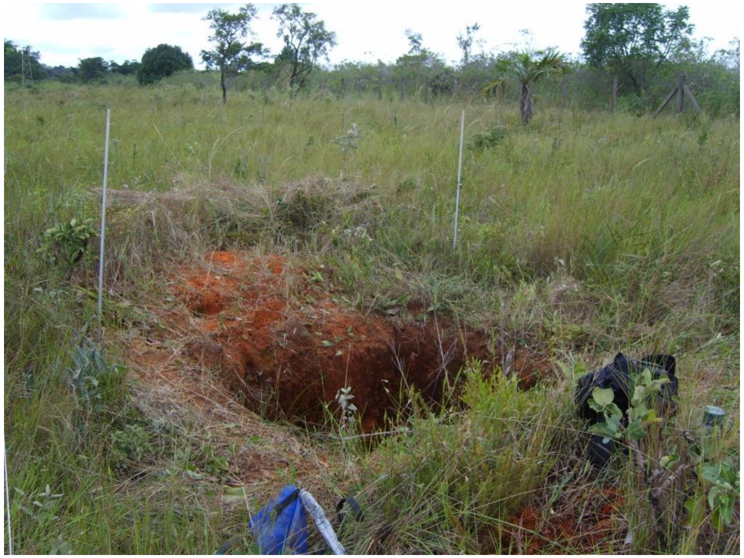
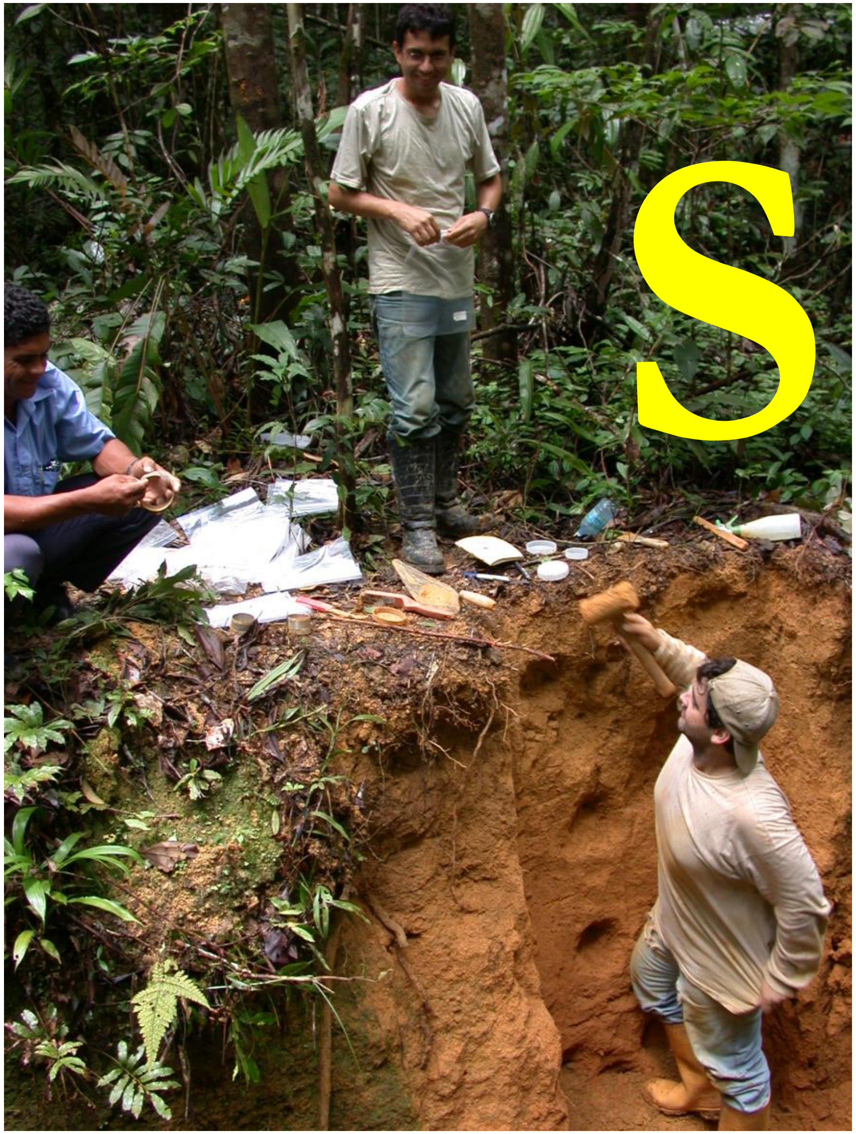
Soils and tropical vegetation structure



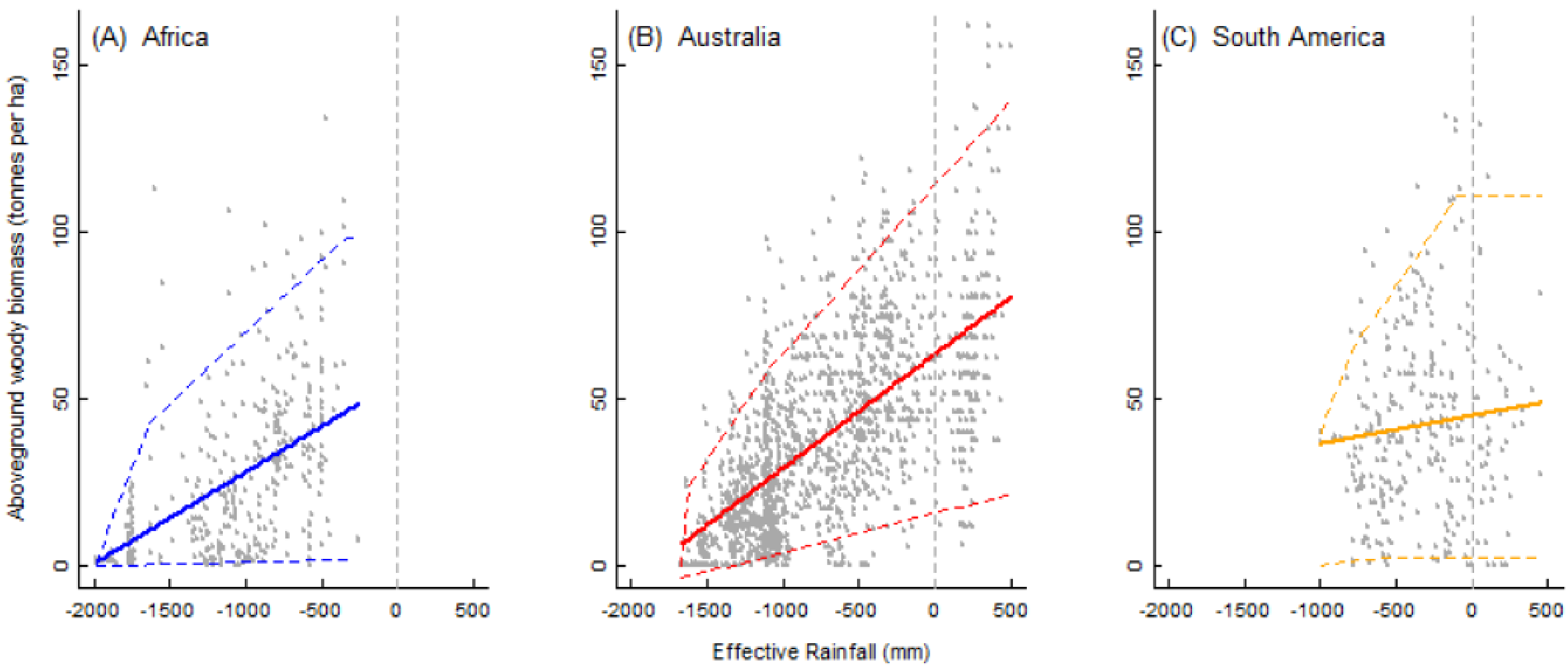


Savanna Vegetation-Fire-Climate Relationships Differ Among Continents

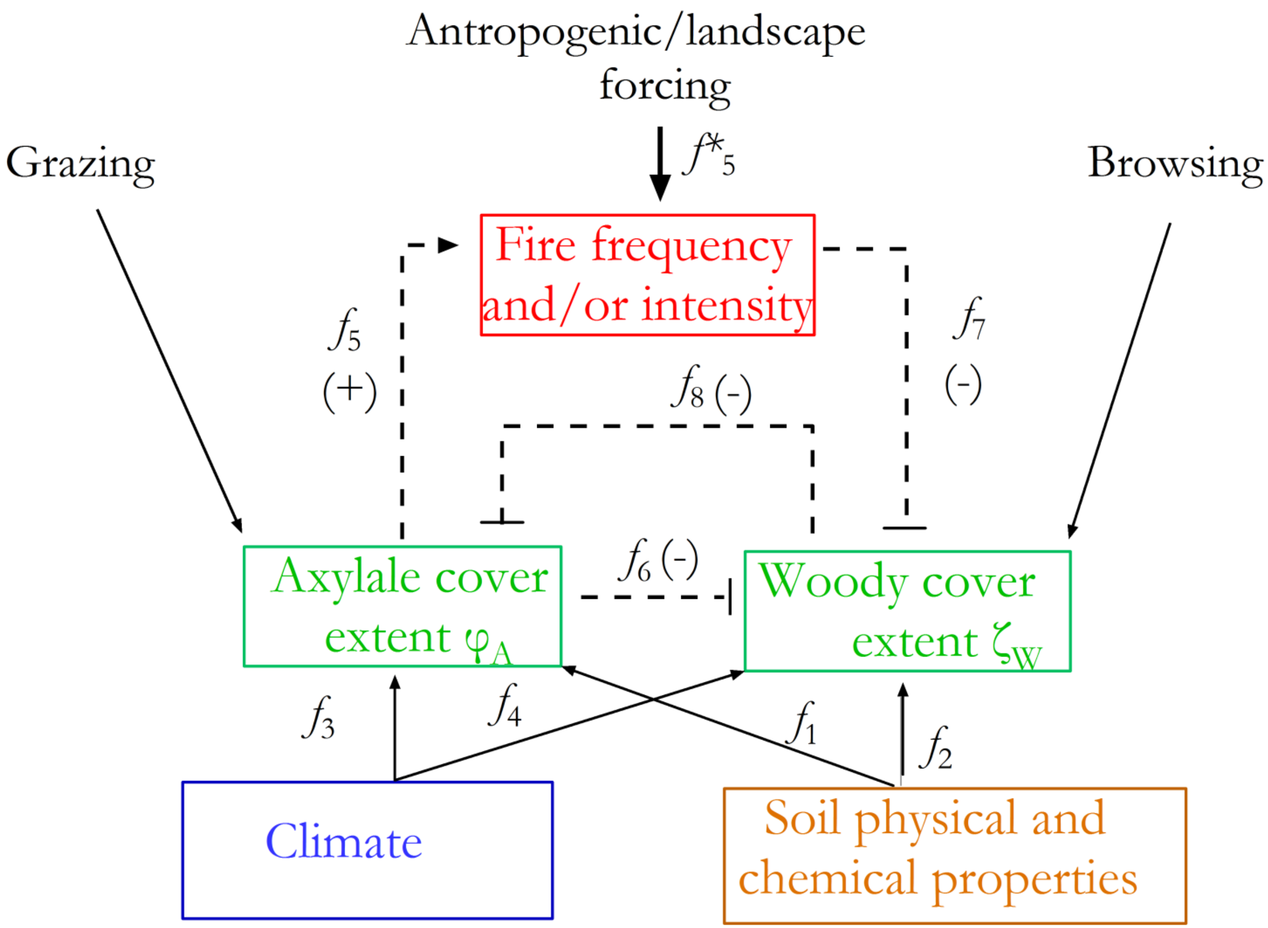
Caroline E. R. Lehmann,* T. Michael Anderson, Mahesh Sankaran, Steven I. Higgins, Sally Archibald, William A. Hoffmann, Niall P. Hanan, Richard J. Williams, Roderick J. Fensham, Jeanine Felfili, Lindsay B. Hutley, Jayashree Ratnam, Jose San Jose, Ruben Montes, Don Franklin, Jeremy Russell-Smith, Casey M. Ryan, Giselda Durigan, Pierre Hiernaux, Ricardo Haidar, David M. J. S. Bowman, William J. Bond

*Corresponding author. E-mail: c.e.r.lehmann@gmail.com

Published 31 January 2014, *Science* **343**, 548 (2014)
DOI: 10.1126/science.1247355



Fire mediated feedbacks



The Global Extent and Determinants of Savanna and Forest as Alternative Biome States

A. Carla Staver,[1*] Sally Archibald,[2] Simon A. Levin[1]

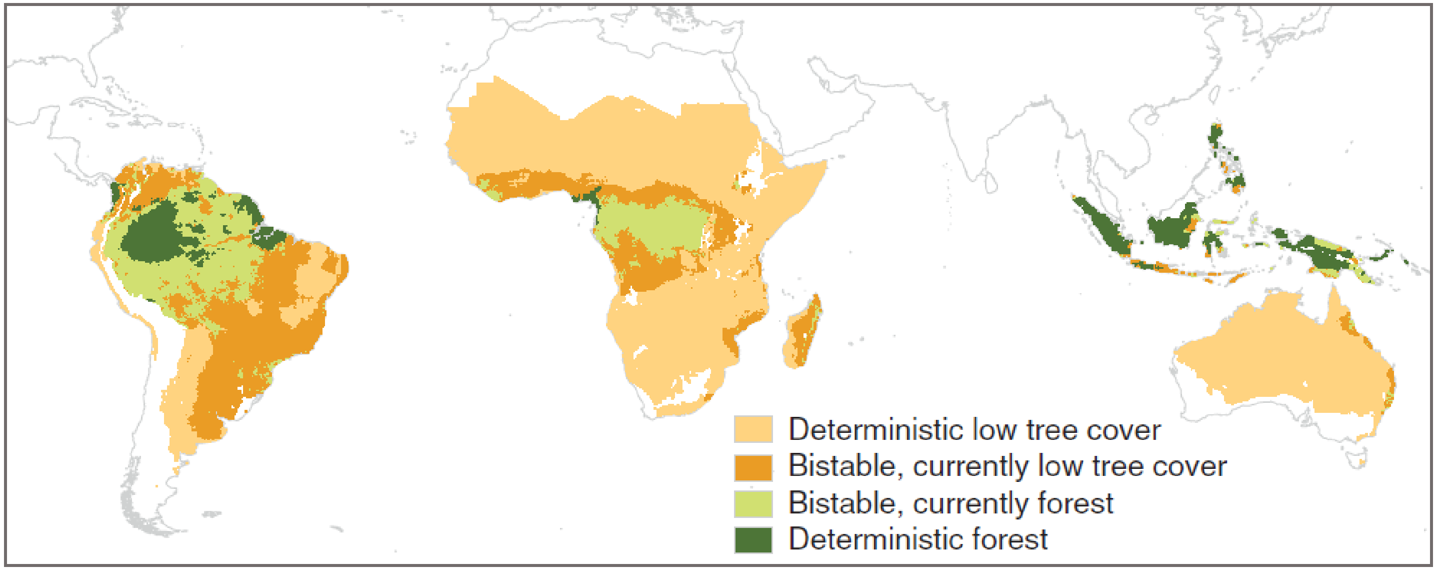
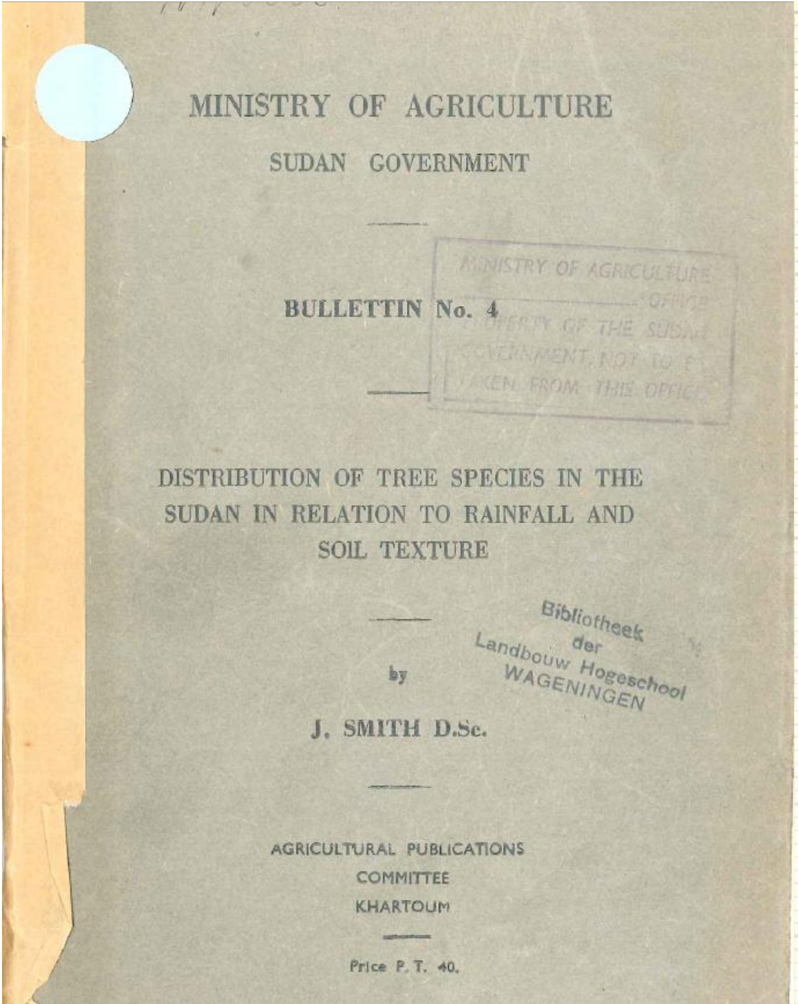


Fig. 4. Distributions of biome types across sub-Saharan Africa, South America, and Southeast Asia/Australia. Biome types are defined as areas where climate (i) deterministically supports low tree cover (low rainfall, high seasonality); (ii) supports biome bistability (intermediate rainfall, mild seasonality), currently savanna; (iii) supports biome bistability, currently forest; and (iv) deterministically supports forest (high rainfall).

Dano, Burkino Faso



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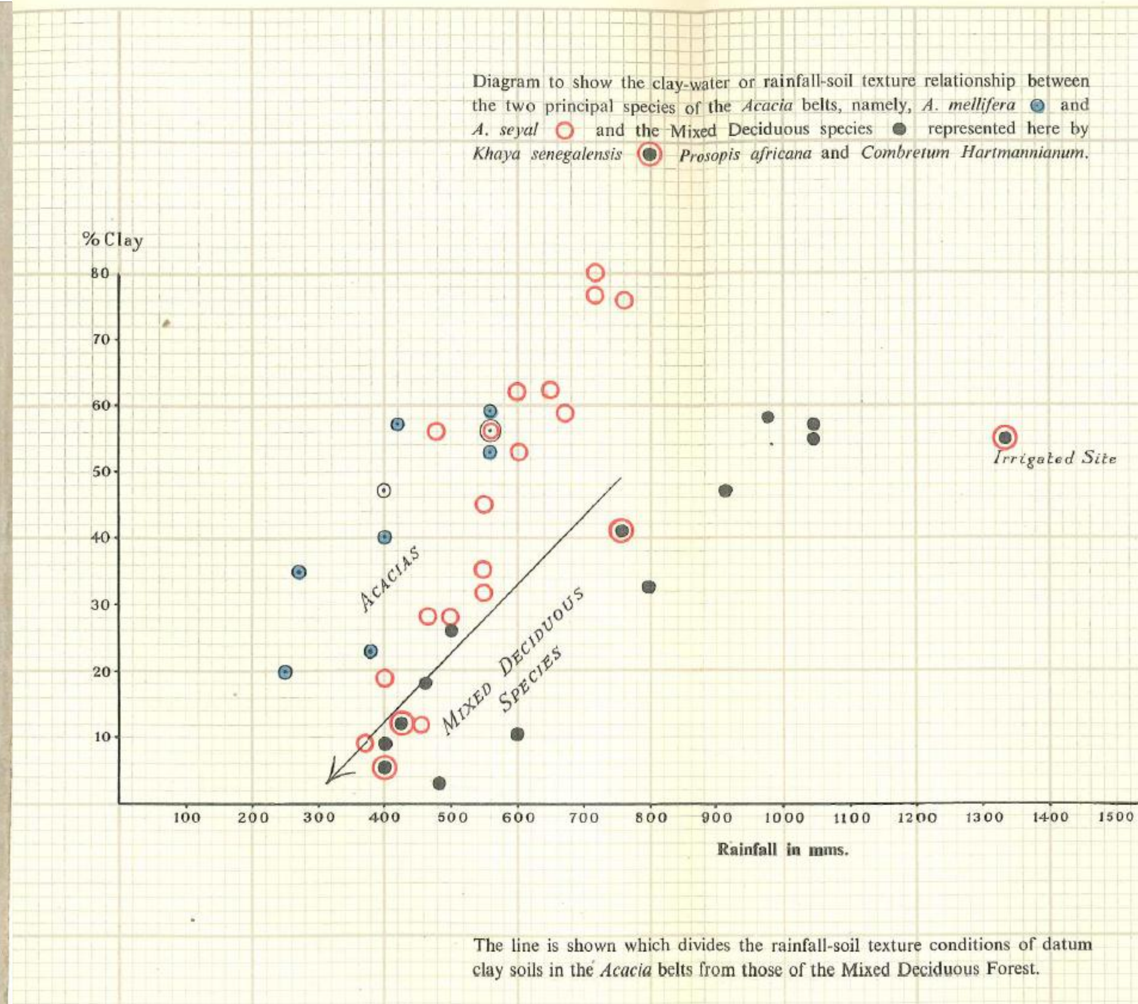
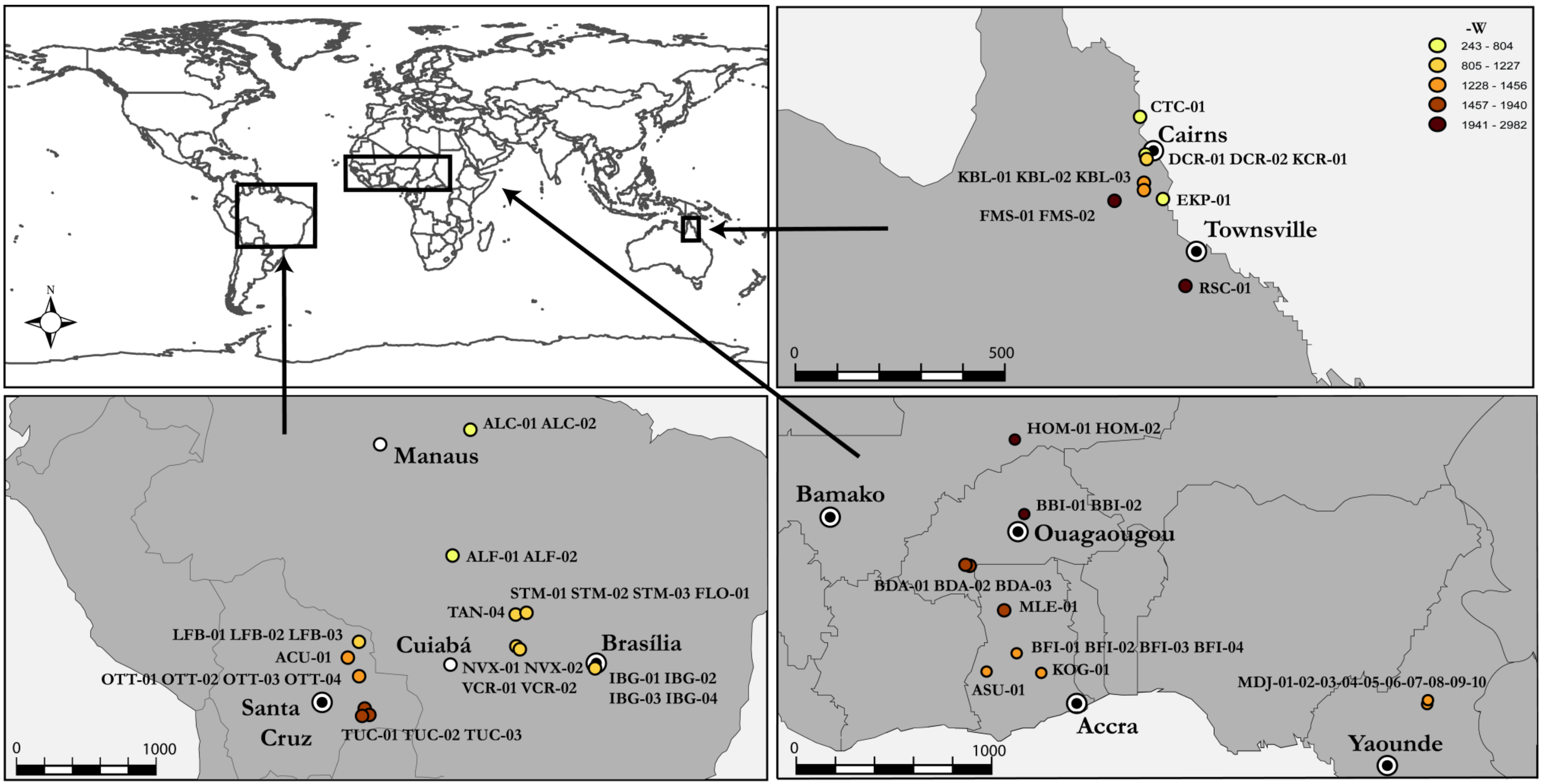



TROPICAL
BIOMES
TROBIT!
IN TRANSITION

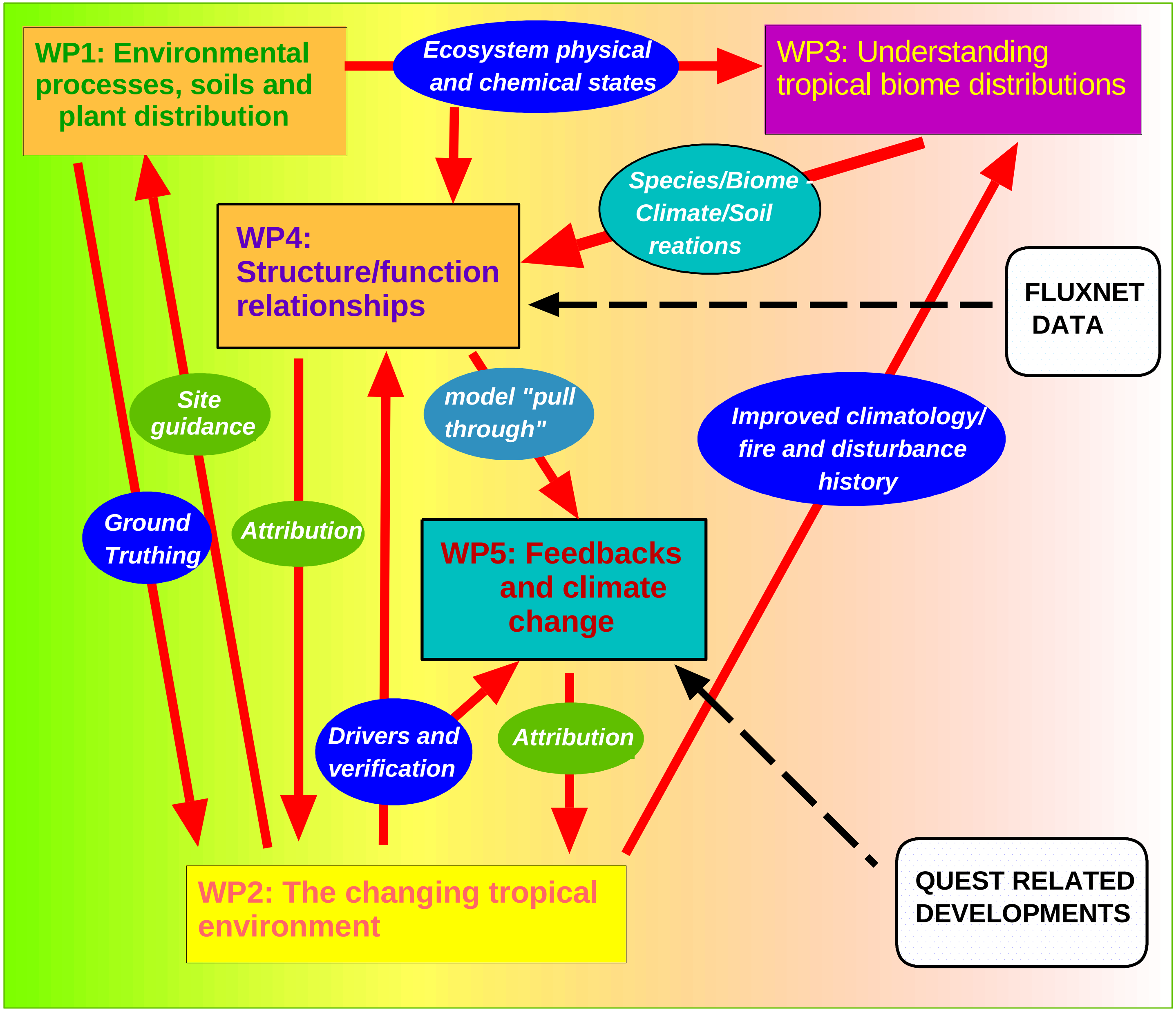
- Comprehensive measurements of vegetation and soil characteristics in *Zones of Transition* (ZOT) on three continents
- Africa
  - West Africa, Cameroon
- South America
  - Brazil, Bolivia
- Australia
  - FNQ

On the delineation of tropical vegetation types with an emphasis on forest/savanna transitions

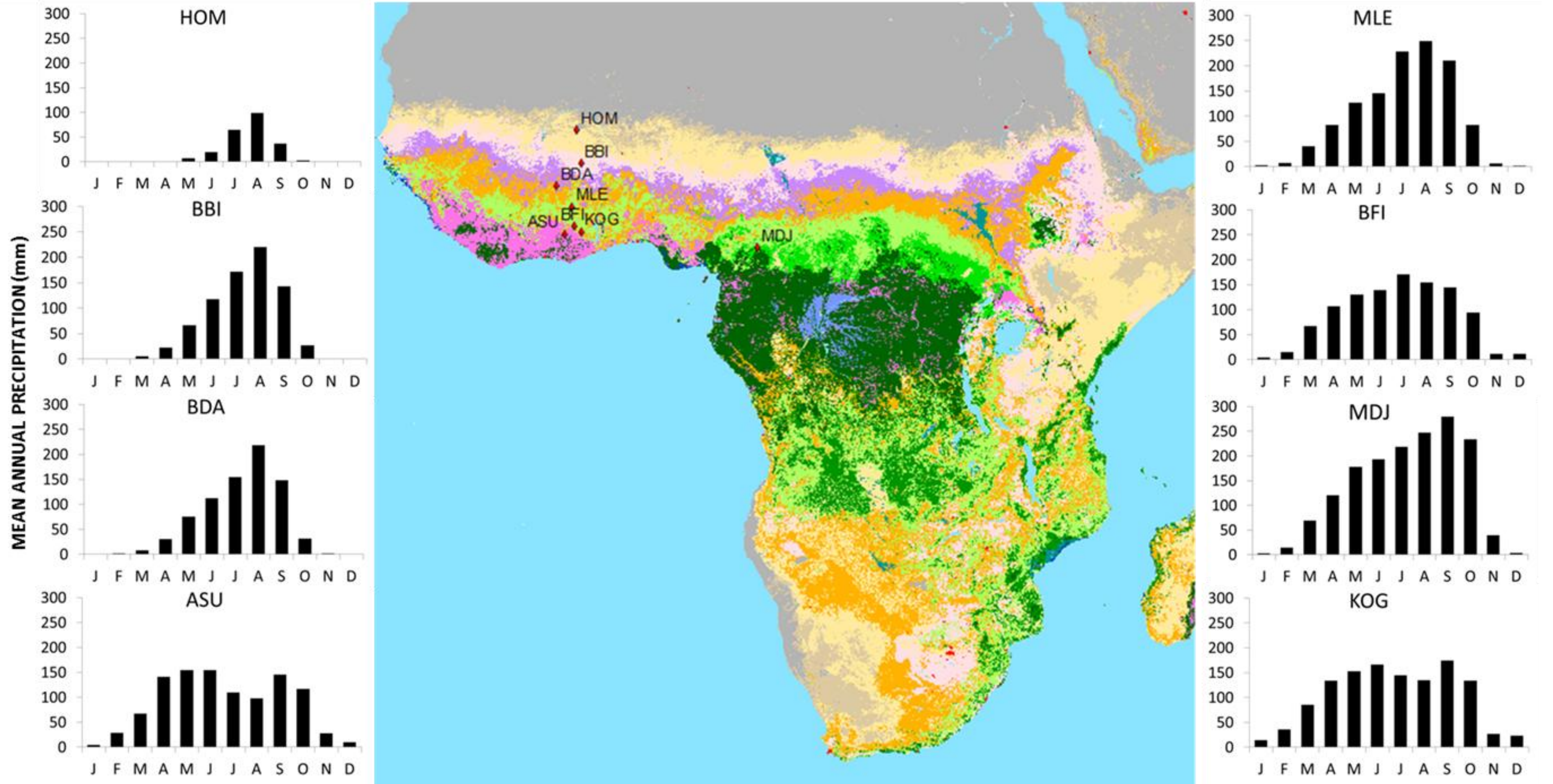
Mireia Torello-Raventos[a,b], Ted R. Feldpausch[b], Elmar Veenendaal[c], Franziska Schrodt[b], Gustavo Saiz[a], Tomas F. Domingues[d], Gloria Djagbletey[e], Andrew Ford[f], Jeanette Kemp[g], Beatriz S. Marimon[h], Ben Hur Marimon Junior[h], Eddie Lenza[h], James A. Ratter[i], Leandro Maracahipes[h], Denise Sasaki[j], Bonaventure Sonké[k], Louis Zapfack[v], Hermann Taedoumg[k], Daniel Villarroel[l], Michael Schwarz[m], Carlos A. Quesada[b,n], F. Yoko Ishida[n], Gabriela B. Nardoto[o,p], Kofi Affum-Baffoe[q], Luzmilla Arroyo[l], David M.J.S. Bowman[r], Halidou Compaore[s], Kalu Davies[a], Adama Diallo[t], Nikolaos M. Fyllas[b], Martin Gilpin[b], Fidèle Hien[s], Michelle Johnson[b], Timothy J. Killeen[l,u], Daniel Metcalfe[f], Heloisa S. Miranda[p], Mark Steininger[u], John Thomson[a], Karle Sykora[c], Eric Mougin[w], Pierre Hiernaux[w], Michael I. Bird[a], John Grace[d], Simon L. Lewis[b,x], Oliver L. Phillips[b] and Jon Lloyd[a,b]*

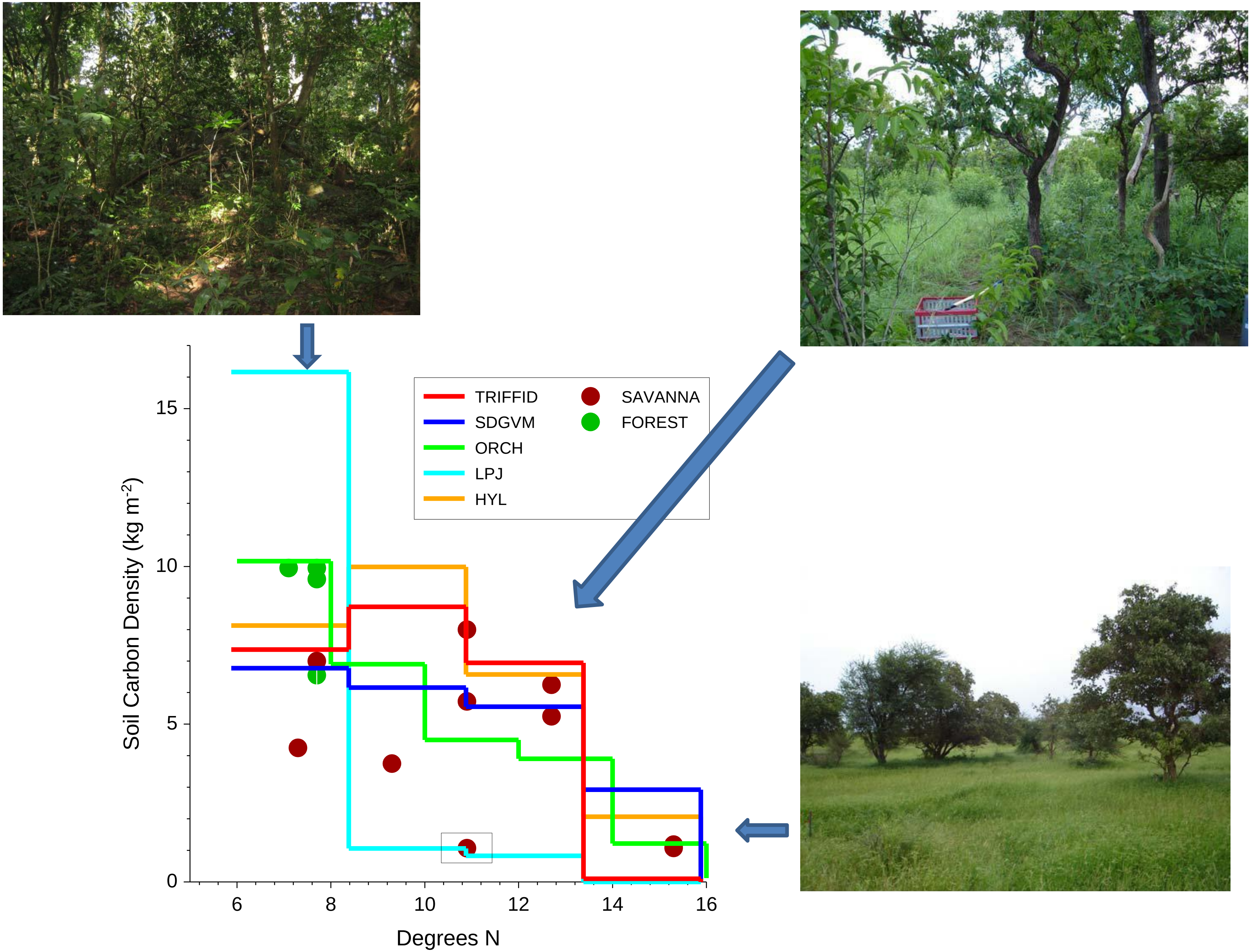


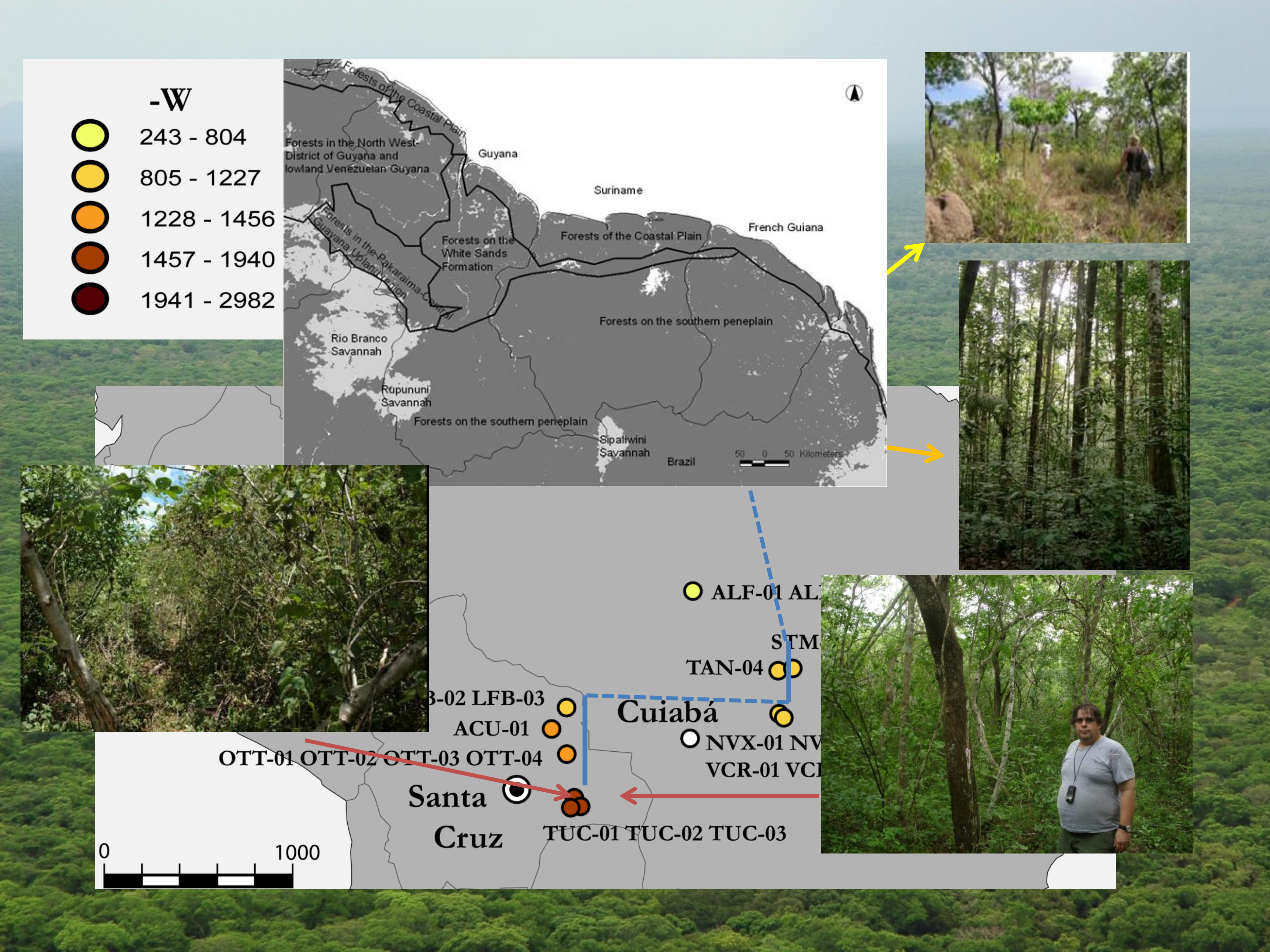
Plant Ecology & Diversity, 2013
http://dx.doi.org/10.1080/17550874.2012.762812


WP1: Environmental processes, soils and plant distribution
Ecosystem physical and chemical states
WP3: Understanding tropical biome distributions
Species/Biome - Climate/Soil reations
WP4: Structure/function relationships
FLUXNET DATA
Site guidance
model "pull through"
Improved climatology/ fire and disturbance history
Ground Truthing
Attribution
WP5: Feedbacks and climate change
Drivers and verification
Attribution
QUEST RELATED DEVELOPMENTS
WP2: The changing tropical environment

TROBIT West African Transect (TWAT)




TRIFFID
SDGVM
ORCH
LPJ
HYL
SAVANNA
FOREST
Soil Carbon Density (kg m-2)
0
5
10
15
6
8
10
12
14
16
Degrees N


-W
243 - 804
805 - 1227
1228 - 1456
1457 - 1940
1941 - 2982
Forests of the Coastal Plain
Forests in the North West District of Guyana and lowland Venezuelan Guyana
Guyana
Suriname
French Guiana
Forests in the Pakaraima-Central Guayana Uplands region
Forests on the White Sands Formation
Forests of the Coastal Plain
Forests on the southern peneplain
Rio Branco Savannah
Rupununi Savannah
Forests on the southern peneplain
Sipaliwini Savannah
Brazil
50 0 50 Kilometers
ALF-01 AL
STM
TAN-04
B-02 LFB-03
ACU-01
Cuiabá
NVX-01 NV
VCR-01 VC
OTT-01 OTT-02 OTT-03 OTT-04
Santa Cruz
TUC-01 TUC-02 TUC-03
0
1000

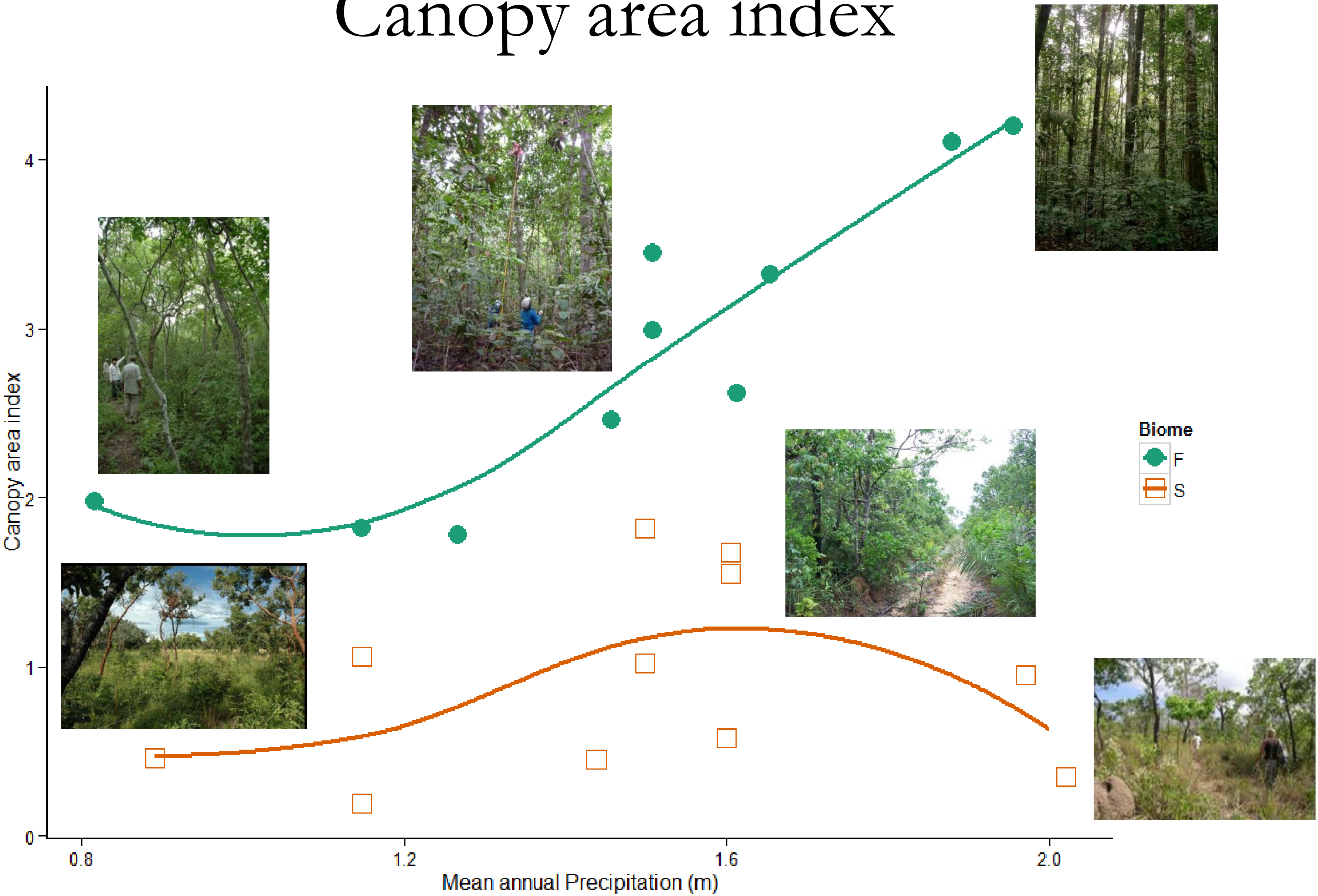
But what exactly is a "savanna" ?
(and by corollary, what exactly constitutes a "forest"?)

- **Vague and simple:**
  - The presence of a *dominant* C_4 grass layer and a *discontinuous* tree cover" (Lehmann et al. 2011)
- **Very precise**

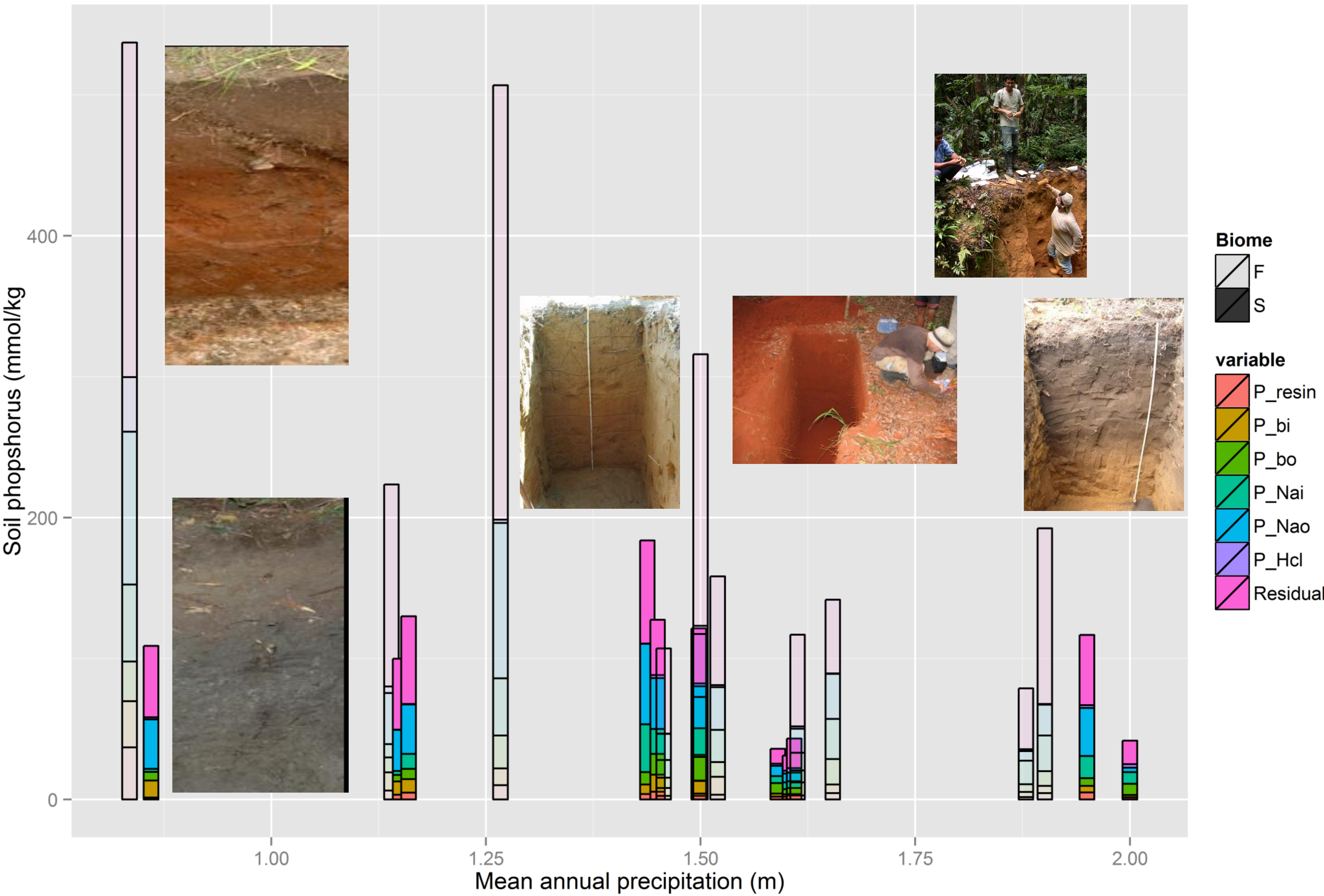
  "a formation where single-stemmed woody plants over 3 m tall occur in excess of 0.2% and less than 90% crown cover and where there is a graminoid component greater than 2% cover" (Walker and Gillison 1982).

- **Usually (but not always) involves both grass and tree cover**

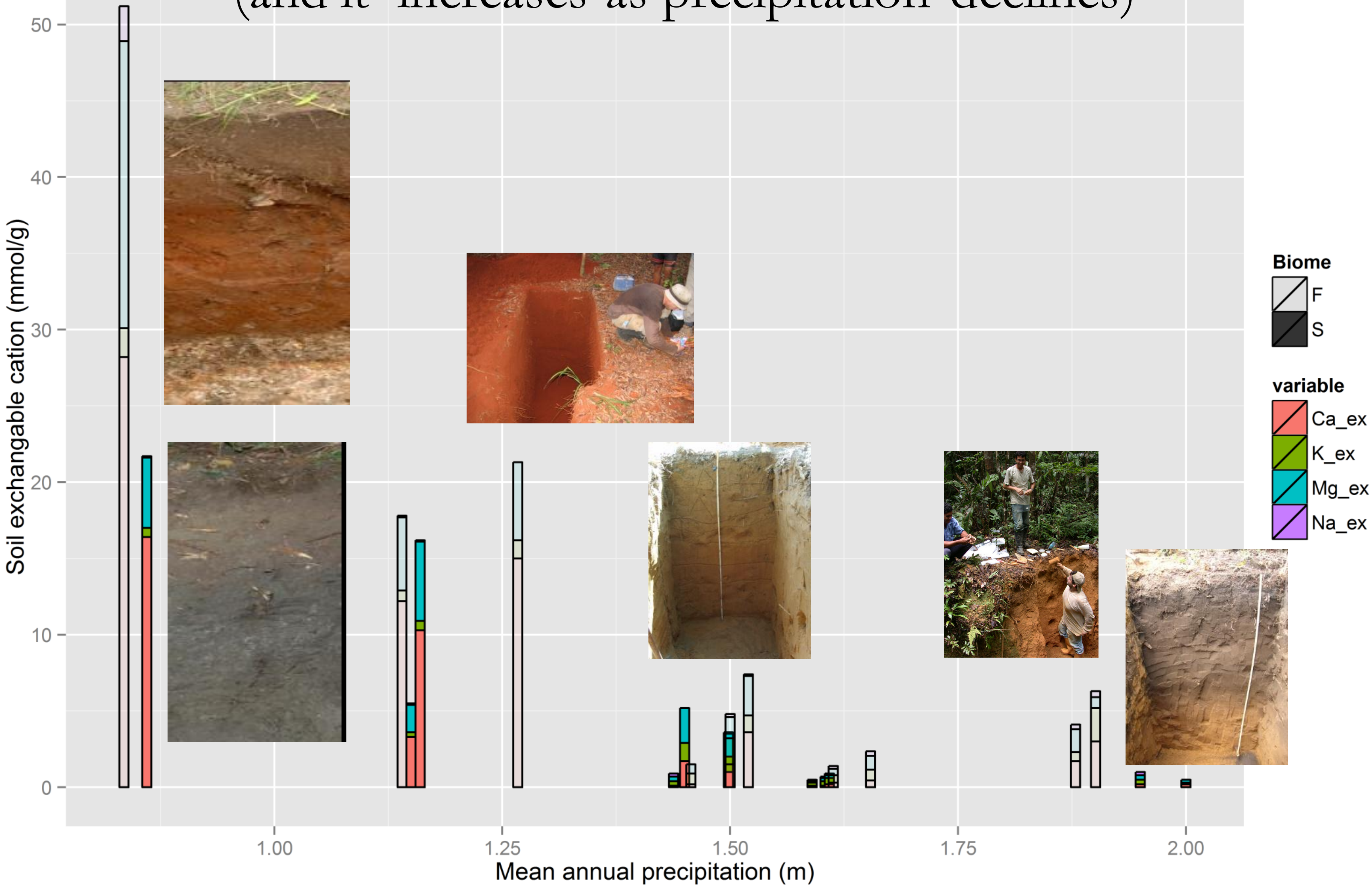
Canopy area index



More phosphorus in forest soil
(and it increases as precipitation declines)

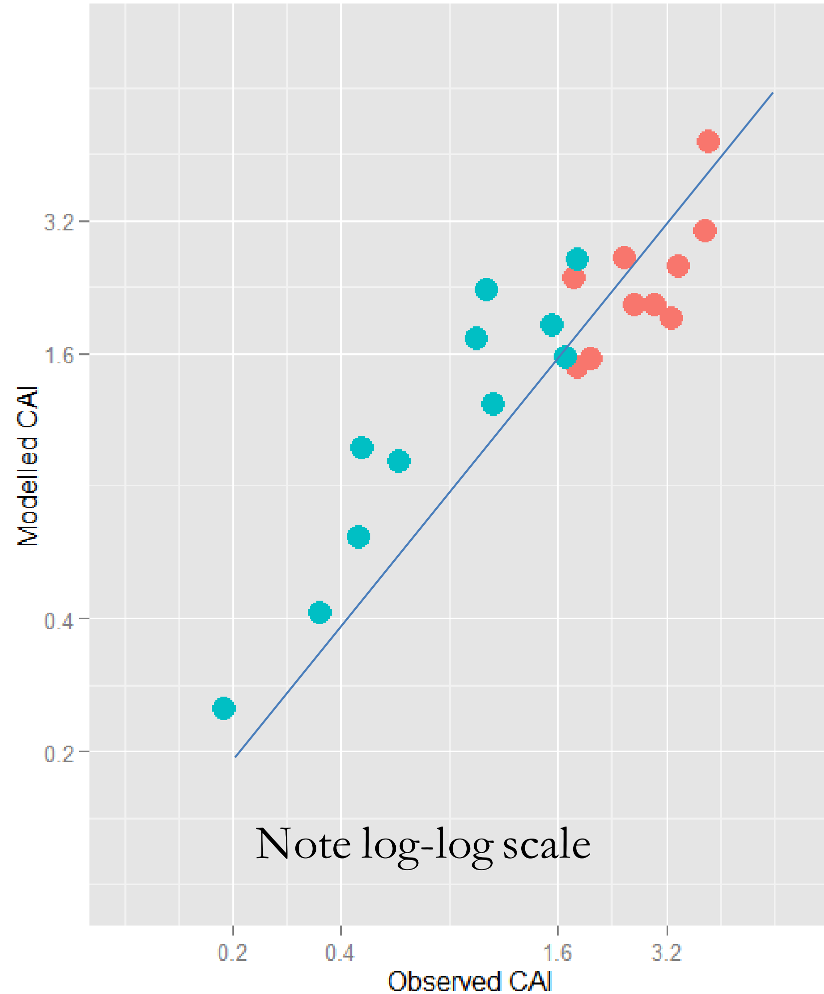


More cations in forest soil
(and it increases as precipitation declines)

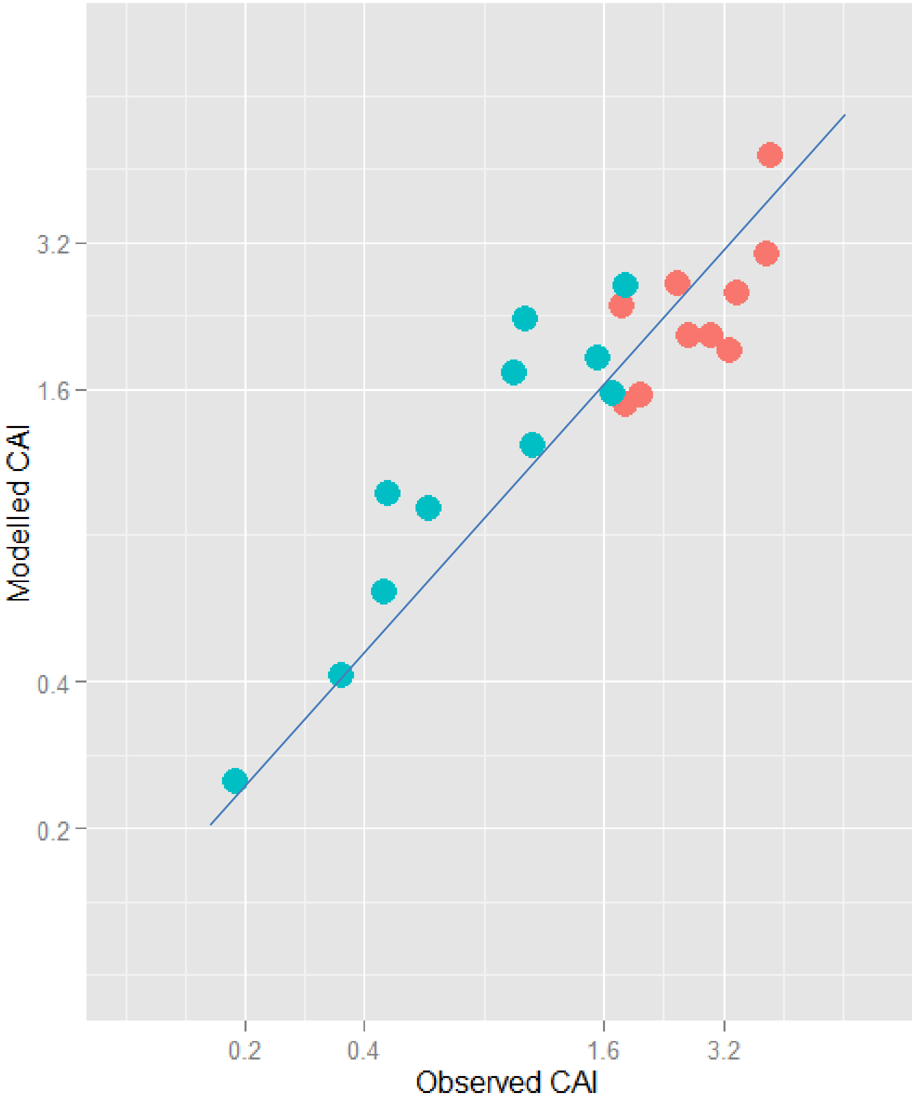


But what can we make of the obvious precipitation and soil potassium associations ?!

```
lm(formula = CAI ~ log(K_sa) + FWC + W:FWC, data =

Residuals:
    Min      1Q  Median      3Q     Max 
-1.2009 -0.5176 -0.1593  0.4295  1.3993 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)   1.7868     0.4034   4.430 0.000367 ** 
log(K_sa)     1.2704     0.2487   5.108 8.75e-05 ** 
FWC          12.9152     2.6453   4.882 0.000140 ** 
FWC:W         9.9622     2.0825   4.784 0.000173 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 

Residual standard error: 0.744 on 17 degrees of freedom
Multiple R-squared:  0.6899,    Adjusted R-squared:  0.6352 
F-statistic: 12.61 on 3 and 17 DF,  p-value: 0.0001389
```

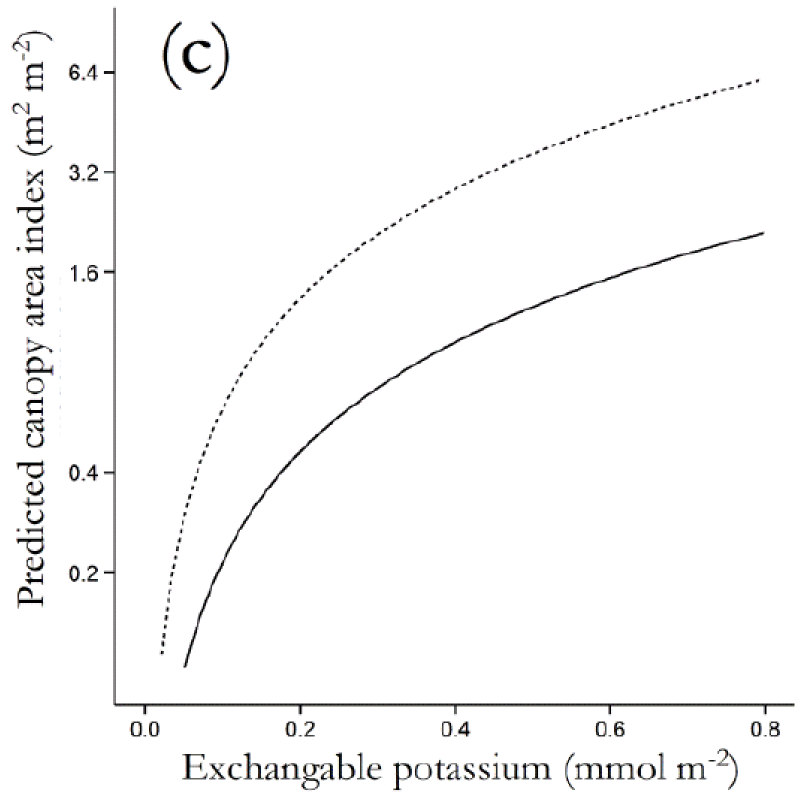


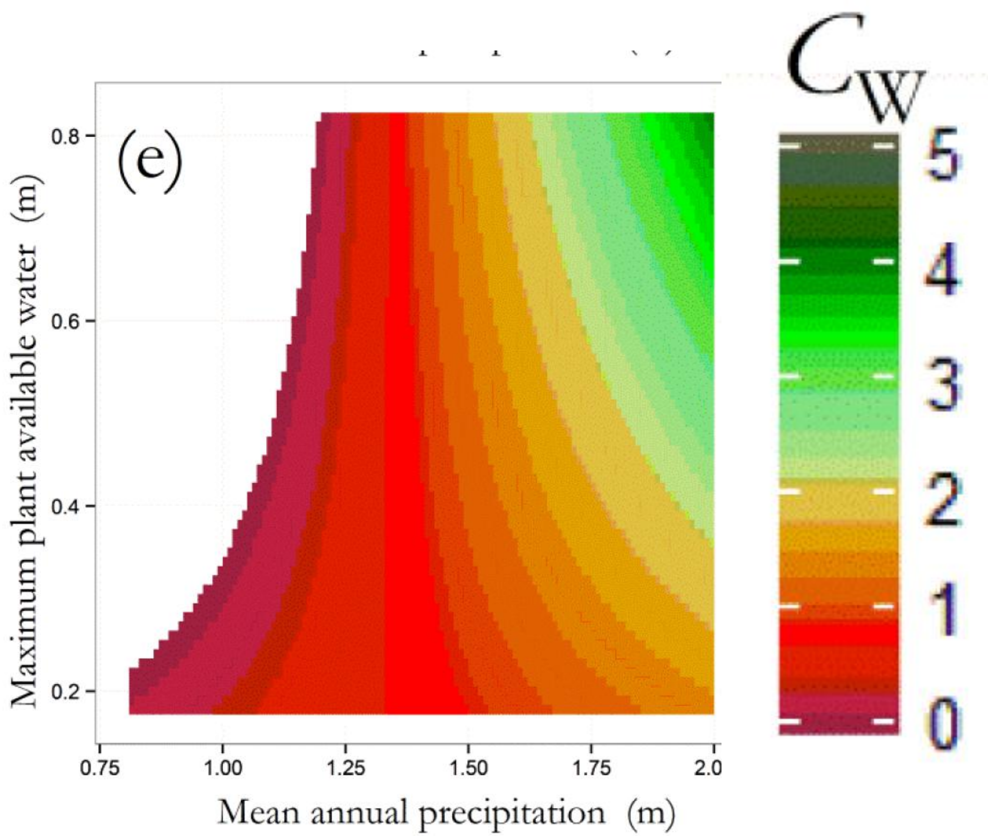
With potassium



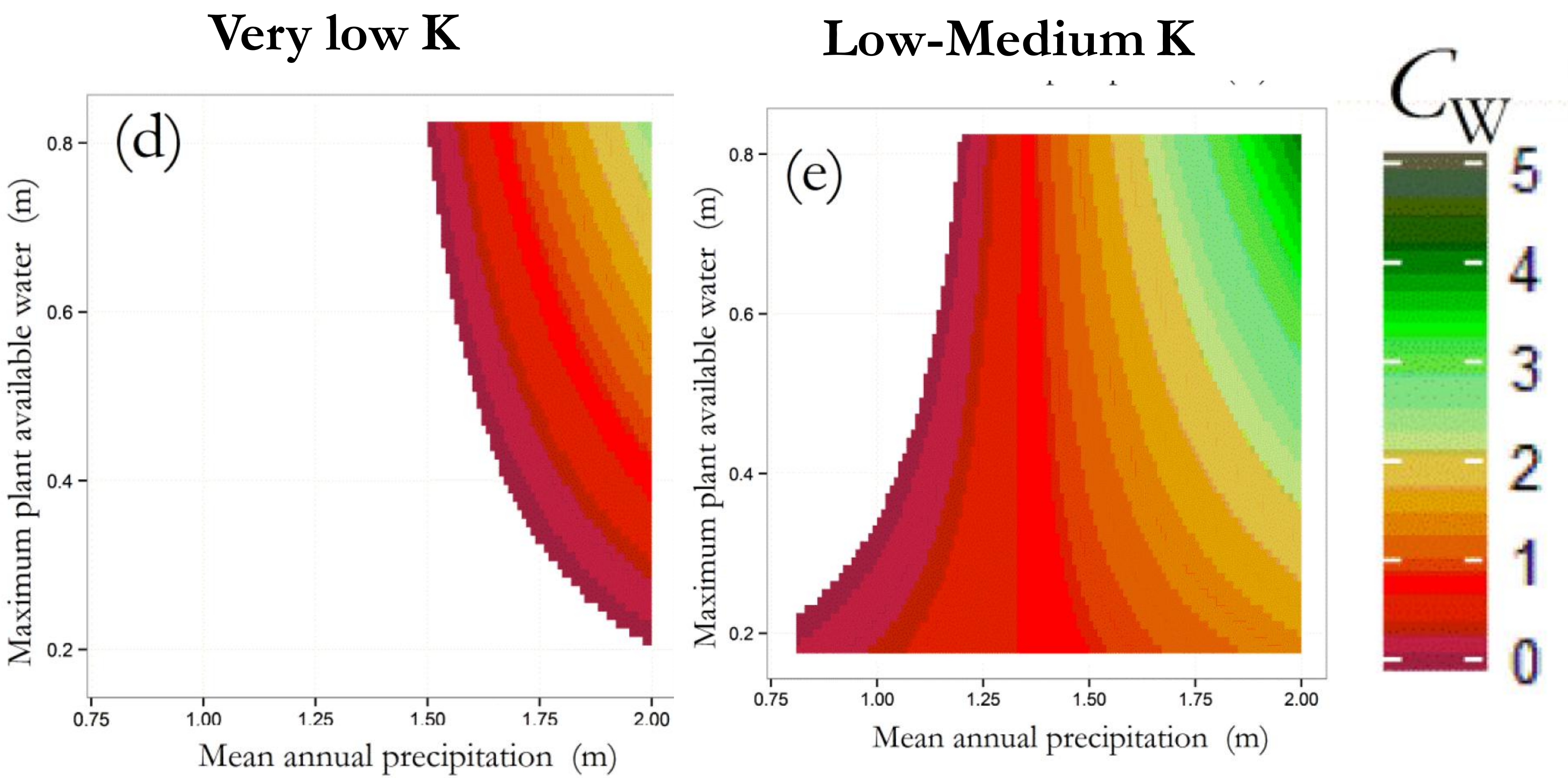
Without potassium

Complex interactions

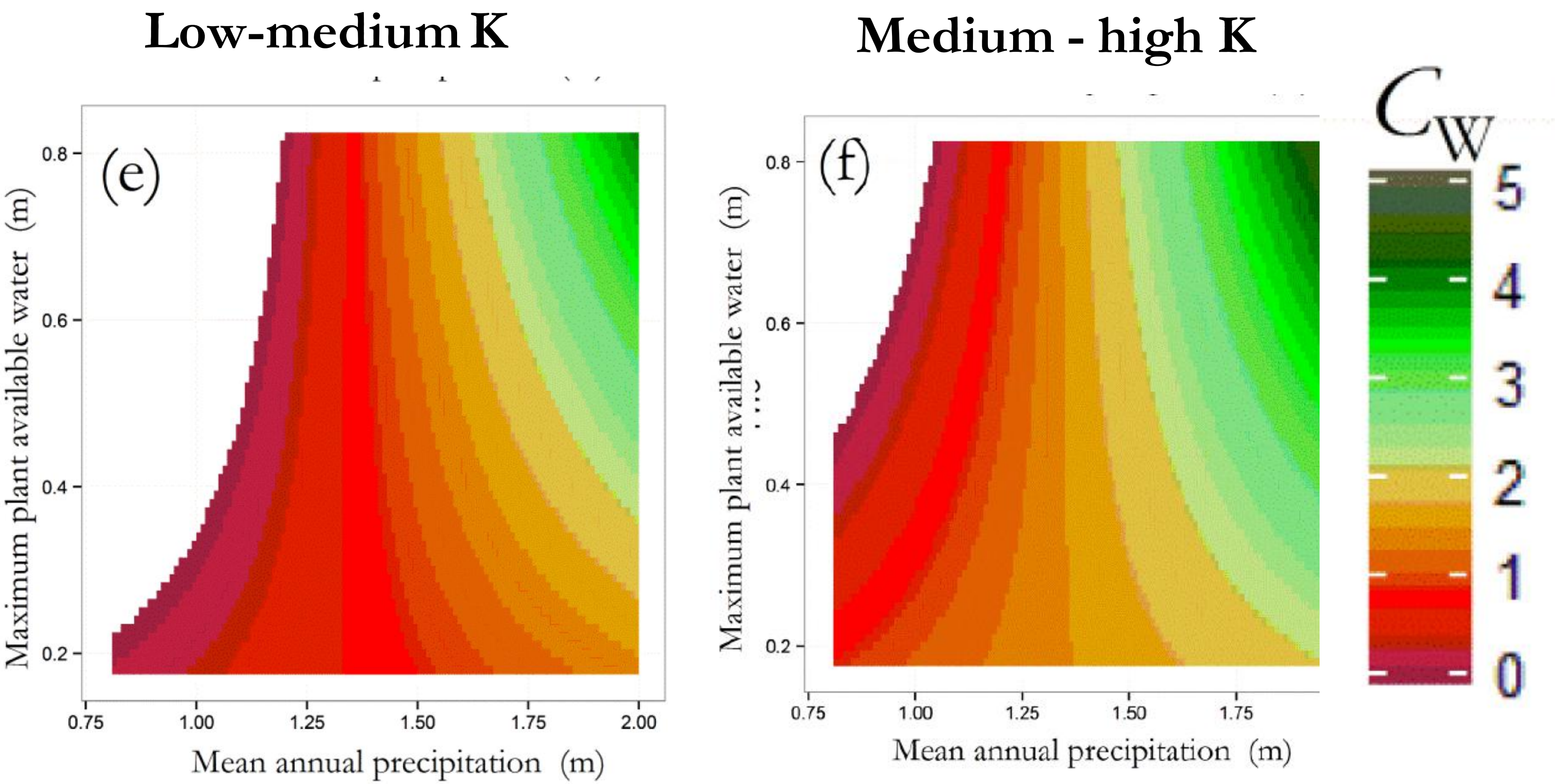




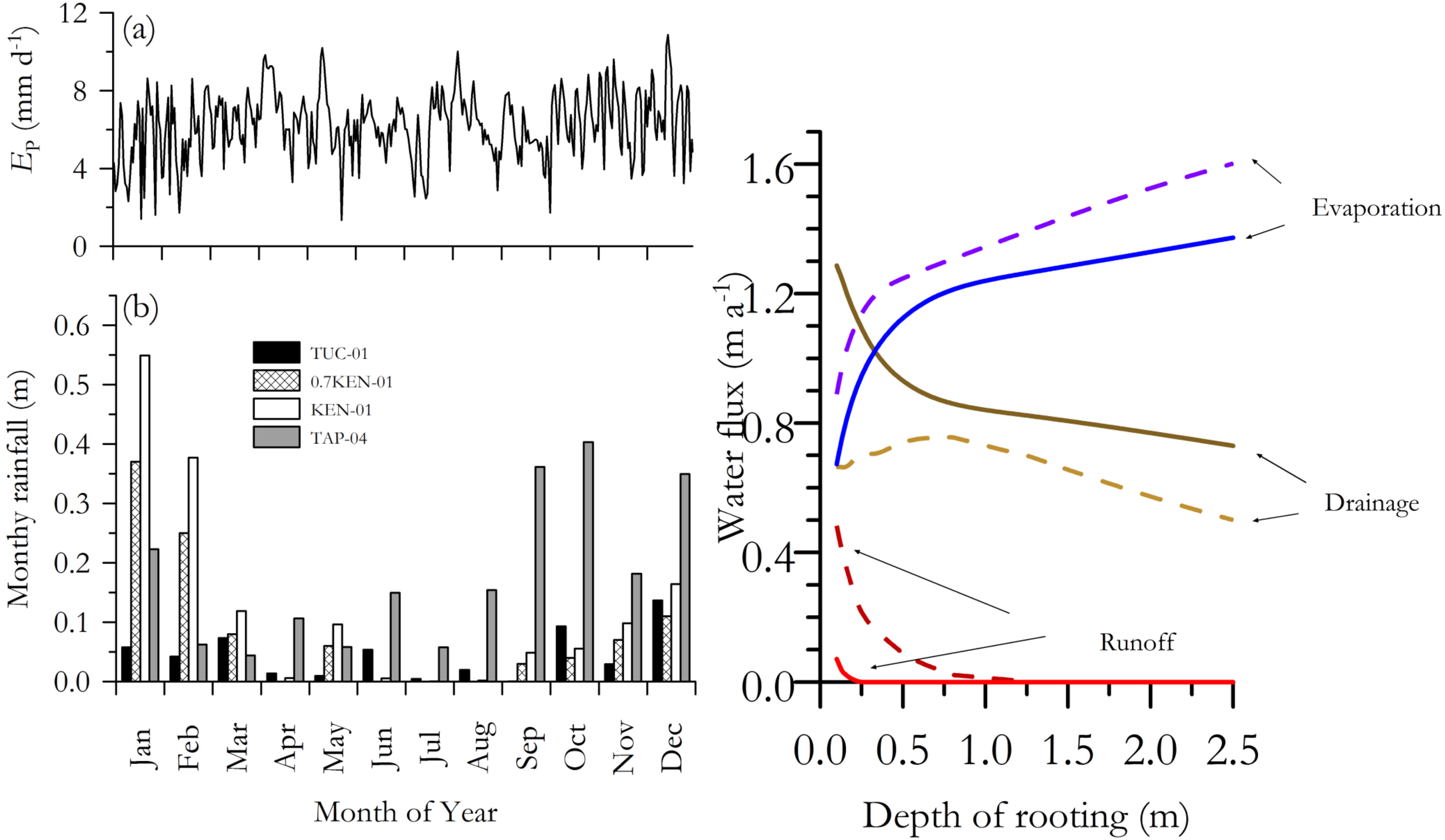
Complex interactions



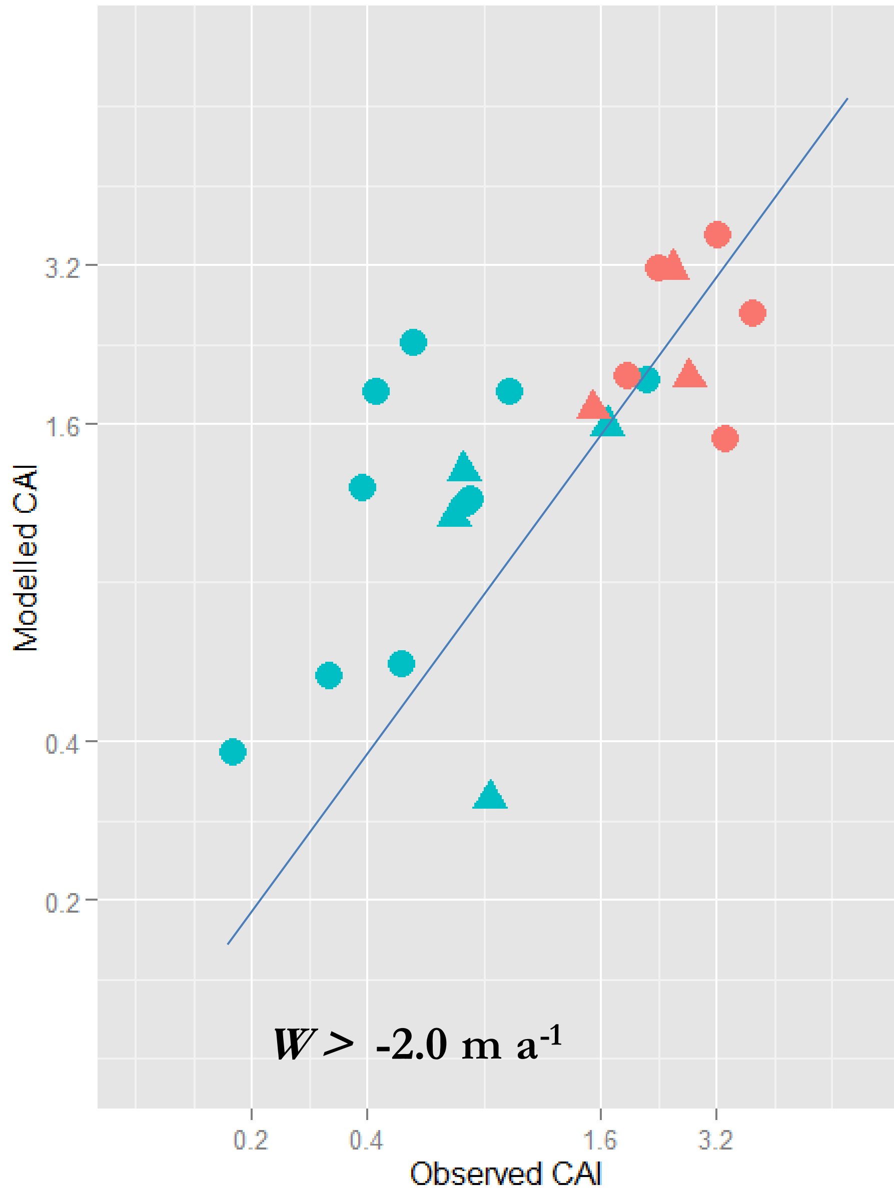
Complex interactions



Restricted root-zones can be beneficial ?



Apply to other continents (circles – Africa; triangles = Australia)



(1)More to soil nutrient effects than just nitrogen and phosphorus

Journal of Plant Physiology 171 (2014) 656–669

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Physiology

Potassium in agriculture – Status and perspectives☆

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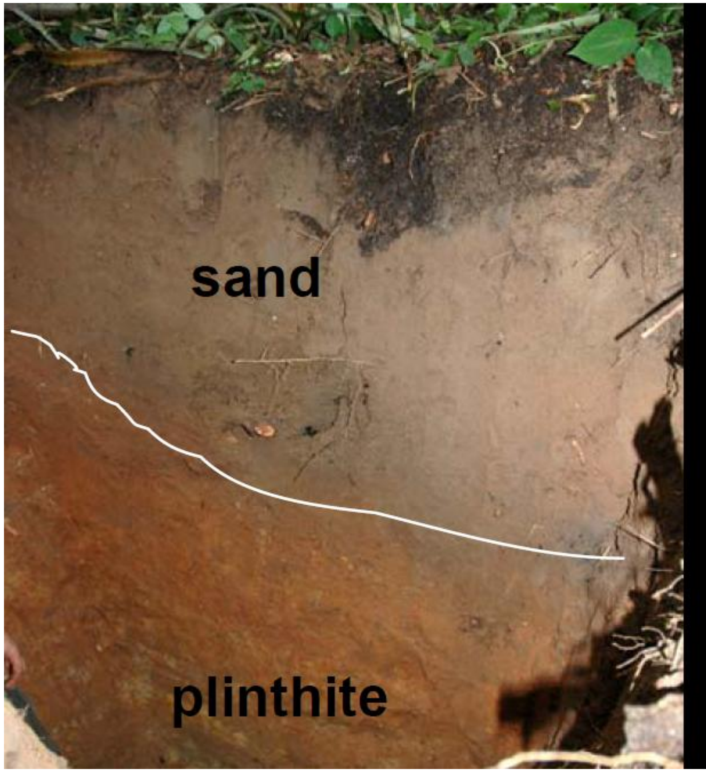
ABSTRACT

In this review we summarize factors determining the plant availability of soil potassium (K), the role of K in crop yield formation and product quality, and the dependence of crop stress resistance on K nutrition. Average soil reserves of K are generally large, but most of it is not plant-available. Therefore, crops need to be supplied with soluble K fertilizers, the demand of which is expected to increase significantly, particularly in developing regions of the world. Recent investigations have shown that organic exudates of some bacteria and plant roots play a key role in releasing otherwise unavailable K from K-bearing minerals. Thus, breeding for genotypes that have improved mechanisms to gain access to this fixed K will contribute toward more sustainable agriculture, particularly in cropping systems that do not have access to fertilizer K. In K-deficient crops, the supply of sink organs with photosynthates is impaired, and sugars accumulate in source leaves. This not only affects yield formation, but also quality parameters, for example in wheat, potato and grape. As K has beneficial effects on human health, its concentration in the harvest product is a quality parameter in itself. Owing to its fundamental roles in turgor generation, primary metabolism, and long-distance transport, K plays a prominent role in crop resistance to drought, salinity, high light, or cold as well as resistance to pests and pathogens. Despite the abundance of vital roles of K in crop production, an improvement of K uptake and use efficiency has not been a major focus of conventional or transgenic breeding in the past. In addition, current soil analysis methods for K are insufficient for some common soils, posing the risk of imbalanced fertilization. A stronger prioritization of these areas of research is needed to counter declines in soil fertility and to improve food security.

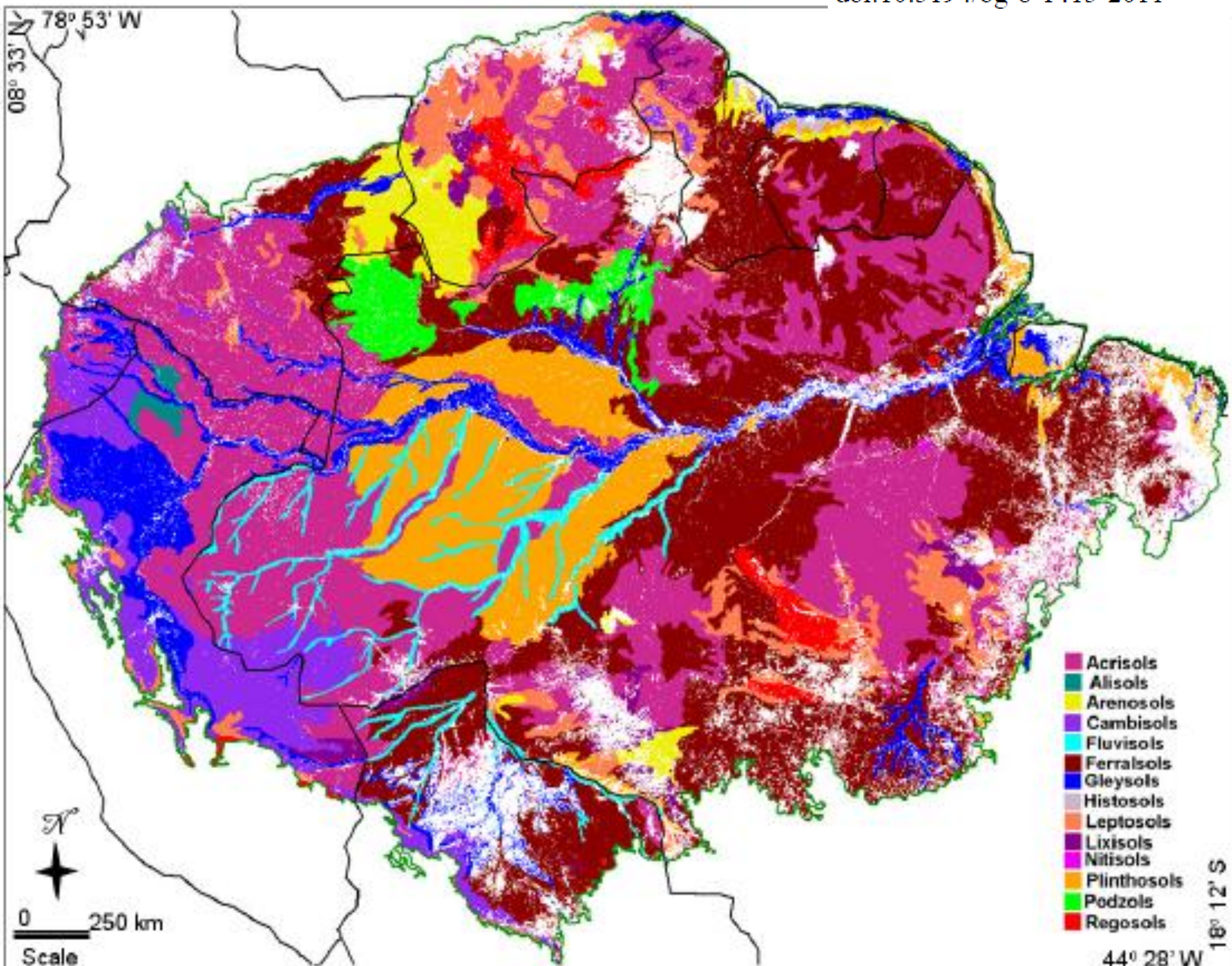
(2) Restricted root-zones can sometimes actually be beneficial ?



Soils of Amazonia with particular reference to the RAINFOR sites

C. A. Quesada[1,2], J. Lloyd[1,3], L. O. Anderson[4], N. M. Fyllas[1], M. Schwarz[5,*], and C. I. Czimczik[5,**]

Biogeosciences, 8, 1415–1440, 2011
www.biogeosciences.net/8/1415/2011/
doi:10.5194/bg-8-1415-2011



Patterns of forest biomass & productivity across Amazonia

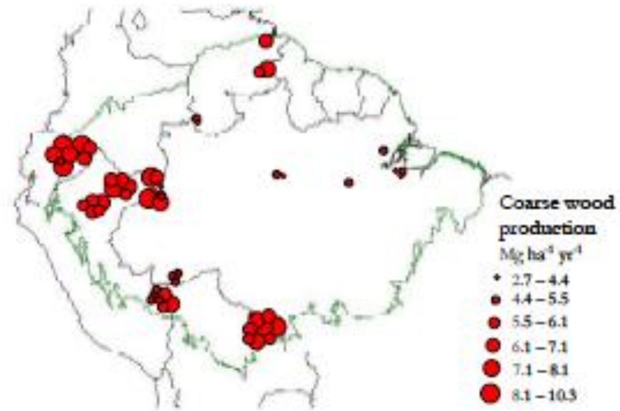
Western Amazonia

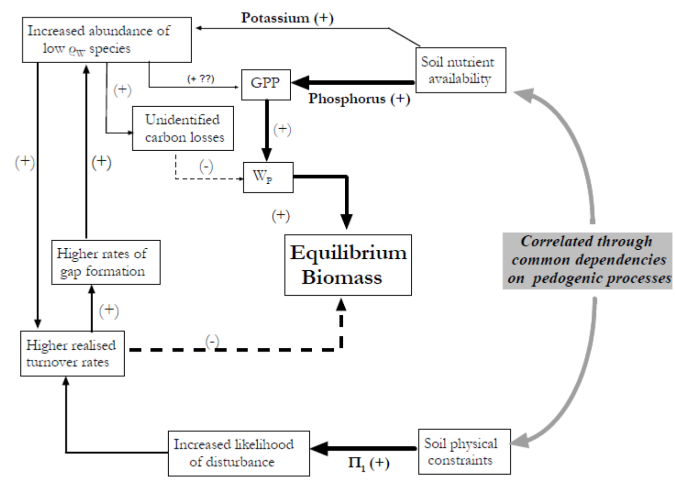
Central and Eastern Amazonia

Biogeosciences, 9, 2203–2246, 2012
www.biogeosciences.net/9/2203/2012/
doi:10.5194/bg-9-2203-2012

Biogeosciences

At a basin-wide scale Amazon forest growth and turnover rates are independently controlled by variations in the physical and the chemical properties of soils.





Basin-wide variations in Amazon forest structure and function are mediated by both soils and climate

C. A. Quesada[1,2], O. L. Phillips[1], M. Schwarz[3], C. I. Czimczik[4], T. R. Baker[1], S. Patiño[1,4,†], N. M. Fyllas[1], M. G. Hodnett[5], R. Herrera[6], S. Almeida[7,†], E. Alvarez Dávila[8], A. Arneth[9], L. Arroyo[10], K. J. Chao[1], N. Dezzeo[6], T. Erwin[11], A. di Fiore[12], N. Higuchi[2], E. Honorio Coronado[13], E. M. Jimenez[14], T. Killeen[15], A. T. Lezama[16], G. Lloyd[17], G. López-González[1], F. J. Luizão[2], Y. Malhi[18], A. Monteagudo[19,20], D. A. Neill[21], P. Núñez Vargas[19], R. Paiva[2], J. Peacock[1], M. C. Peñuela[14], A. Peña Cruz[20], N. Pitman[22], N. Priante Filho[23], A. Prieto[24], H. Ramírez[16], A. Rudas[24], R. Salomão[7], A. J. B. Santos[2,25,†], J. Schmerler[4], N. Silva[26], M. Silveira[27], R. Vásquez[20], I. Vieira[7], J. Terborgh[22], and J. Lloyd[1,28]

Biogeosciences, 9, 2203–2246, 2012
www.biogeosciences.net/9/2203/2012/
doi:10.5194/bg-9-2203-2012

Biogeosciences

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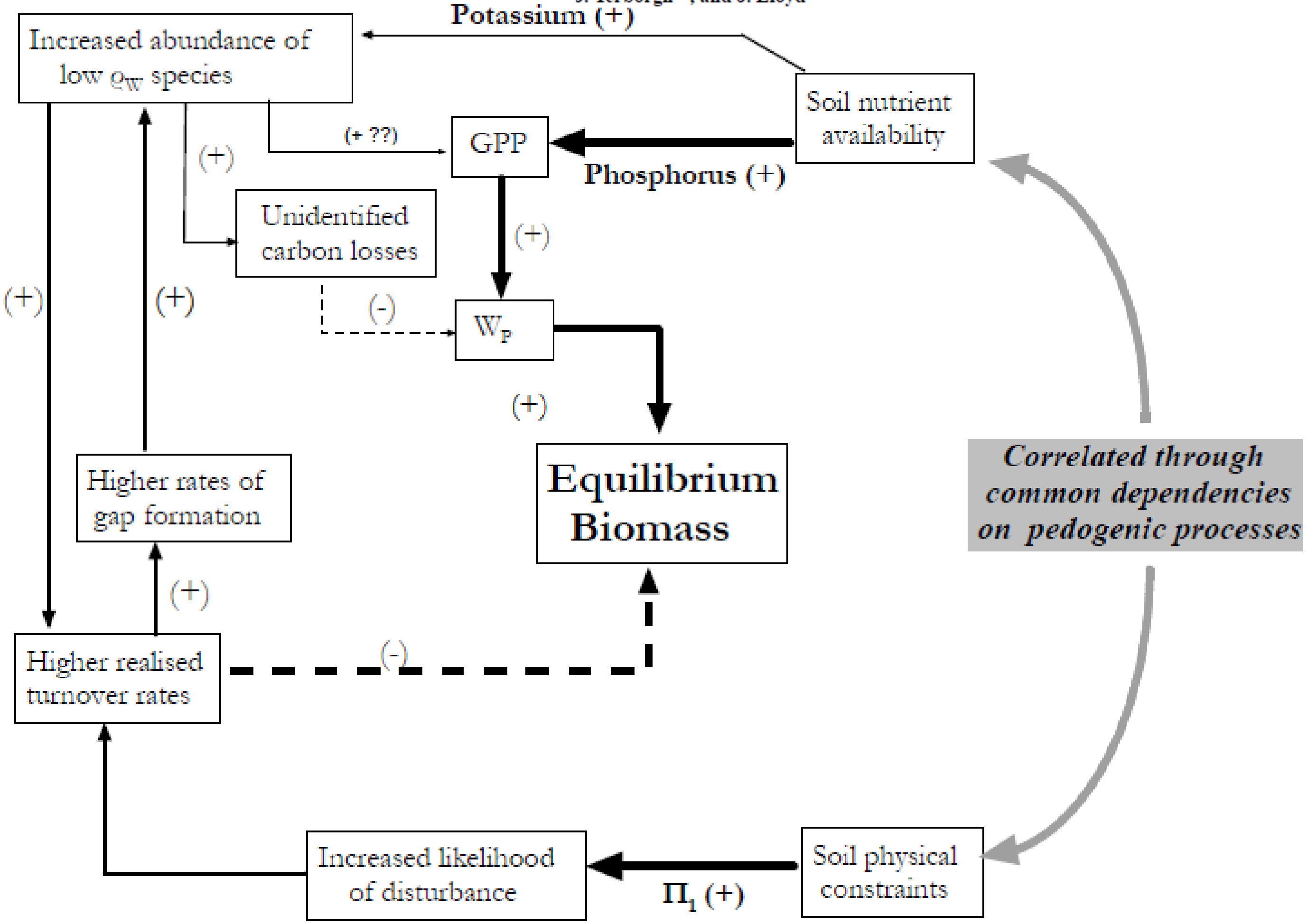


If it dries out

Forests will transform to SDTF only where soils are fertile (and shallow)

On deeper less fertile soils (much of the eastern Amazon) cerrado would be the new vegetation type

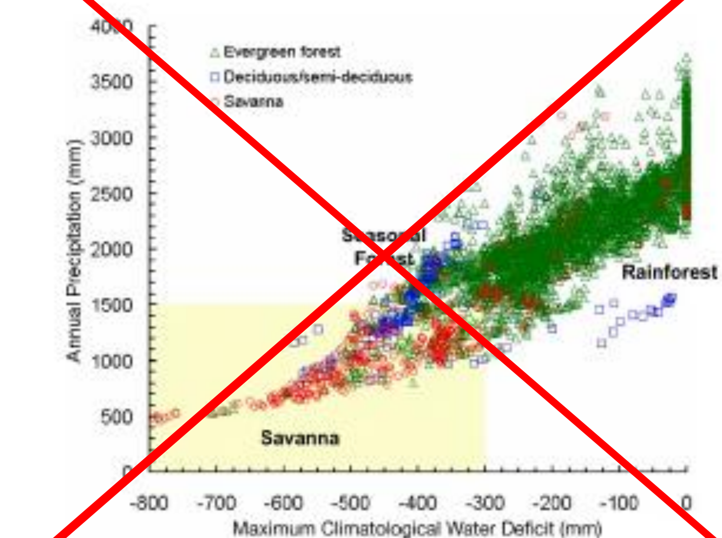
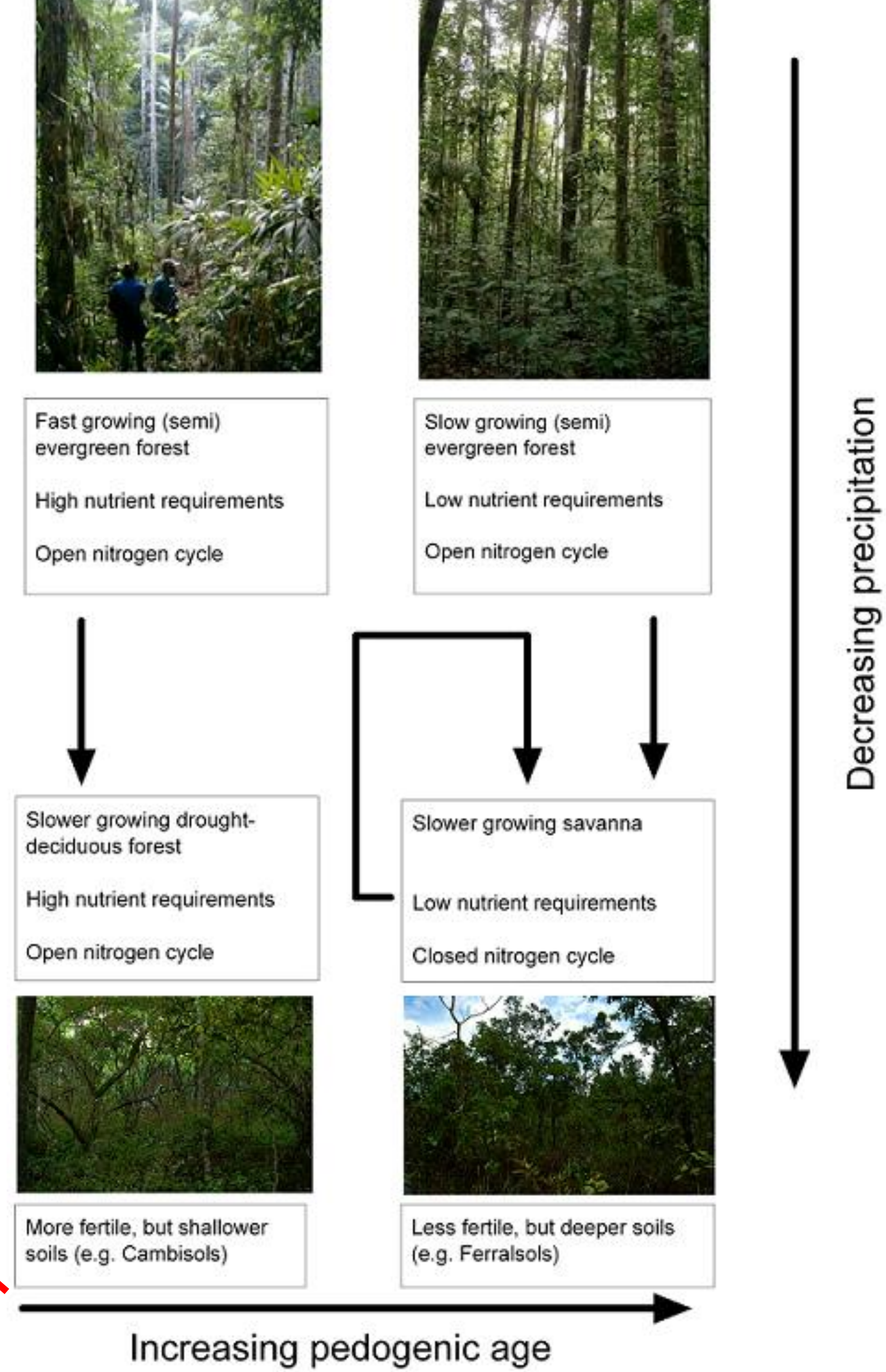


Fig. 1. The relationship between vegetation type and rainfall regime. Rainfall regime is derived from TRMM for the period 1998–2006. Our suggested savanna zone is shaded (MCWD < −300 mm, AP < 1500 mm).

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