Water withdrawal from deep soil layers: a key strategy to sustain growth during dry seasons in tropical *Eucalyptus* plantations.

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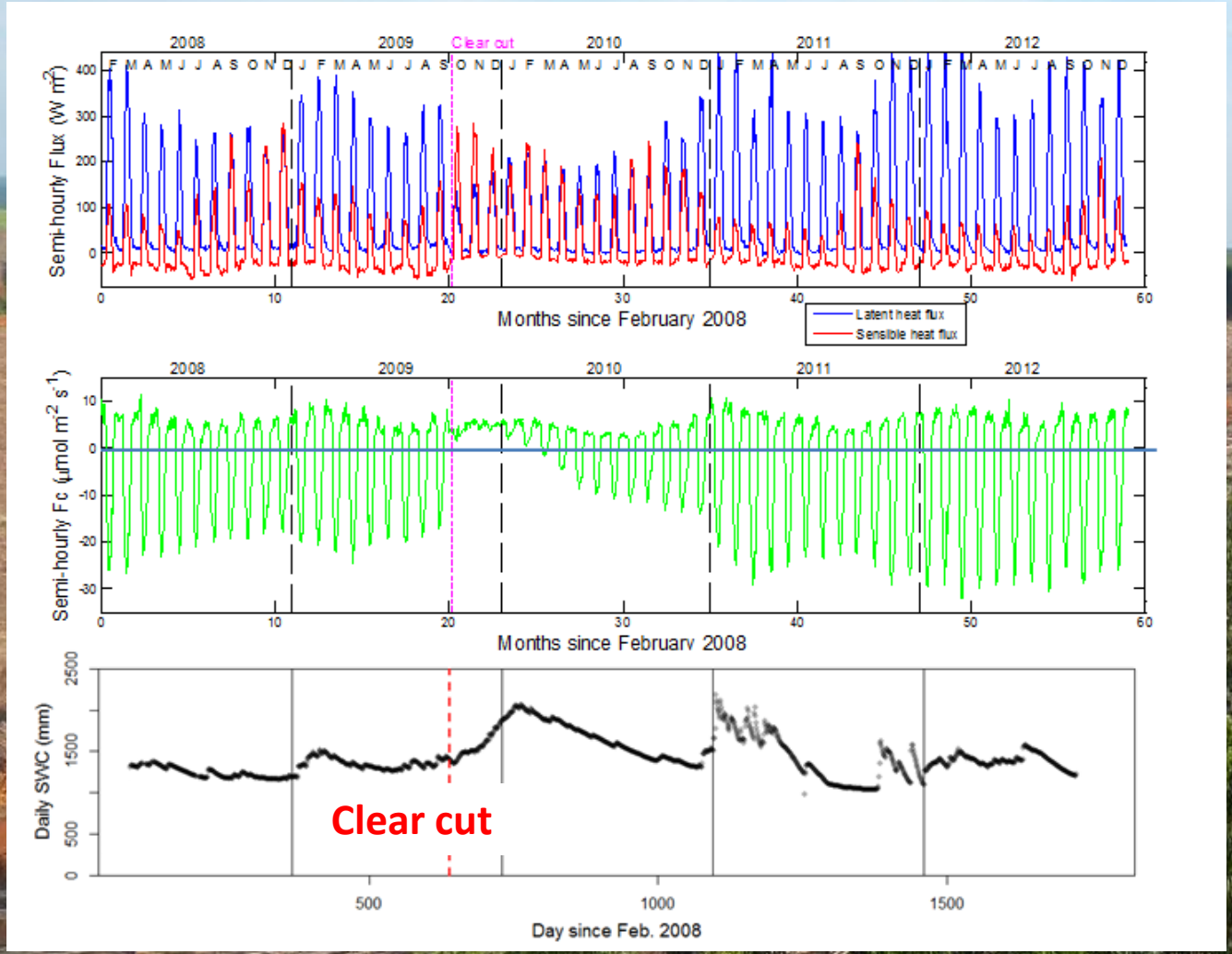
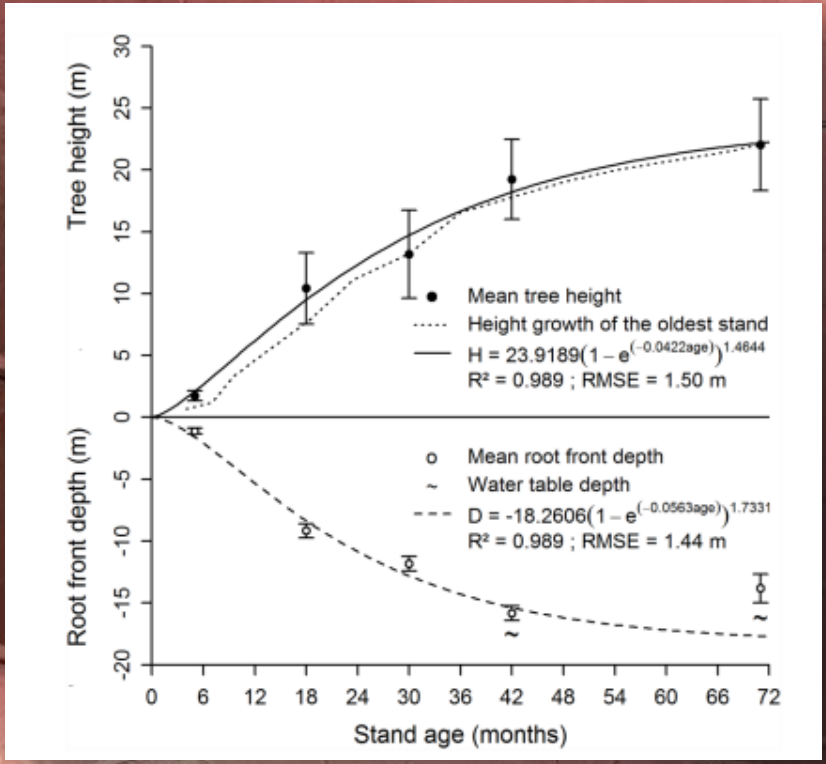
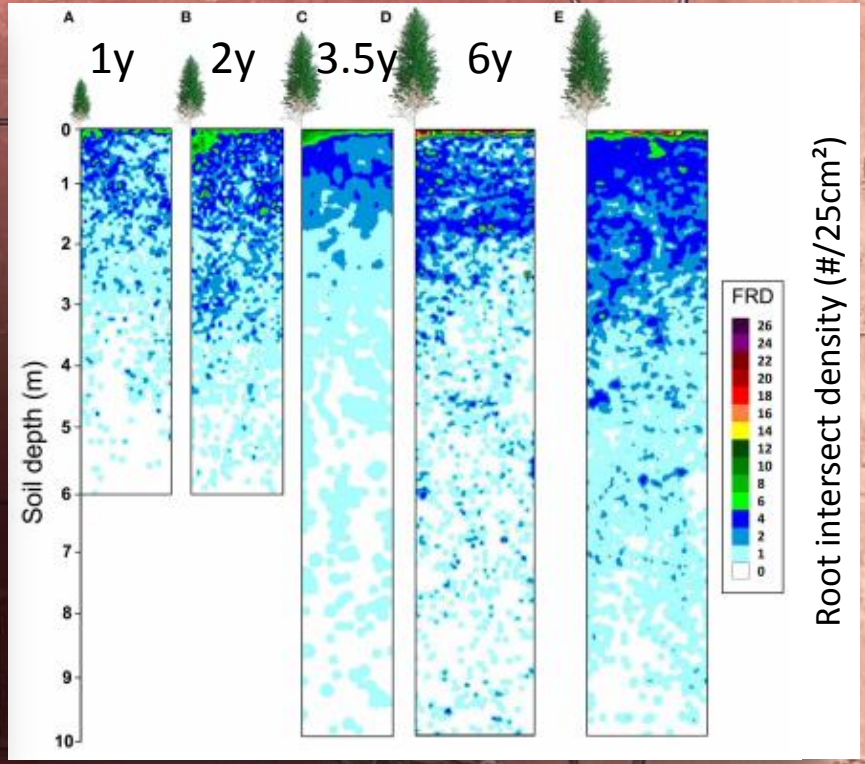
Context: Carbon and water balance in managed *Eucalyptus* plantations in Brazil (Nouvellon et al. AGU 2013 Poster)



Context: deep root profiles in *Eucalyptus* plantations

→ Many deep roots have been recently observed in tropical *Eucalyptus* plantations (Christina et al. 2011, Laclau et al. 2013)





Hypothesis

→ Deep water uptake supplies a significant share of tree water demand during dry periods, in *Eucalyptus* plantation.

→ The fast root front velocity give access to water stored in deep soil layers after clear-cutting and allow using of the transient water flowing down.

→ Deep water uptake contributes to sustaining high photosynthesis rates throughout the year.

Material & Methods

Site description

-**Site: EUCFLUX project, Itatinga, state of Sao Paulo, Brazil**

→ 200ha *Eucalyptus grandis* plantations since Nov. 2009.

→ 4 plots of 365 trees including border trees.

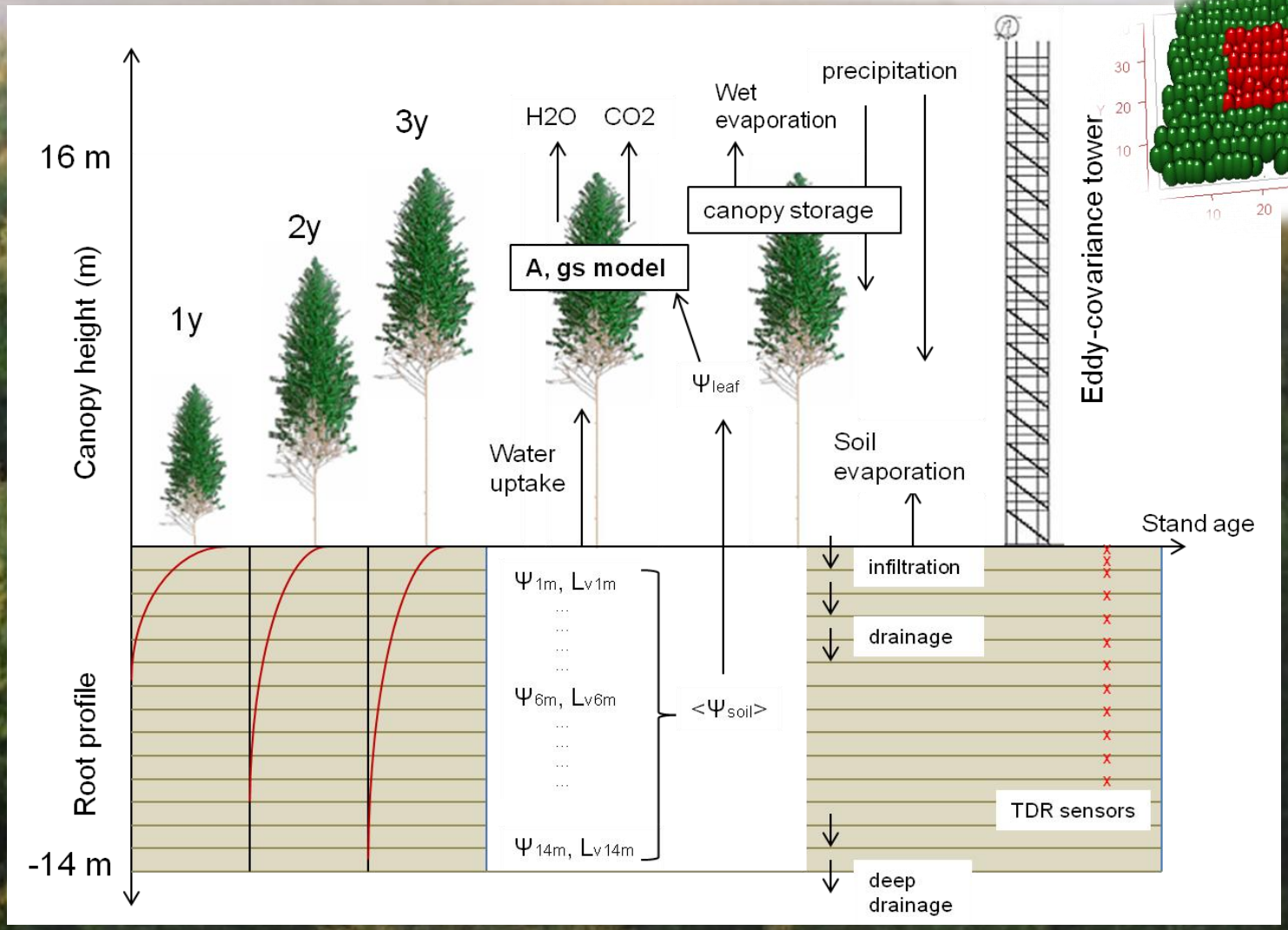
→ Eddy-flux tower: Latent heat flux measurements + meteorological data.

→ Soil water contents: probes down to 10m depth over the whole rotation cycle.

→ MAESPA parameterization: inventory, leaf area, LAD, LID, capacity for photosynthesis,…

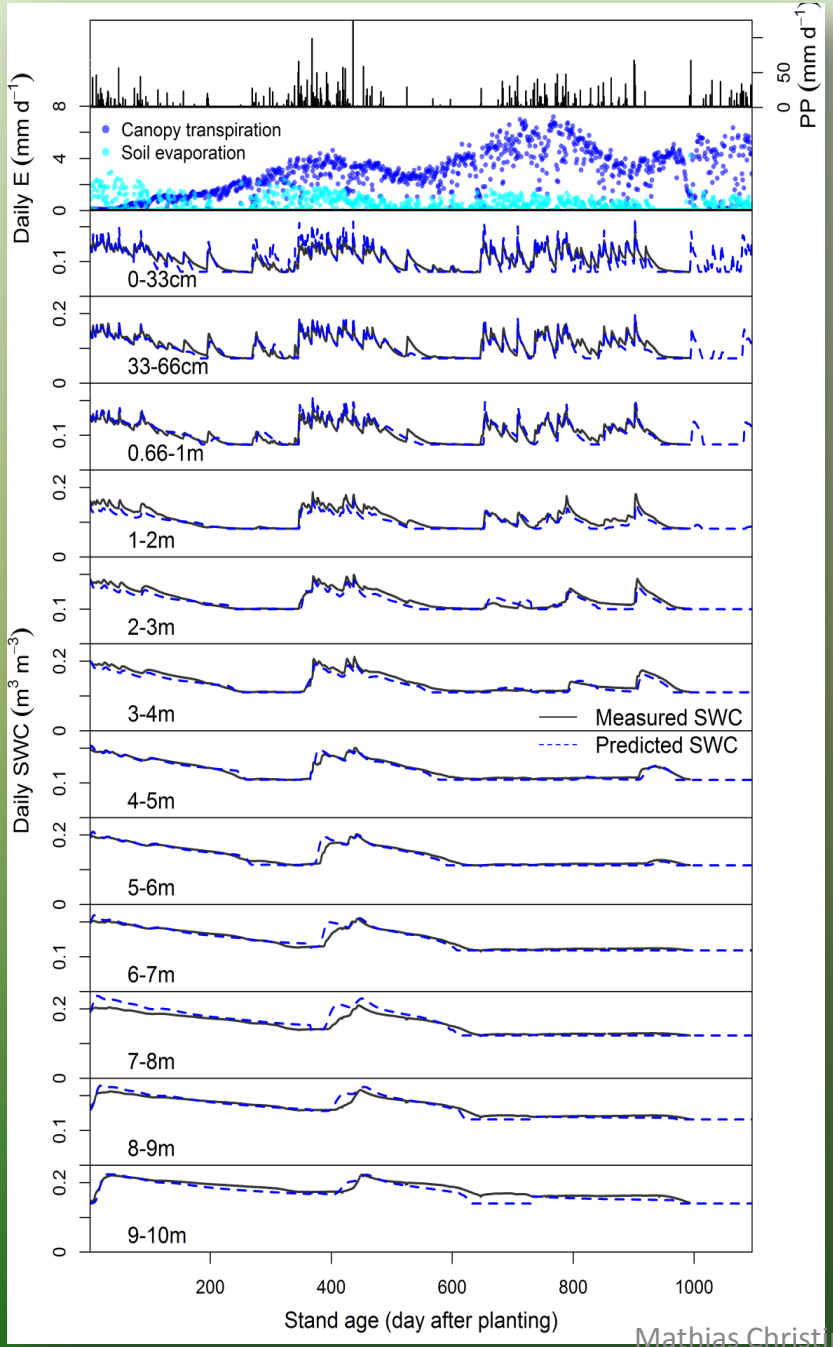
Material & Methods

Eco-physiological model: MAESPA (Duursma and Medlyn 2012)

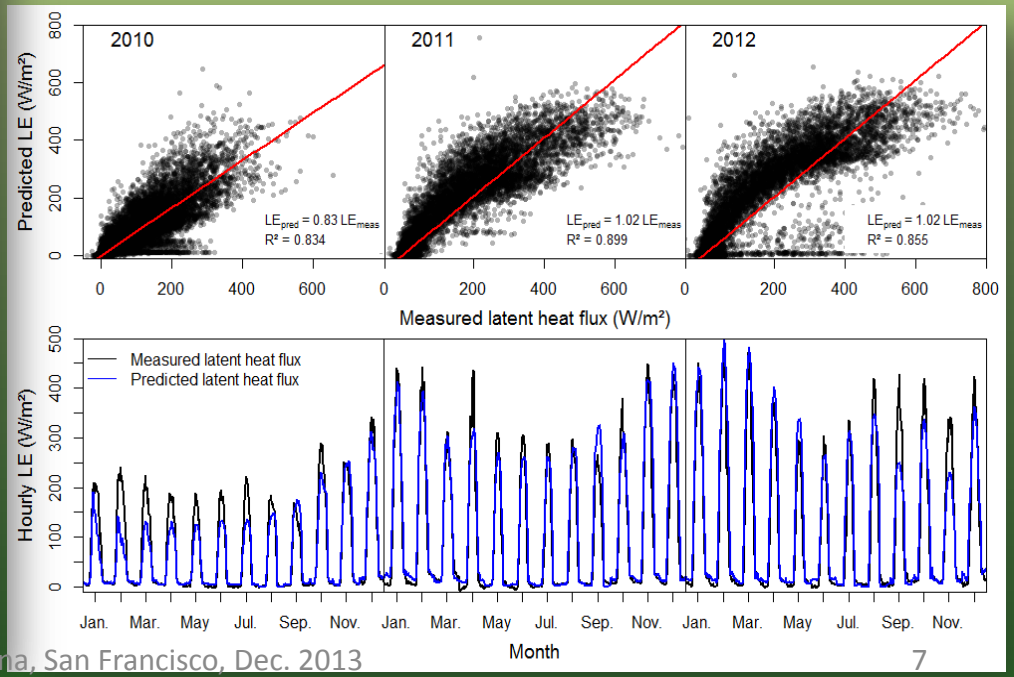


Results – model predictions

Time course of soil water contents

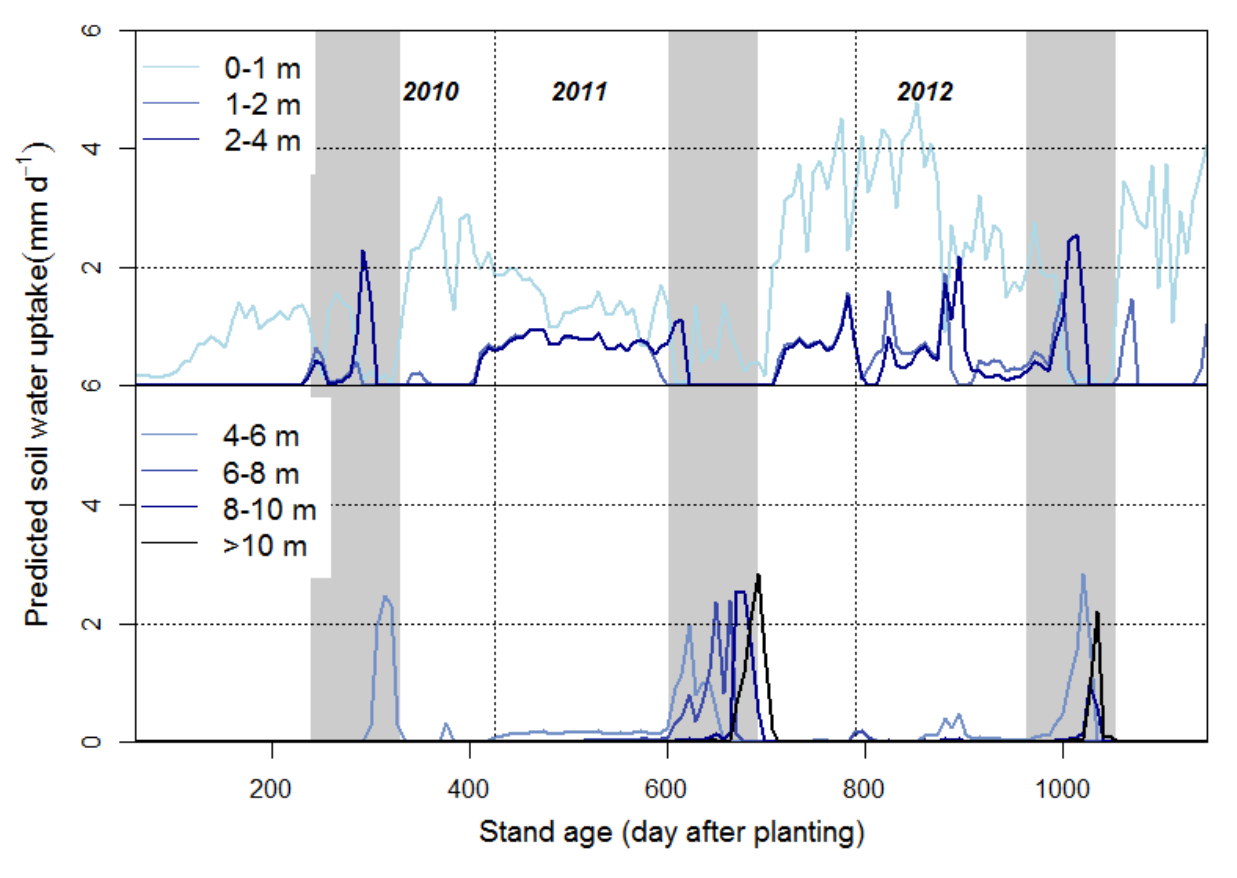


Time course of latent heat flux



Results

Time course of daily water uptake over the first half of rotation cycle in commercial *Eucalyptus* plantation



→ Successive drying of deep soil layers during each dry season

Results

Components of water balance in our *Eucalyptus* plantation

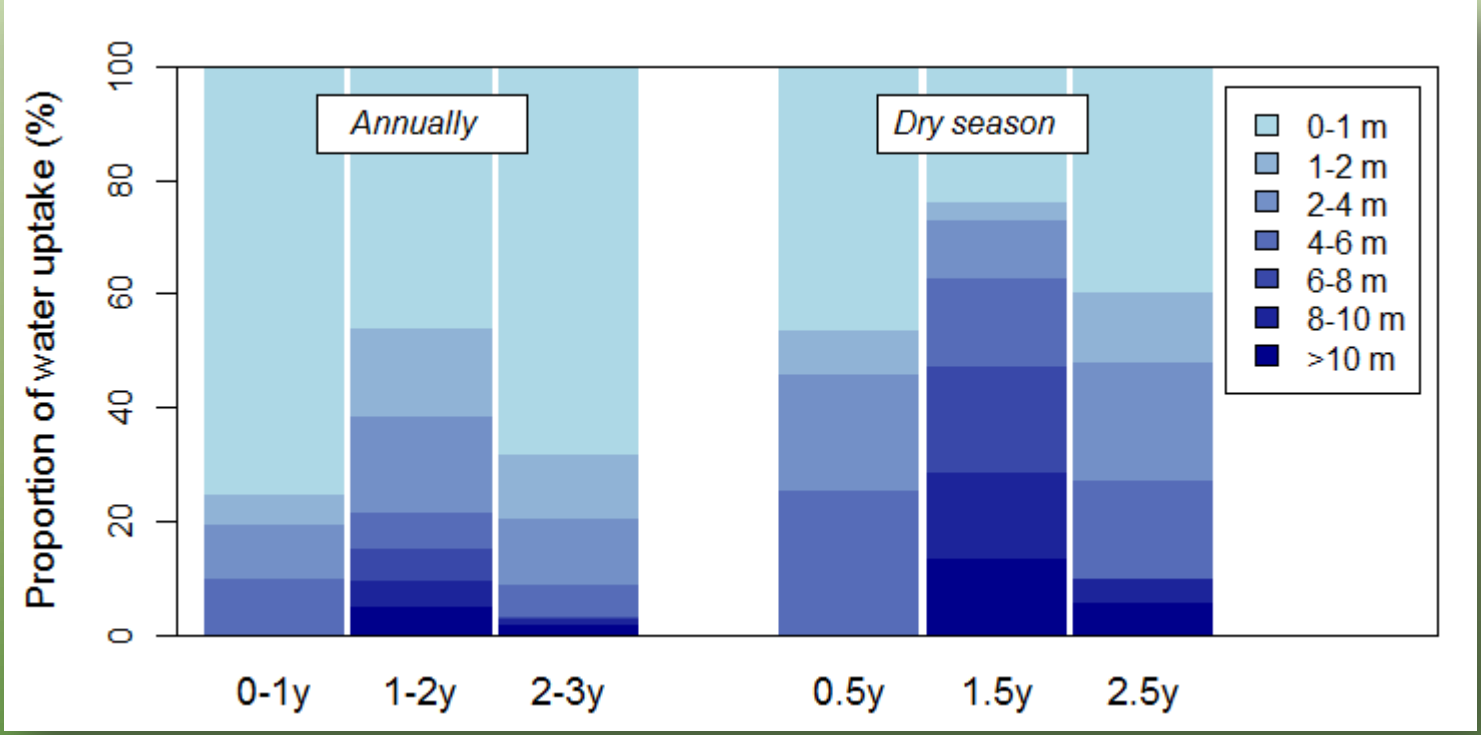
Water flux (mm)	Rainy (Jan.-Jun. 2010)	Dry (Jul.-Sep. 2010)	Rainy (Oct. 2010-Jun. 2011)	Dry (Jul.-Sep. 2011)	Rainy (Oct. 2011-Jun. 2012)	Dry (Jul.-Sep. 2012)
Surface root WU (0-1m)	139	57	469	50	813	81
Deep root WU (1-6m)	2	106	315	69	317	155
Very deep root WU (>6m)	0	0	4	172	16	37
Total WU	141	163	788	291	1146	273
Precipitation	690	102	1638	41	1367	115
Deep drainage	476	151	473	130	58	7

→ Deep water uptake plays a major role during dry seasons

→ No water seepage below roots layer after 2 years of growth

Results

Contribution of deep roots to water balance in our plantation



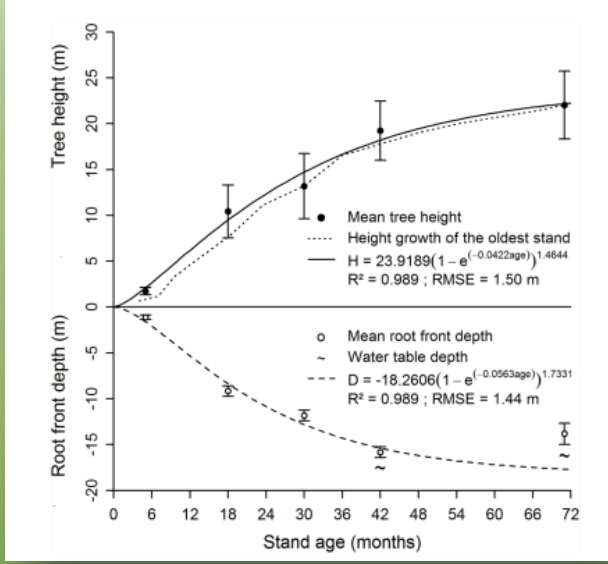
→ Annually, deep water withdrawal (<6m) represents a low proportion of total water use (0, 15% and ~5%, for the 1st, 2nd and 3rd year)

→ Deep water withdrawal (<6m) is a high component of tree water loss during the dry season.

→ Large amount of water uptake in deep soils at 1.5 years (~50%). The soil between 6 and 10m is dried up.

Discussion

Belowground root growth strategy



→ Amazonian forests and *Eucalyptus* plantations explore a considerable volume of soil with limited carbon cost (<10% below 1m, Christina et al. 2011, Nepstad, 1994).

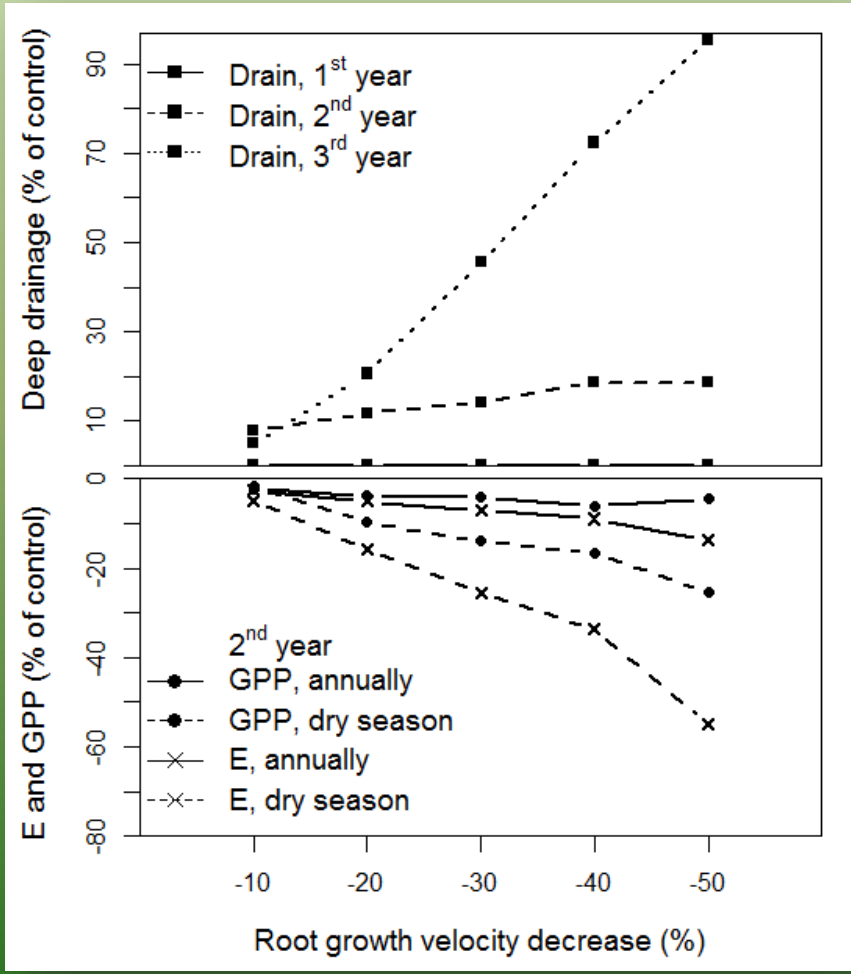
→ Functional equilibrium hypothesis whereby plants adapt their strategies of root biomass allocation to edaphic and climatic variations does not seem to apply in fast-growing tropical plantations

Rapid exploration of deep soil layers by tropical forests = territorial strategy?

→ Effect of root front decrease in depth
→ Constant root biomass and surface area
→ No feed-back on C allocation (LAI, and root biomass) in the model.

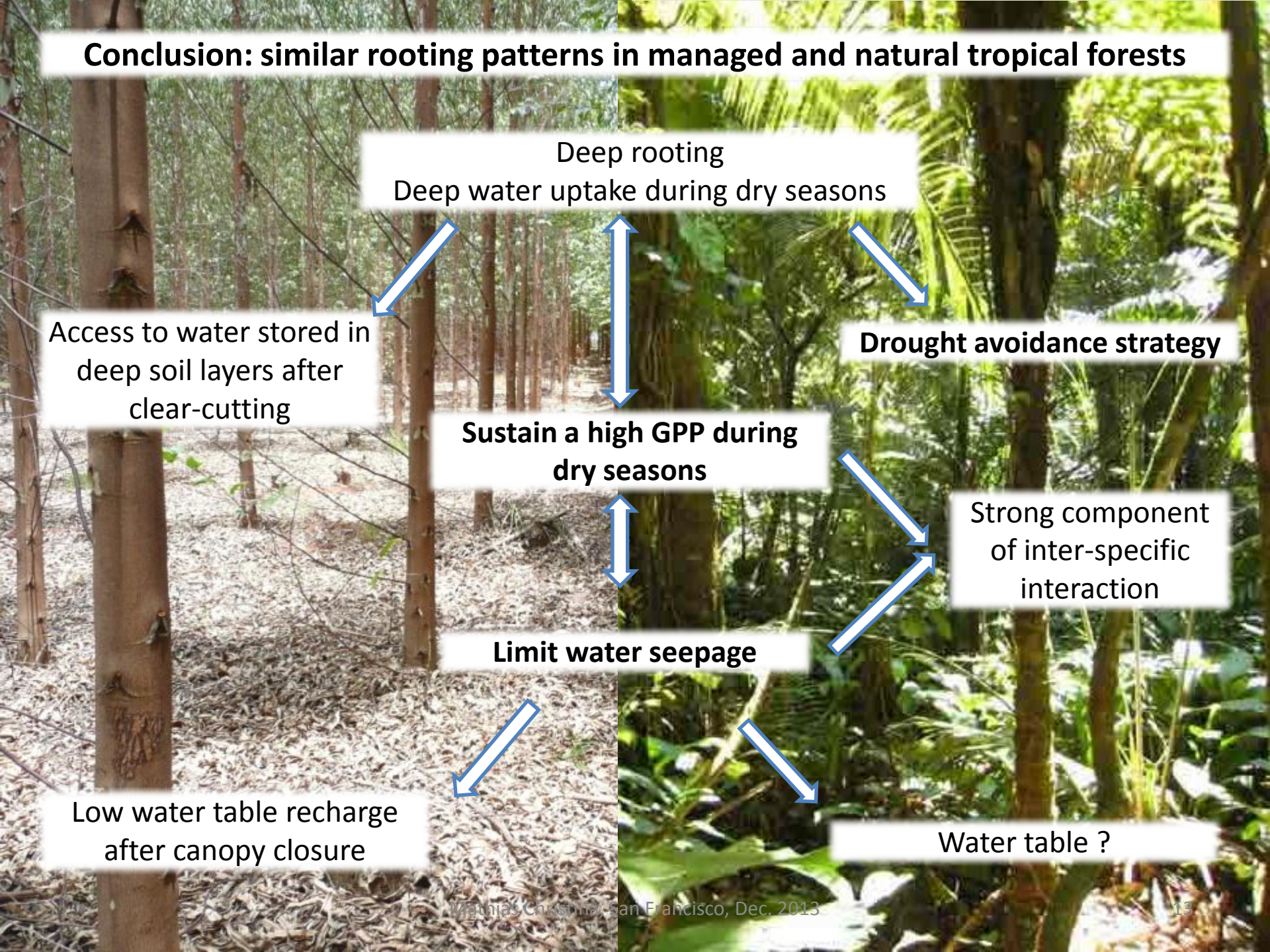
Discussion

What would happen with a slower root growth in depth?
a model analysis…



→ Strong increase in water seepage (= recharge of water table)

→ Strong decrease in GPP during the second year of growth, particularly during the dry season.


Conclusion: similar rooting patterns in managed and natural tropical forests
Deep rooting
Deep water uptake during dry seasons
Access to water stored in deep soil layers after clear-cutting
Drought avoidance strategy
Sustain a high GPP during dry seasons
Strong component of inter-specific interaction
Limit water seepage
Low water table recharge after canopy closure
Water table ?

Perspective: effect of forest management on water resources

→ What is the influence of rotation duration on water storage in deep soils and water seepage?

Modeling contrasting *Eucalyptus* rotation cycle durations

Optimizing the trade-off between forest productivity and water resources preservation

And more:
→ Influence of rain frequency and quantity on root uptake patterns
→ Influence of fertilization on root growth
→ C sequestration in deep soil layer ?
→ …


Thank you for your attention