Modelling the transport and utilization of water and carbohydrates in tropical trees to elucidate observed tree responses to drought

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E-corridor meeting 1st of March 2018

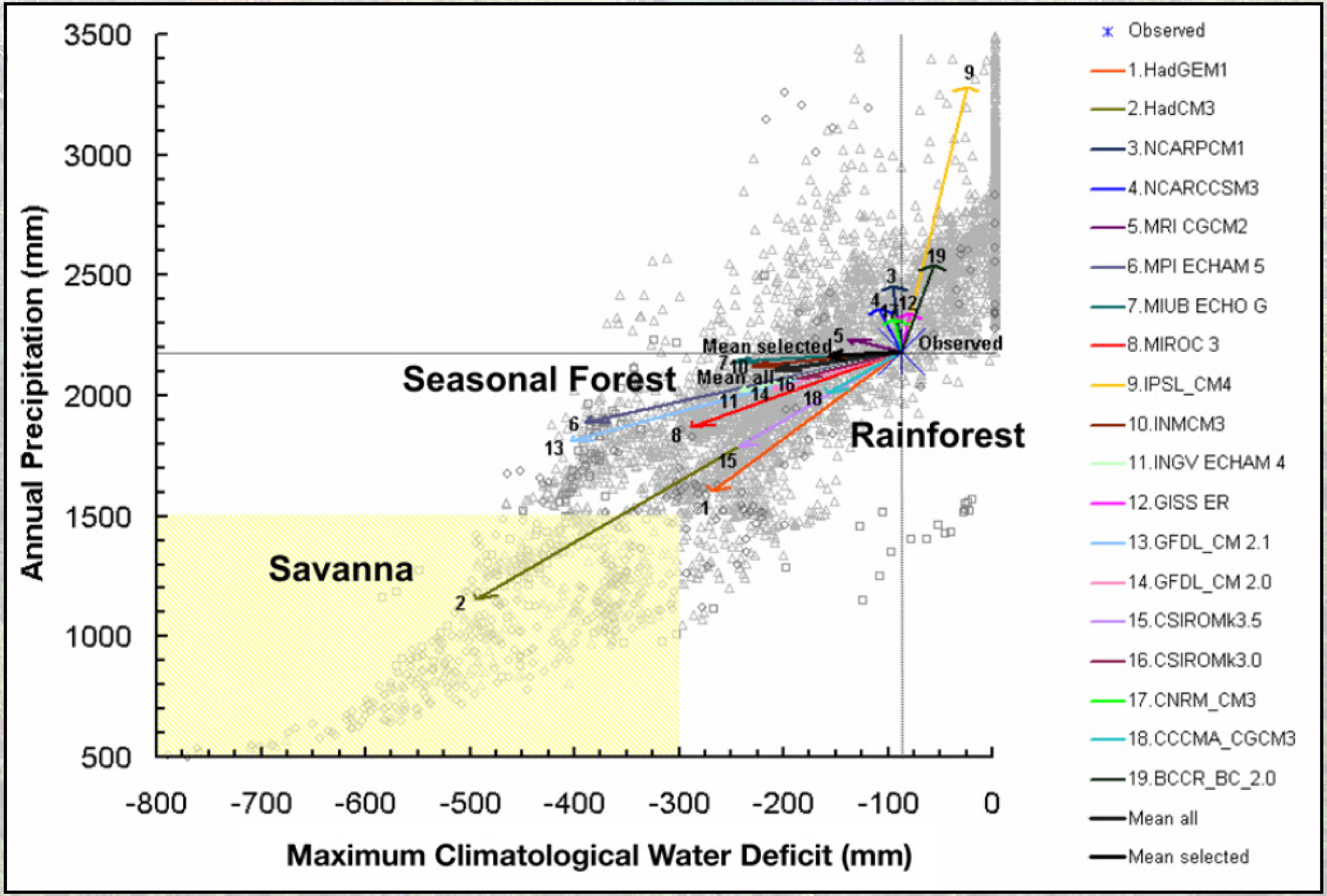
Climate change in the Amazon basin

Surface temperatures have been rising since the 1970's.

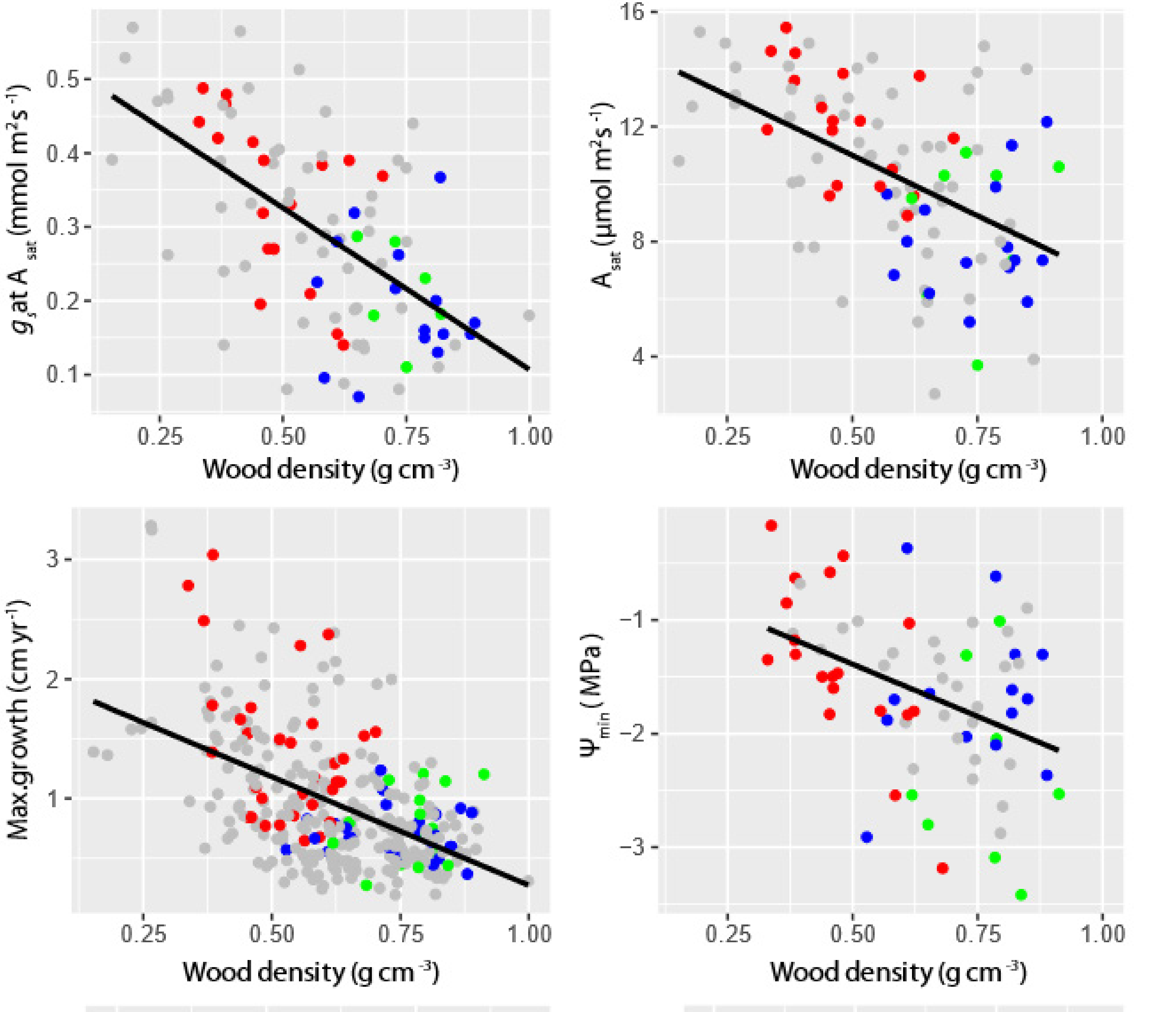
Average temperature is predicted to increase with 6 - 9 °C by the end of the 21st century.

Trends in precipitation are less certain dry season can become drier

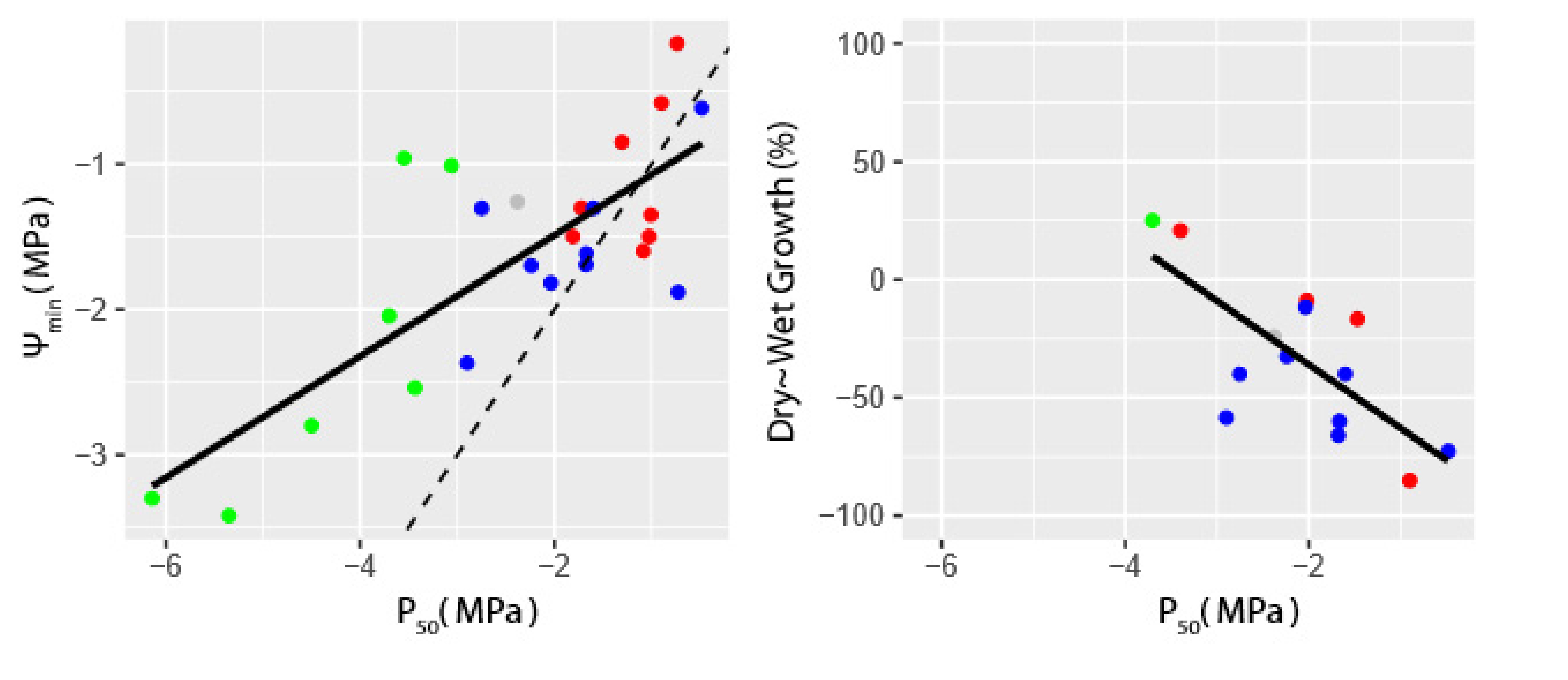
Droughts are expected to become more frequent and more severe!



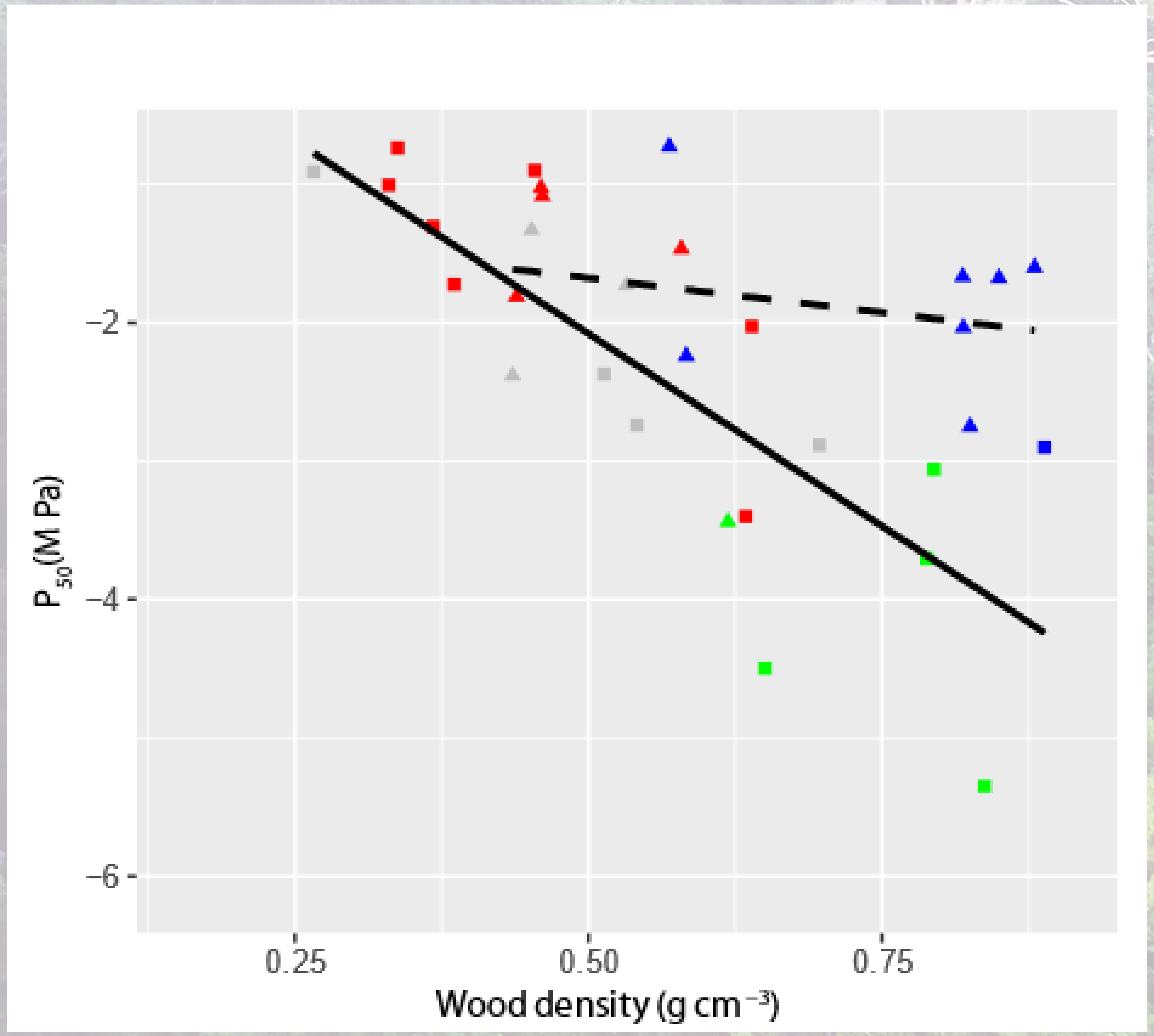
Coordination of traits

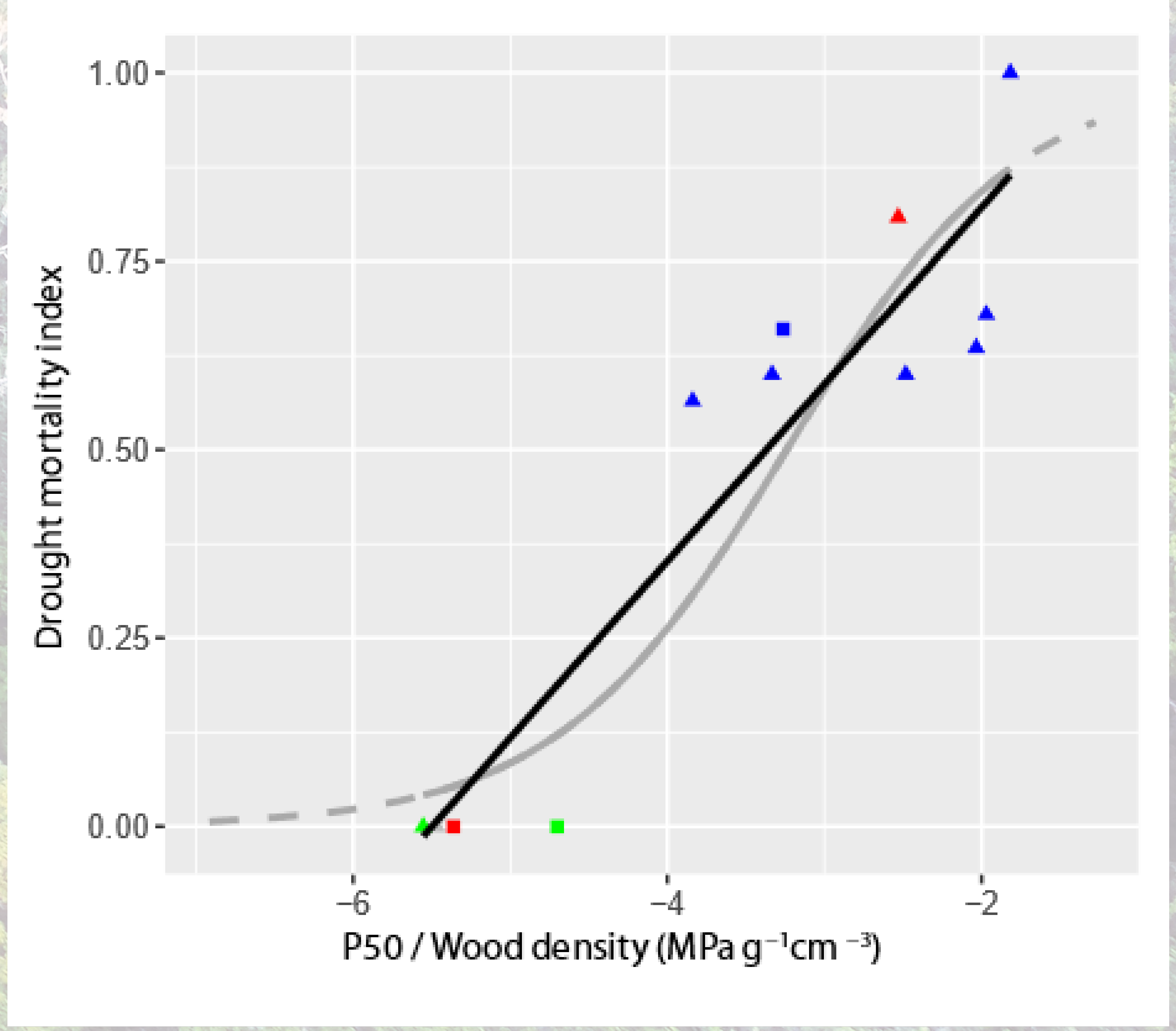


Coordination of traits

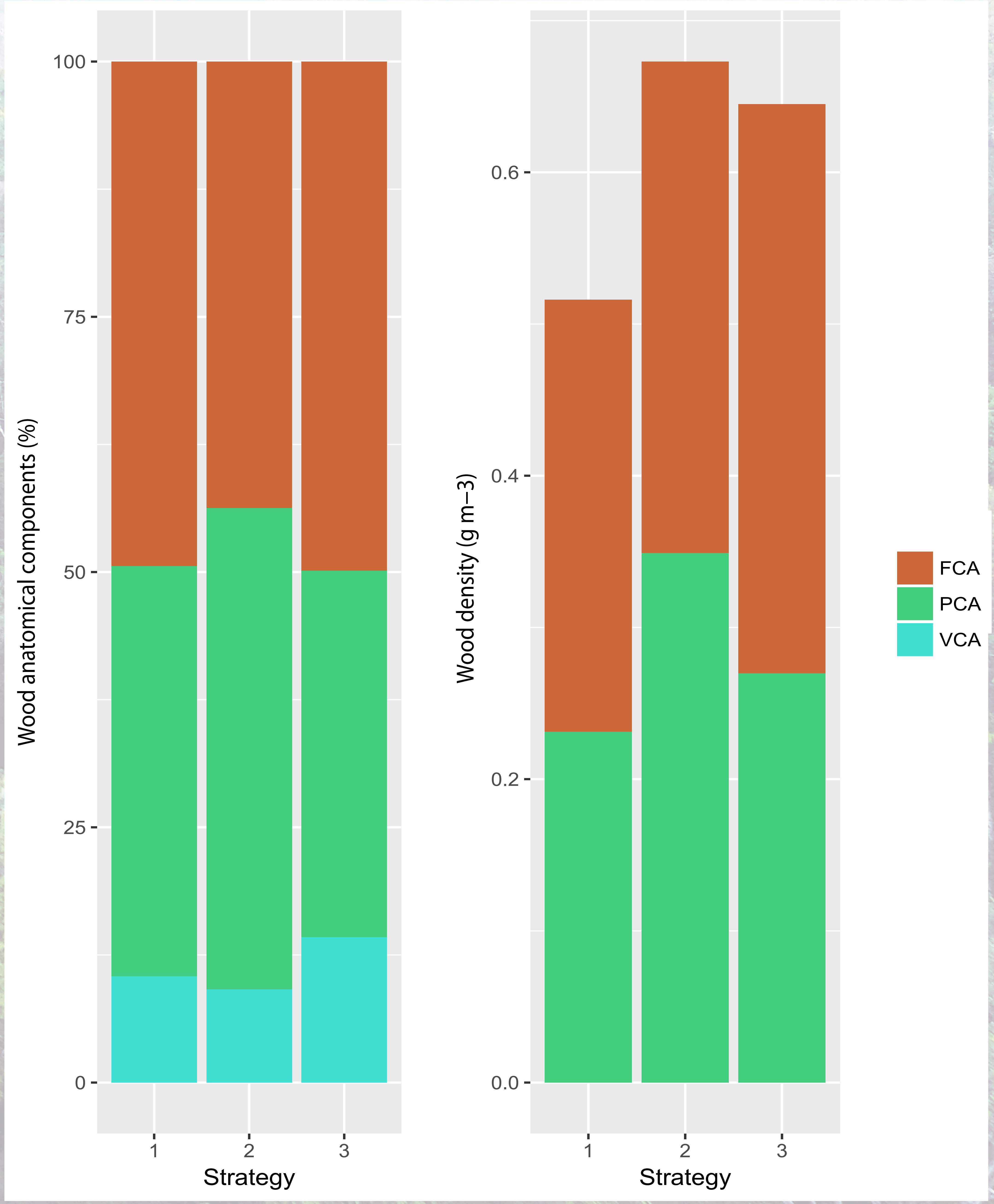


Coordination of traits

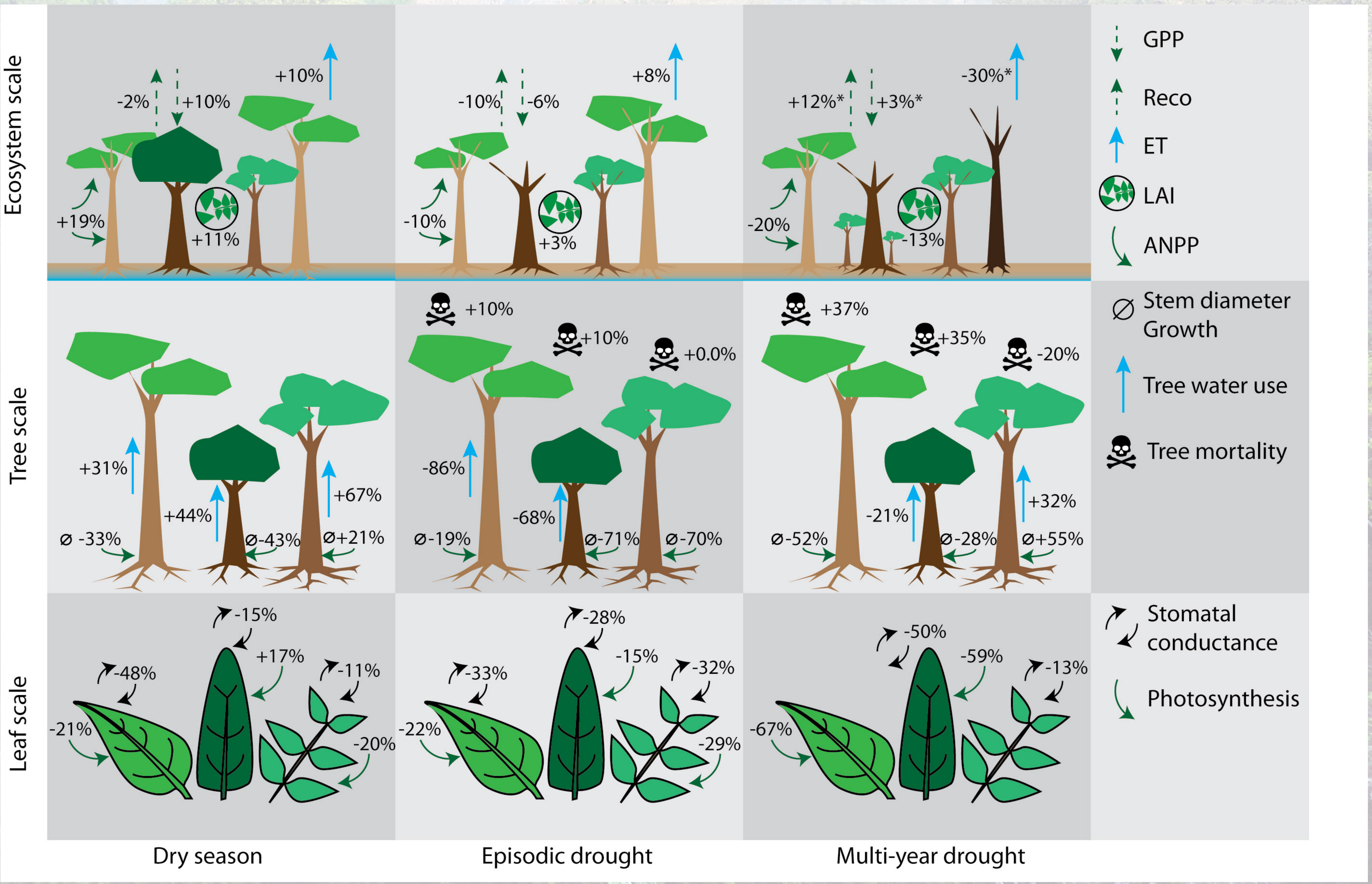




Coordination of traits



Different species, different responses



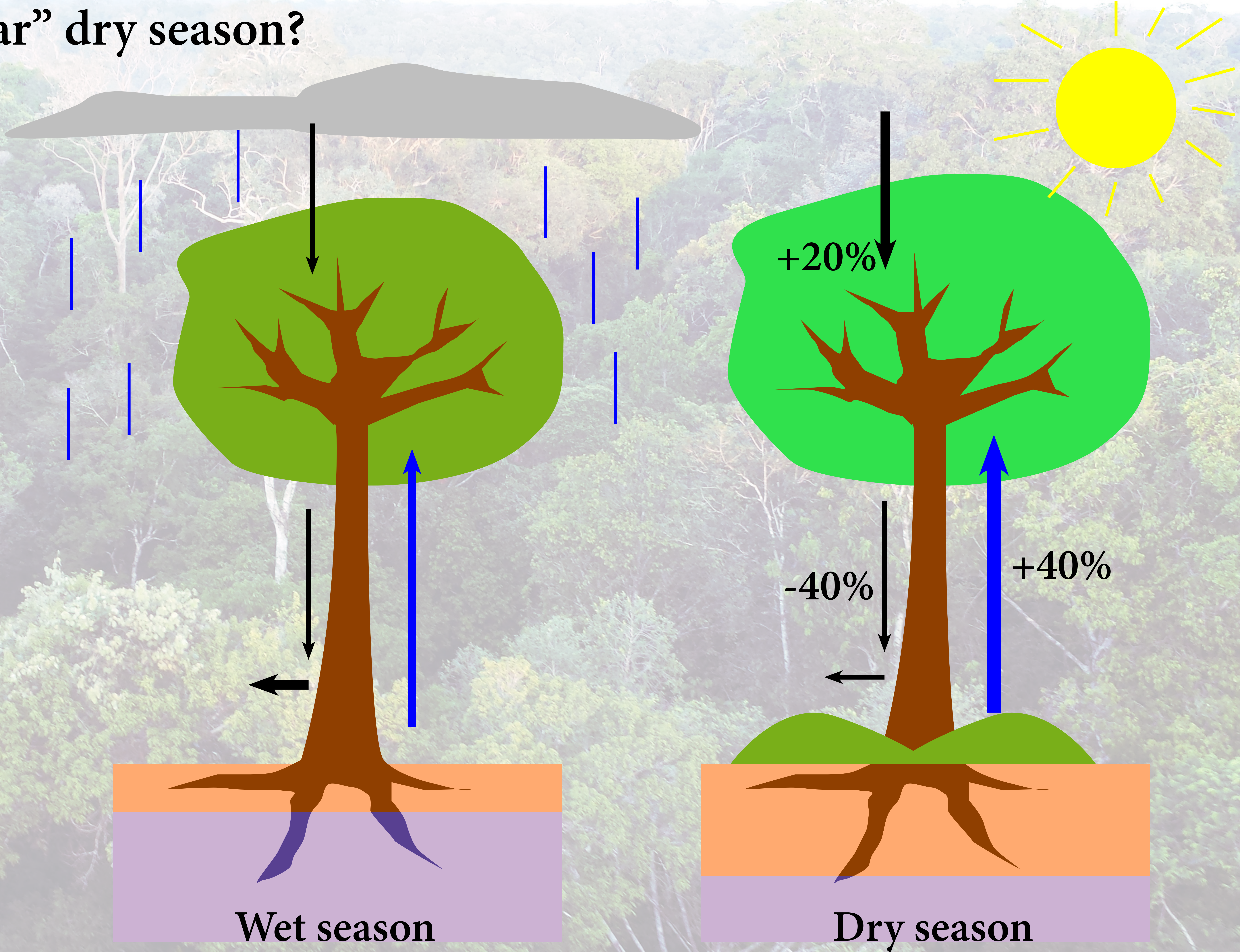
What happens in a “regular” dry season?

Stem growth declines

Growth in the canopy increases (leaf flush)

Transpiration increases

Net productivity increases



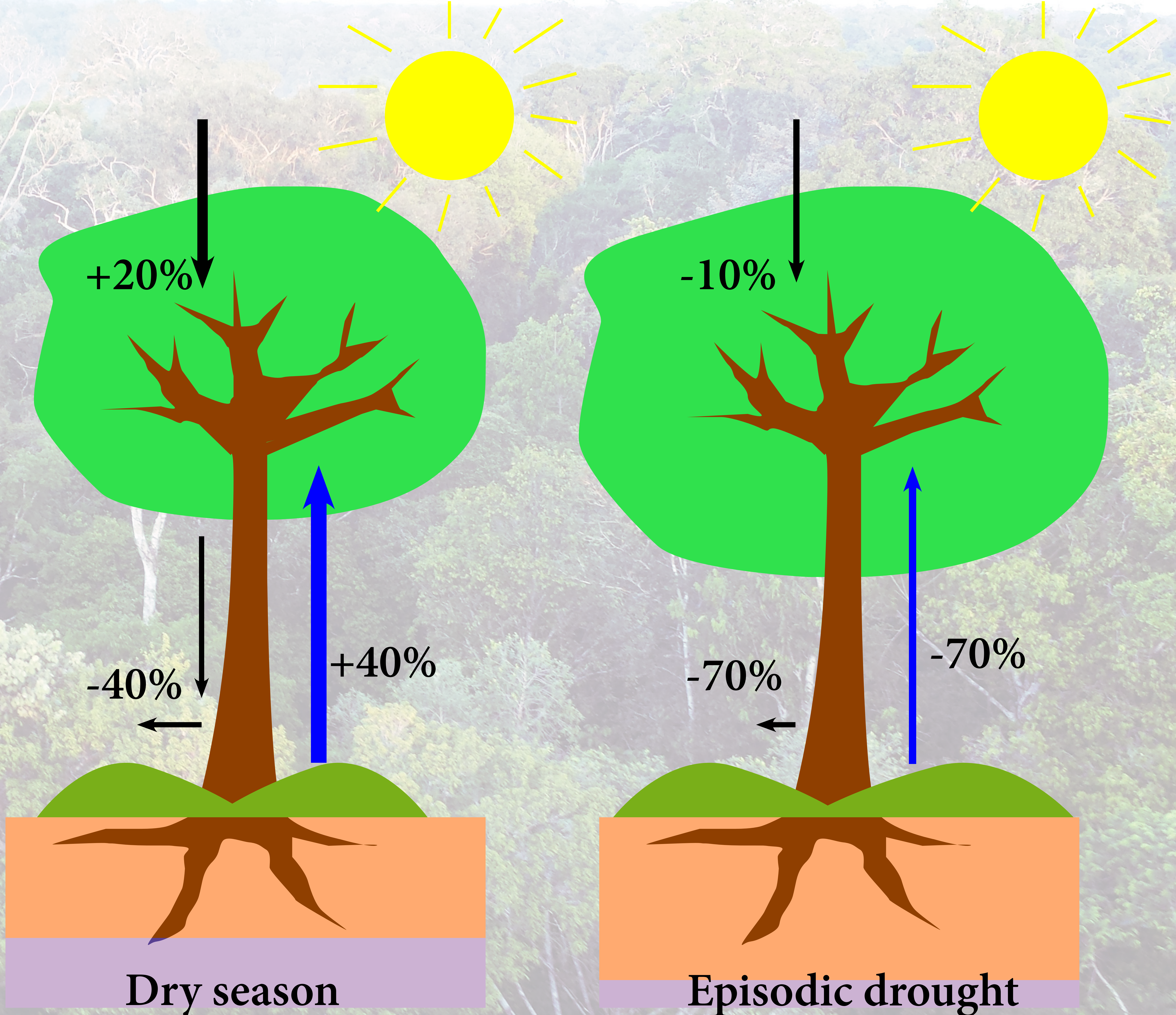
What happens in a real drought?

Stem growth stops / stems shrink

Growth in the canopy increases (leaf flush)

Transpiration declines

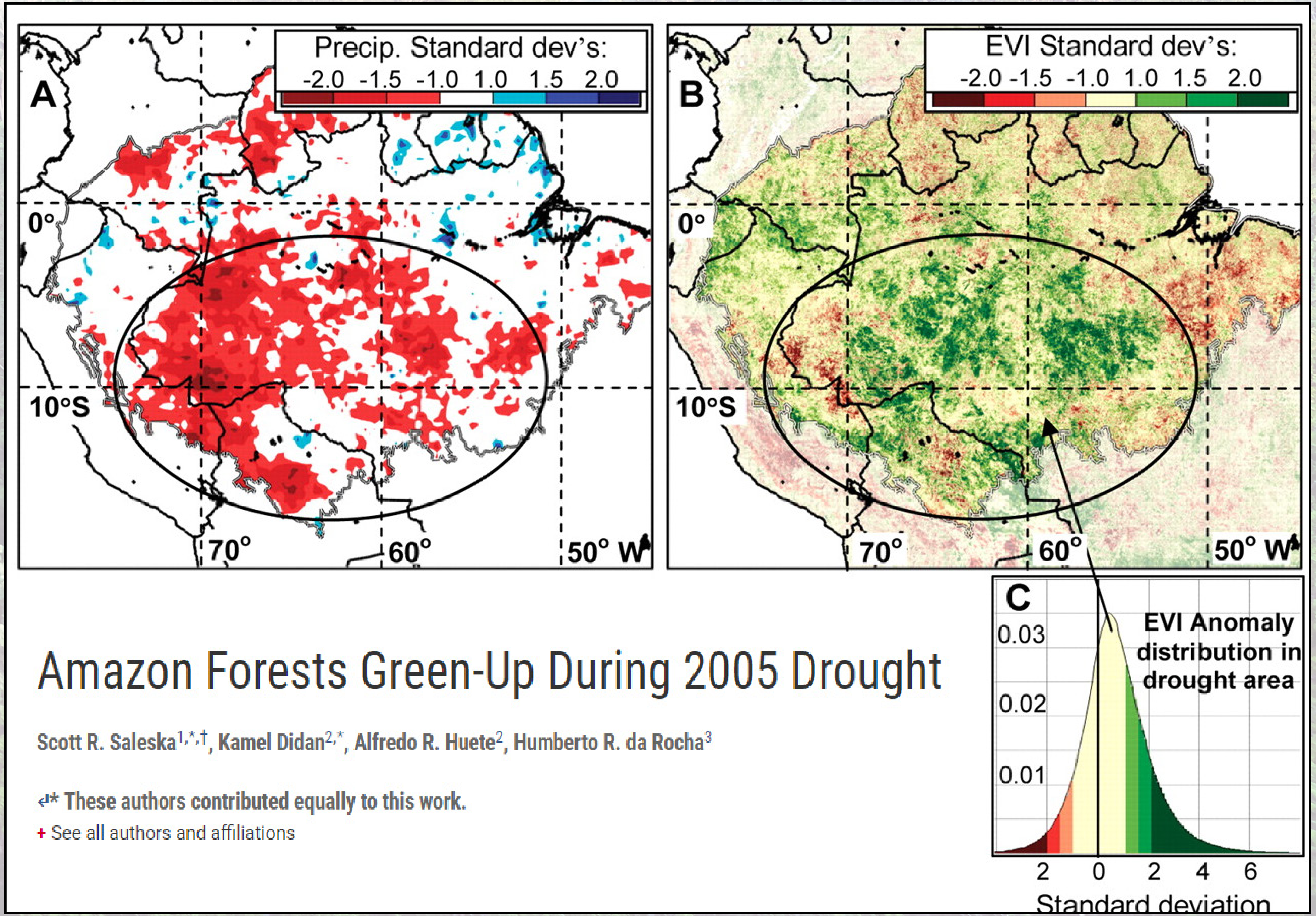
Net prodocutivity declines



The Remote Sensing Perspective: Green-up during drought?

Optical vegetation indices (NDVI / EVI) show green-up during drought...

More radiation, so trees flush more leaves?

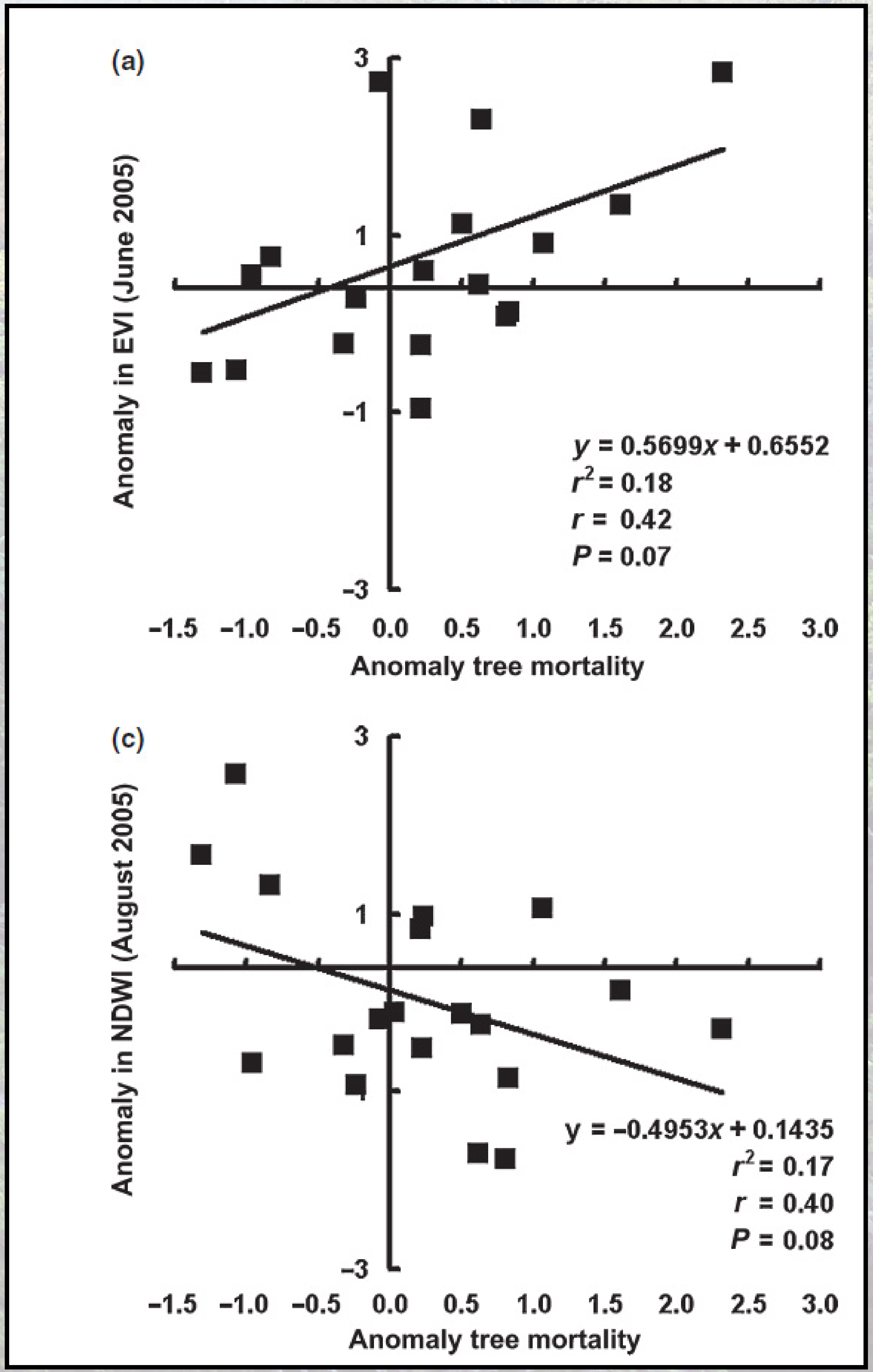


The Remote Sensing Perspective: Green-up during drought?

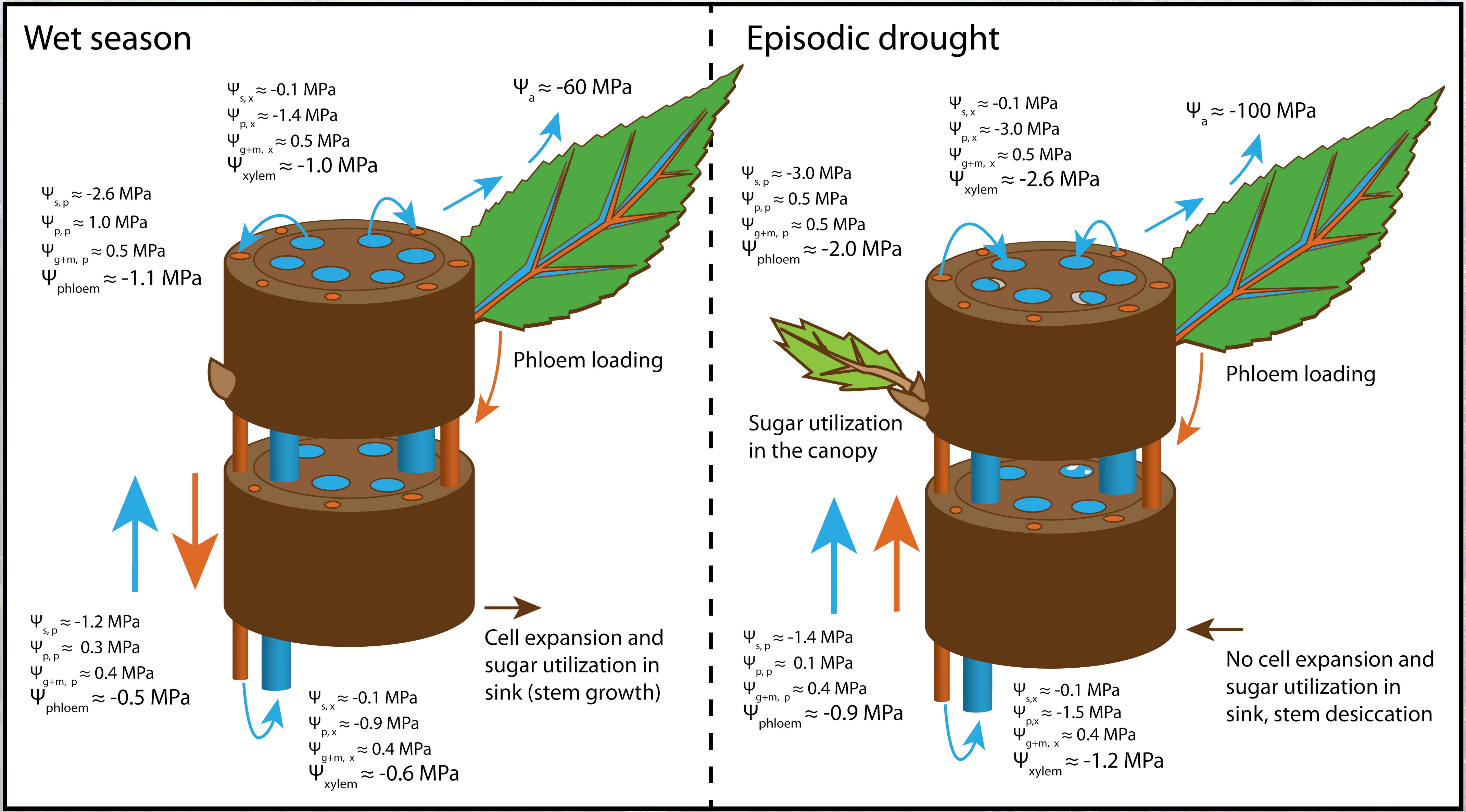
EVI is positively related to tree mortality!?
green-up = tree mortality

Normalized difference water index (NDWI) using NIR and SWIR, shows a negative relationship with mortality

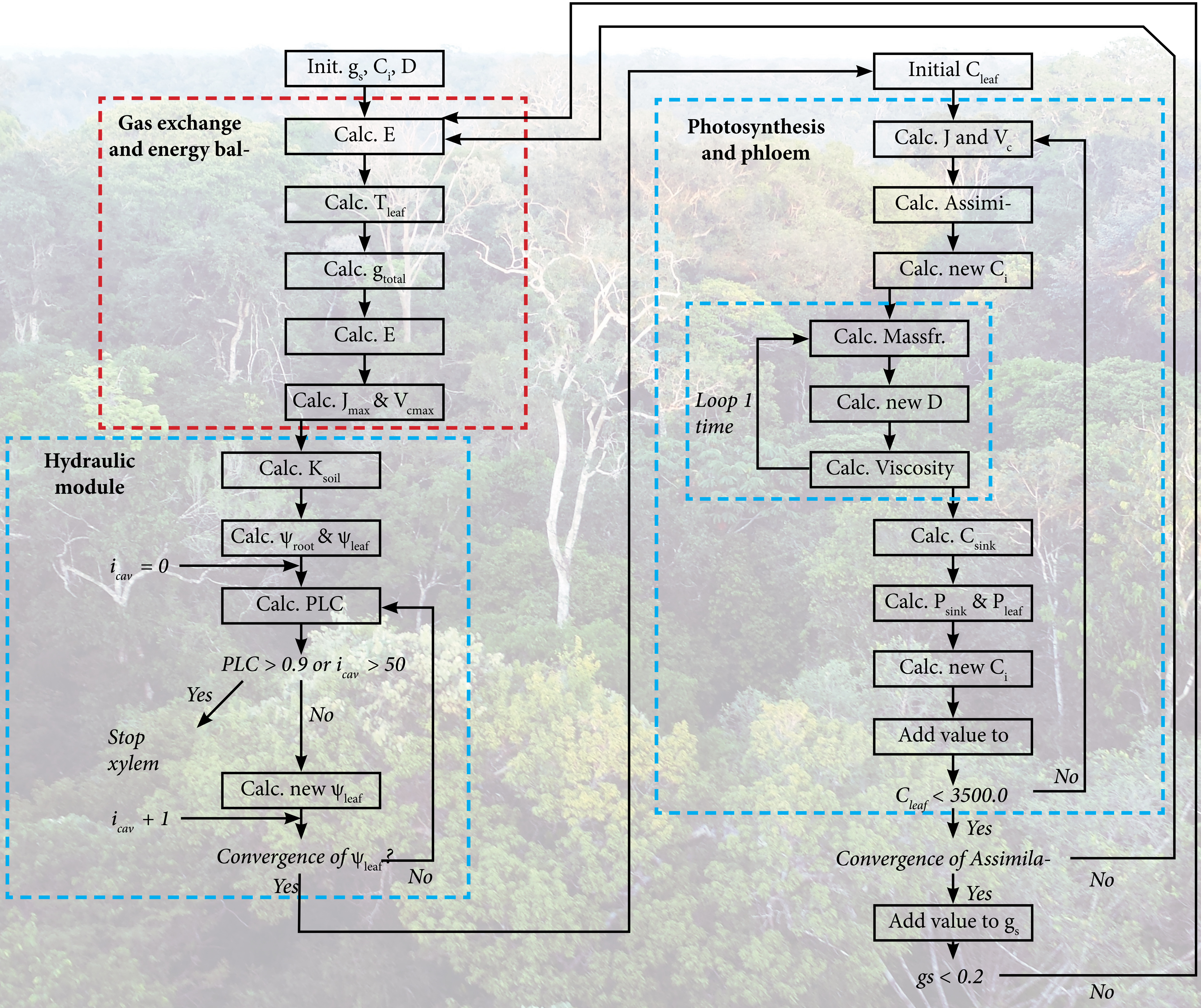
Conclusion: vegetation “greenness” increases while vegetation water content decreases



Can phloem (sugar) and xylem (water) transport explain the observed responses?

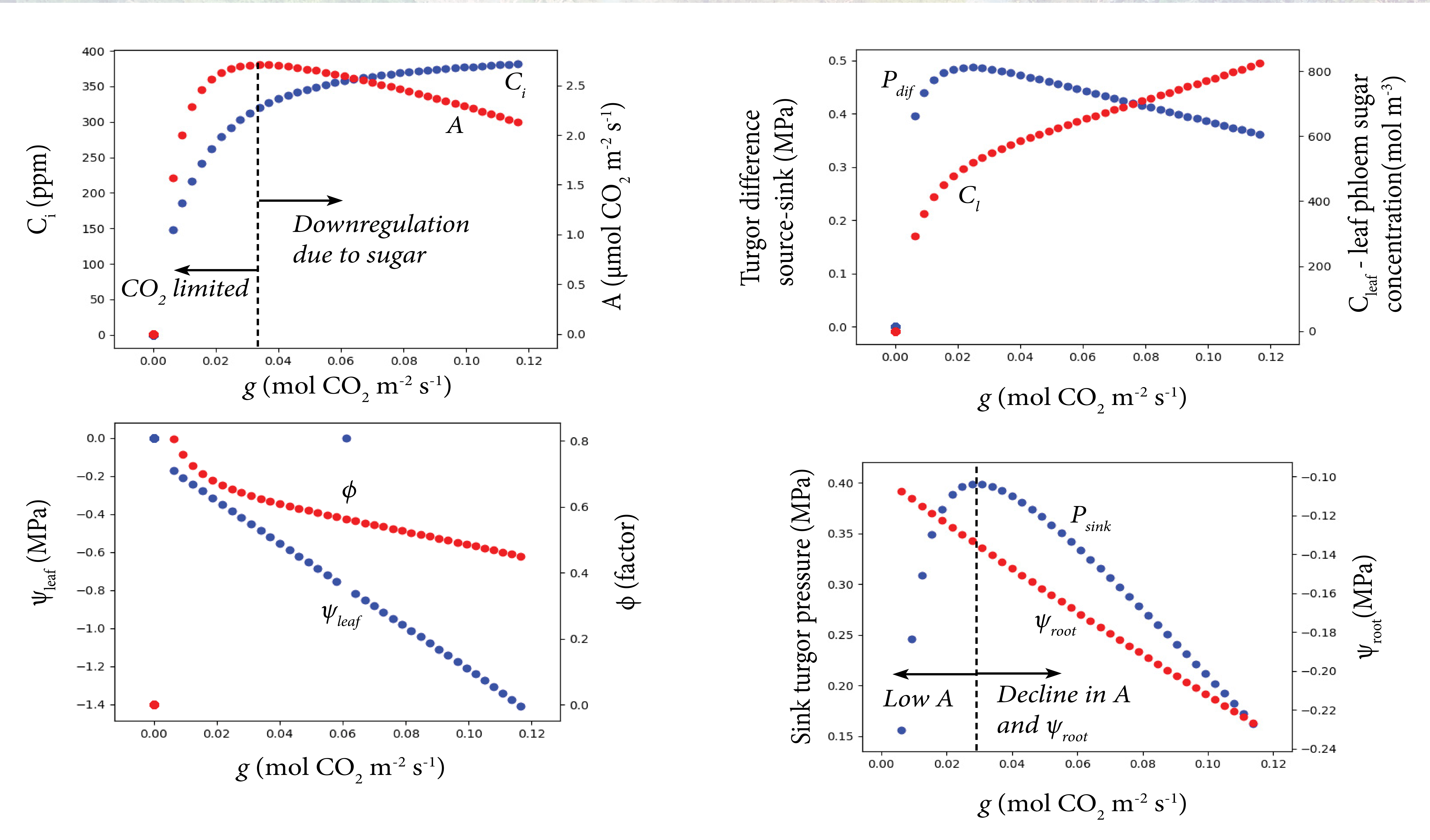


The model



Init. g_s, C_i, D
Gas exchange and energy bal-
Calc. E
Calc. T_{leaf}
Calc. g_{total}
Calc. E
Calc. J_{max} & V_{cmax}
Hydraulic module
Calc. K_{soil}
Calc. ψ_{root} & ψ_{leaf}
$i_{cav} = 0$
Calc. PLC
$PLC > 0.9$ or $i_{cav} > 50$
Yes
Stop xylem
No
Calc. new ψ_{leaf}
$i_{cav} + 1$
Convergence of ψ_{leaf}?
Yes
No
Initial C_{leaf}
Photosynthesis and phloem
Calc. J and V_c
Calc. Assimi-
Calc. new C_i
Calc. Massfr.
Loop 1 time
Calc. new D
Calc. Viscosity
Calc. C_{sink}
Calc. P_{sink} & P_{leaf}
Calc. new C_i
Add value to
$C_{leaf} < 3500.0$
No
Yes
Convergence of Assimila-
No
Yes
Add value to g_s
$gs < 0.2$
No

First model runs...



Hypotheses to be tested

Water stress in tropical forest trees can cause the temporary disappearance or reversal of the phloem-xylem pressure gradient, resulting in the buildup/depletion of sugars at the source/sink.

Glucose homeostasis in the phloem results in increased respiration and the initialization of sugar utilization in the canopy during drought, explaining the observed increase of leaf respiration and canopy growth in response to drought.

The reduced phloem sap flow downward causes a local depletion of carbohydrates in the stem and roots, explaining the observed reduced root and stem growth and reduced root and stem respiration during drought.

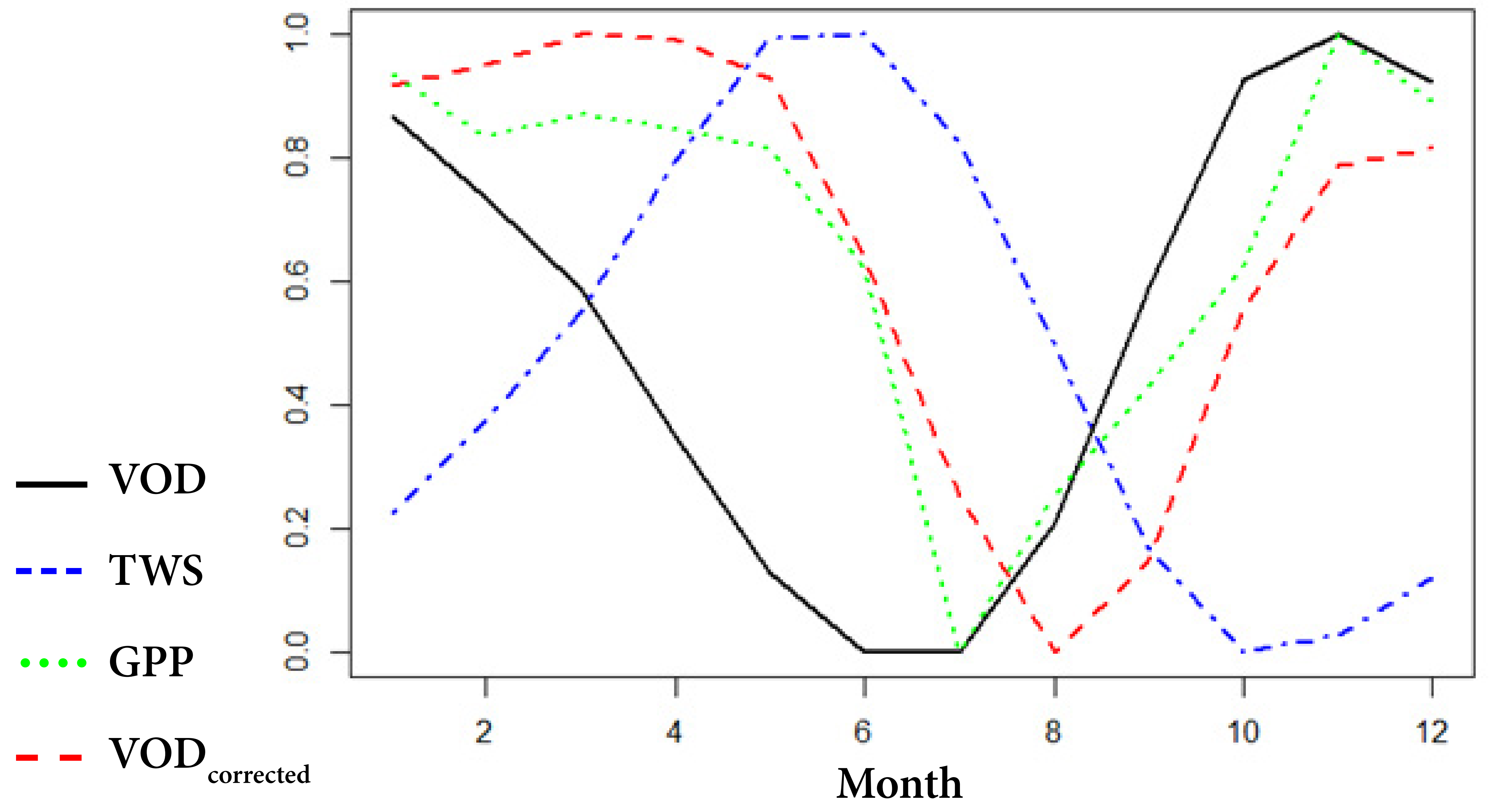

Thank you!

Improving VOD as indicator of productivity

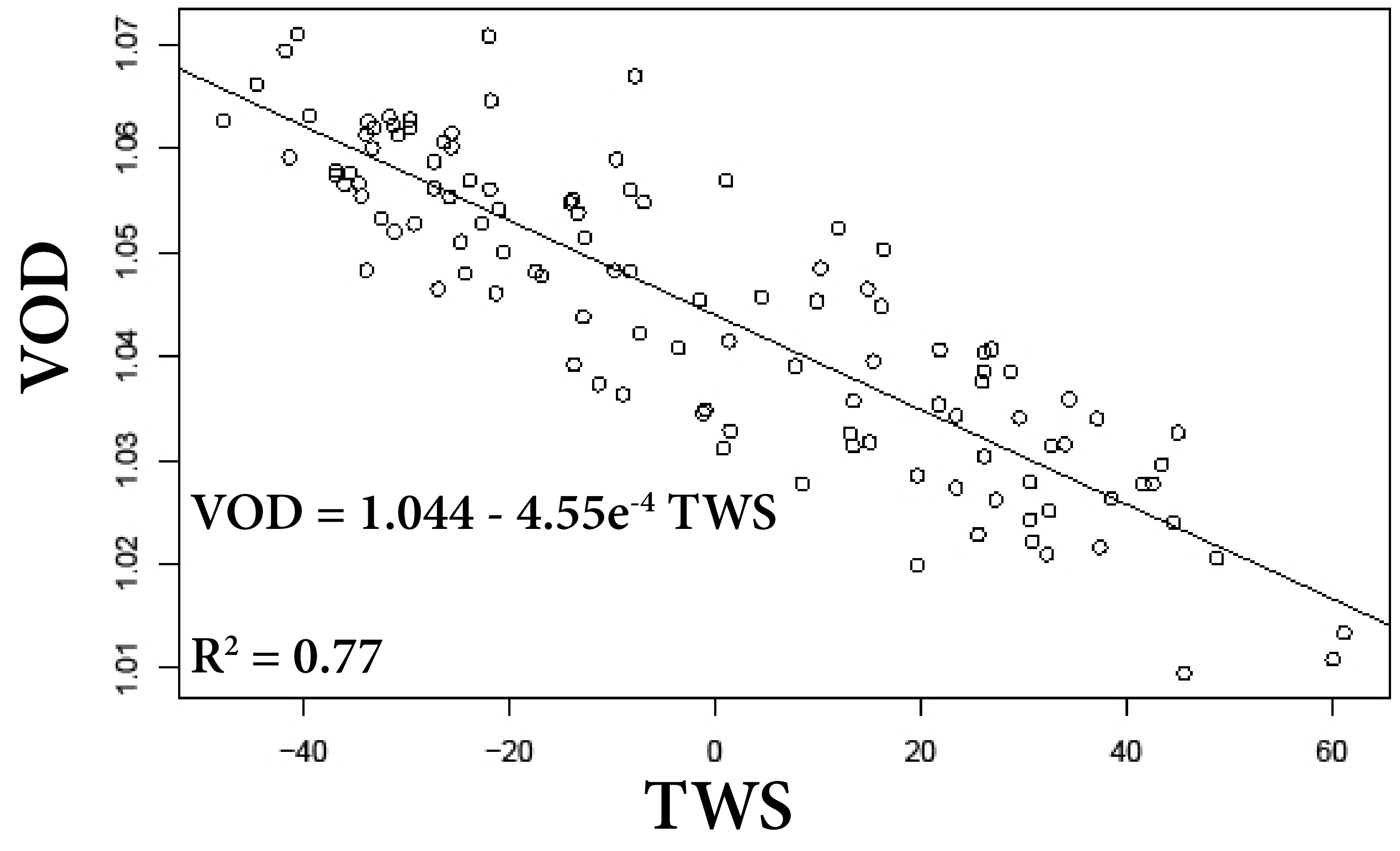
VOD is corrected for TWS using a linear model

New VOD seems to be a better indicator of GPP

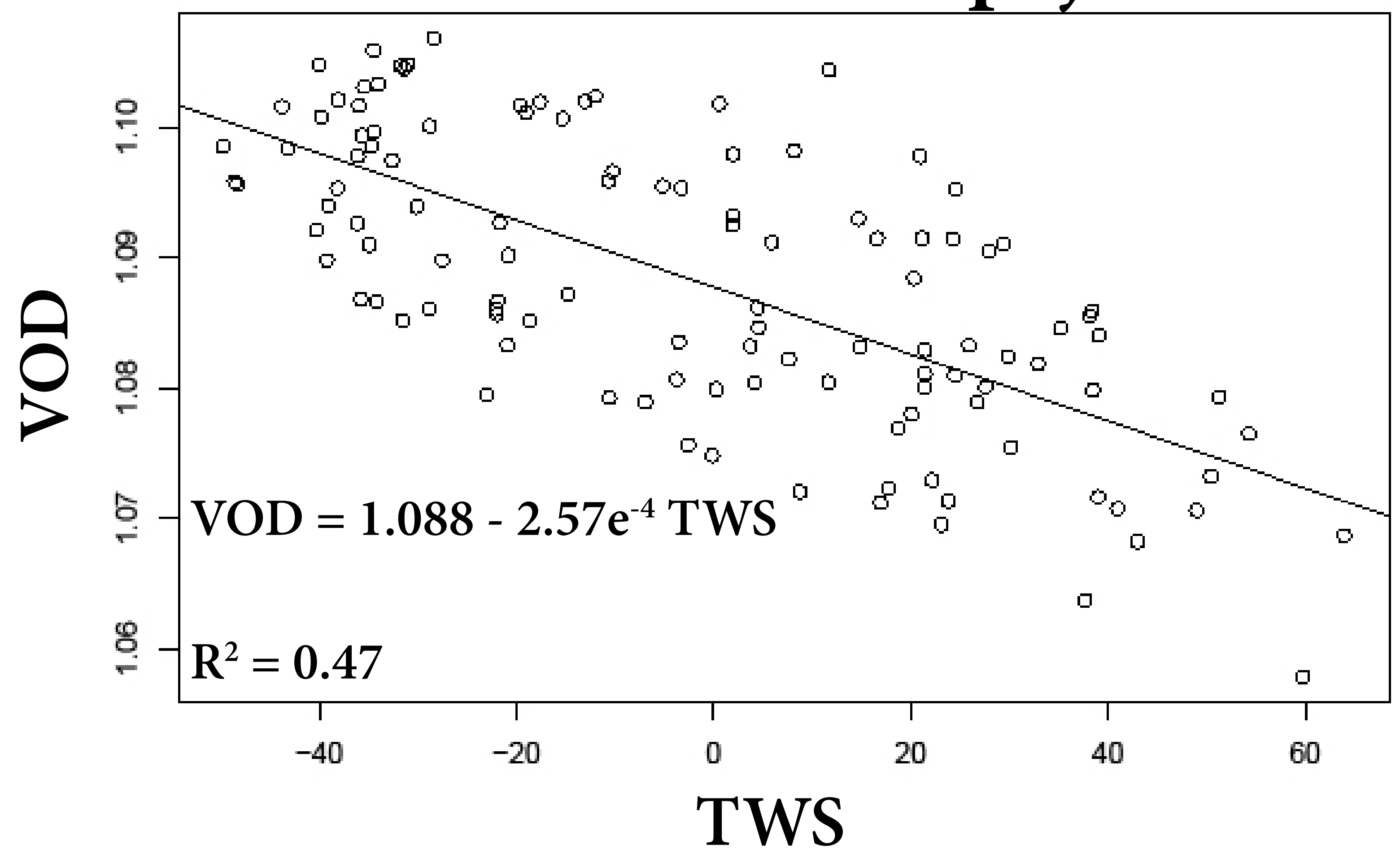
Seasonal trends at K34



VOD~TWS K34 Manaus



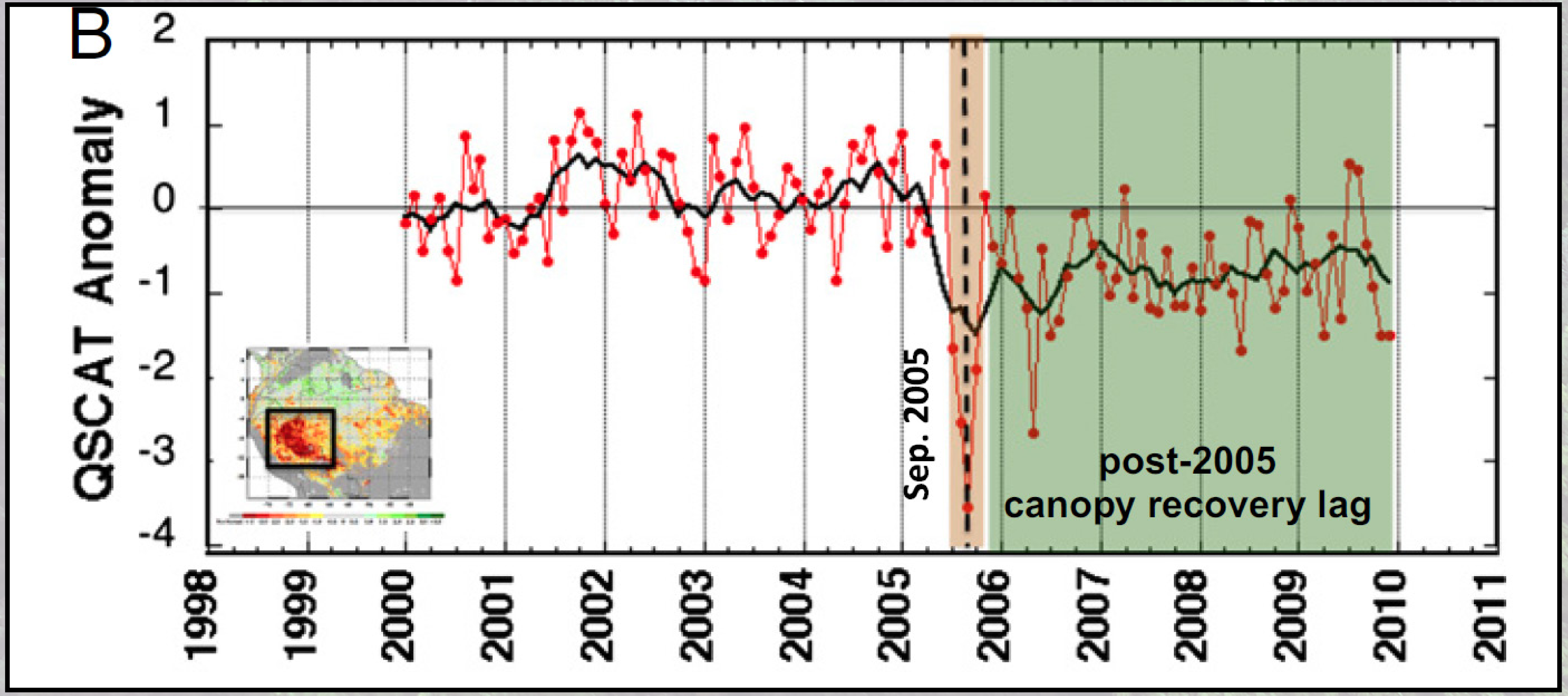
VOD~TWS Tapajós

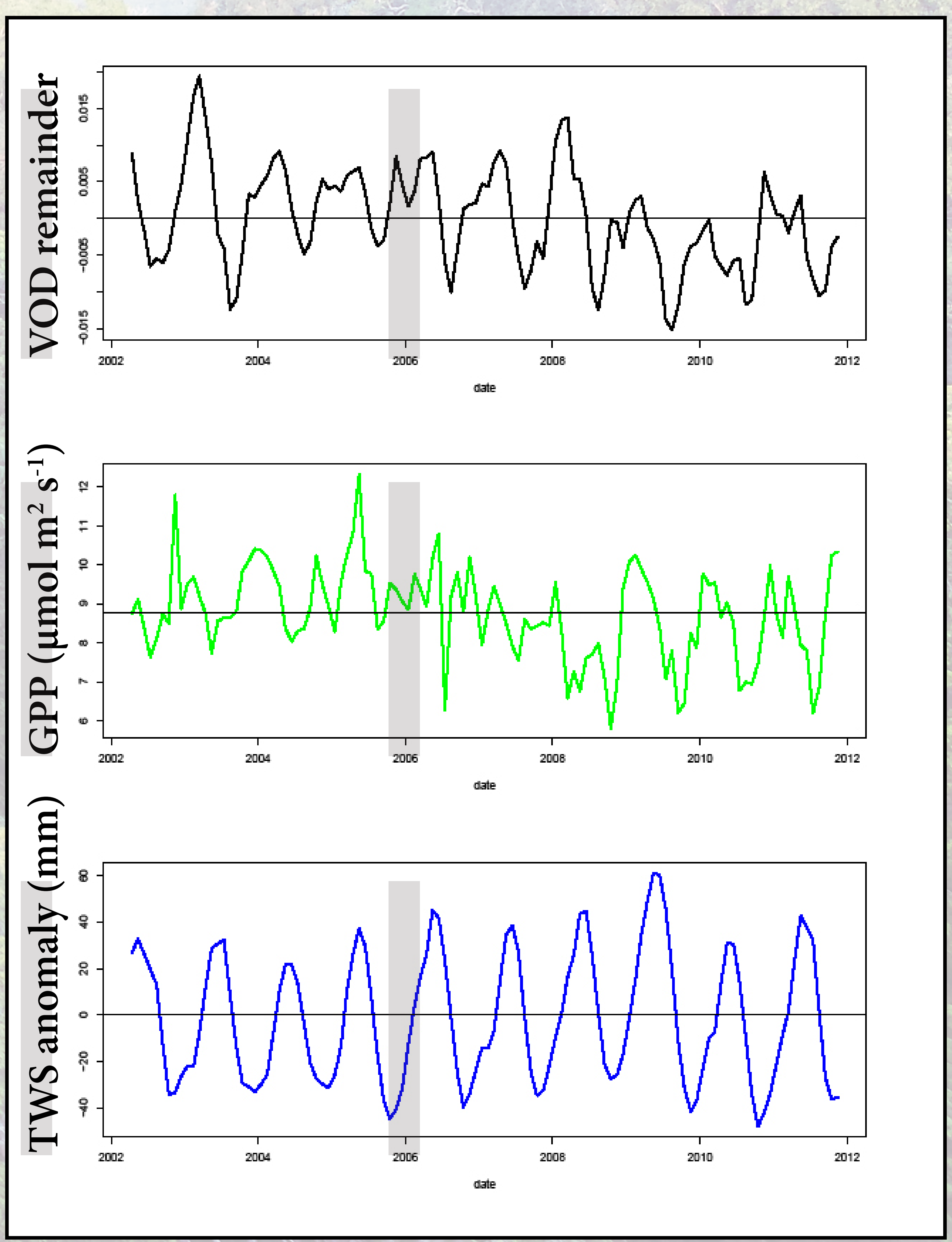


VOD and GPP

Trend of “cleaned” VOD seems to correspond to observed GPP

Persitent effect of 2005 drought on canopy biomass and productivity, also visible in radar backscatter (Saatchi et al. 2013)





Preliminary conclusions

VOD is used as an indicator of canopy biomass and water content but is strongly influenced by high soil water content and flooding in wet regions

Correcting for soil moisture can reduce the “contamination” effect and possibly enhance the usability of VOD in upscaling basin-wide CO_2 exchange

Thank you!

What happens in a "regular" dry season?

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Growth in the canopy increases (leaf flush)

Transpiration increases

Photosynthesis increases