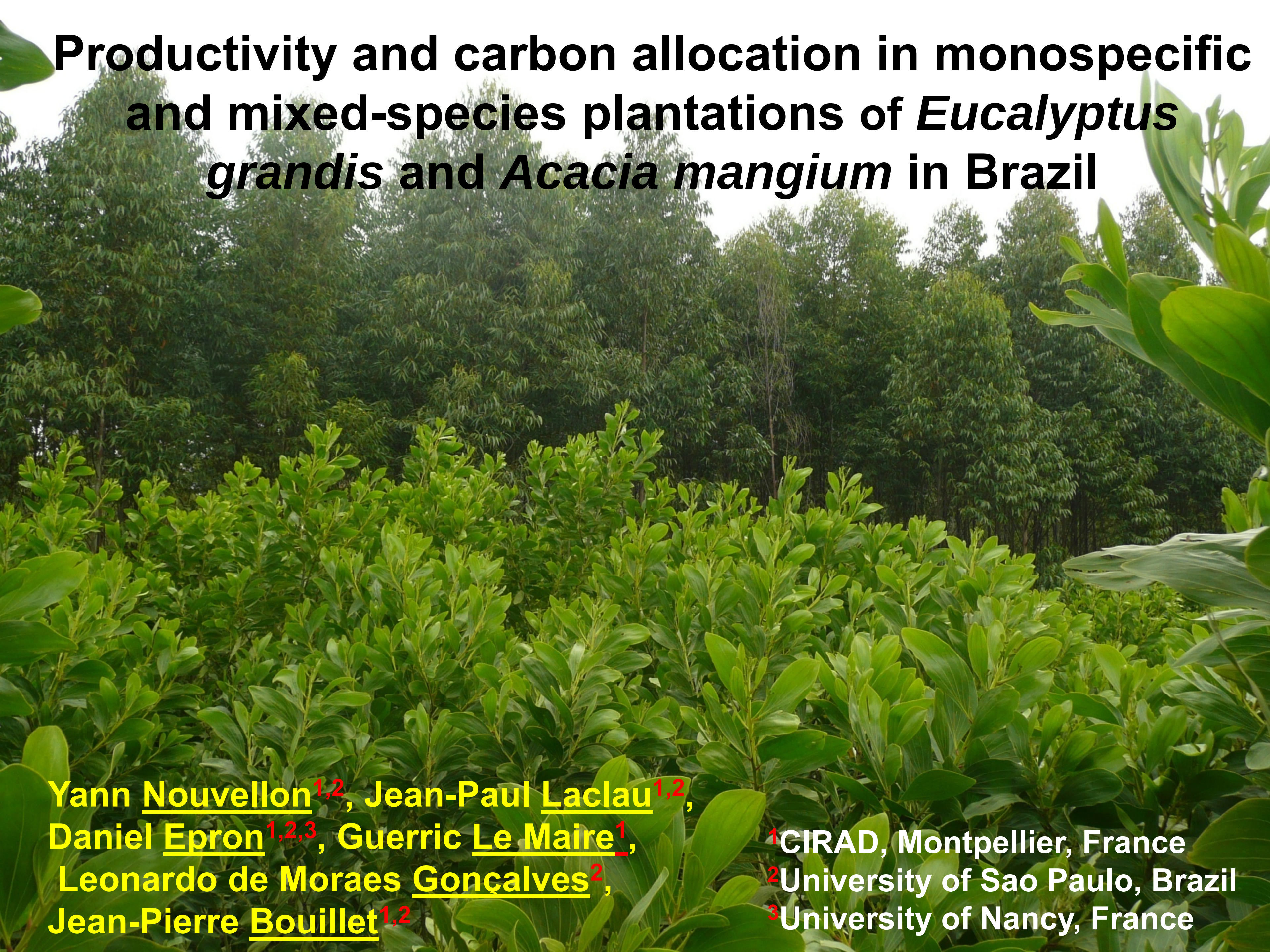
Productivity and carbon allocation in monospecific and mixed-species plantations of *Eucalyptus grandis* and *Acacia mangium* in Brazil



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Overall Context

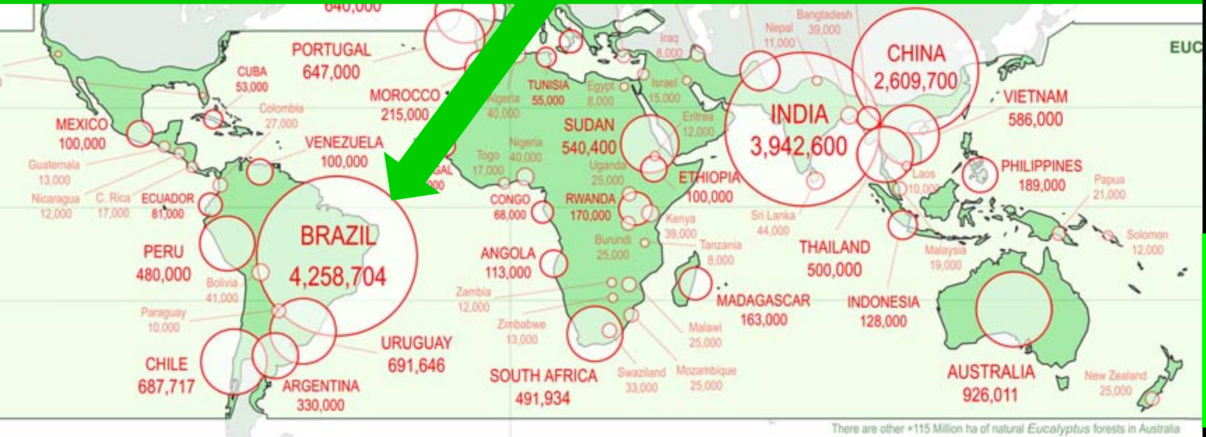
- Increase in world demand for wood products

	1980	2005
Wood production for industry (M m^3 yr^{-1})	1450	1710
Wood production for Energy (M m^3 yr^{-1})	1530	1840
Production of cellulose (M t yr^{-1})	125	175

http://www.fao.org

- In 2000, forest plantations represented 5% of total forest area, but provided 33% of collected wood (Millenium Ecosystem Assessment, 2005)

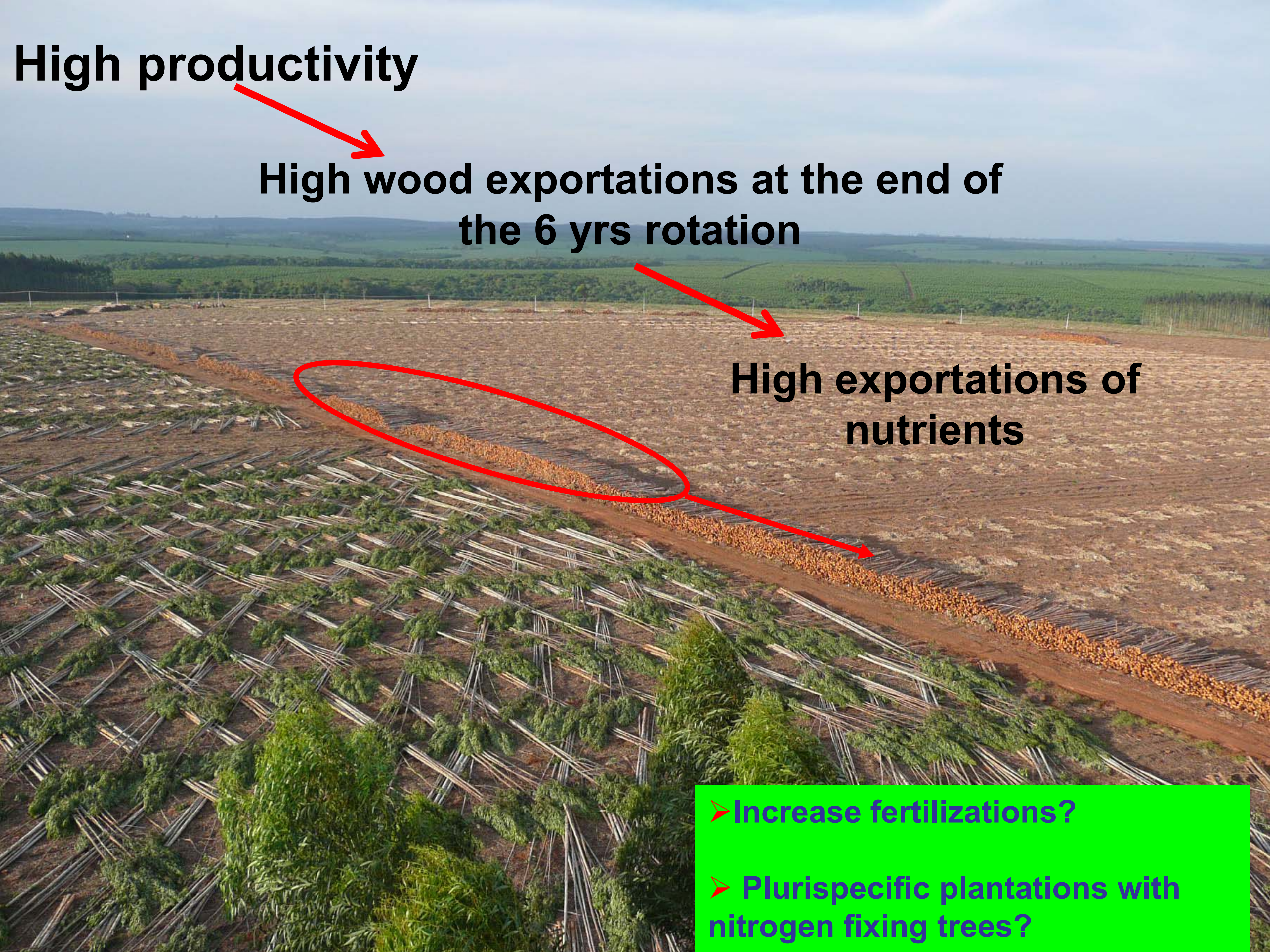
<u>Eucalyptus plantations in Brazil</u> :
plantation rate: + 300 000 ha/yr in Brazil

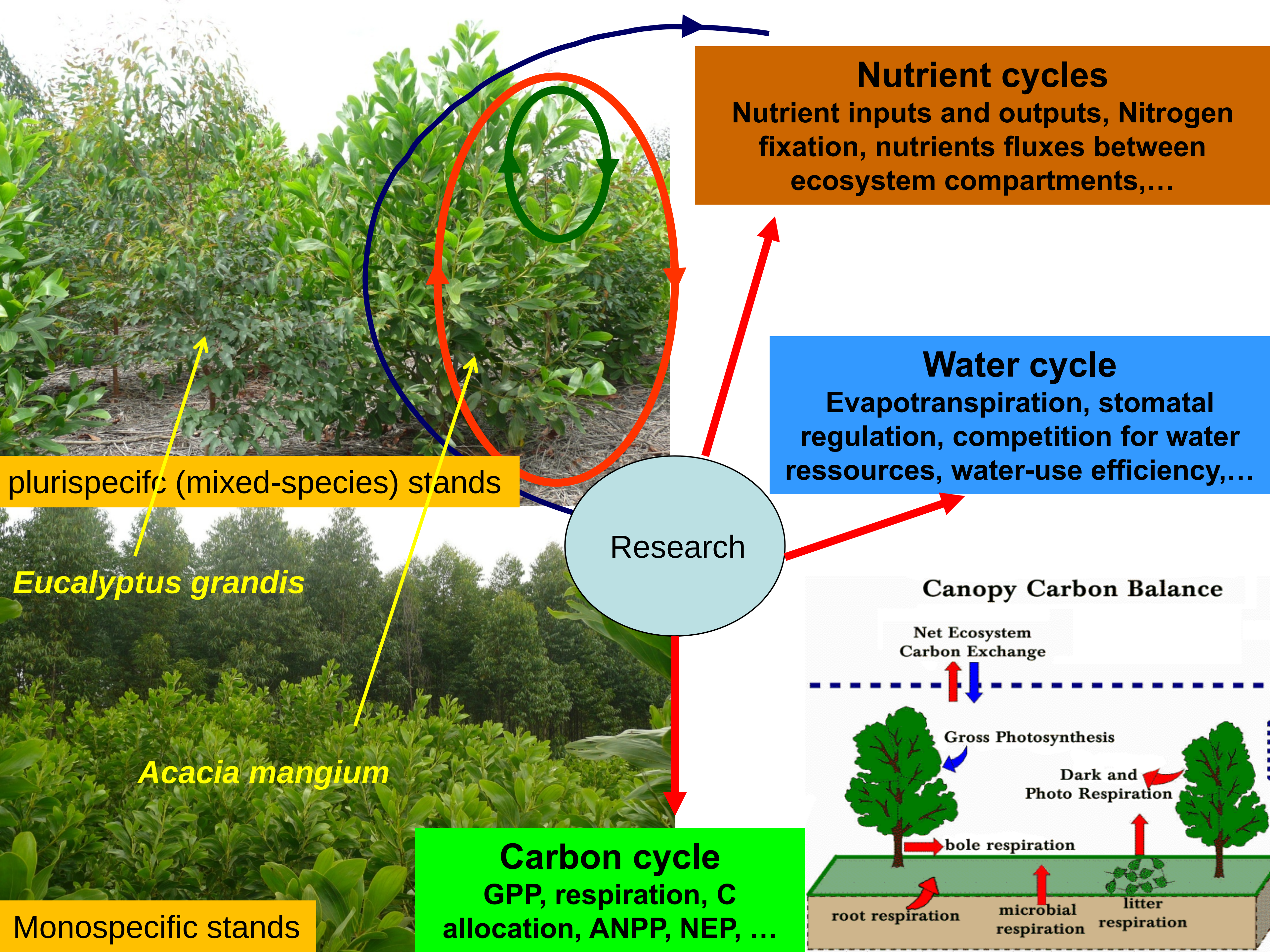


- **Planted mostly for <u>cellulose</u>, and <u>charcoal</u> (steel industry, ect)**

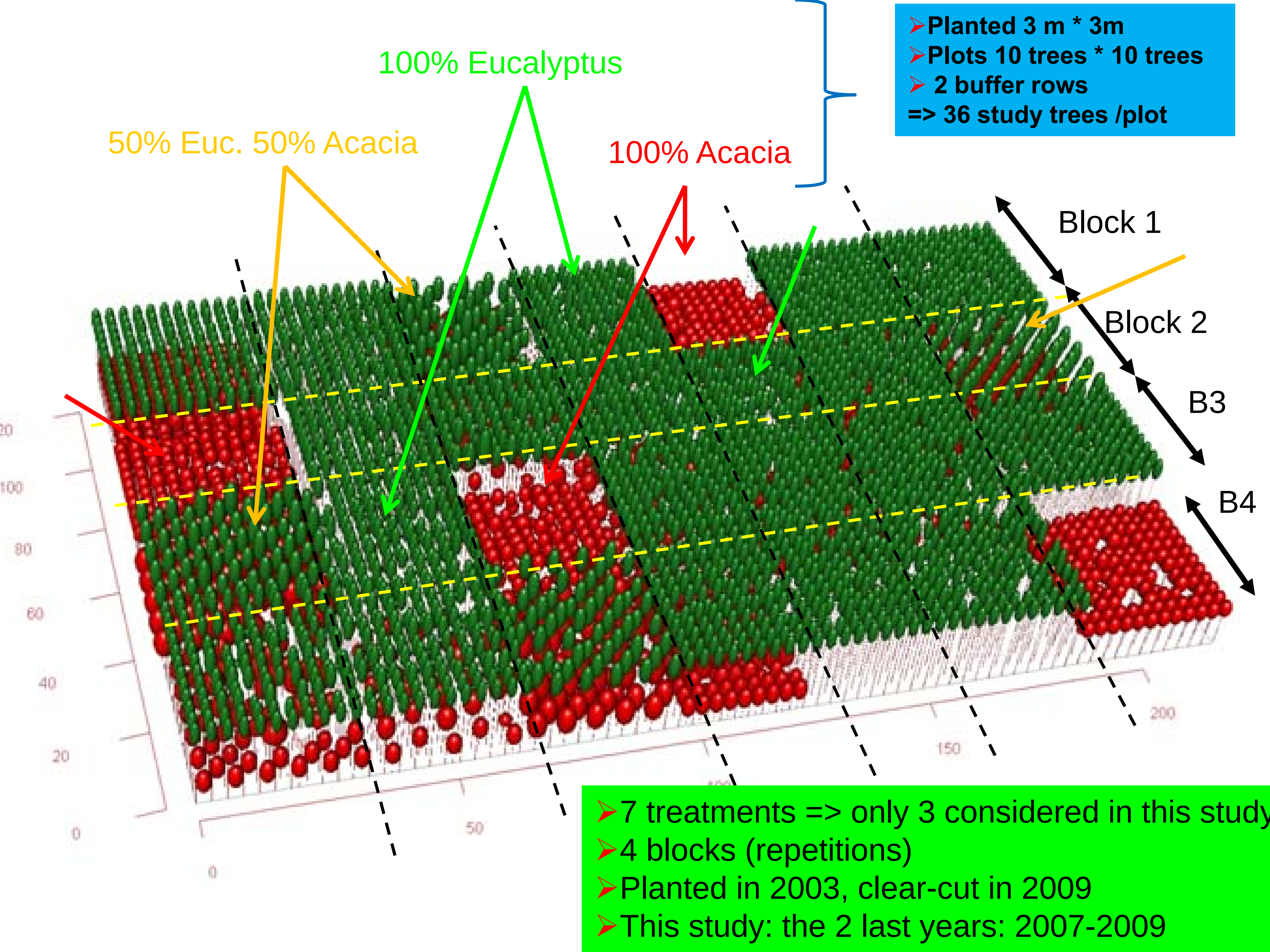
Main reasons for their success:

- High yields despite highly weathered tropical soils (30 to 70 $m^3\ ha^{-1}\ yr^{-1}$ in Brazil (SP))
- Ability to grow as coppice


High productivity
High wood exportations at the end of the 6 yrs rotation
High exportations of nutrients
➢Increase fertilizations?
➢ Plurispecific plantations with nitrogen fixing trees?



Nutrient cycles
Nutrient inputs and outputs, Nitrogen fixation, nutrients fluxes between ecosystem compartments,…
Water cycle
Evapotranspiration, stomatal regulation, competition for water ressources, water-use efficiency,…
plurispecifc (mixed-species) stands
Research
Eucalyptus grandis
Acacia mangium
Canopy Carbon Balance
Net Ecosystem Carbon Exchange
Gross Photosynthesis
Dark and Photo Respiration
bole respiration
root respiration
microbial respiration
litter respiration
Carbon cycle
GPP, respiration, C allocation, ANPP, NEP, …
Monospecific stands


➢Planted 3 m * 3m
➢Plots 10 trees * 10 trees
➢ 2 buffer rows
=> 36 study trees /plot
100% Eucalyptus
50% Euc. 50% Acacia
100% Acacia
Block 1
Block 2
B3
B4
80
60
40
20
0
0
50
150
200
➢7 treatments => only 3 considered in this study
➢4 blocks (repetitions)
➢Planted in 2003, clear-cut in 2009
➢This study: the 2 last years: 2007-2009

Main goals and hypotheses

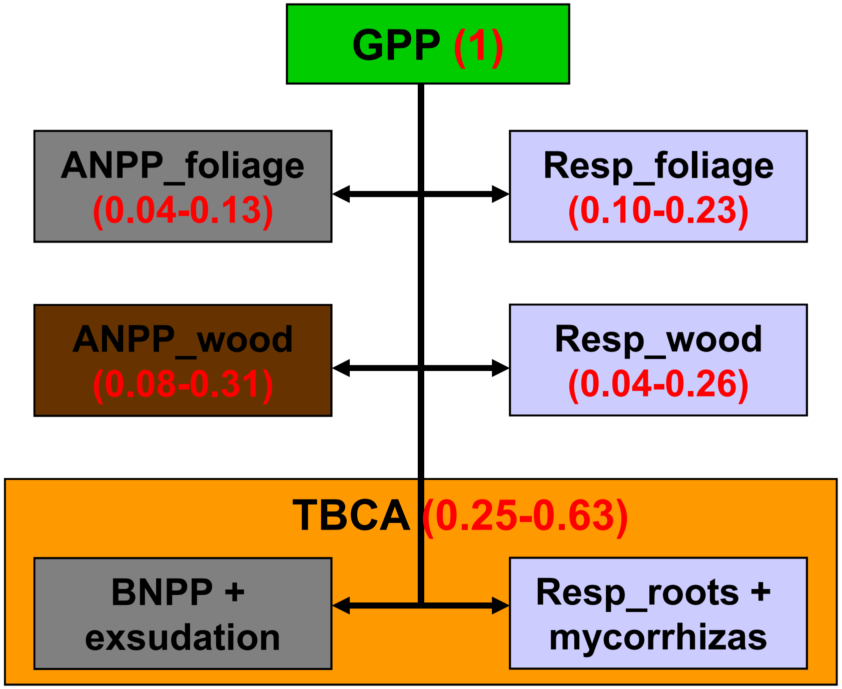
Goals

=> compare the wood production, and C allocations of monospecific stands of Acacia and Eucalypt, and plurispecific stands Acacia/Eucalypt

Hypotheses

⇒ a large part of the differences in wood production between monospecific stands is explained by differences in C allocation

⇒ The C allocation patterns of each species is modified in mixed- species plantations compared to mono-specific plantations due to inter-specific interactions and shifts in soil N status

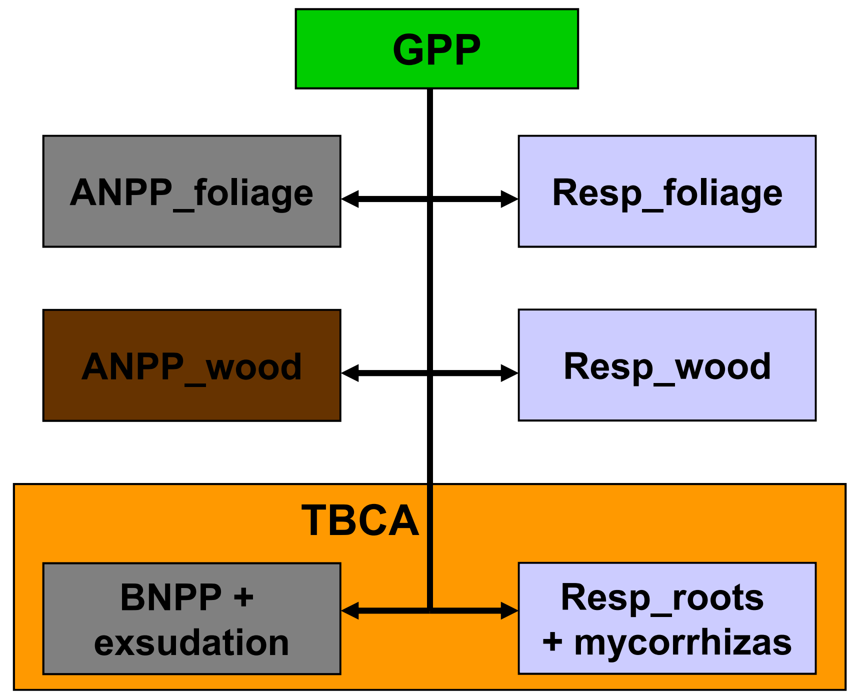


Litton et al., 2007

Methodology

Monitoring of litterfall + Δ foliage biomass

Inventories (Tree height, diameter) + allometry



$$TBCA = F_s - L_a + \frac{\Delta C_L + \Delta C_s + \Delta C_R}{\Delta t}$$

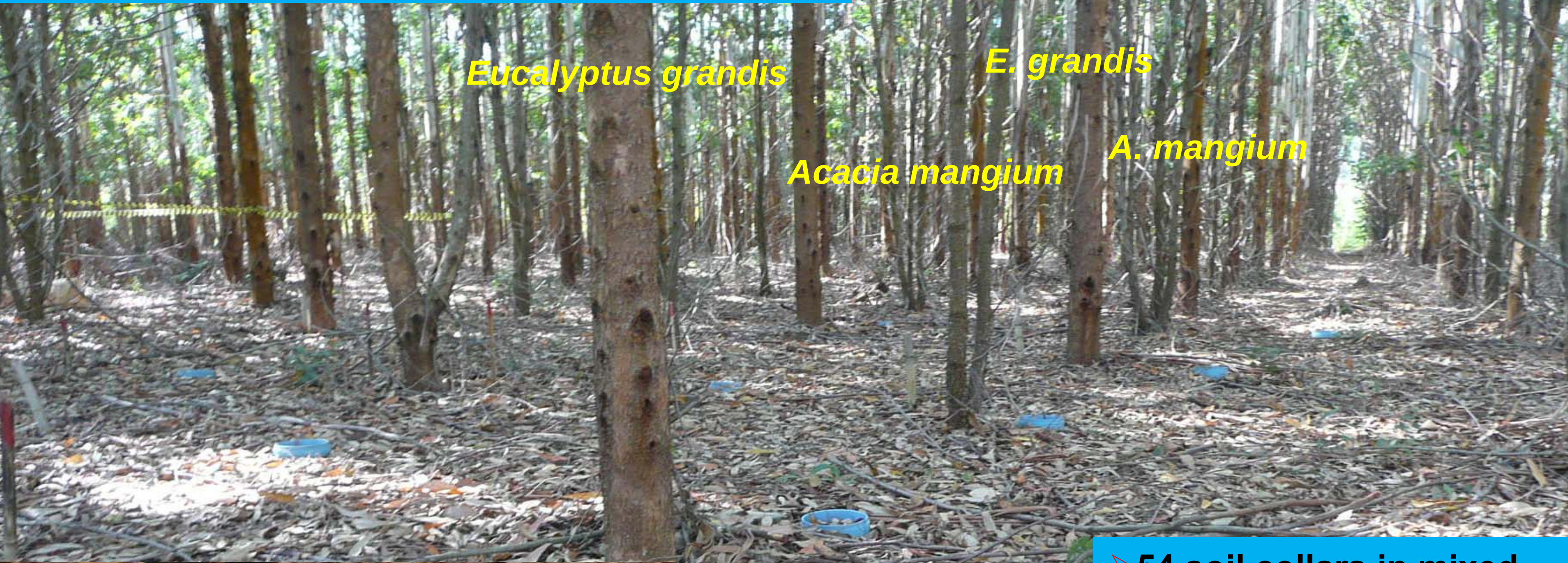
Cumulated soil CO2 effluxes

Litter fall

Changes in C stocks in the soil, forest floor, roots

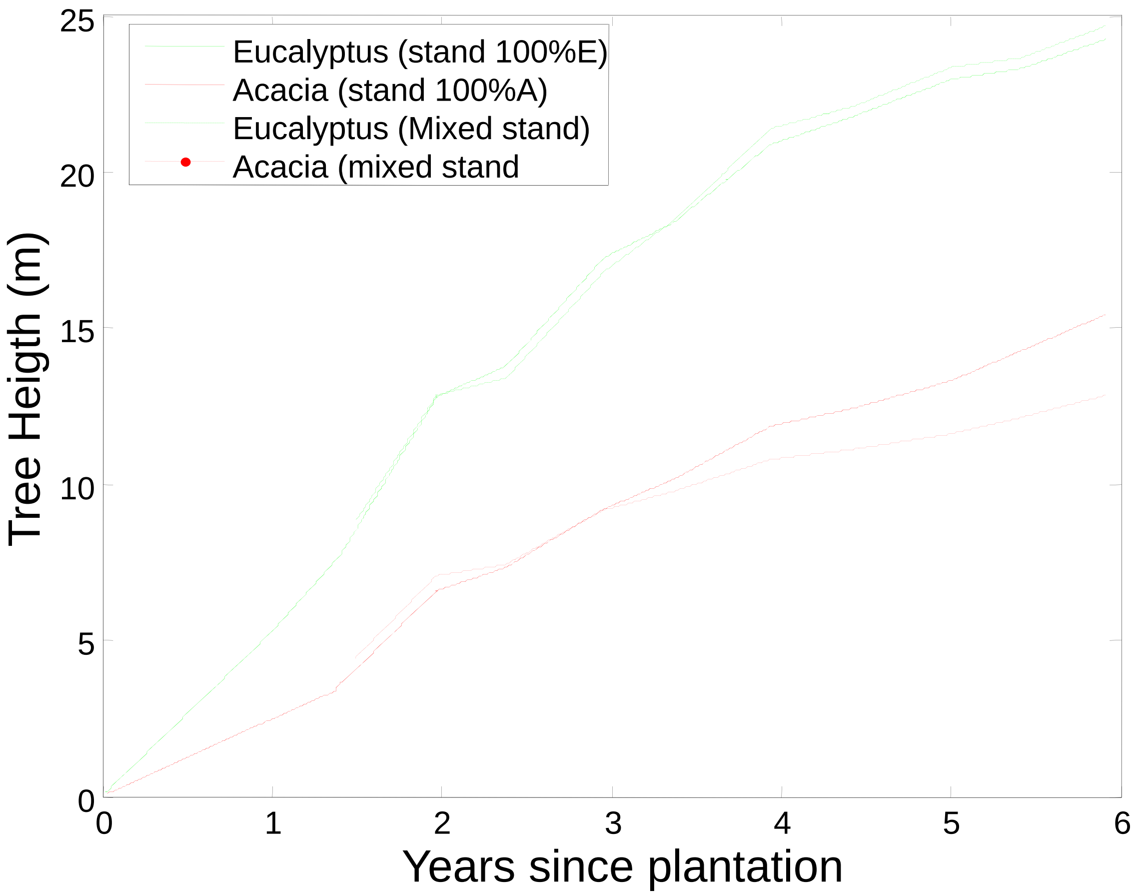
Giardina et al., 2004; Ryan et al. 2004, 2010

Soil CO_2 effluxes measurements



- 54 soil collars in mixed-species stands (27 by species = 9 * 3 blocks)
- 27 soil collars in each monospecific stand
- Measurements every two weeks

Results: Tree Growth



In plurispecific stands, Acacia were clearly dominated by Eucalyptus

Despite low differences in tree height, Acacias in mixed stands were much lighter than in 100%A stands, and Eucalyptus trees in mixed were much heavier than in 100%E stands

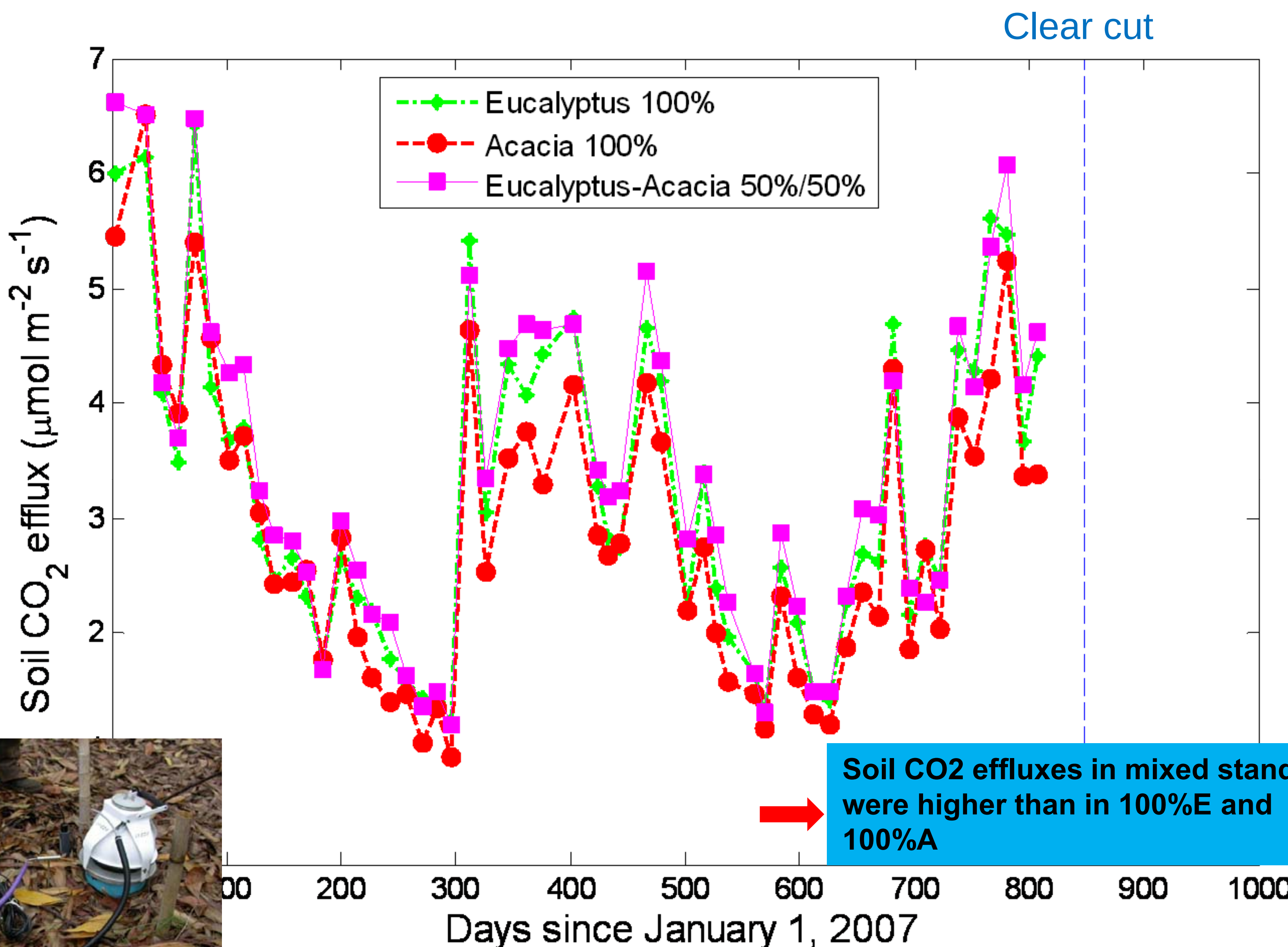
Despite lower biomass in 100%A than in 100%E at year 6, production during the two last years was higher in Acacia stands

Total aboveground biomass at the end of the 6 yr-rotation

- **68.2 tC/ha in 100%E**
- **66.0 tC/ha in 100%A**
- **62.0 tC/ha in 50%E50%A**

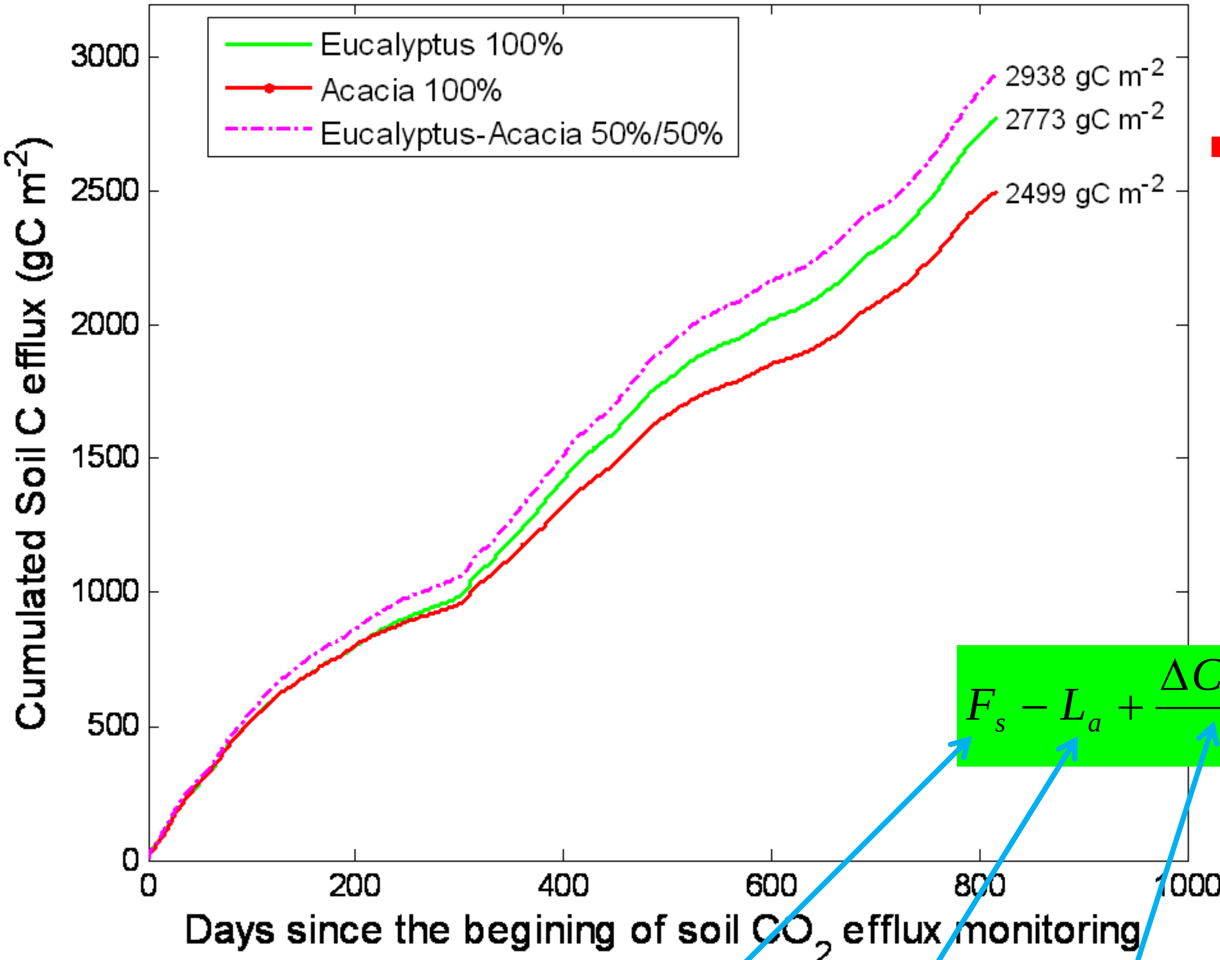
Total production is lower in mixed stand compared to monospecific stand

Results: Soil CO_2 effluxes



Soil CO2 effluxes in mixed stands were higher than in 100%E and 100%A

Results: Soil CO_2 effluxes



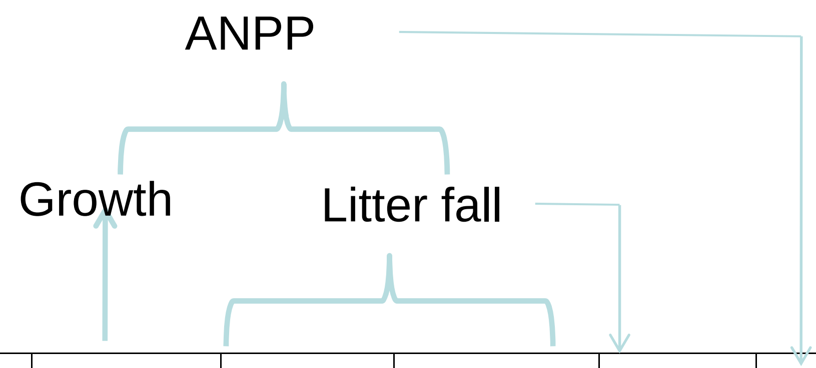
F_s is the highest in mixed stand, lowest in Acacia 100%, and intermediate in Eucalyptus 100%

$$F_s - L_a + \frac{\Delta C_R + \Delta C_s + \Delta C_L}{\Delta t} = TBCA$$

Over 27 months (gC m^{-2})

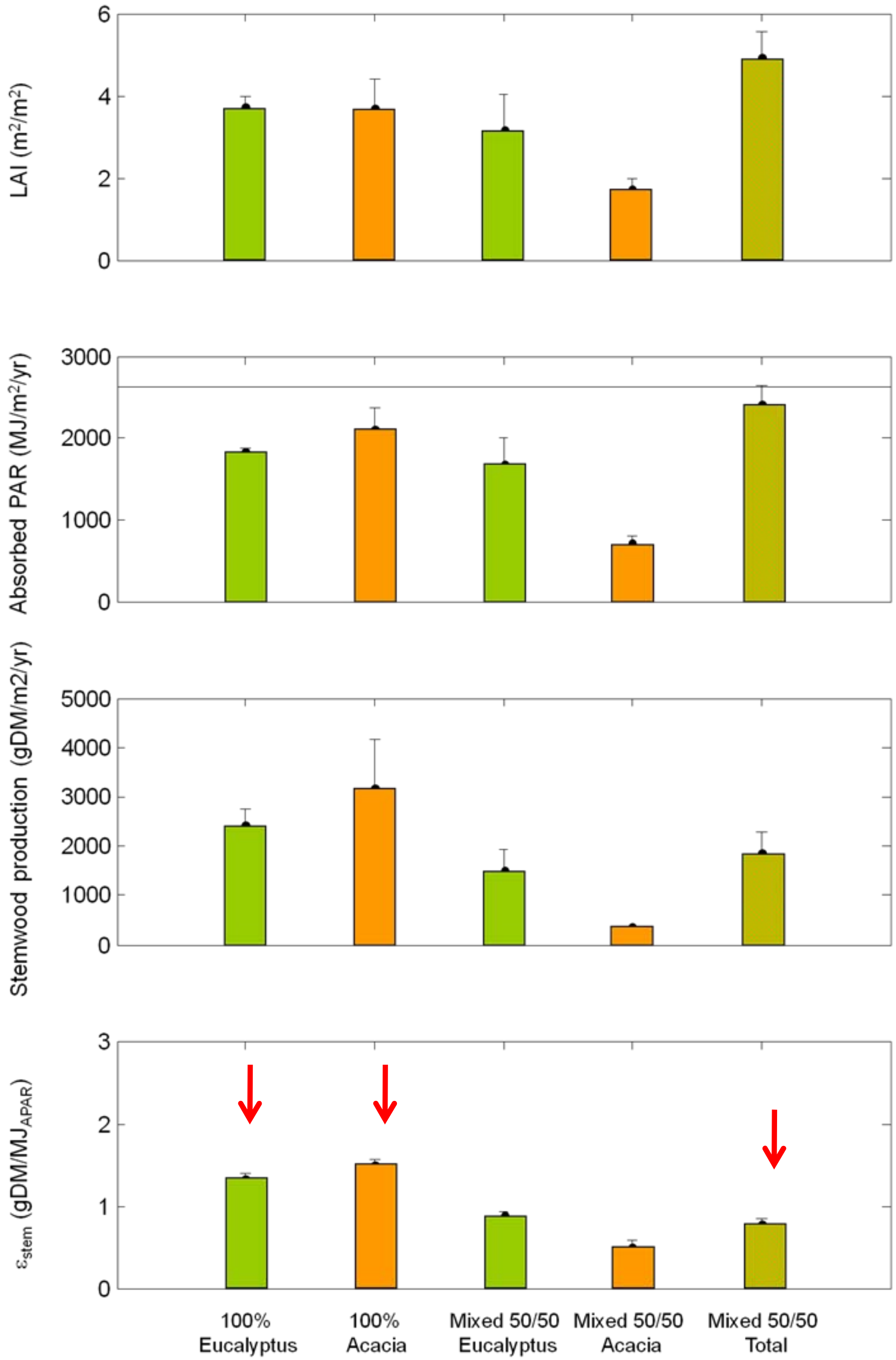
	Fs	Litterfall	Δ root	Δ Lit	TBCA
Acacia 100%	2499	736	246	-94	1915
Eucalyptus 100%	2773	1163	569	330	2509
Mixed stand E50%A50%	2938	1062	510	265	2651

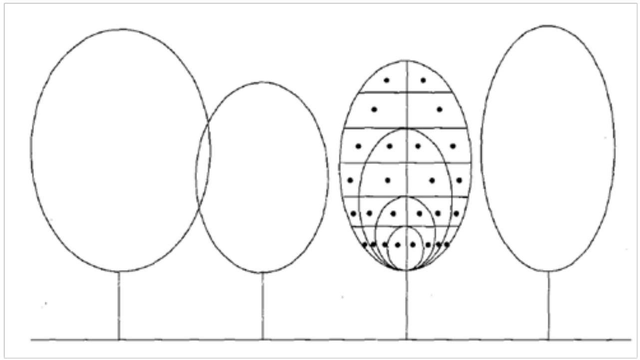
Annual Carbon budget (gC m^{-2} yr^{-1})



	Fs	Growth (Δ wood)	Leaf LF	Branch & Bark LF	Total LF	ANPP	TBCA	Lit/ANPP	TBCA/ANPP
Acacia	**1111**	**1592**	**303**	**24**	**327**	**1919**	**851**	**0.17**	**0.44**
Eucalyptus	**1232**	**1268**	**284**	**233**	**517**	**1785**	**1115**	**0.29**	**0.62**
Mixed stand E50%A50%	**1306**	**1045**	**297**	**175**	**472**	**1516**	**1178**	**0.31**	**0.78**
Acacia in Mixed stand		191	52	6	58	249		0.23	
Eucalytus in mixed stand		853	245	169	414	1267		0.33	

- **In the stands with the highest wood production, the fraction of ANPP allocated to litter production was the lowest**
- **Stands with highest wood production, also allocate proportionally less to the belowground system**
- **Allocation patterns explain a large part of the differences in wood production**



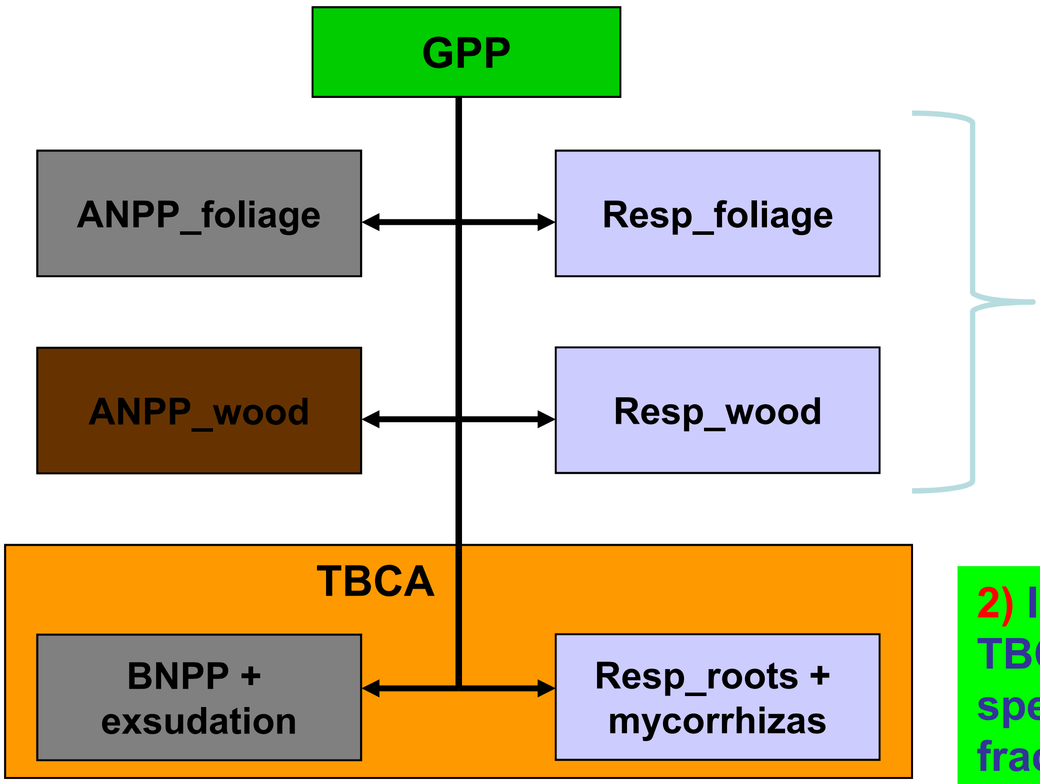


MAESTRA model

- **Simulation of APAR with MAESTRA showed that both at the individual tree scale and the stand scale, light-use efficiency (LUE) is higher for Acacia 100% stands, lowest for mixed stands, and intermediate for Eucalyptus 100% stands**

- **Differences in C allocations shown in this presentation explain a large part of these differences in LUE**

Perspectives



1) Quantify carbon allocations to aboveground respiration (=> differences in carbon use efficiencies?)

2) In mixed-species stands, to estimate TBCA for each species => do inter-specific competitions change the fraction of GPP allocated belowground?

3) Describe the allocations patterns over a whole rotation => are age-related changes in carbon allocation pattern species-specific?


Thanks….