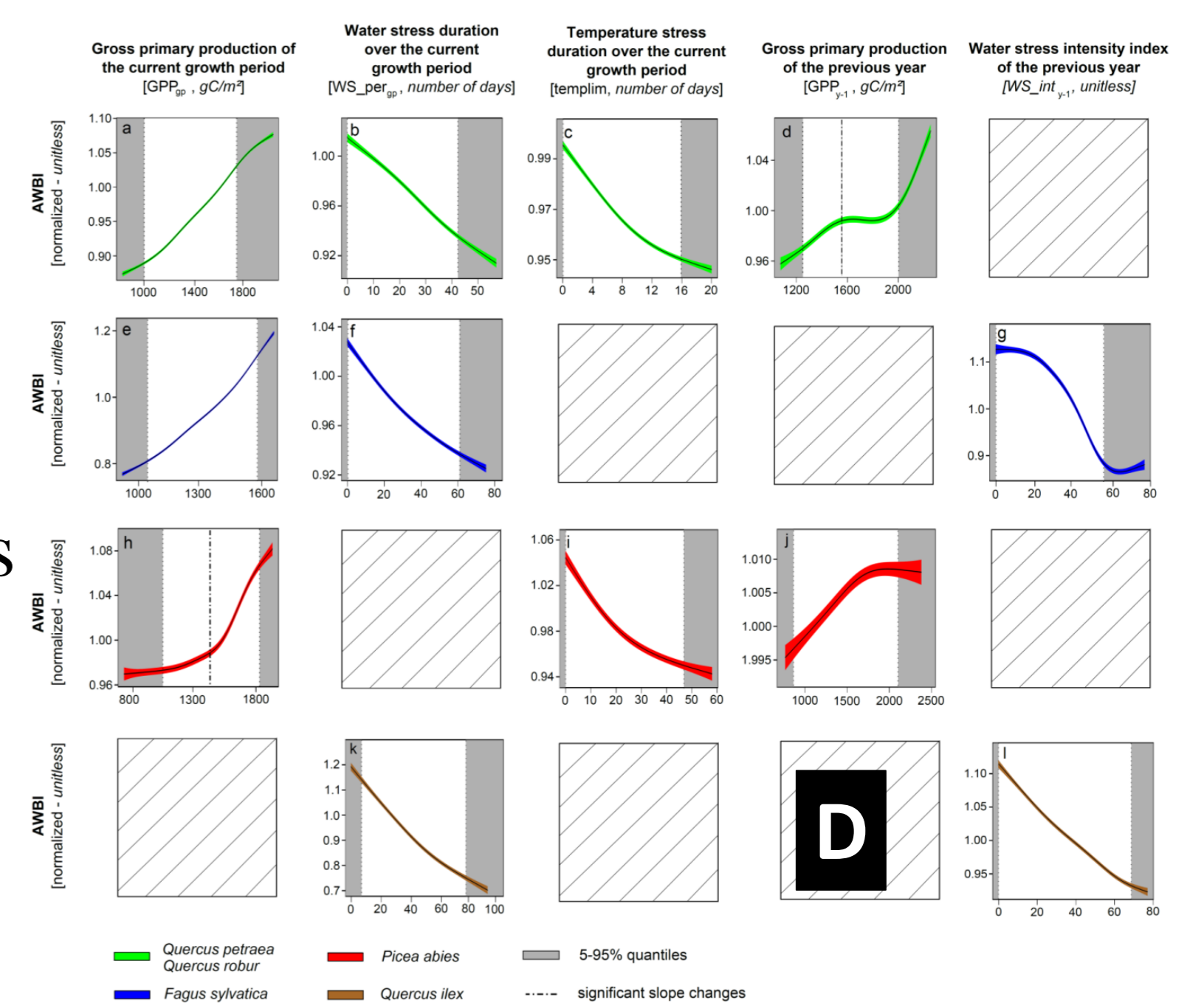
- ❑ European forest growth is under a complex panel of source and sink limitations, related to ontogeny, direct effect of water shortage and lagged response to past condition.
- ❑ C supply – growth homeostasis and sink controls should both be involved in growth modeling. This will strongly change our predictions regarding the future of forest growth.

Results and Discussion



- GPP – growth relationship is not consistent in temperate oak across France ([C]).
- Inter-site variability of C allocation to wood was mainly driven by an age-related decline.

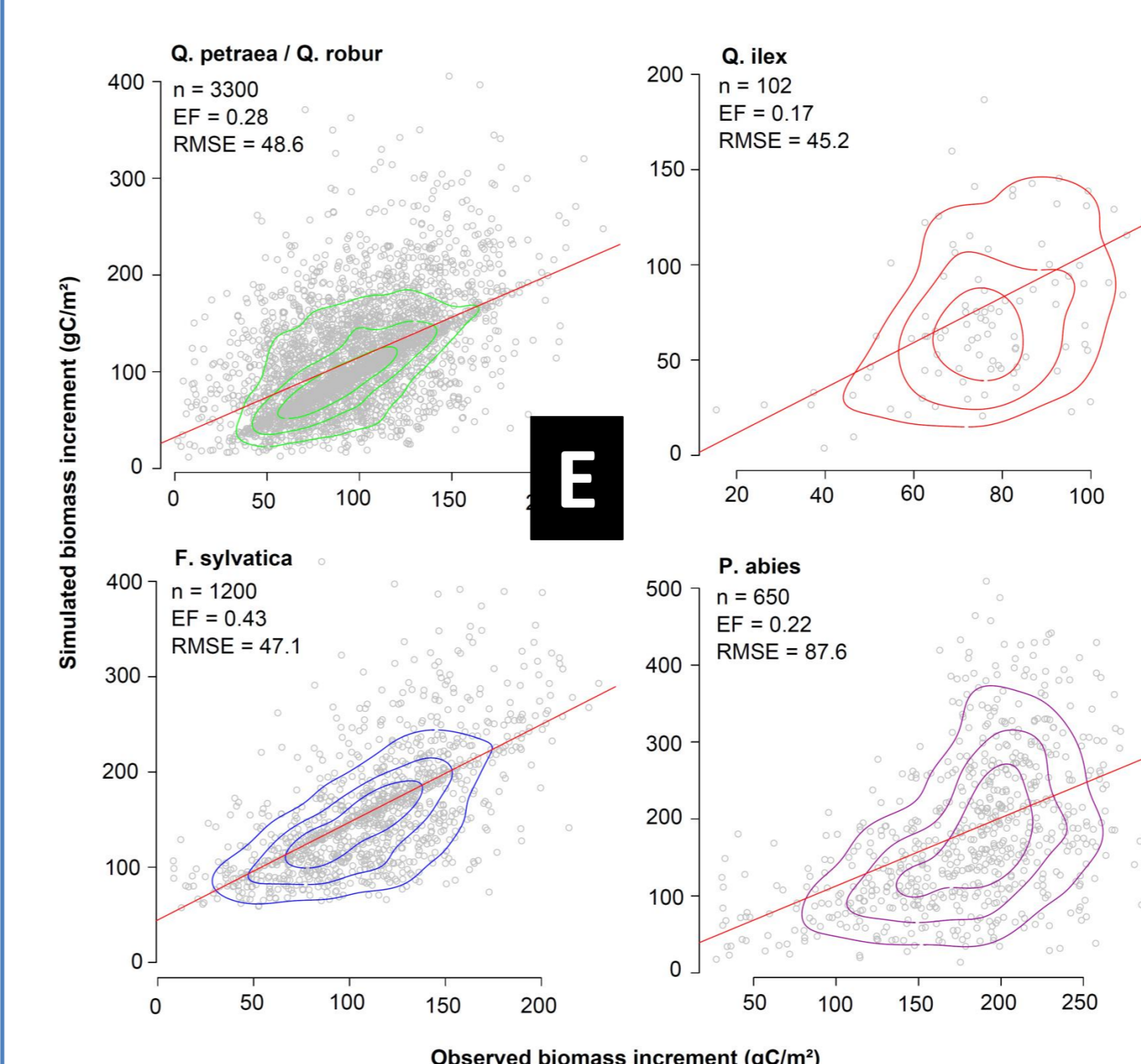
- The direct control of temperature or water stress on sink activity exerted a strong influence on the annual wood growth ([D]).



- The lagged effect of the past environment conditions was a significant driver of the annual C allocation to wood ([D]).

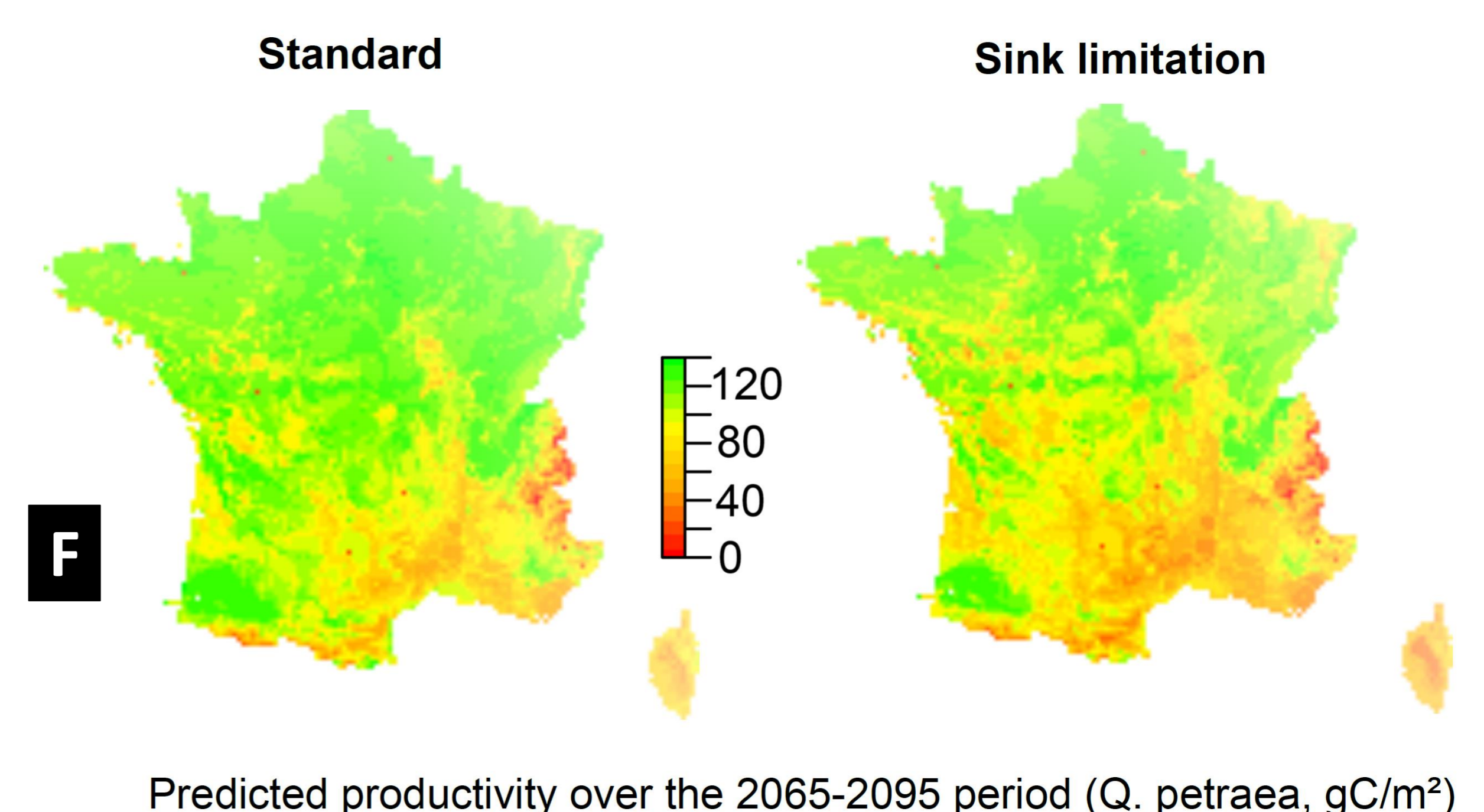
- C supply strongly limited growth only in deciduous temperate species.

- The source- sink- C allocation scheme performed satisfactorily against observed forest productivity ([E]), unlike the CASTANEA standard version (*data not shown*).



- It is crucial to evaluate TBMs against productivity (flux) rather than against stand biomass (stock) to gain insight into the underlying processes of forest growth.

- The CASTANEA projections for the French forest productivity are strongly affected by the implementation of the sink-limitation of growth ([F]).



Predicted productivity over the 2065-2095 period (Q. petraea, gC/m²)