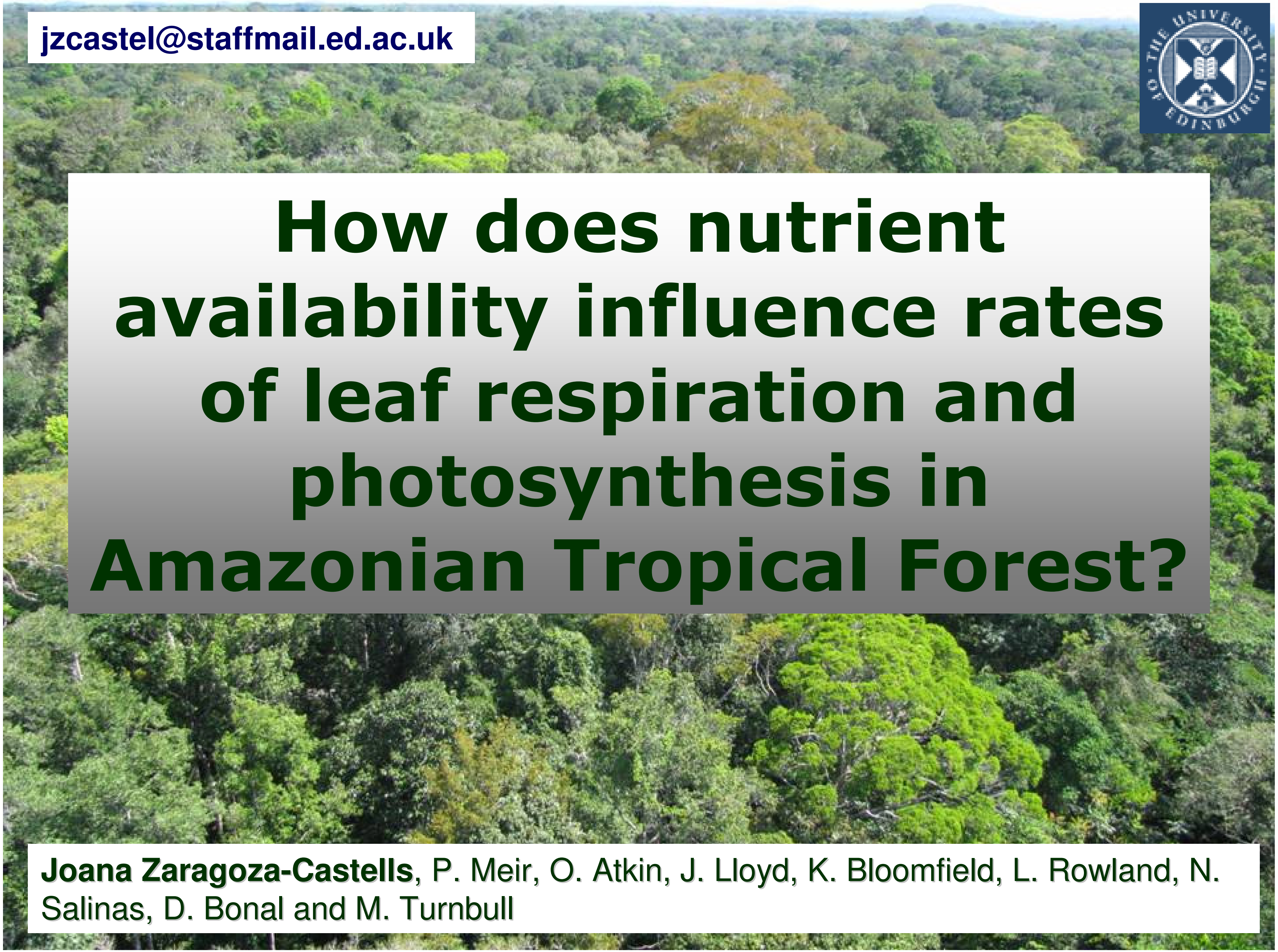
How does nutrient availability rates of photosynthesis and leaf respiration in Amazonian tropical forest ?

Joana Zaragoza-Castells, Patrick Meir, Owen Atkin, Keith Bloomfield, Lucy Rowland, Jon Lloyd, Norma Salinas, Damien Bonal, Matthew Turnbull



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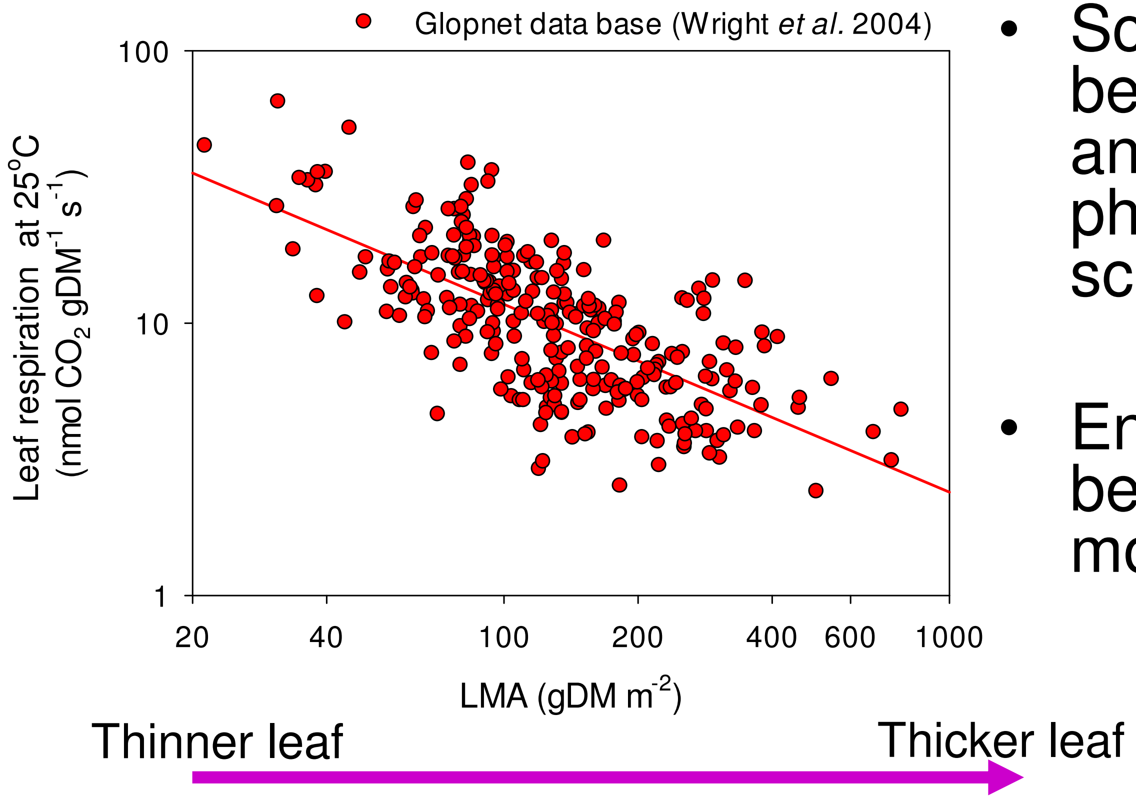
How does nutrient availability influence rates of leaf respiration and photosynthesis in Amazonian Tropical Forest?

Joana Zaragoza-Castells, P. Meir, O. Atkin, J. Lloyd, K. Bloomfield, L. Rowland, N. Salinas, D. Bonal and M. Turnbull

Introduction:

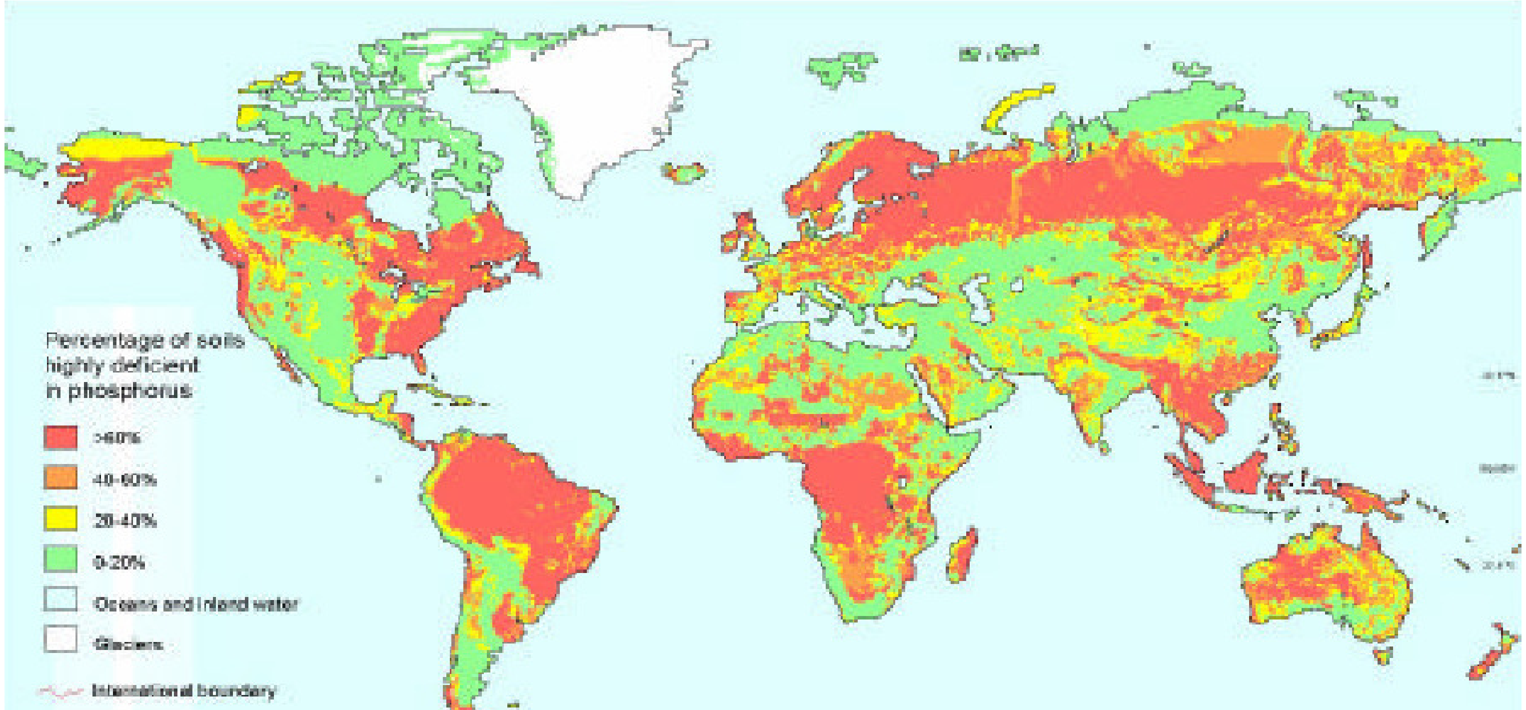
The worldwide leaf economics spectrum

Ian J. Wright[1], Peter B. Reich[2], Mark Westoby[1], David D. Ackerly[3], Zdravko Baruch[4], Frans Bongers[5], Jeannine Cavender-Bares[6], Terry Chapin[7], Johannes H. C. Cornelissen[8], Matthias Diemer[9], Jaume Flexas[10], Eric Garnier[11], Philip K. Groom[12], Javier Gulias[10], Kouki Hikosaka[13], Byron B. Lamont[12], Tali Lee[14], William Lee[15], Christopher Lusk[16], Jeremy J. Midgley[17], Marie-Laure Navas[11], Ülo Niinemets[18], Jacek Oleksyn[2,19], Noriyuki Osada[20], Hendrik Poorter[21], Pieter Poot[22], Lynda Prior[23], Vladimir I. Pyankov[24], Catherine Roumet[11], Sean C. Thomas[25], Mark G. Tjoelker[26], Erik J. Veneklaas[22] & Rafael Villar[27]



- Scaling relationships between leaf respiration and leaf traits (e.g. LMA, photosynthesis) on global scale
- Enables generalisations to be made in large-scale models

➢However,…



N.H. Batjes 2003; *ISRIC-WISE dataset at 0.5x0.5 degree resolution, v.1.0. ISRIC-WISE Soil Database*. 2003 Global distribution of soils with a high inferred P deficiency 2003

- Phosphorus (P) limitation is widespread in the tropics
- Currently, there is limited information on how this affects plant metabolic rates, although:
  - P limitation has been shown to reduce both photosynthesis and leaf respiration (Reich *et al*. 2009; Meir *et al*. 2001)
  - Unclear how this alters the global scaling relationship between LMA and leaf respiration, OR between leaf respiration and photosynthesis

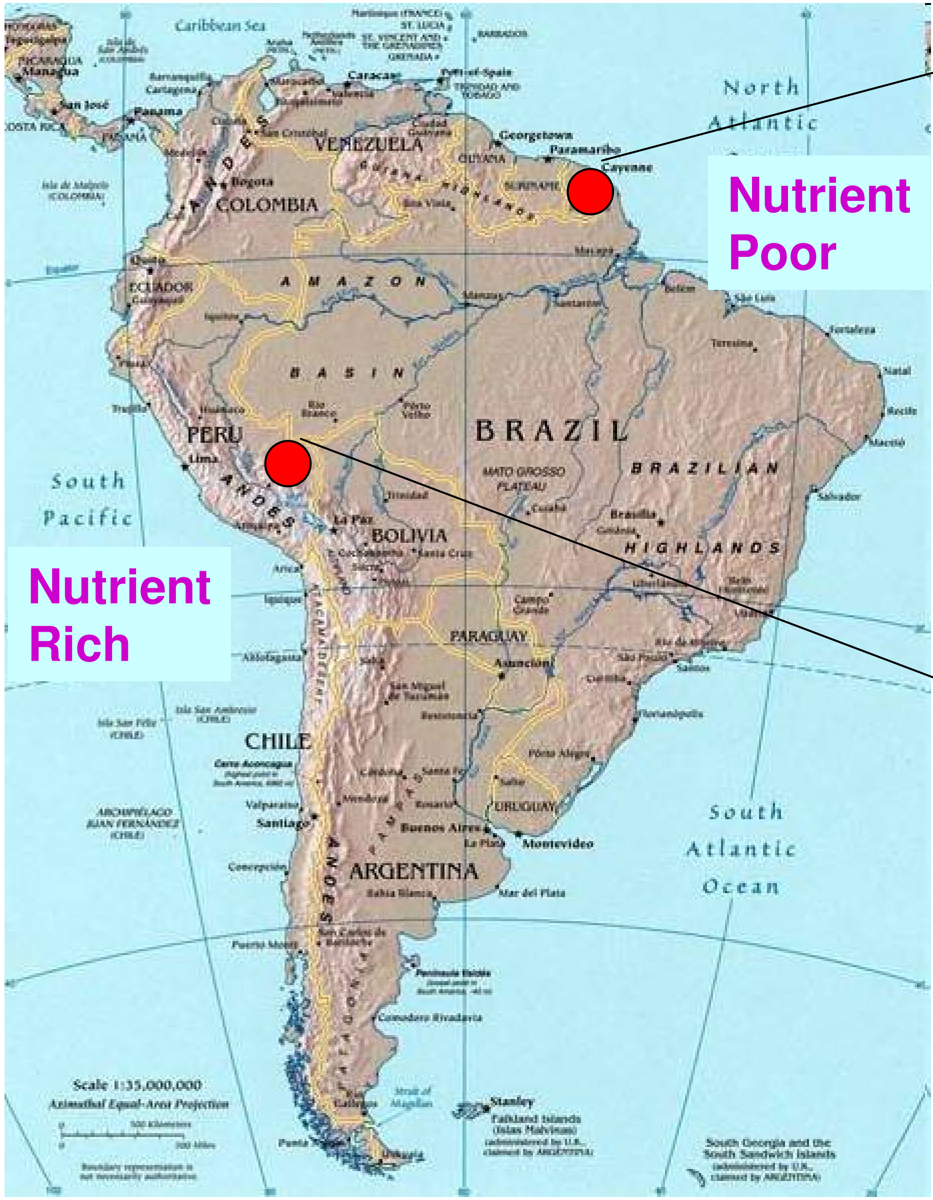
Objectives

1. Do the scaling relationships between leaf respiration (*R*) and related leaf traits (e.g. LMA) differ between Amazonian Tropical Forests and the Glopnet dataset, that is based largely on Northern Hemisphere ecosystems?

2. Do gradients in soil [P] availability in Amazonian Tropical Ecosystems result in systematic changes in rates of *R* and the relationship between *R* and other leaf traits (*i.e.* LMA, Photosynthesis (*A*)).
   - To what extent is the balance between *R* and *A* altered under high versus low [P]?

➢French Guiana – Peru: 6 fold increase in soil available [P], and soil [N] increases by ~40%

(Hättenschwiler *et al*. 2008; Quesada *et al*. 2009)



French Guiana – Paracou

Gx1-9 & Gx7

- Three-fold difference in soil extractable P concentrations.

Baraloto *et al.* 2005

- Field trip: October-November 2010

Peru – Tambopata

Plot 3 & Plot 4

- Two-fold difference in leaf P contents.

Fyllas *et al.* 2009

- Field trip: May-July 2010

Measurements:

Photosynthesis:

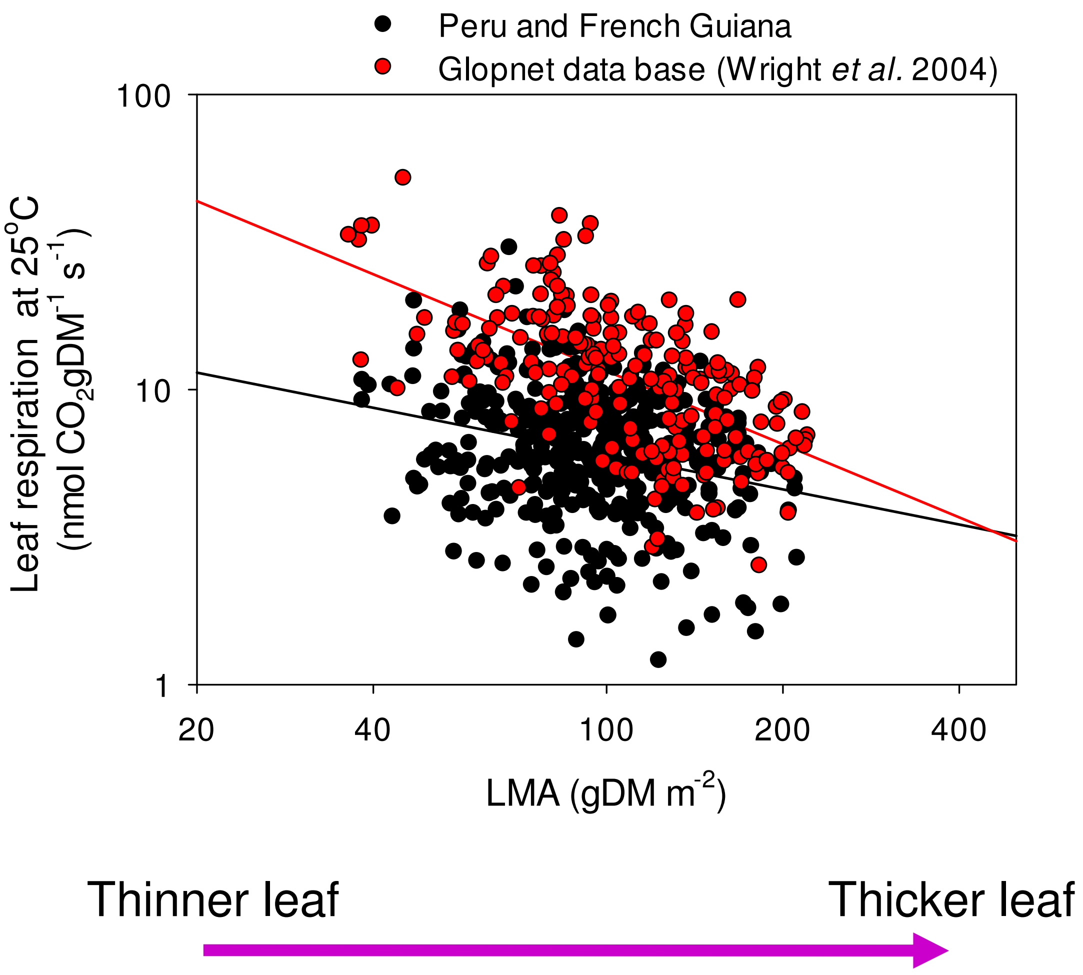
- Saturated irradiance and ambient CO_2 (A_{sat})
- Saturated irradiance and saturated CO_2 (A_{max})

Leaf Respiration in darkness (R)

More than 400 trees belonging to over 200 species were measured

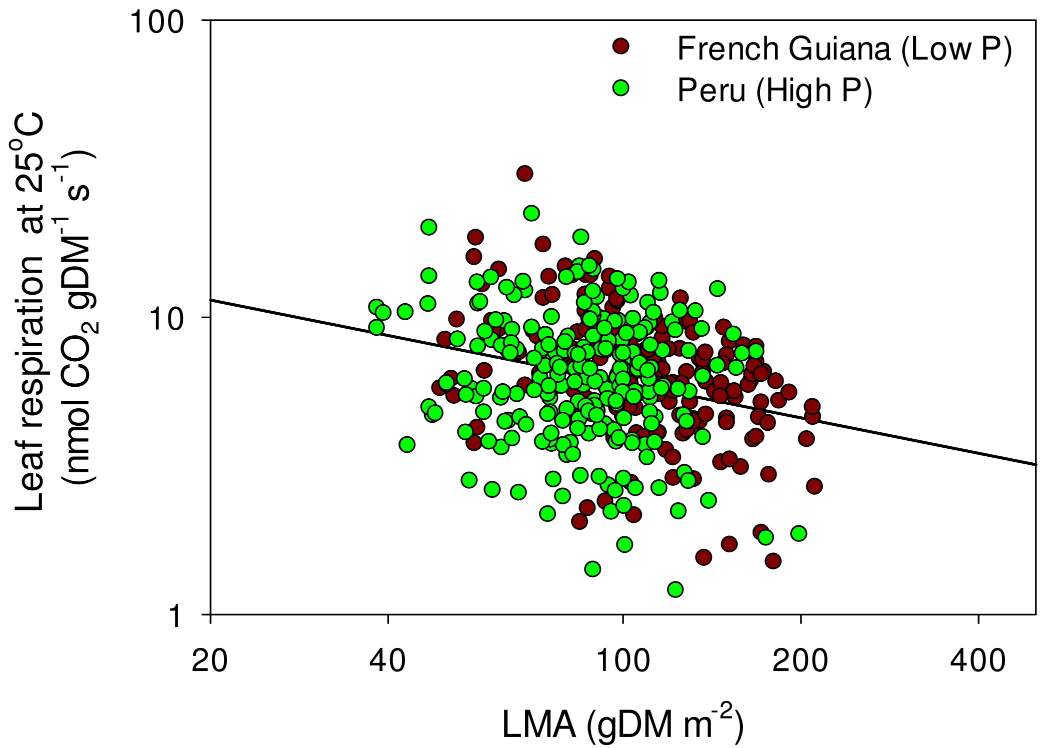
- **Nutrient Analysis:**
  - N and P
  - Sugar and starch
  - Rubisco

Results: Amazon Vs Glopnet



- Lower R_{25} in Tropical systems at most LMA values.
  - *R* at 100 gDM m^{-2} in Amazon is 50% lower than Glopnet predicts
- Impact for model predictions.
- Why?
  - Growth temp. OR
  - **P limitation**

Results: Peru Vs French Guiana

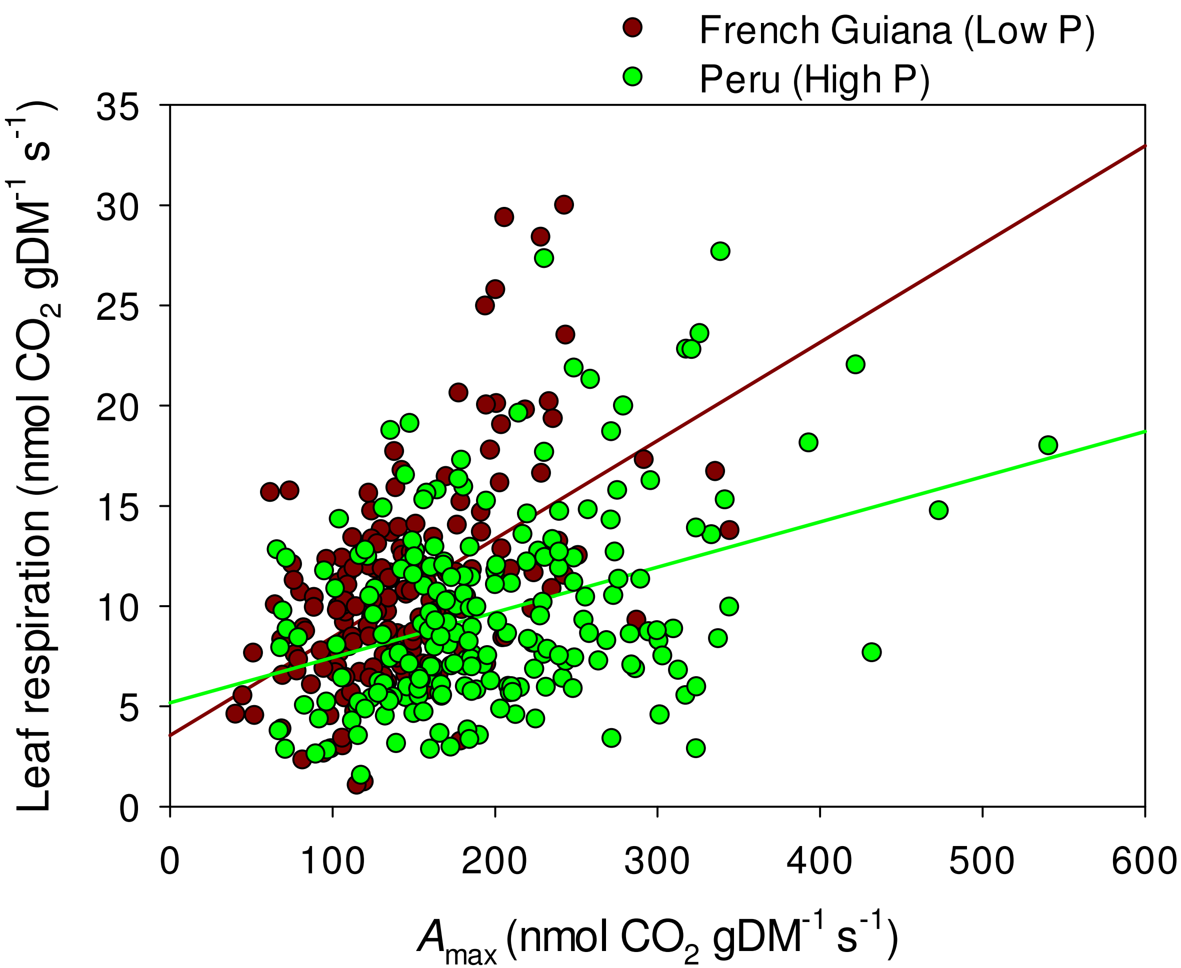


- Nutrient availability has <u>no</u> systematic effect on *R*-LMA scaling.

- Explanation for low *R* in tropics may be the thermal history?

➢Need completed leaf nutrient analysis

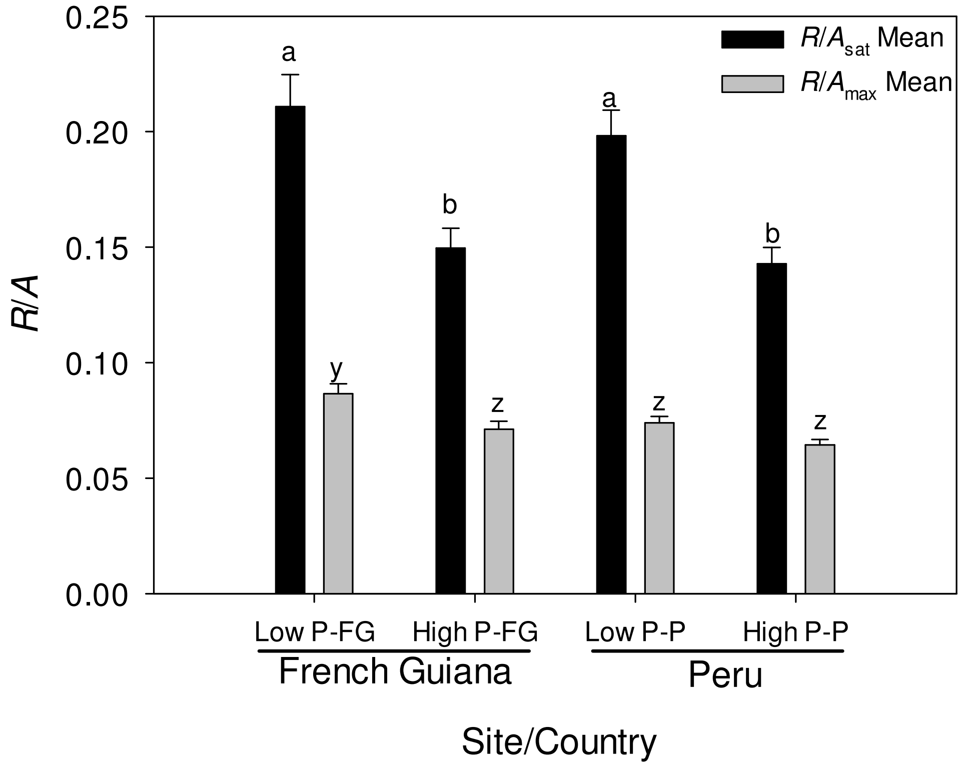
Results: Peru Vs French Guiana



- Higher R/A_{max} in French Guiana
  - Especially at high A_{max}
- Greater % of carbon gain is lost through R at low nutrient availability

Results: Within and between country variability

ALL SPECIES



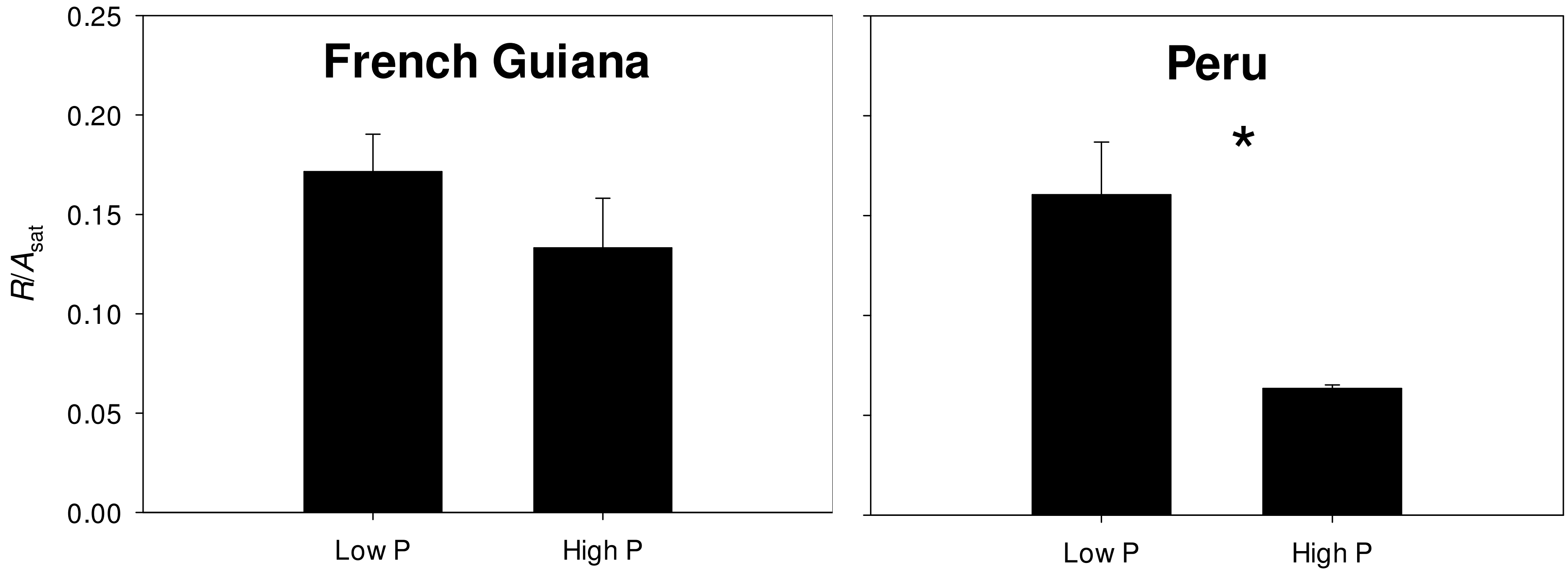
- *R*/*A* is <u>not</u> constant
- Soil fertility affects within and/or between the two countries

➢ Responses within species, or due to different species being found at high versus low nutrient availability

Results: Within country

- Differences maintained comparing same species
- Low fertility has an effect on the relationship *R*/*A*

SPECIES COMMON ACROSS PLOTS



Conclusions:

1. **Amazon species exhibit lower rates of *R* at 25°C for a given LMA, than the Glopnet database.**
    - **Low [P] appears <u>not</u> to be the main factor explaining this, rather growth temperature appears to be important.**

2. **Under low [P] there is little effect on *R*, but *A* declines strongly. Therefore, *R*/*A* is not constant; there is a negative effect on plant net carbon gain.**

3. **Models should <u>not</u> assume:**
    - **The Glopnet database can predict *R* in Amazonian Tropical Forest**
    - **That *R*/*A* is constant**

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•INRA Groupe Régional de Guyane

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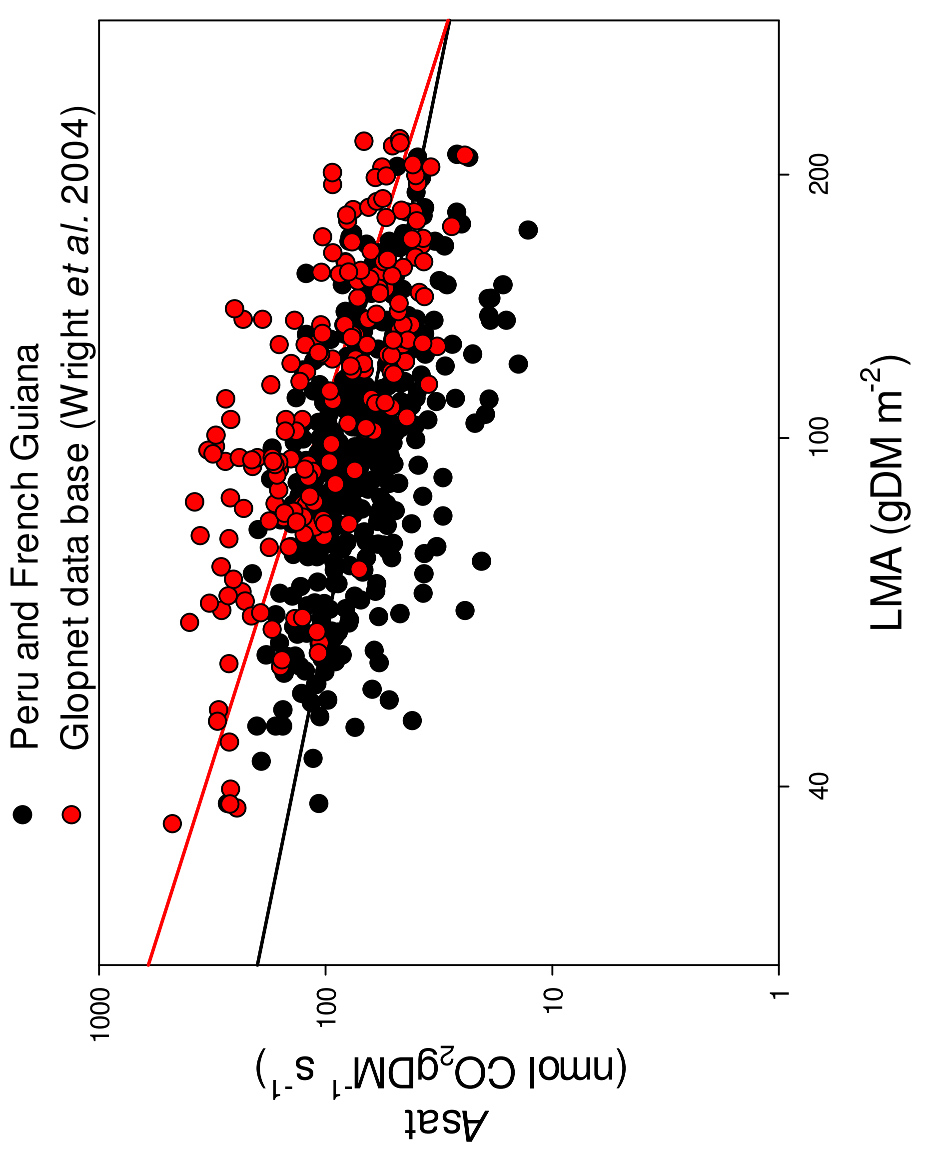
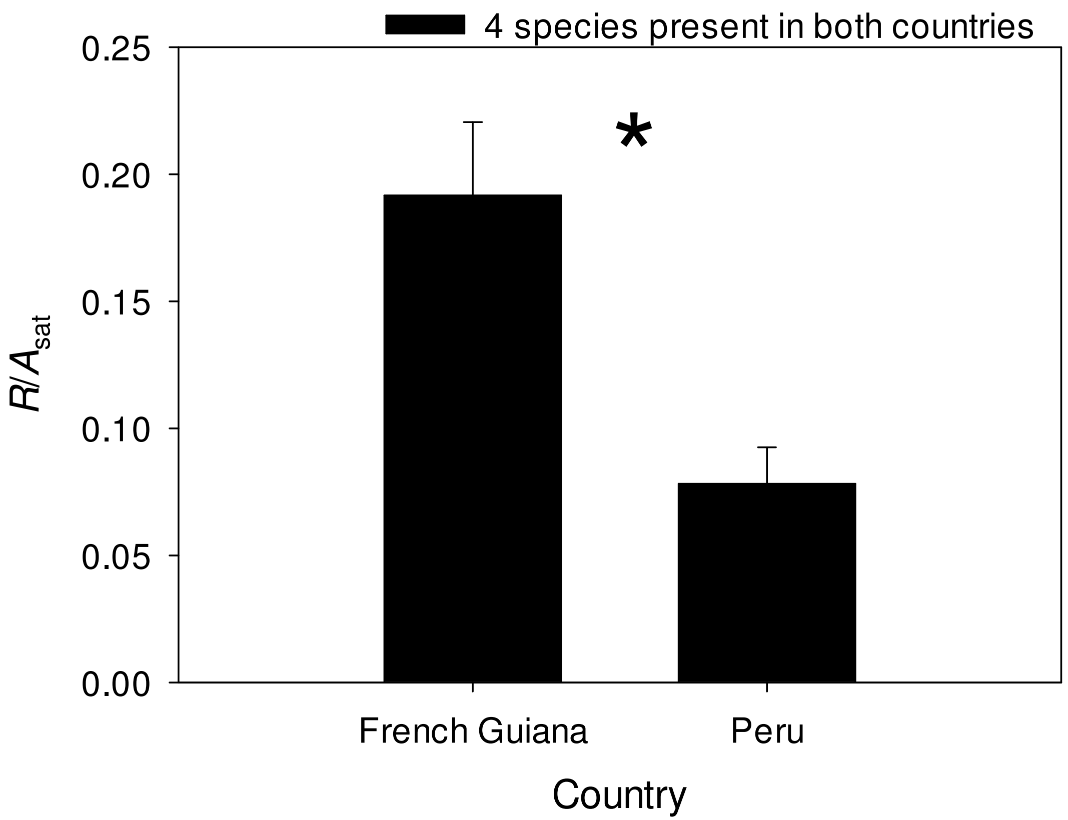


Peru and French Guiana
Glopnet data base (Wright et al. 2004)
Asat
(nmol CO_2gDM^{-1} s^{-1})
1000
100
10
1
40
100
200
LMA (gDM m^{-2})



- Yes, low fertility has an effect on the relation *R*/*A*.