

A decade of interspecific interaction dynamics in agroforestry plantations including tree and crop nitrogen-fixing species in northeastern France



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Context and objectives

Increasing demand:

- for renewable energy sources, including **wood biomass**
- for more **sustainable production systems**

➔ **Agroforestry combining fast growing tree species and nitrogen fixing species**

What is the dynamic of species interactions in this kind of temperate agroforestry systems?

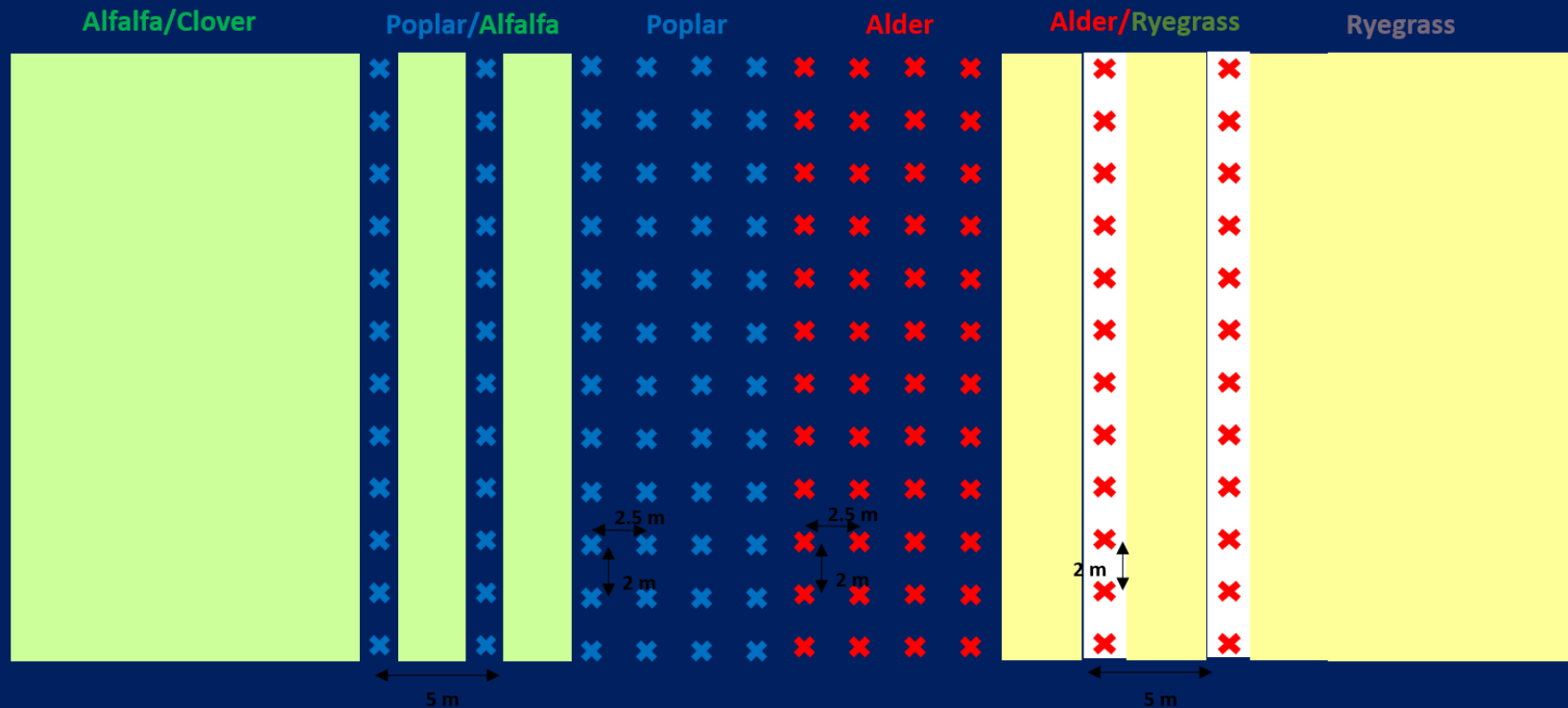
(from the tree growth and development point of view)



Experimental trial

Two tree species and two crops in association or in monoculture

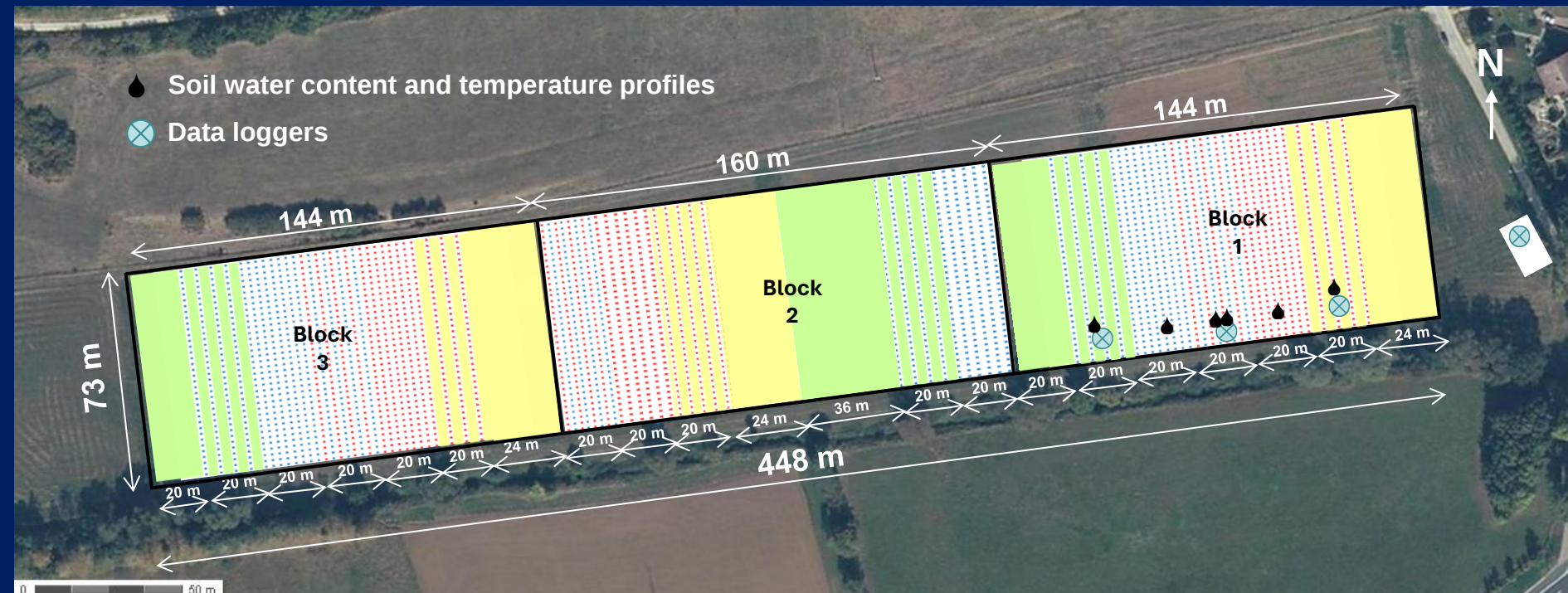
- Poplar (*Populus deltoides* × *Populus nigra*)
- Alder (*Alnus glutinosa*)
- Alfalfa (*Medicago sativa*, 2014-2018), clover (*Trifolium pratense*, 2018-2022)
- Temporary grassland (ryegrass, fescue)





Experimental trial

Three blocks, instrumented for the monitoring of pedoclimatic conditions



Alfalfa (then clover) plot

Poplar / alfalfa (then clover) mixture

Poplar monoculture

Poplar / alder mixture

Alder monoculture

Alder / graminoids mixture

Graminoids plot



Experimental trial

Technical itinerary over time



August 2014

Year 1



August 2015

Year 2



August 2016

Year 3



August 2017

Year 4



July 2018

Year 5



August 2019

Year 6



August 2020

Year 7



August 2021

Year 8



July 2022

Year 9



February 2023

Reset!



July 2023

Year 10



June 2024

Year 11

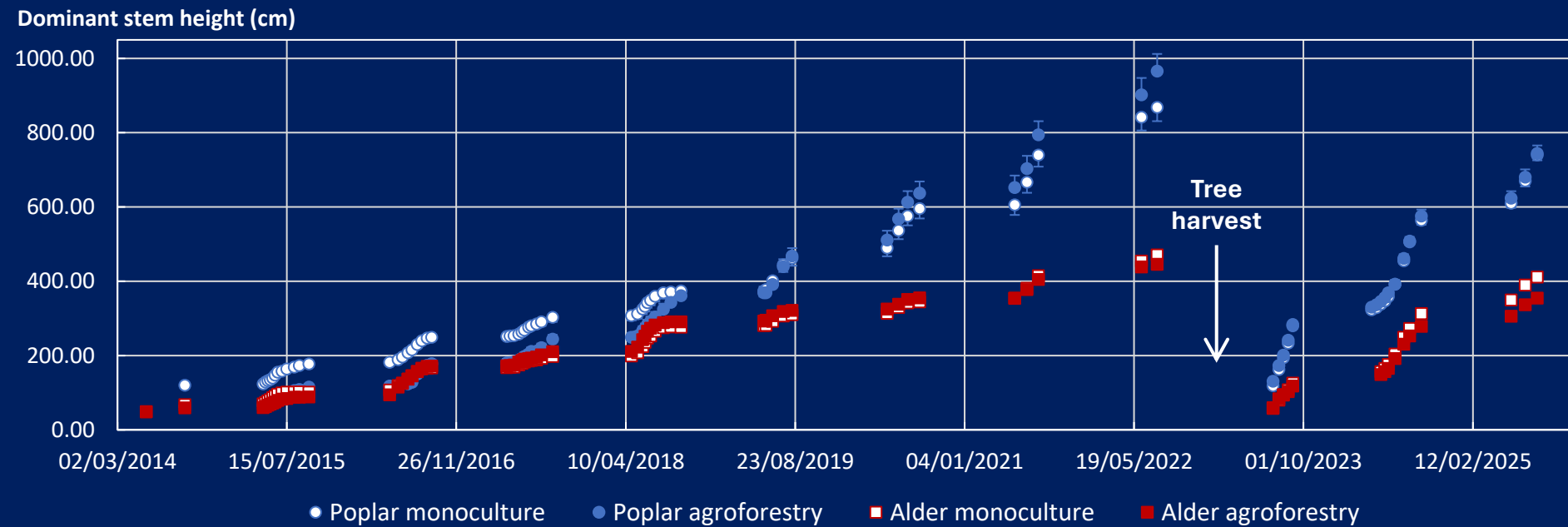


September 2025

Year 12



Interaction dynamics

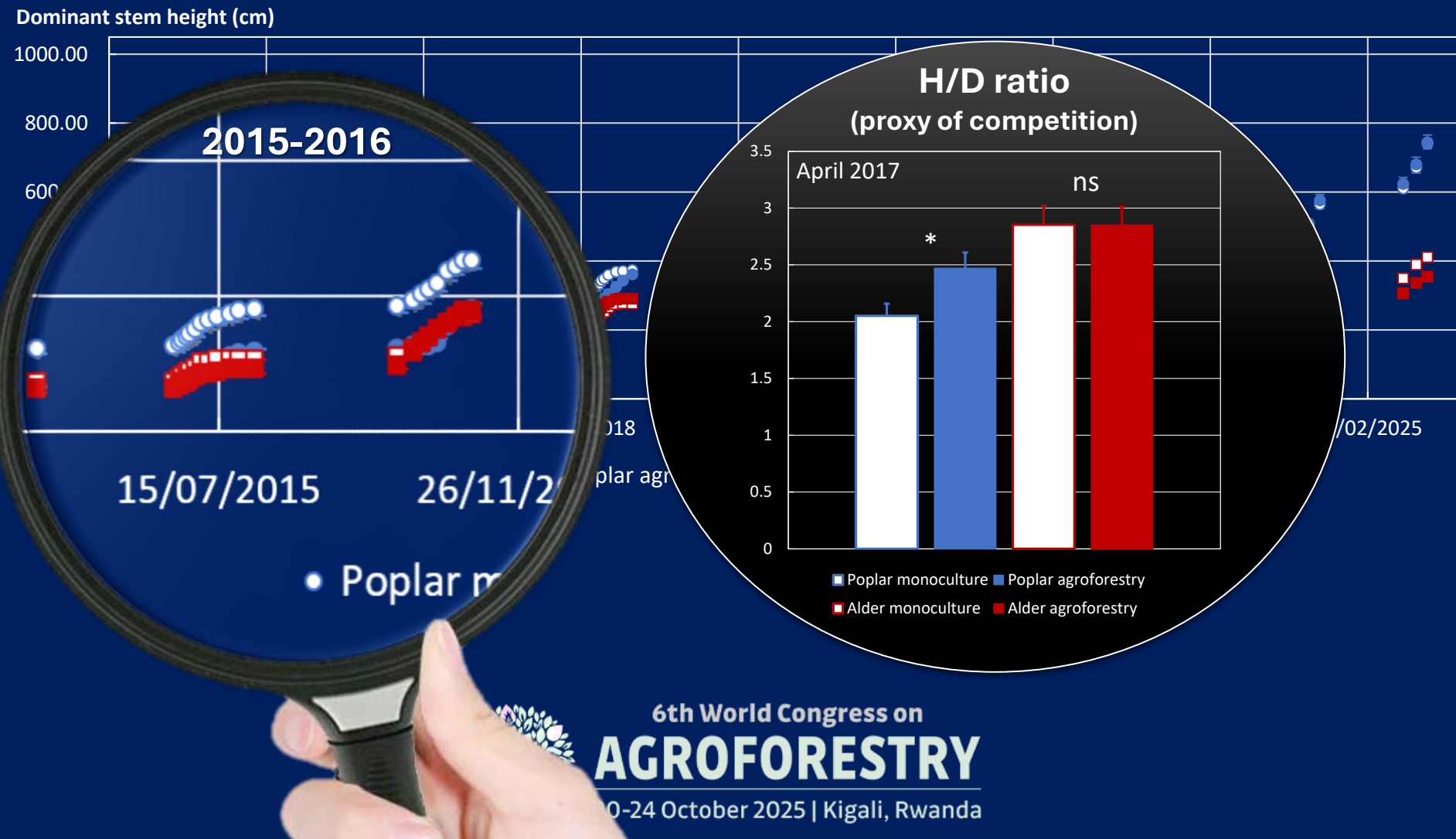


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Interaction dynamics

Period 1 (beginning of rotation): Tree growth (and survival) challenged by crops in AF



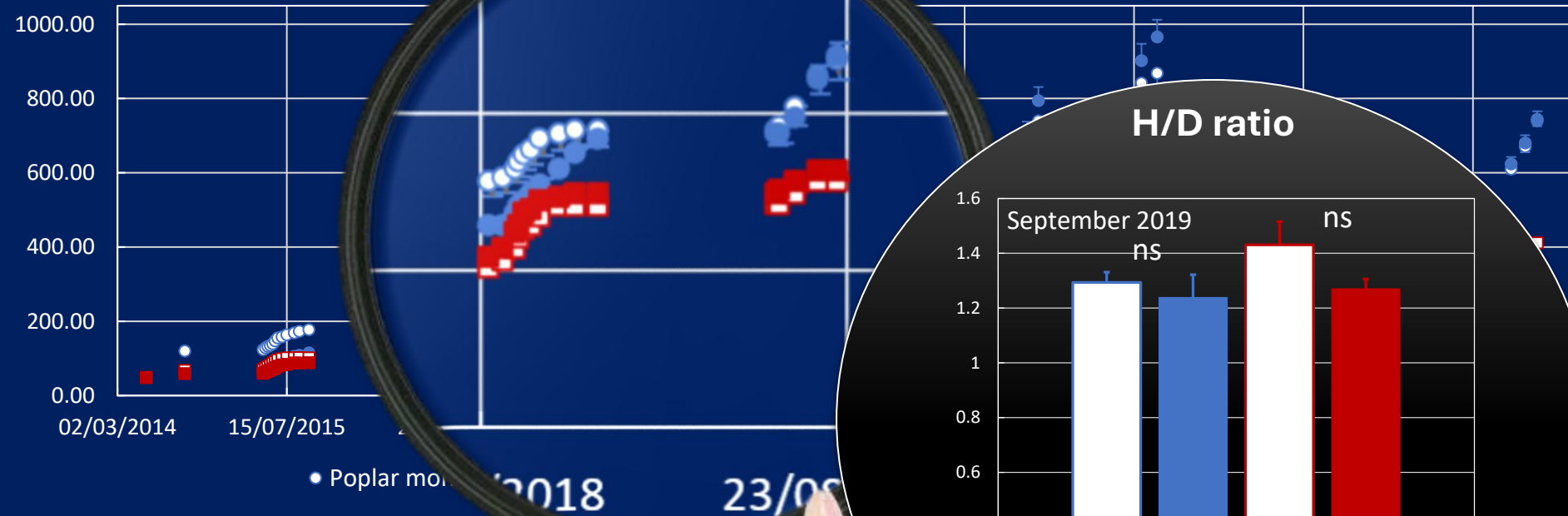


Interaction dynamics

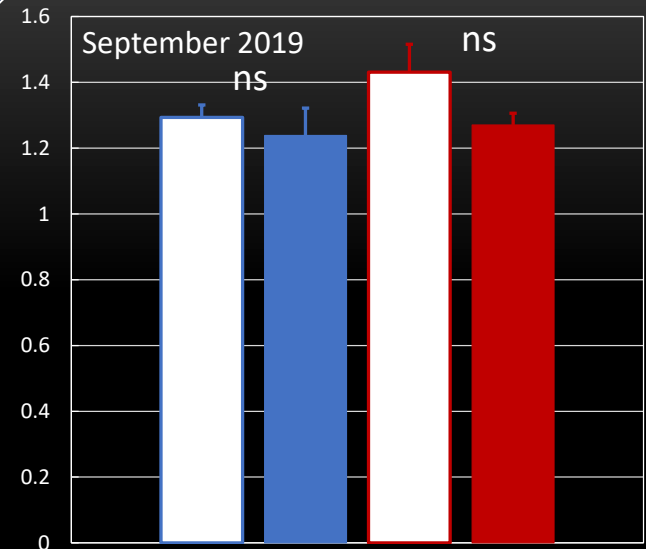
**Period 2 (middle of rotation): Tree growth boosted by crops in AF
(no difference anymore between monoculture and AF)**

Dominant stem height (cm)

2018-2019



H/D ratio



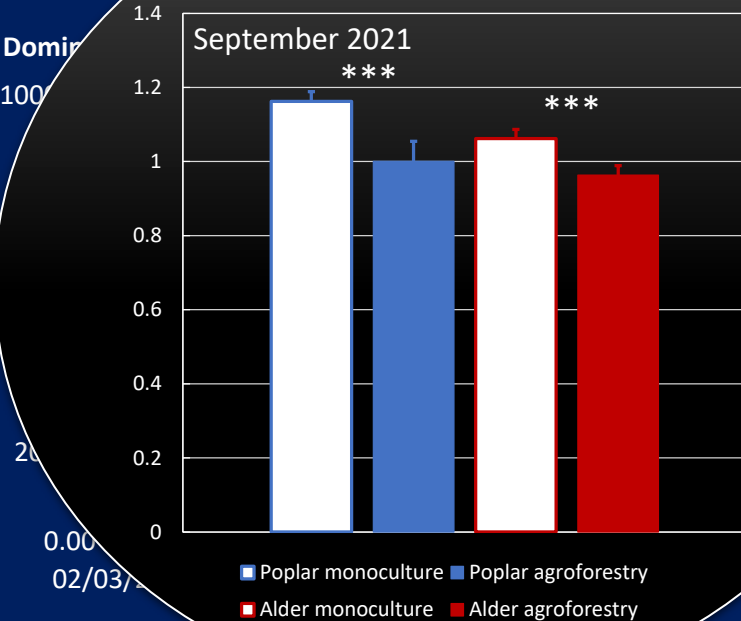
A
20-24



Interaction dynamics

H/D ratio

September 2021



2021-2022



Period 3 (end of rotation): Tree highly competitive in AF

➔ Tree harvest



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Interaction dynamics

Period 4 (new rotation): Already more competition among trees in monoculture than in AF

Dominant stem height (cm)

1000.00
800.00
600.00
400.00
200.00
0.00

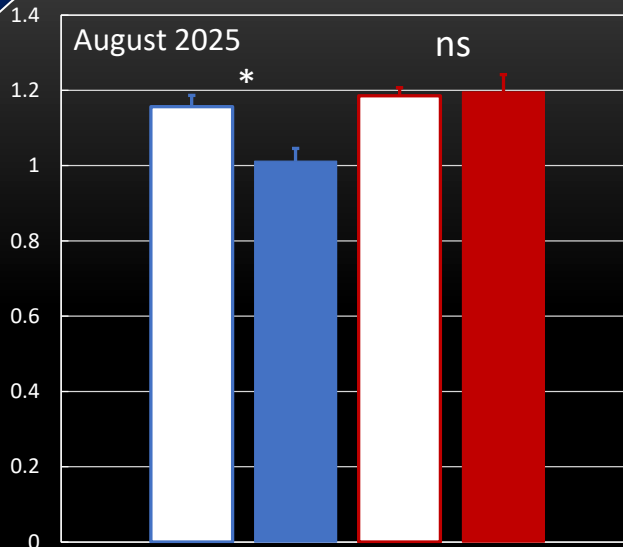
02/03/2014

1

H/D ratio

August 2025

ns



■ Poplar monoculture ■ Poplar agroforestry
■ Alder monoculture ■ Alder agroforestry

4/01/2021

19/05/2022

Alder monoculture

■ Alder agroforestry

2024-2025



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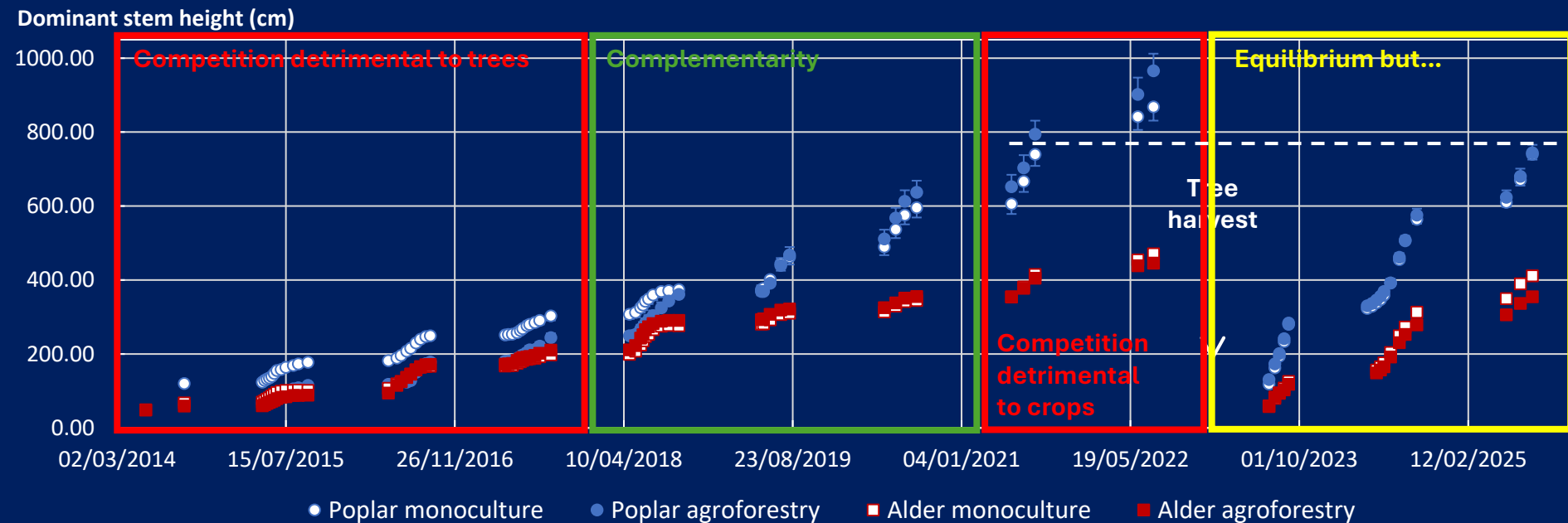
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Interaction dynamics

In summary...

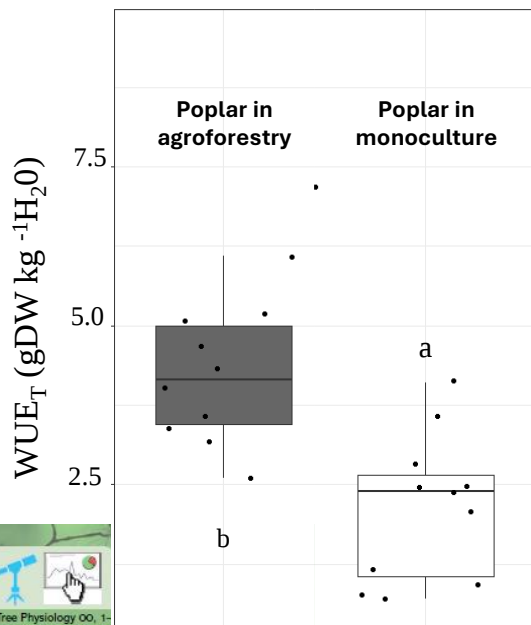


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Strikable results over time

Impact of AF on other factors than tree growth: **Water-Use Efficiency**

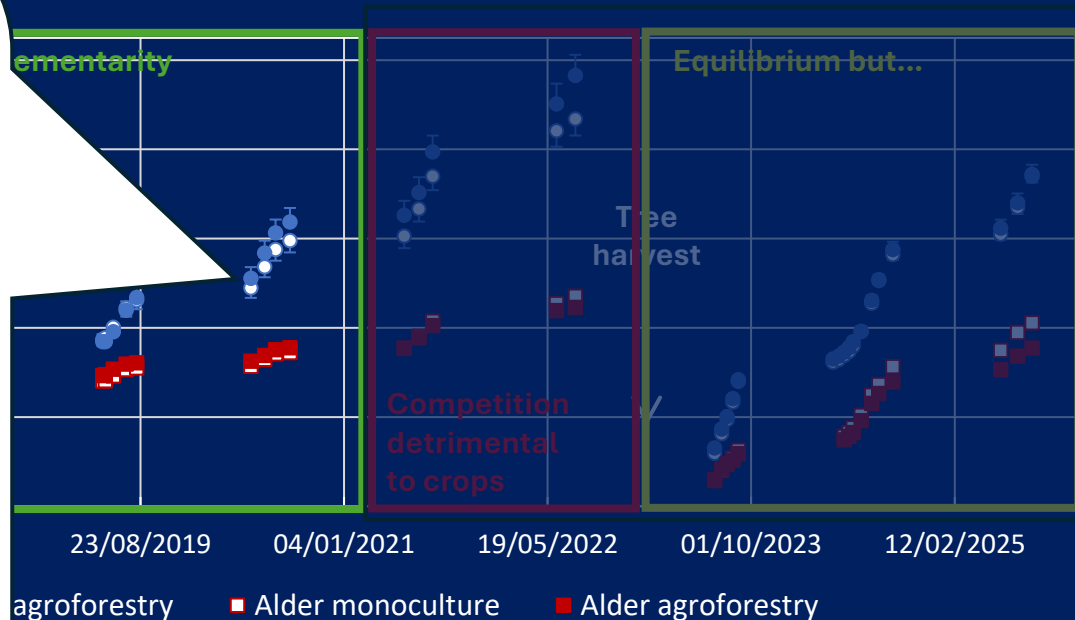


Tree Physiology 00, 1-11
<https://doi.org/10.1093/treephys/tpac094>

Research paper

Leaf and tree water-use efficiencies of *Populus deltoides* × *P. nigra* in mixed forest and agroforestry plantations

Anaïs Thomas¹, Nicolas Marron¹, Damien Bonal¹, Séverine Piutti², Erwin Dallé¹ and Pierrick Priault^{1,3}

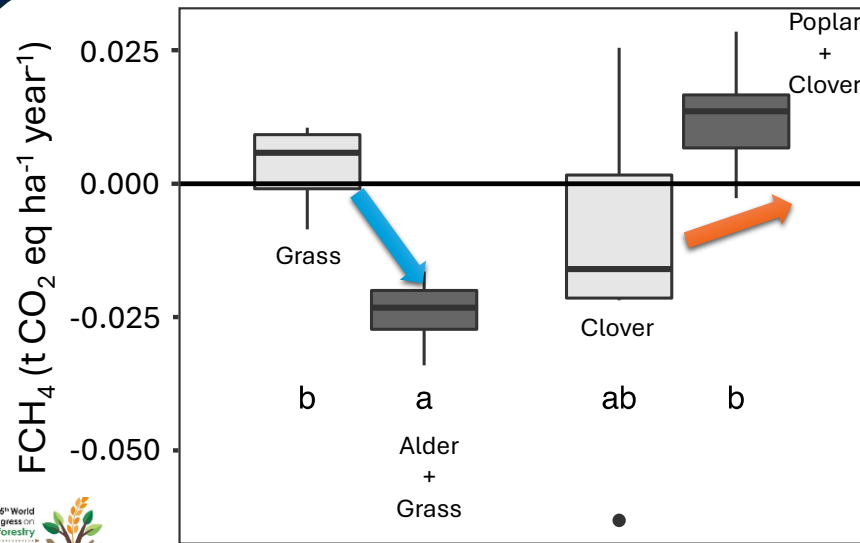


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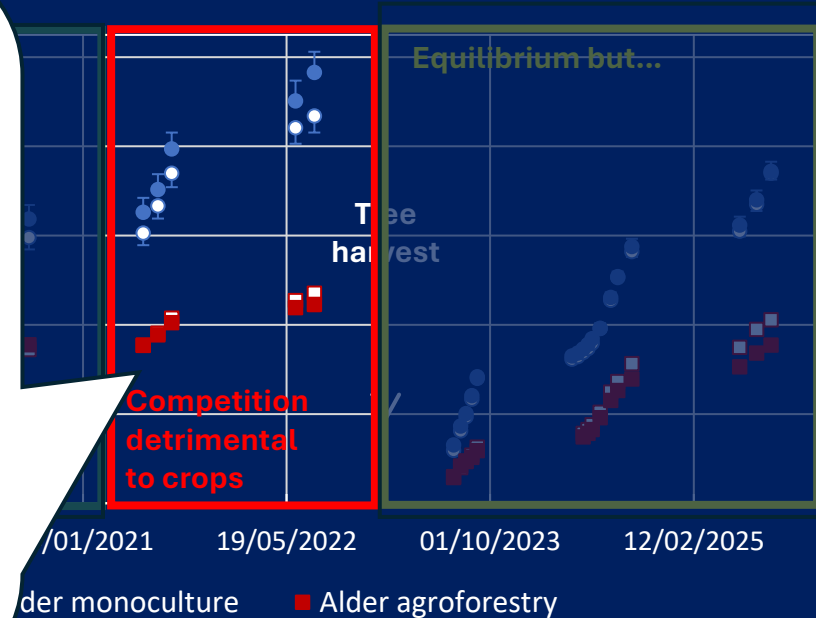
Strikable results over time

Impact of AF on other factors than tree growth: **Soil methane emissions**



Does alley cropping agroforestry with nitrogen-fixing species mitigate greenhouse gas emissions?

[Plain Caroline](#)¹, [Marron Nicolas](#)¹, [Piutti Séverine](#)², [Dallé Erwin](#)¹, [Epron Daniel](#)^{1,3}



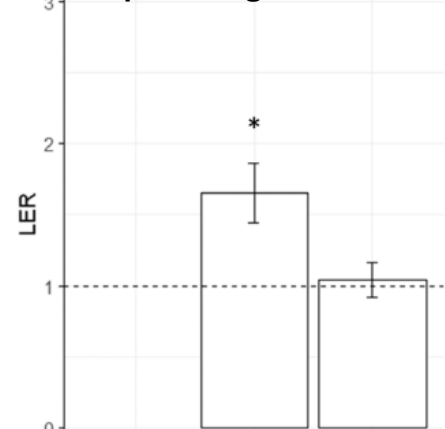
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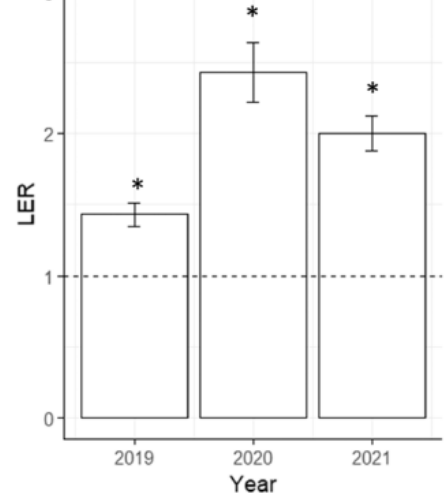
Strikable results over time

Impact of AF on other factors than tree growth: Land Equivalent Ratio

A Poplar + Leguminous

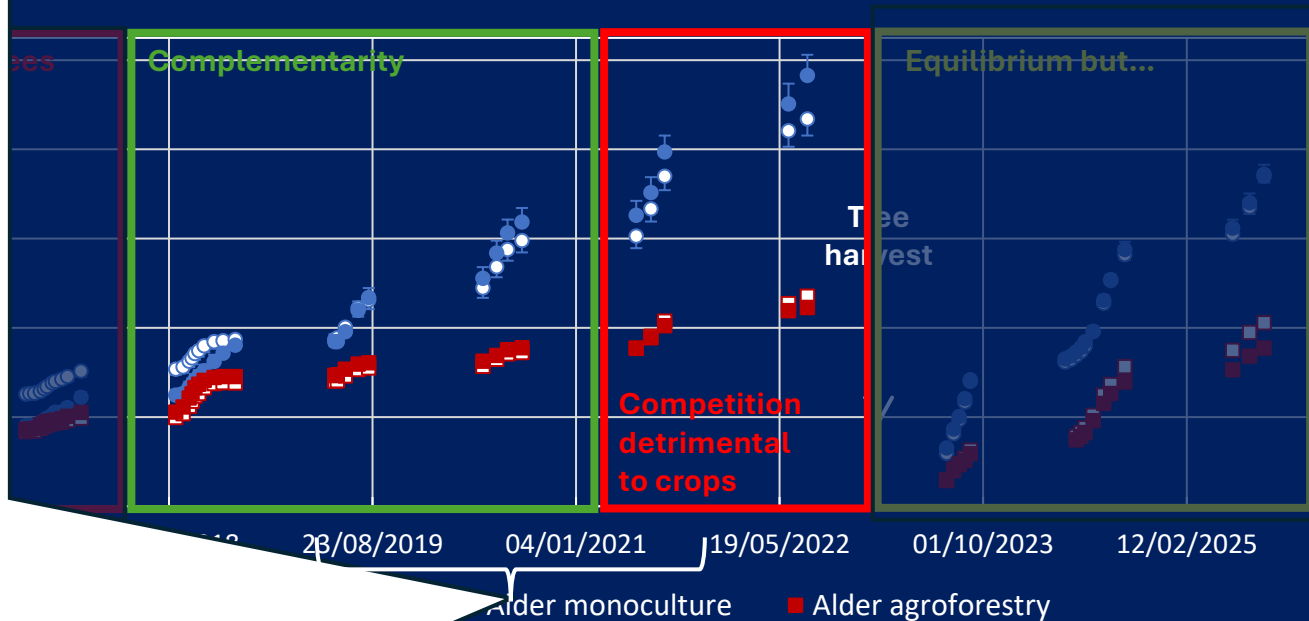


B Alder + Grass



N₂-fixing species benefit biomass production in agroforestry mixtures depending on spatial scale and plantation age but not in the mixed forestry system

Abdoulaye Ndiaye^a, Pierrick Priault^a, Erwin Dallé^a, Alexandre Larlotte^b, Nicolas Marron^{a, *}



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Take home messages

Alley cropping AF including N₂-fixing species and fast-growing tree species can have highly positive effects on parameters such as:

- **Global yields**
- **Efficiency to use resources**
- **Green house gas emissions**

But **positive effects can become negative** depending on:

- **The timing!** (aka development stage of trees)
- **The kind of species association**



THANK YOU!

Merci!

SOME QUESTIONS?

More information: <https://potage.hub.inrae.fr/agro-tcr-site-pilote>

Poster by Ndiaye et al. about tree root biomass