Promoting sustainable land-use management:

water, carbon and nutrient turnover

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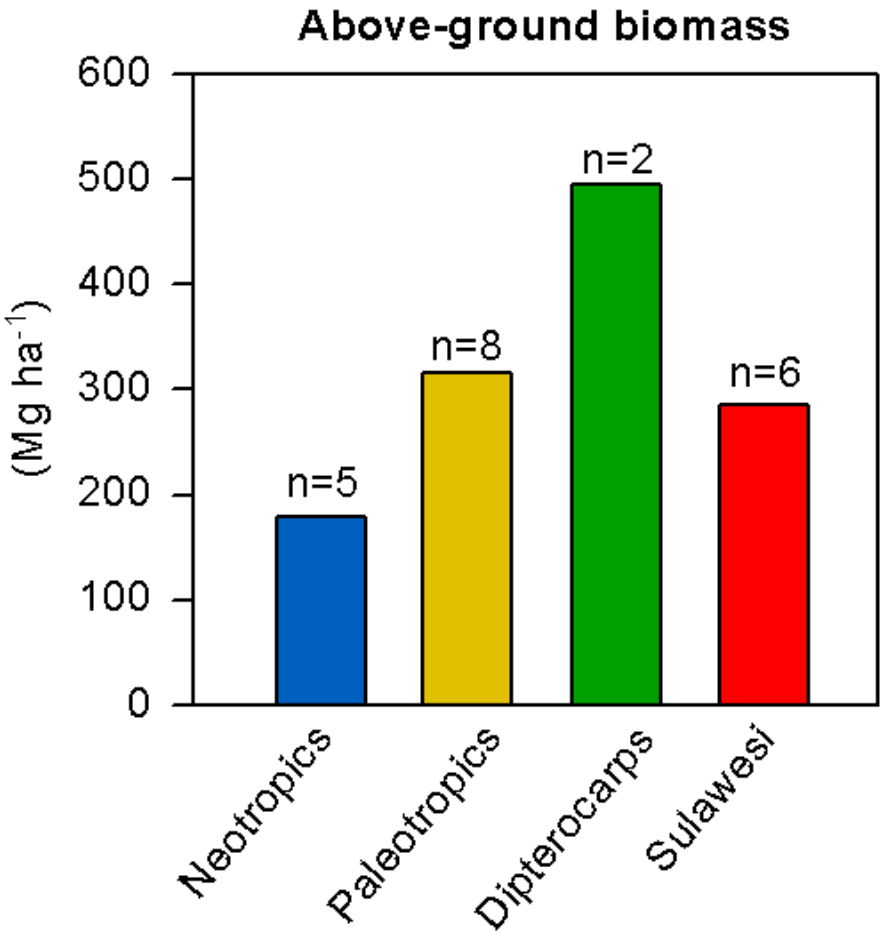
Pak Soekisman

Objectives

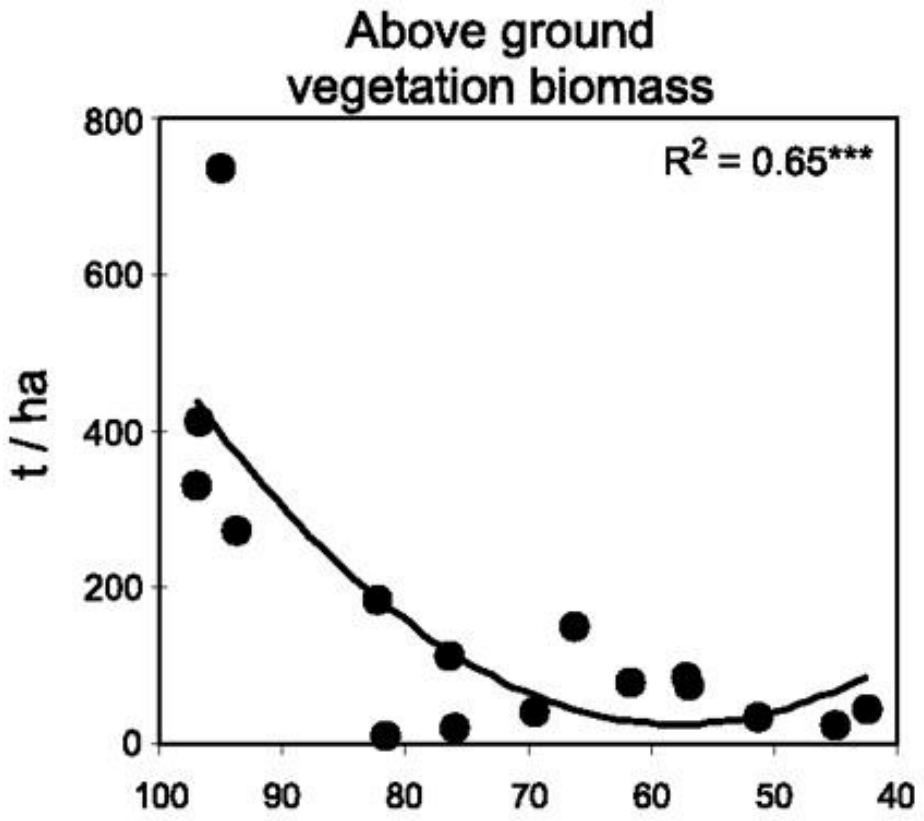
- Present key results
- Draw conclusions for agricultural and forest management

Land use types & land use gradients

Aboveground biomass, premontane natural forests



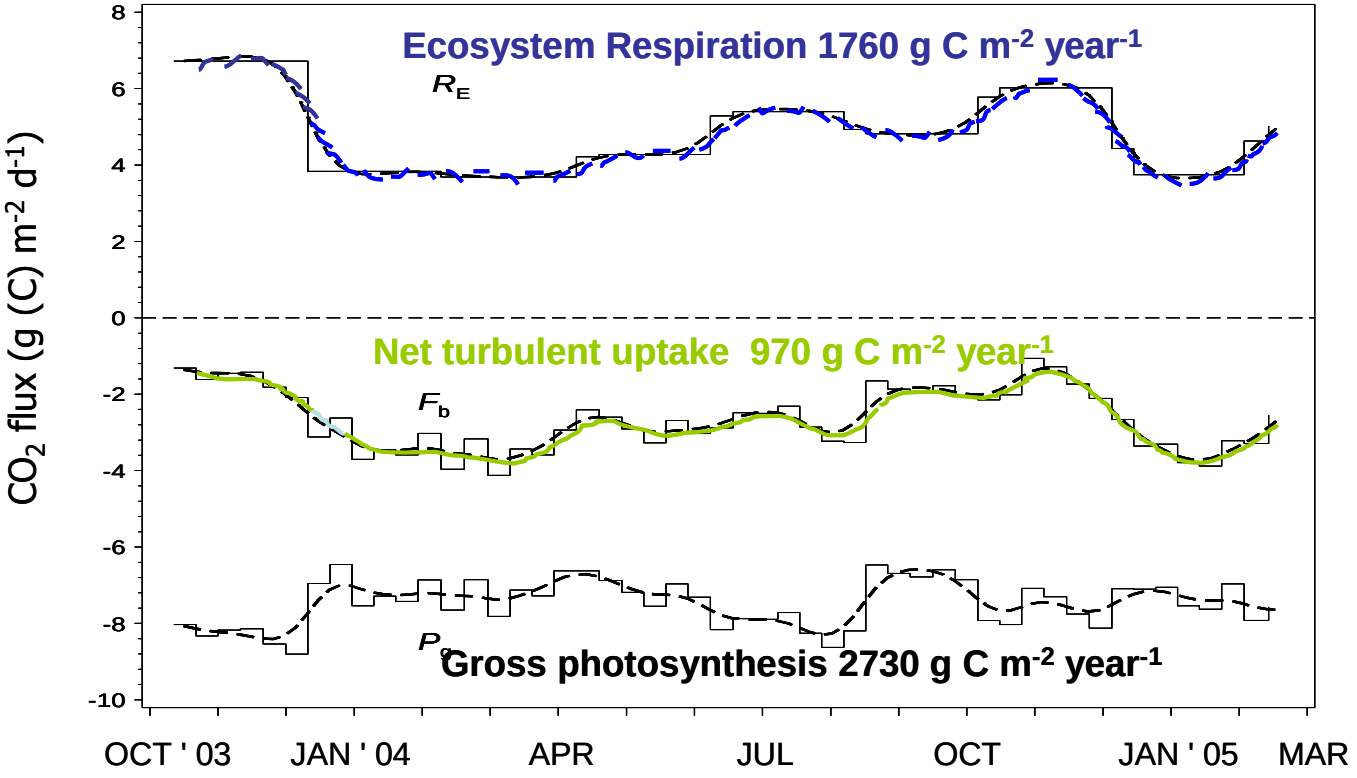
Hertel et al. 2009



Steffan-Dewenter et al., 2007

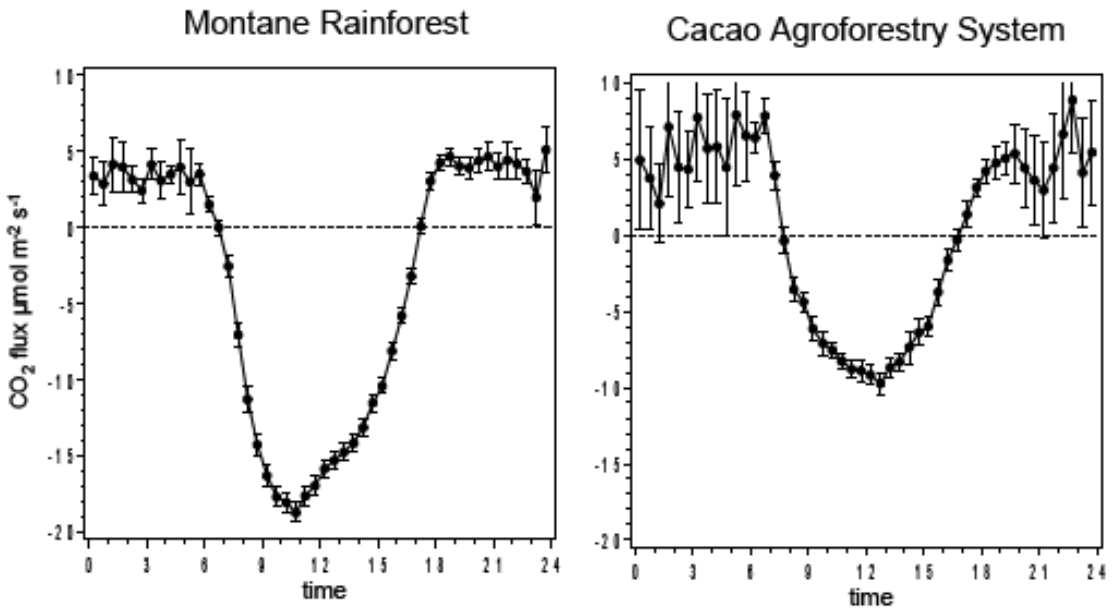
Meteorological flux tower in a montane rainforest, Bariri

Measured net ecosystem exchange flux F_c, extrapolated respiration flux RE, and the sum of both fluxes Pg (gross photosynthesis)



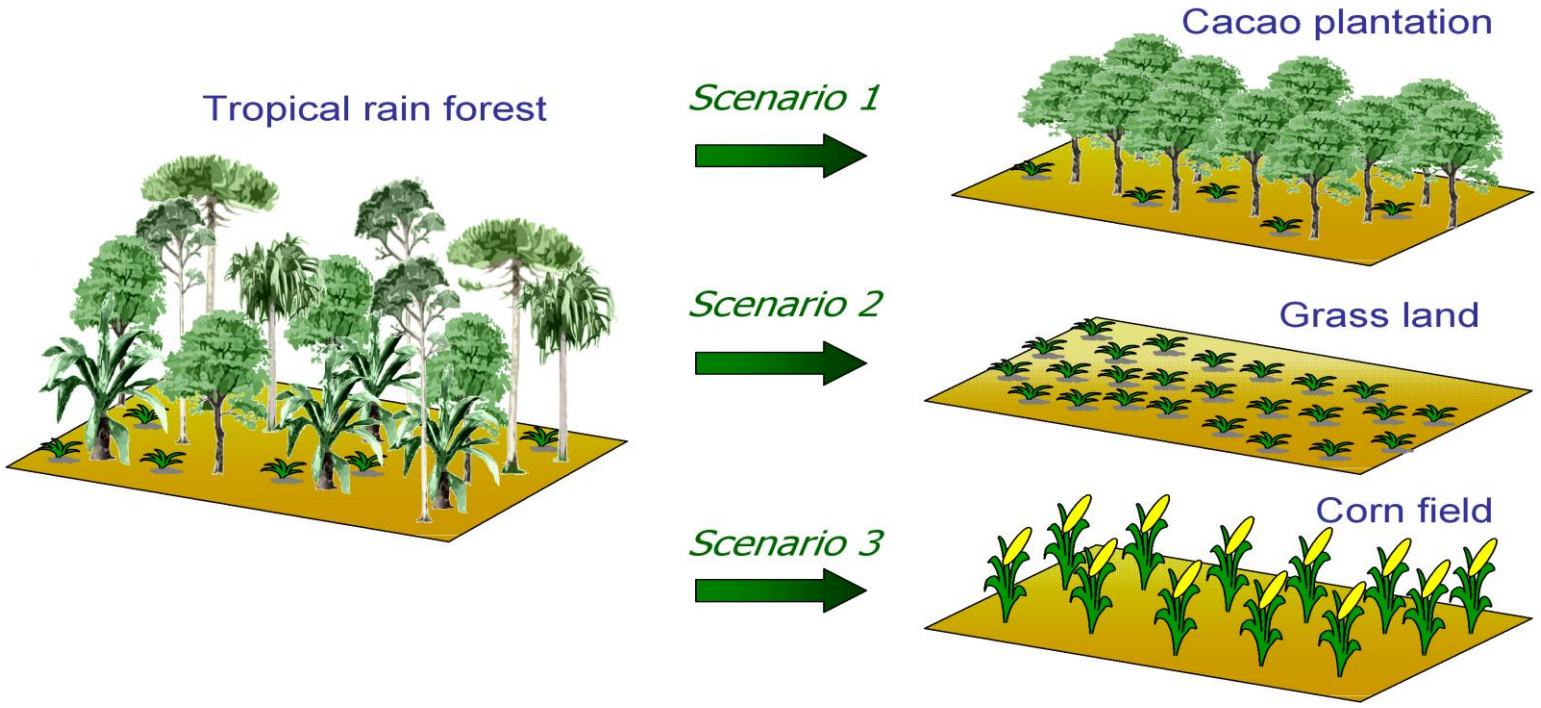
Ibrom et al., 2007

CO_2 fluxes between the atmosphere: forest vs. cacao



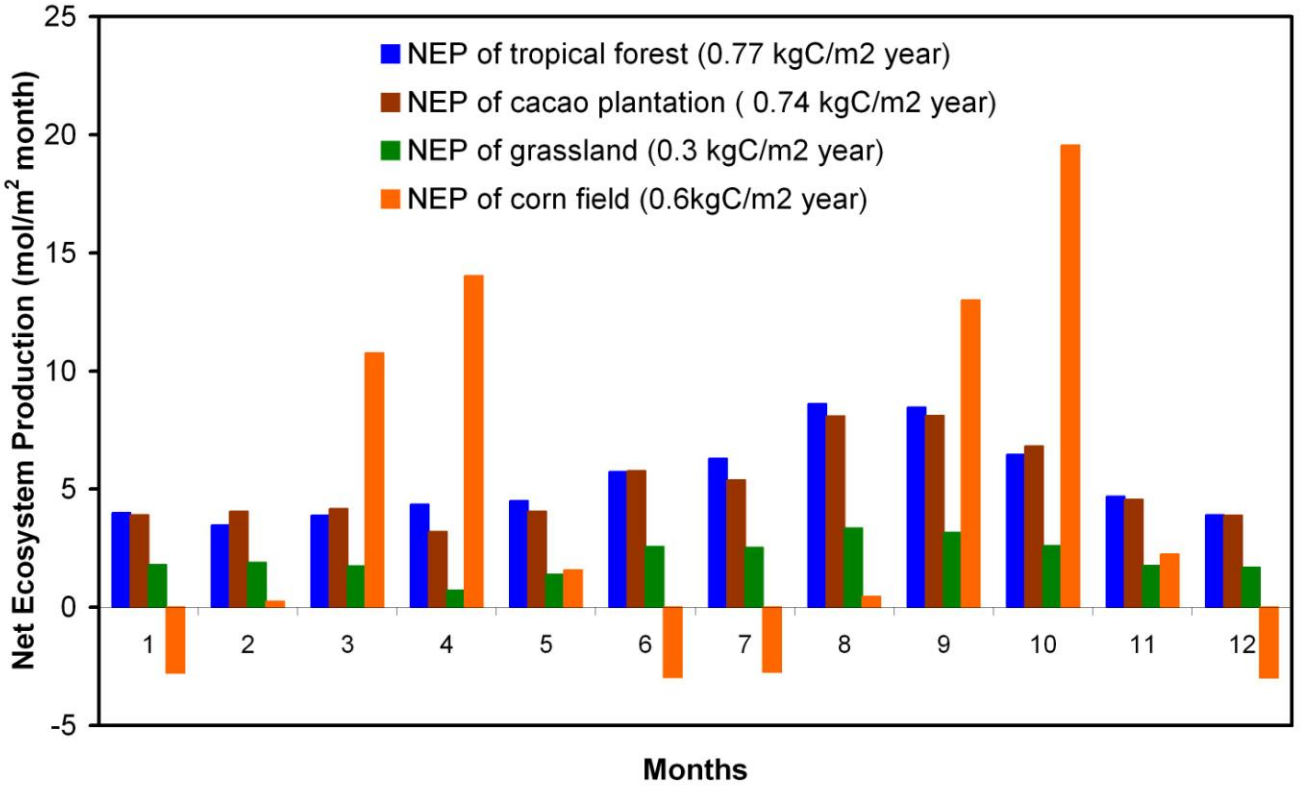
Ibrom et al., 2007

Land use types and net ecosystem productivities: scenarios



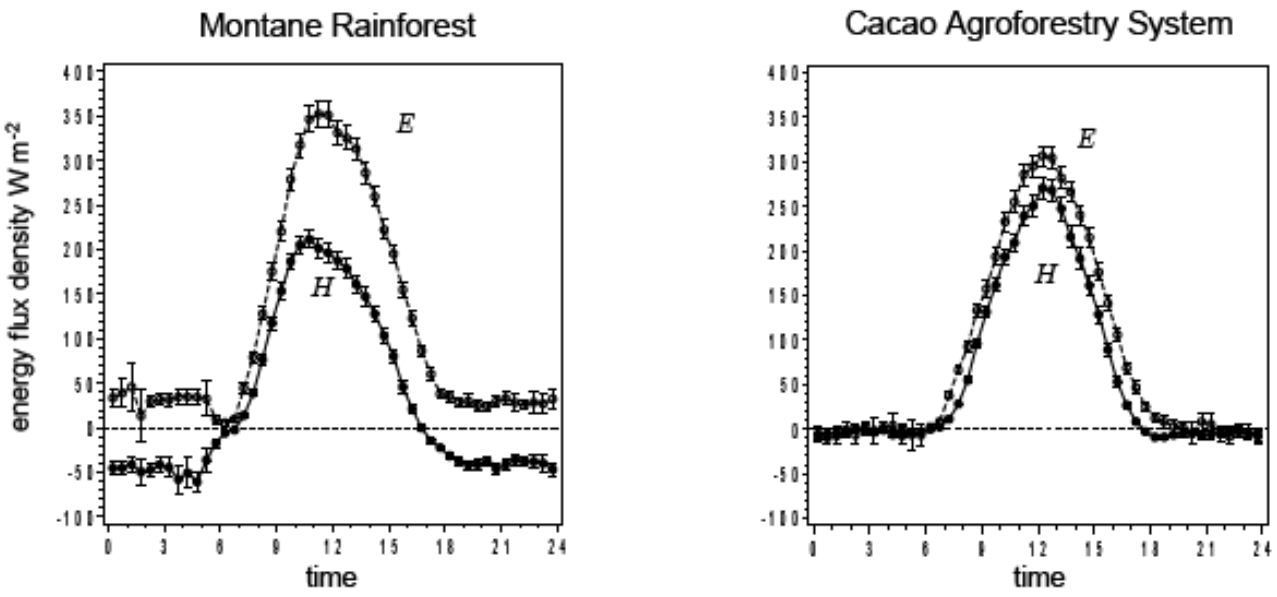
Olchev et al., 2008

Land use types and net ecosystem productivities: model results



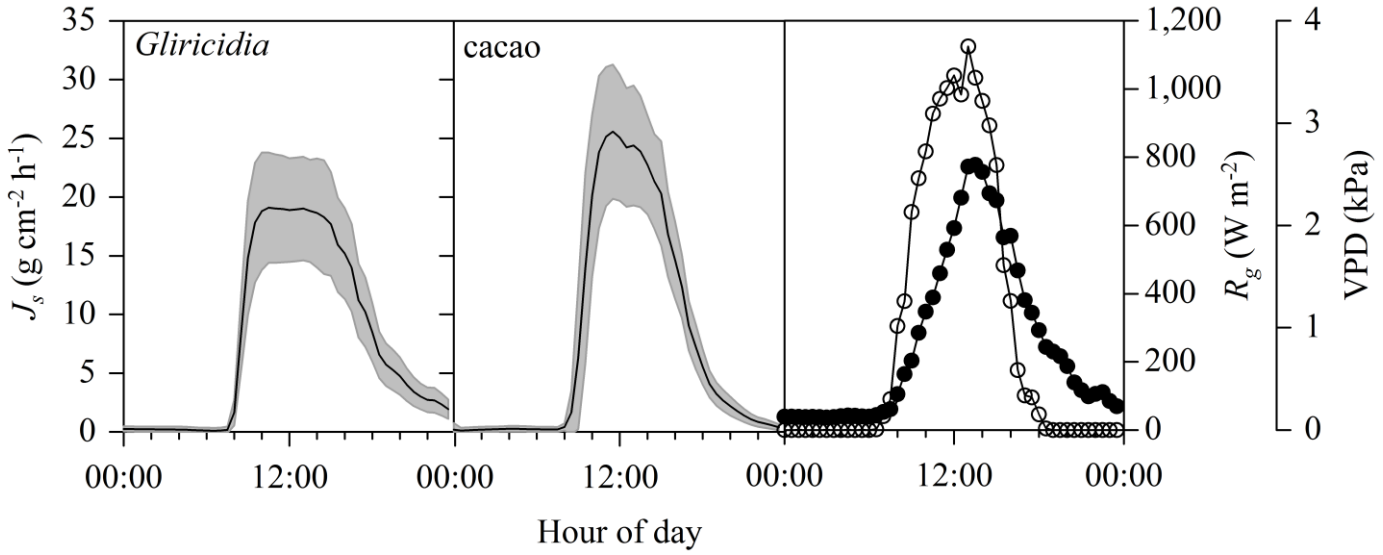
Olchev et al., 2008

Fluxes of sensible (H) and latent (E) energy: forest vs. cacao



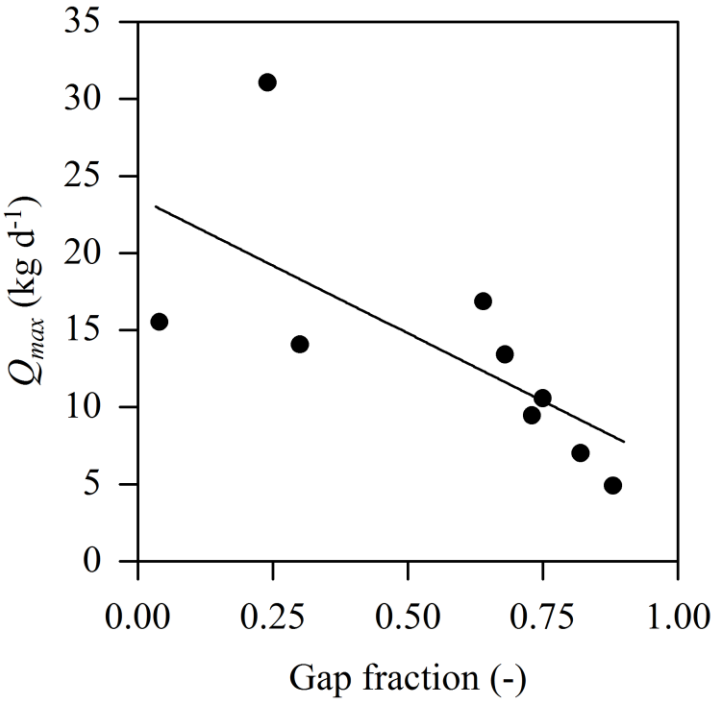
Ibrom et al., 2007

Sap flux of cacao and shade trees



Köhler et al. 2009

Cacao tree water use vs. canopy gap fraction



Shade trees enhanced water use by cacao trees

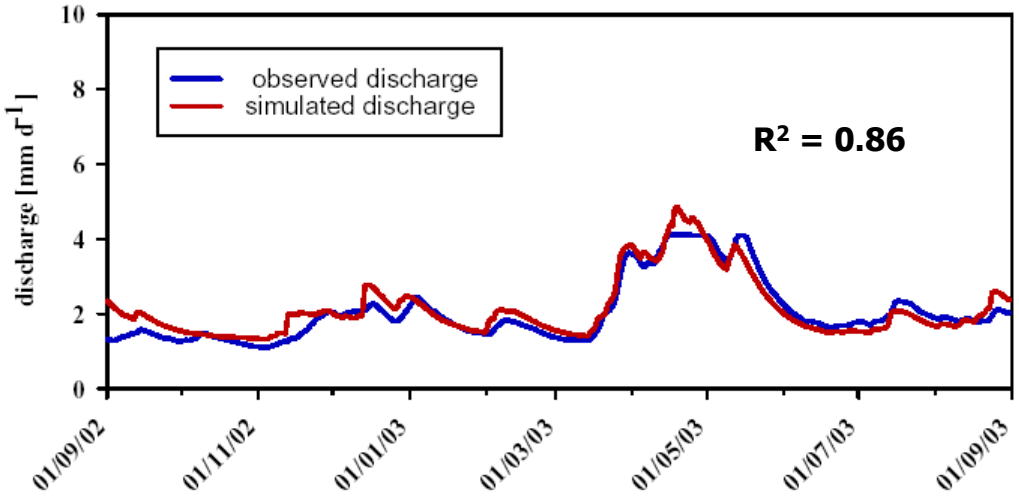
(R^2_{adj} = 0.39, p = 0.043, n = 9)

Köhler et al. 2009

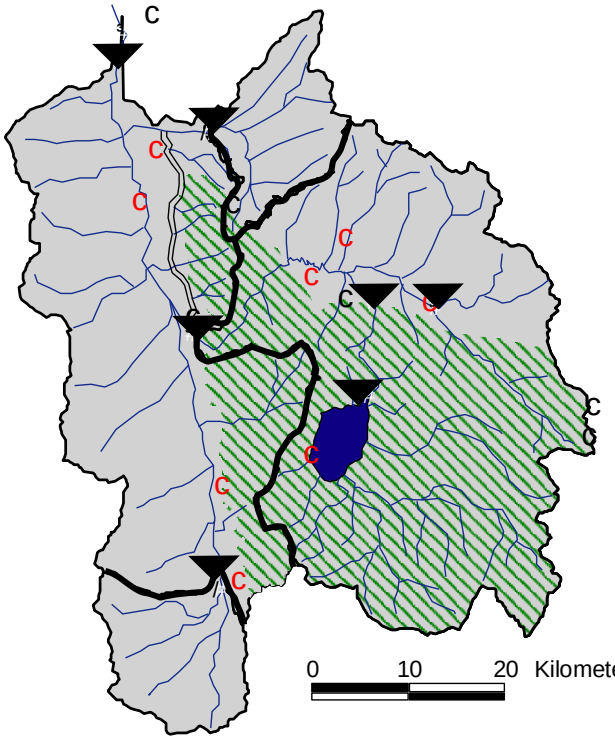
Gumbasa river watershed

Catchment size: **1275 km²**

River discharge



Gerold & Leemhuis 2008



automatic stage recorder
stage recorder – Forestry
climate station
climate station STORMA
main irrigation chanel
Lore Lindu National Park
Palu river watershed

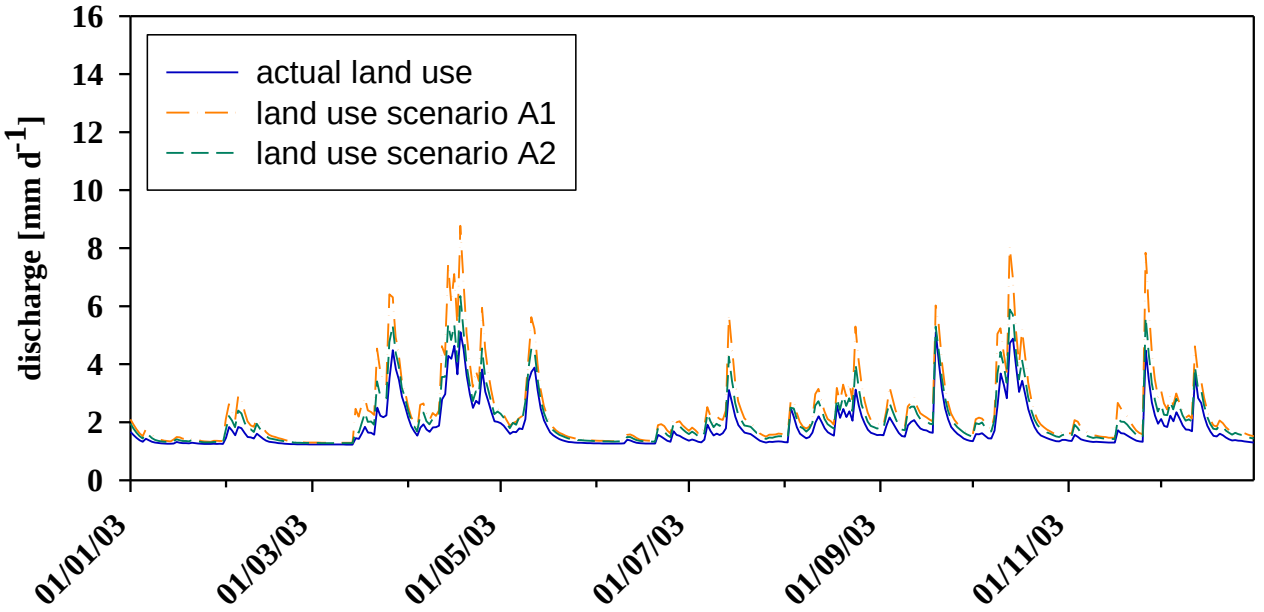
Gauging stations

Modeling discharge of the river discharge, Gumbasa watershed: effects of land cover change

Discharge (2003): status quo 2003: 590 mm

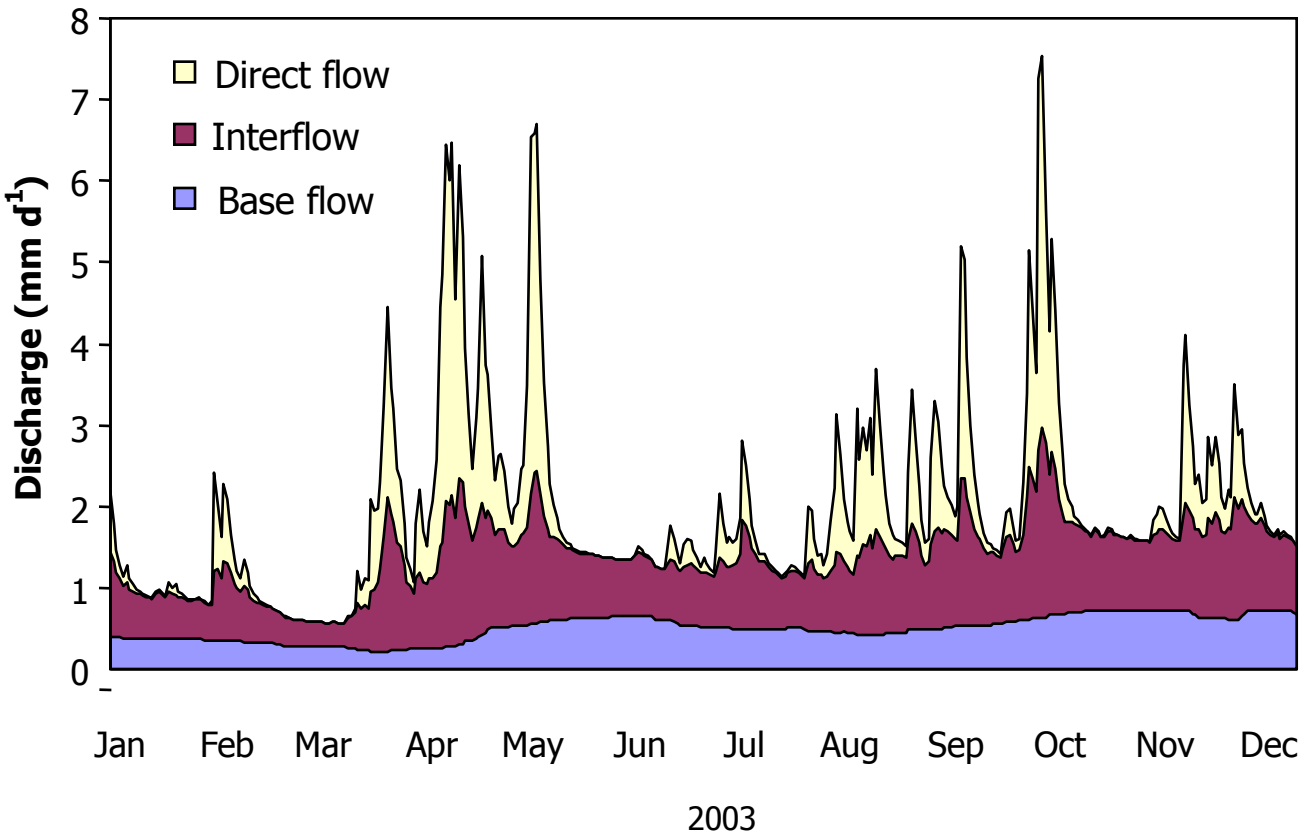
land use scenario A1: 838 mm **+ 42%** **≤ 1200m annual crops**

Land use scenario A2: 724 mm **+ 23%** **≤ 1200m change into cacao**



Gerold & Leemhuis 2008

Modeled run off components



Kleinhans et al. 2004

Nutrient balance of maize and agroforest

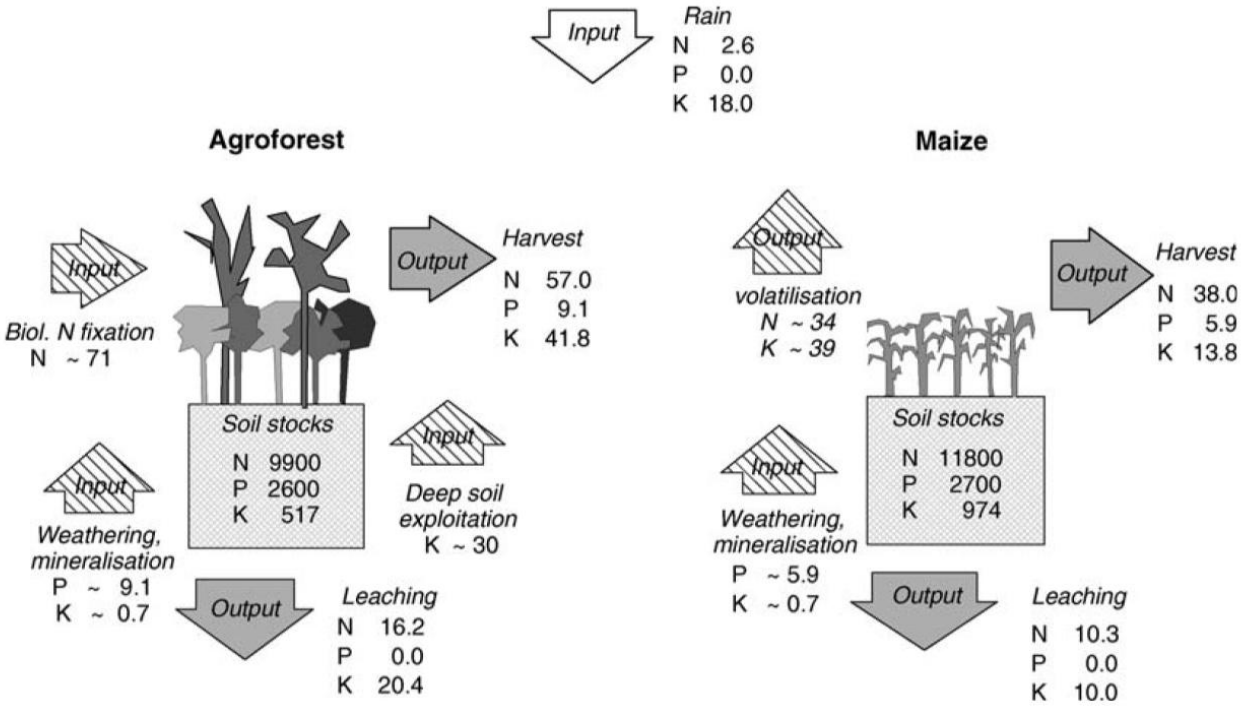


Figure 2. Nutrient balance of agroforestry and maize, location 1. Solid arrows indicate measured fluxes, hatched arrows indicate nutrient fluxes that were not measured, but estimated based on indirect evidence (see text). Soil stocks (0–40 cm, total N and P, exchangeable K) are in kg ha^{-1}, all fluxes in kg ha^{-1} a^{-1}.

Dechert et al., 2004

Summary
land use types & land use gradients

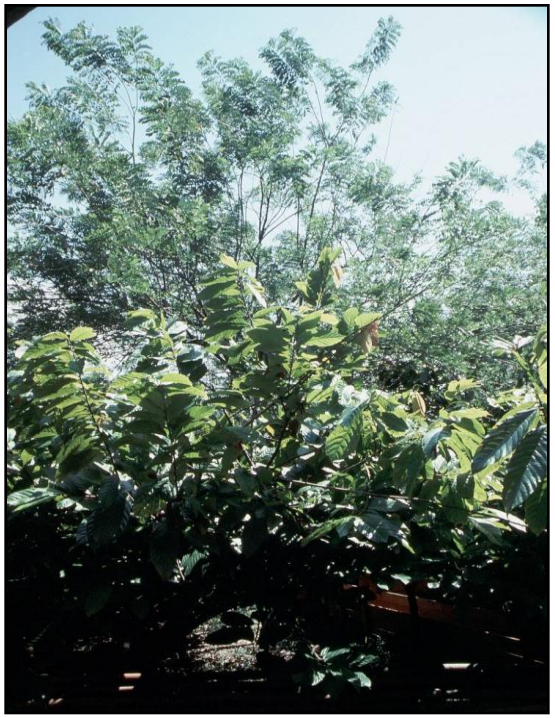
- High carbon storage in forests of Sulwesi
- High carbon uptake by forest
- Shade trees enhance transpiration from agrofrests
- River discharge change with land cover change suggested
- Agroforestry strongly benefits from nitrogen input by N fixing shade trees

Implications

- Very important to conserve remaining forests
- Shade trees positively influence cacao cultivation

Drought experiments

Premontane rainforest



Cacao/Gliricidia agroforest

Cacao-*Gliricidia* agroforest

80% of plot area was covered by plastic panels (March 07- mid April 08);

n=3 roof (treatment) plots, n=3 control plots

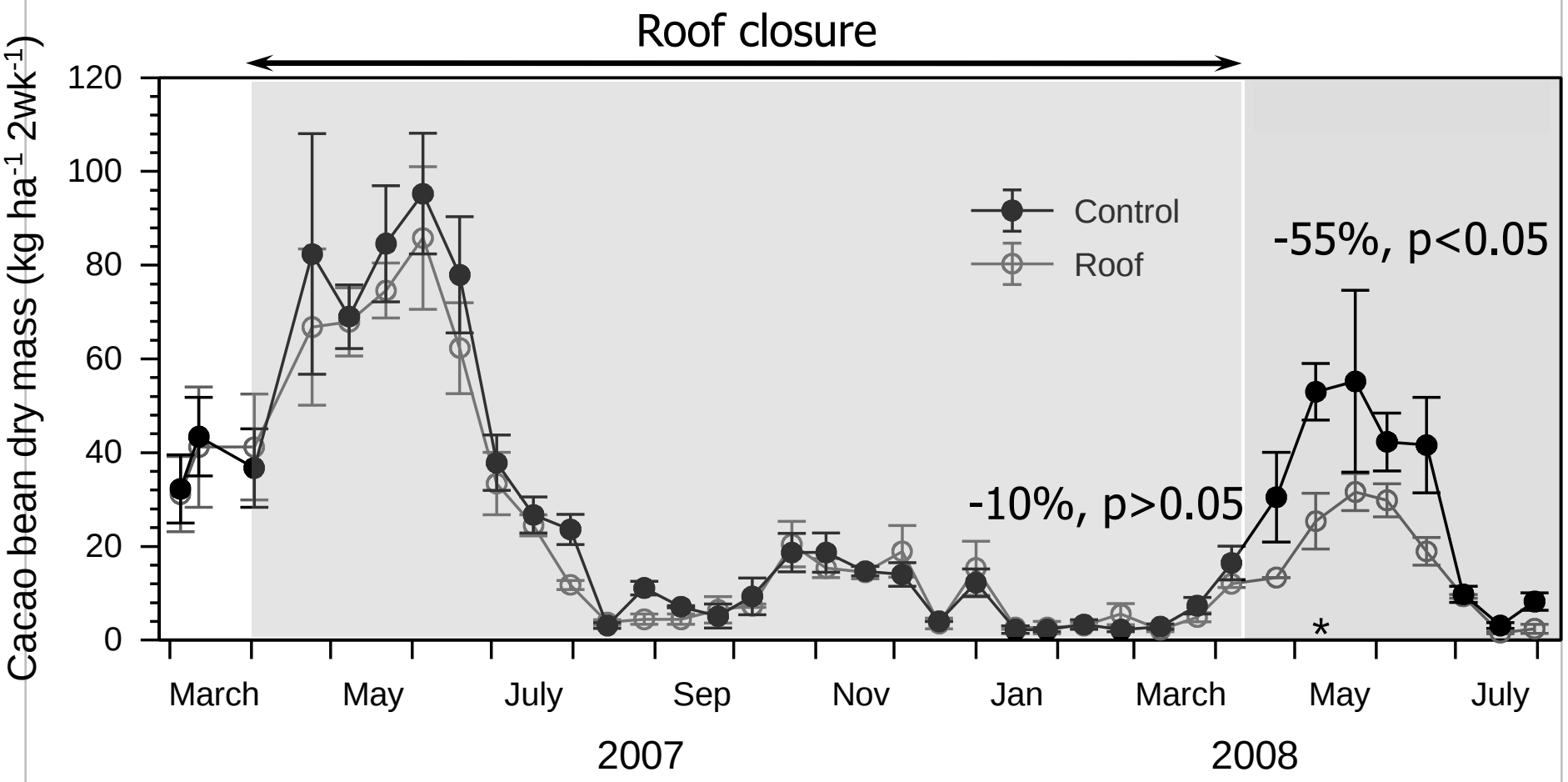
Tree sap flux

Soil water content

Cacao bean yield

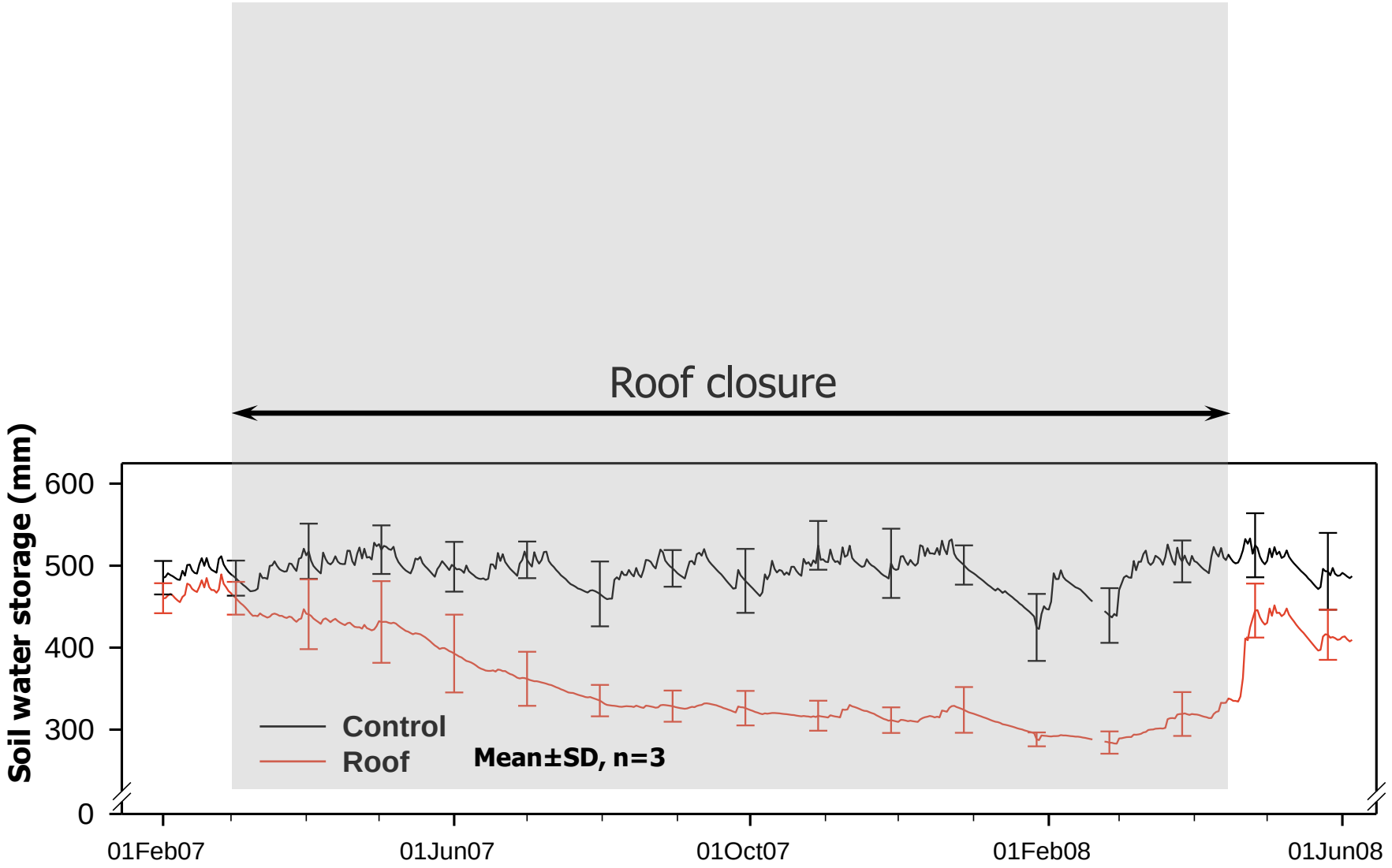
Litterfall

Cacao yield



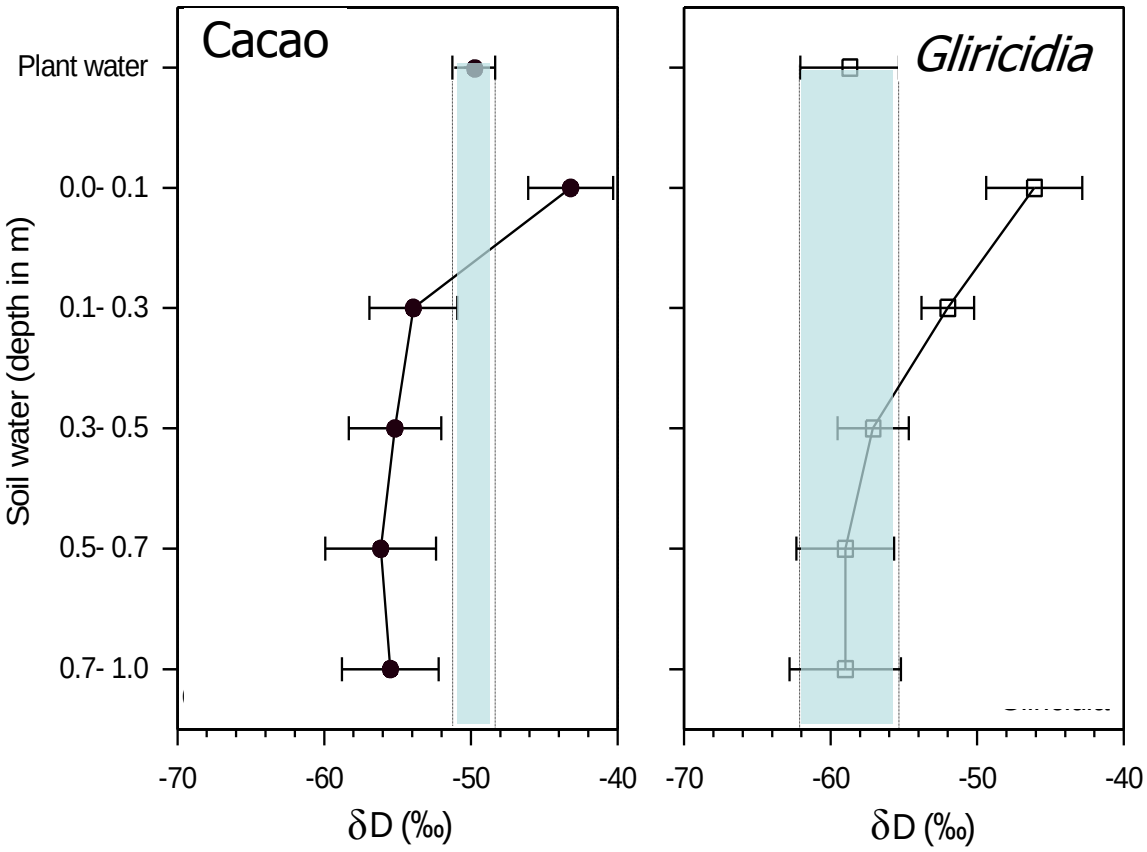
Moser et al. under review

Soil water storage and cacao water use



Complementary use of soil water

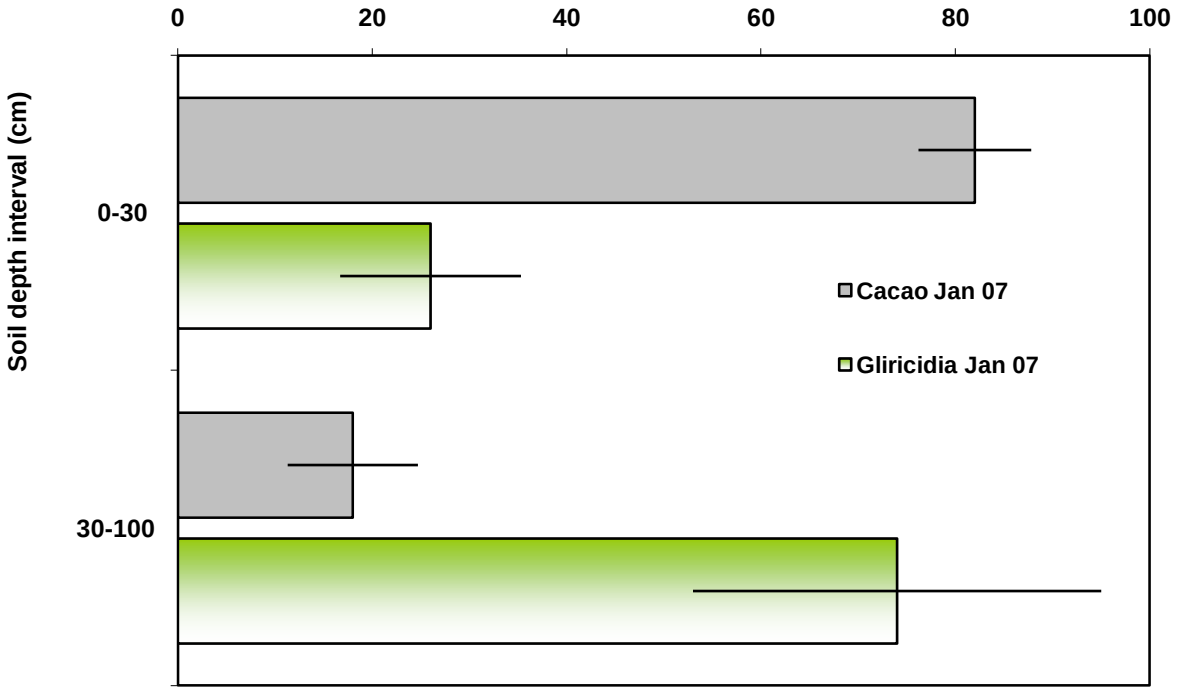
deuterium signal



Schwendenmann et al. 2009

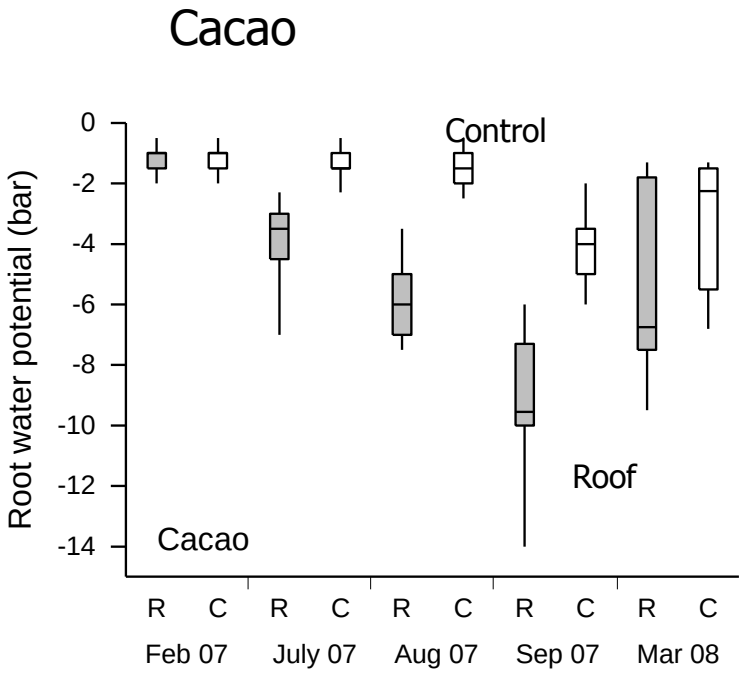
Water uptake depth cacao and Glricidia

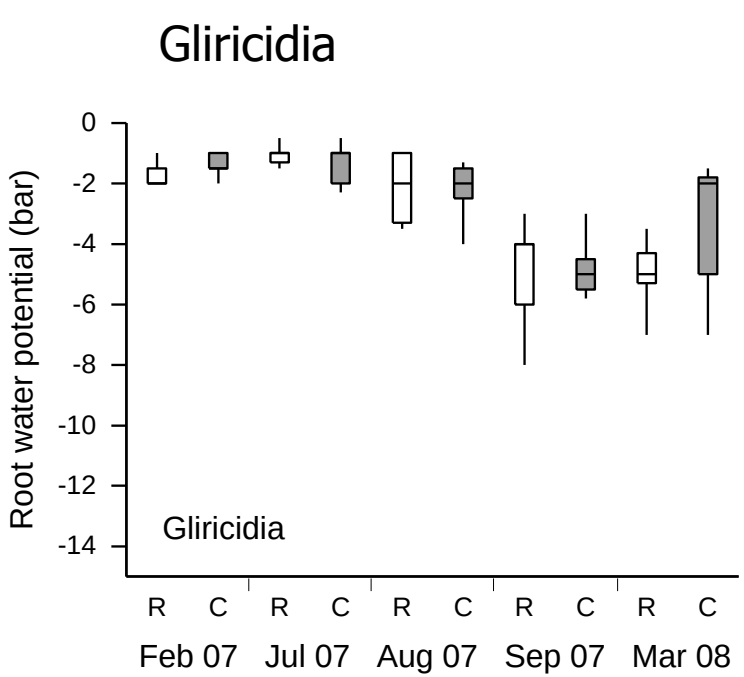
Proportion of water uptake from a given soil depth interval (%)



Schwendenmann, unpublished

Root water potential

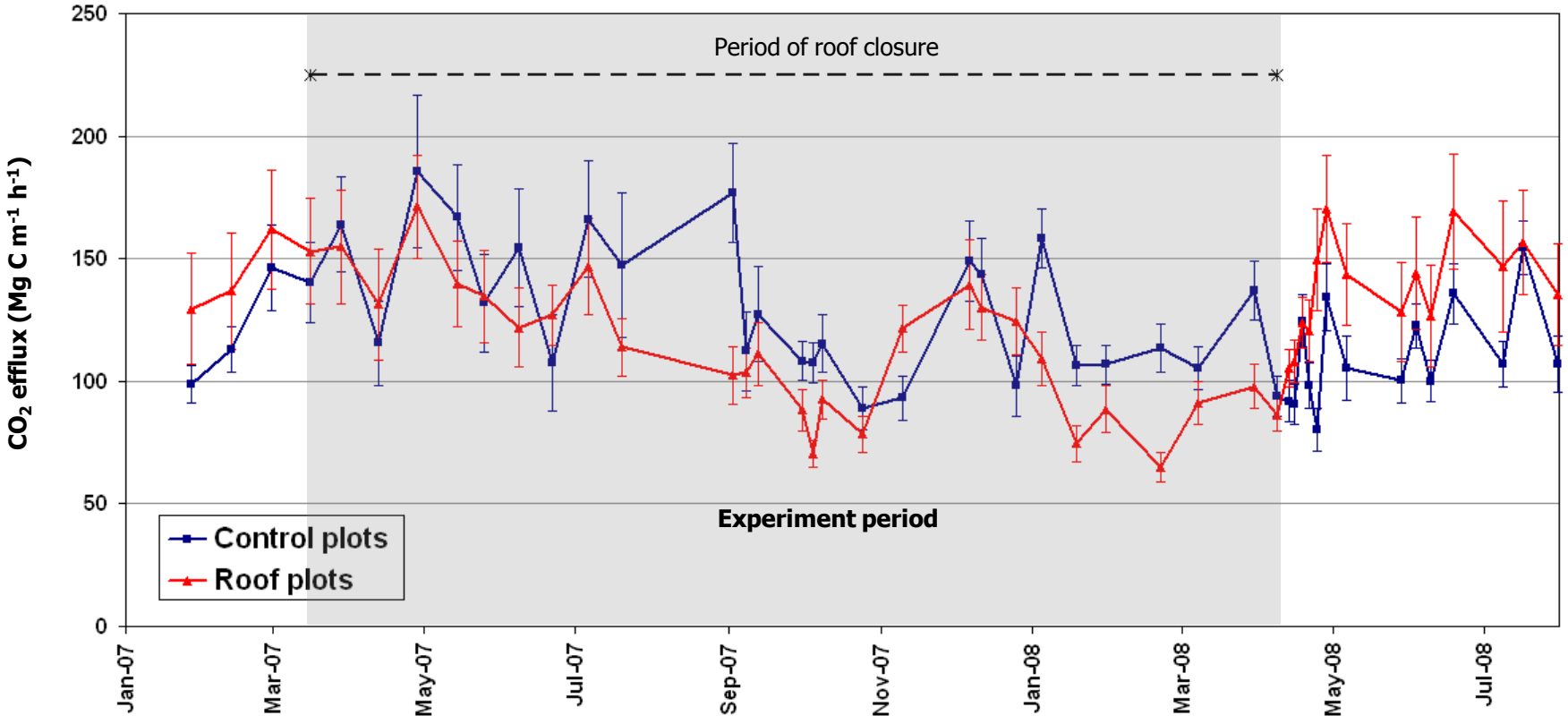




Osmotic adjustment in cacao

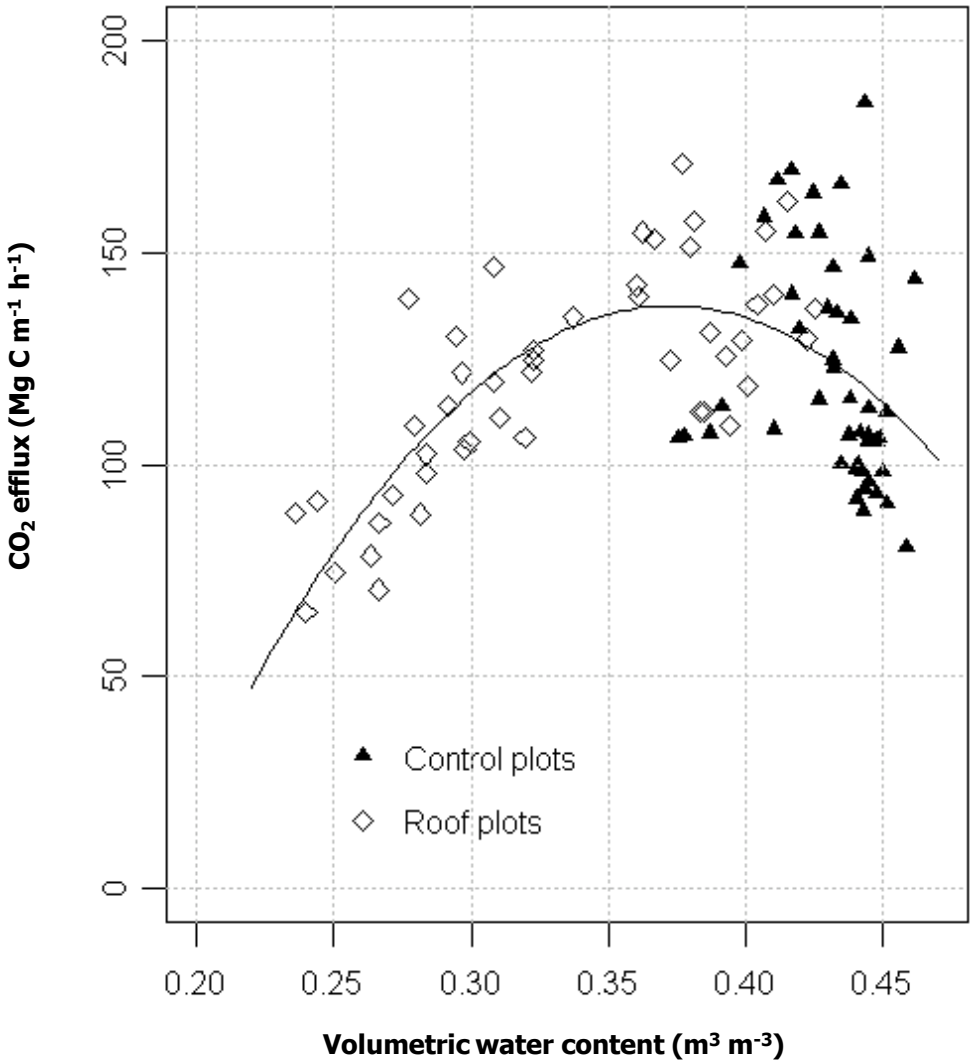
Moser et al. under review

CO_2 soil efflux



Van Straaten, unpublished

CO_2 efflux response to soil moisture



(Adj R^2 = 0.338, n = 94)

Van Straaten, unpublished

Summary
cacao drought experiment

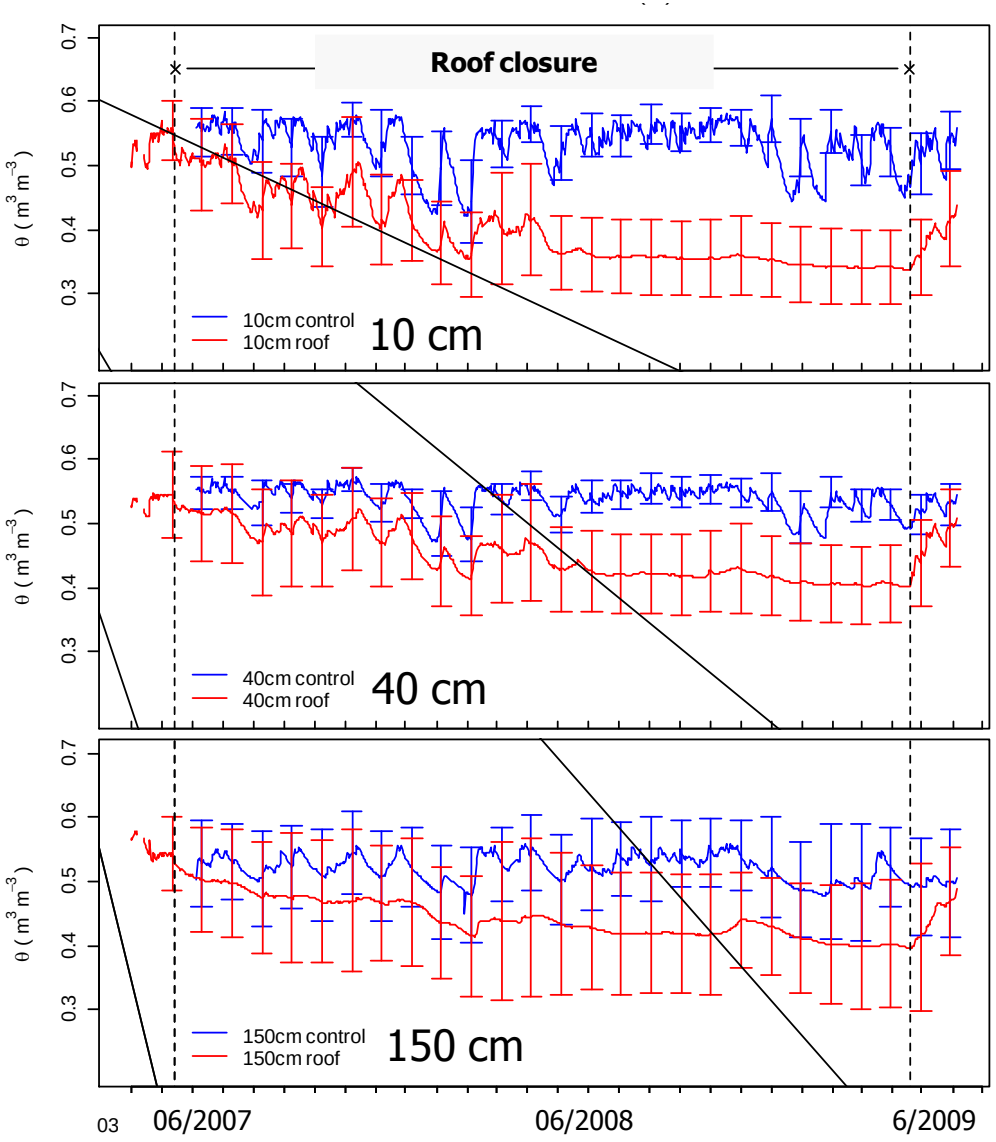
- Cacao yield was little influenced for several months; a strong (~50%) reduction was observed at the end of the experiment
- Little response of tree water use to drought
- Cacao and Glriricidia trees use soil water resources complementary
- Small effects of drought on soil CO_2 efflux

Implications

- Cacao is a suitable crop even where short dry spells occur
- Shade trees: no negative effect on cacao tree performance

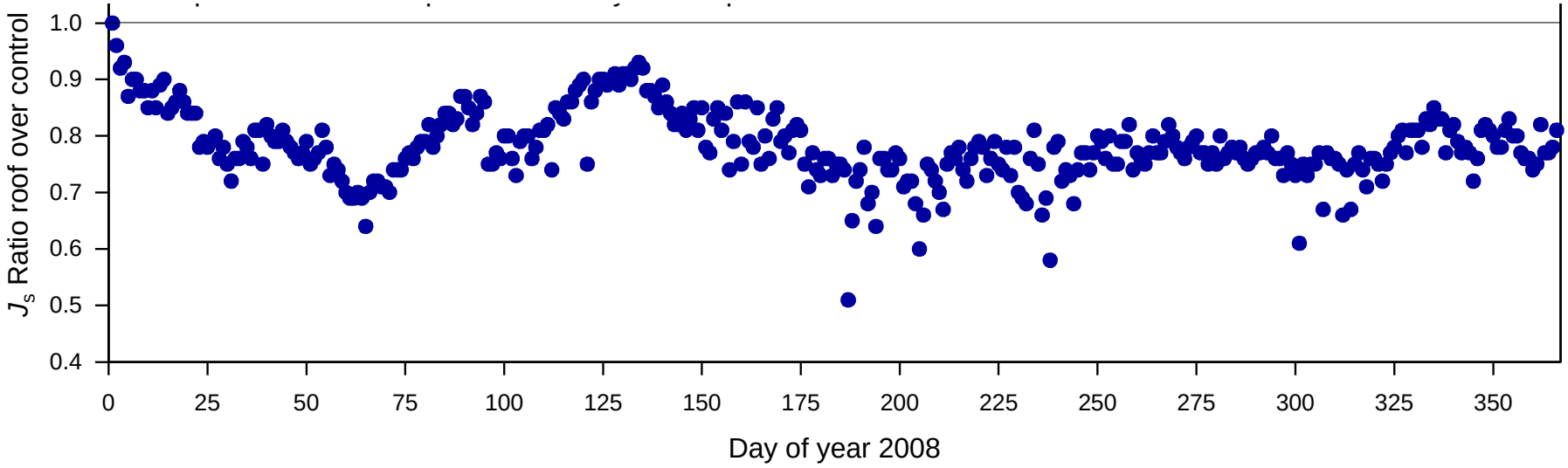
Forest

Soil moisture



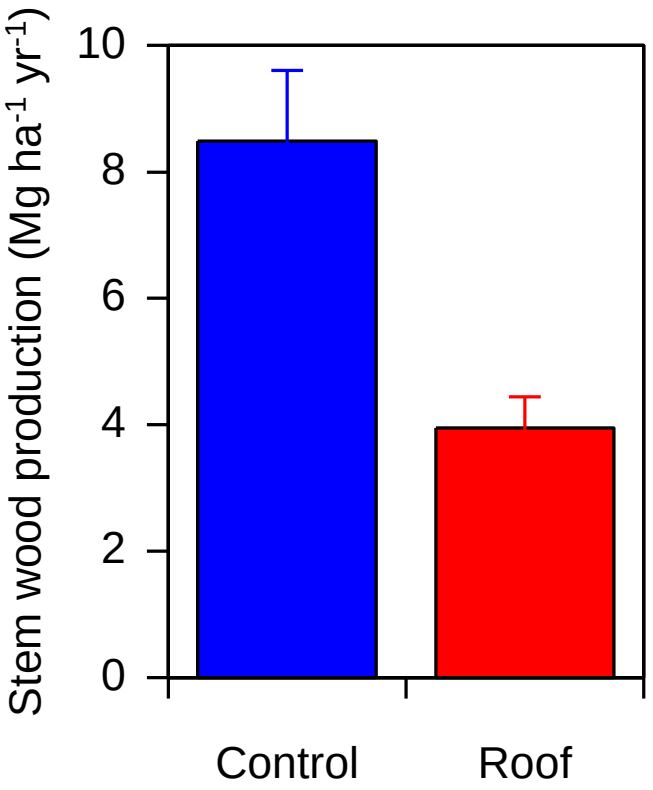
Köhler, unpublished

Sap flux: all trees



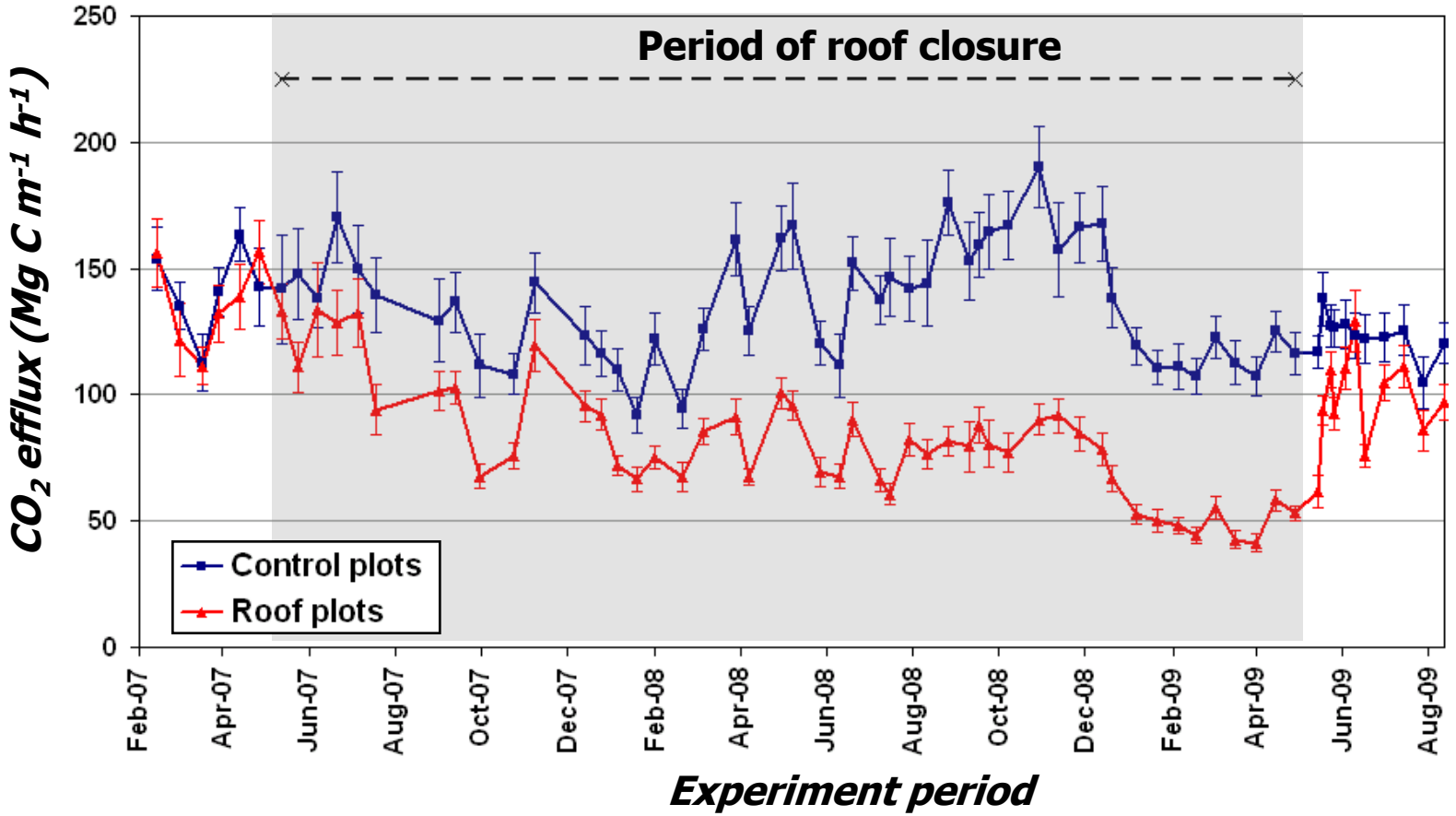
Schuldt, unpublished

Stem wood production (2nd year)



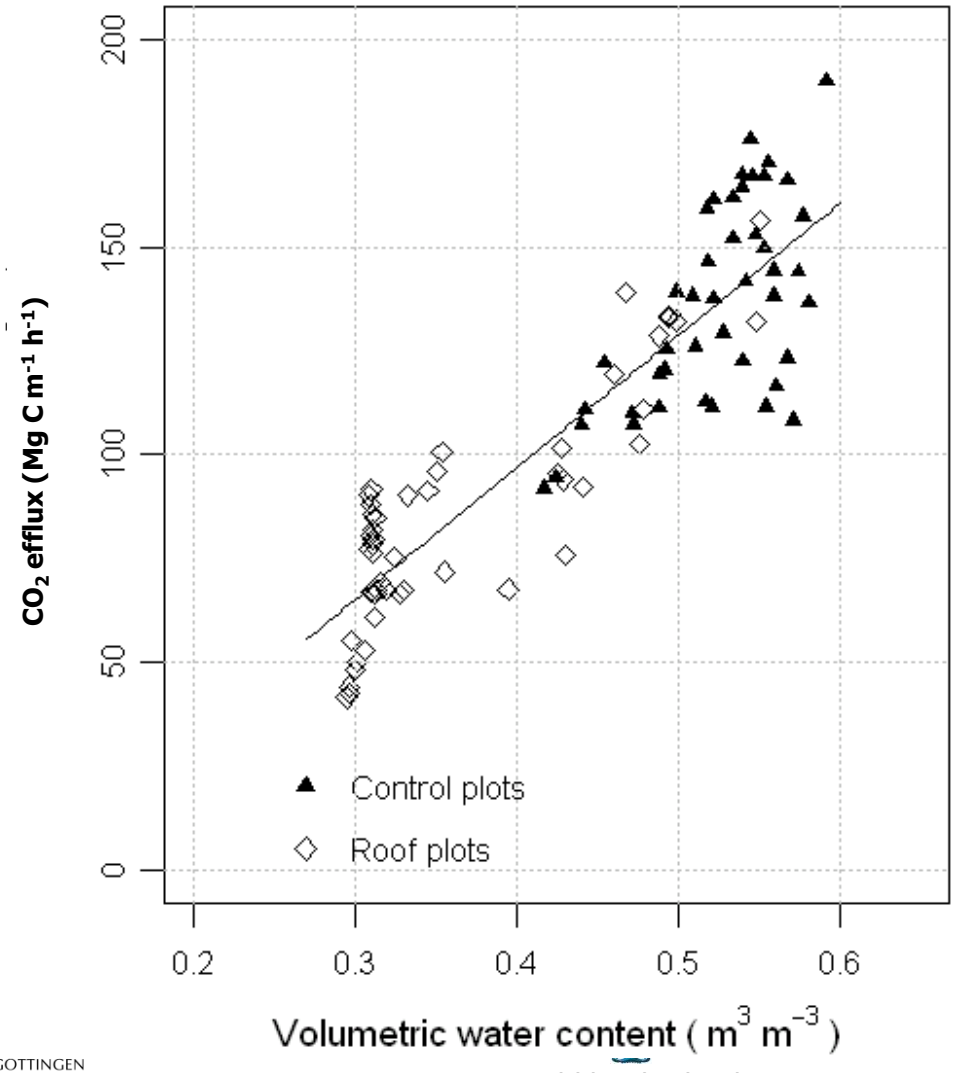
Moser, unpublished

CO_2 soil efflux



Van Straaten, unpublished

CO_2 soil efflux vs. soil moisture



(Adj R^2 = 0.79, n = 93)

Van Straaten, unpublished

Summary
forest drought experiment

- Little response in tree sap flux to drought
- Tree diameter growth was significantly reduced
- Strong effect of drought on soil CO_2 efflux

Overall summary

- Old-growth forest is to be conserved
- Agroforestry is a promissing option in post-forest landscapes
- Shade trees play a central role in cacao cultivation

Thank you for attention!