Inconstant exponents of scaling leaf nitrogen to phosphorus

Di Tian, Zhengbing Yan, Wenxuan Han, Jingyun Fang* and other collaborators

Institute of Ecology, Peking University, China

College of Life Sciences, Capital Normal University, China

Corresponding: jyfang@urban.pku.edu.cn; tiandi@cnu.edu.cn

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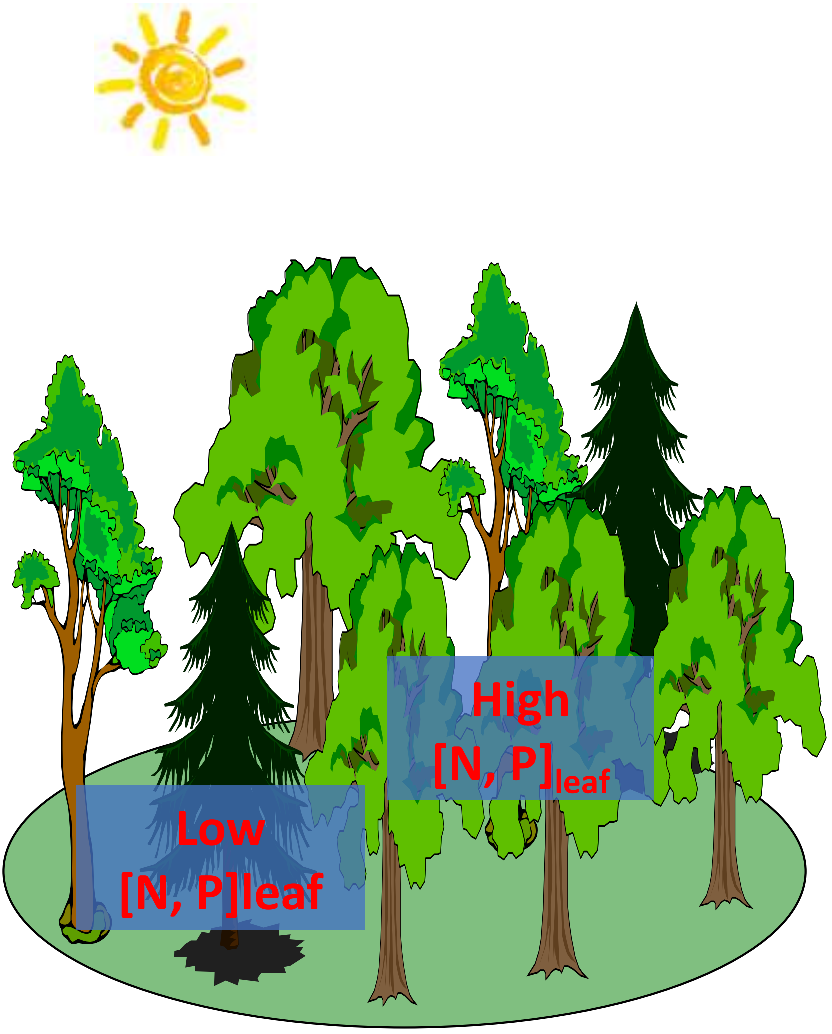
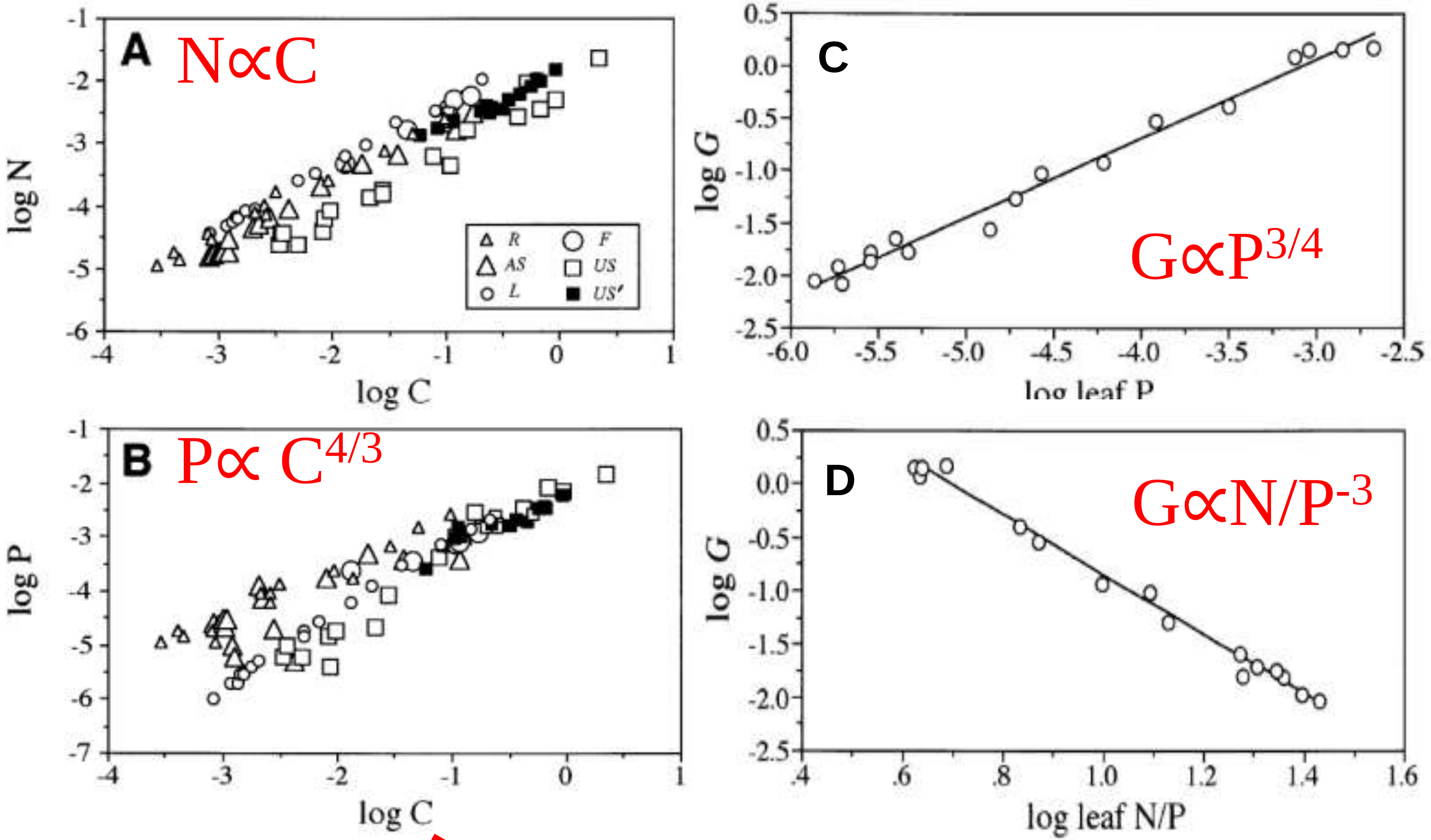
Jena, Gemany

Why N ~ P scaling?





$N \propto P^{3/4}$

Individuals/Species/Community/Ecosystems

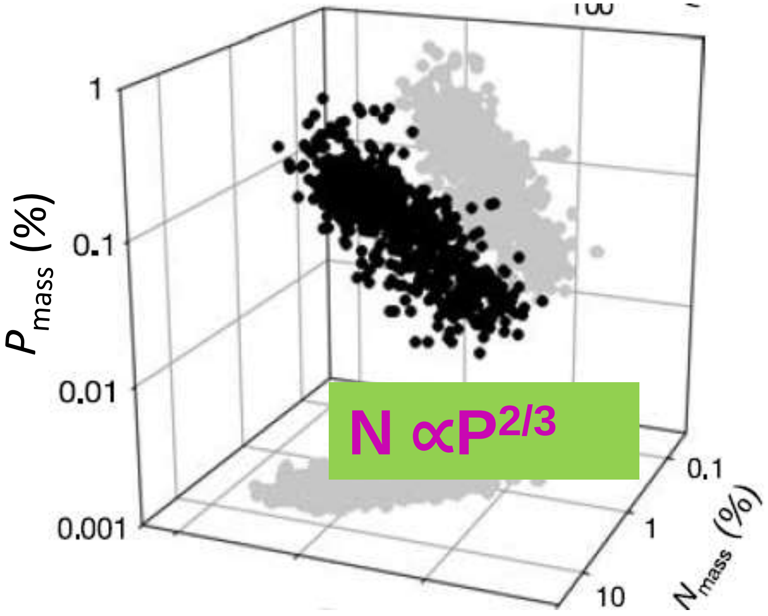
(Niklas & Cobb 2005. AM. J. BOT.)

Why N ~ P scaling?

$$\log \text{leaf N} = \alpha \log \text{leaf P} + \beta$$

Scaling exponent

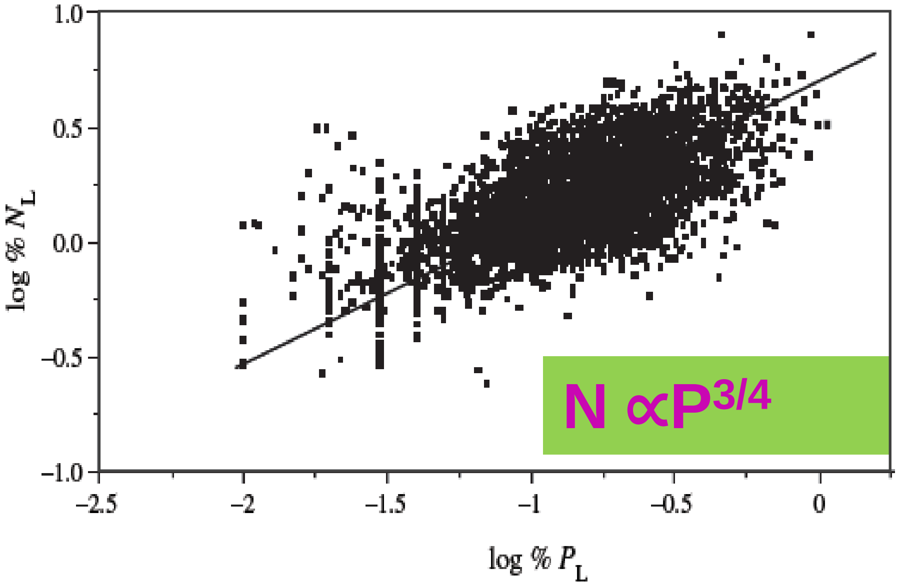
α =2/3



N ∝$P^{2/3}$

Wright et al. 2004. *Nature*

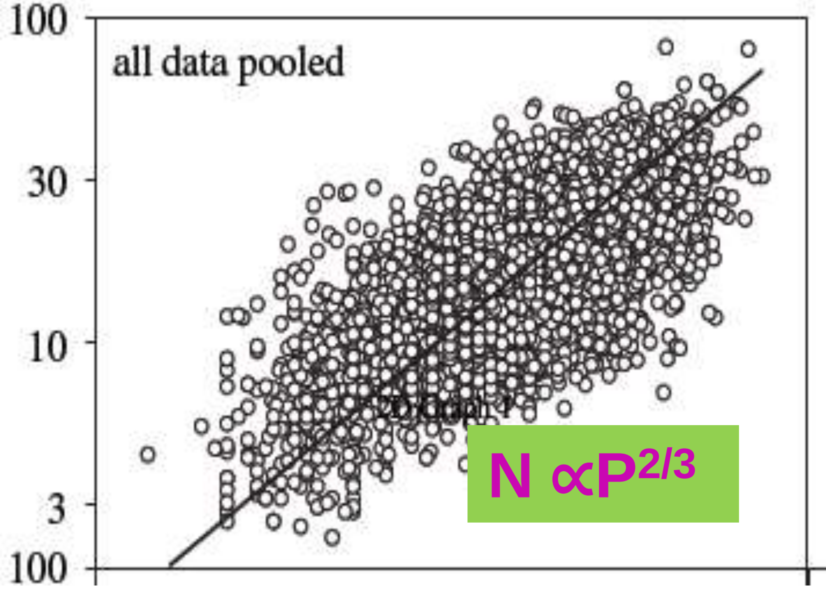
α =3/4



N ∝$P^{3/4}$

Niklas et al. 2006. *Ecol Lett*

α =2/3



N ∝$P^{2/3}$

Reich et al., 2010. PRS-B

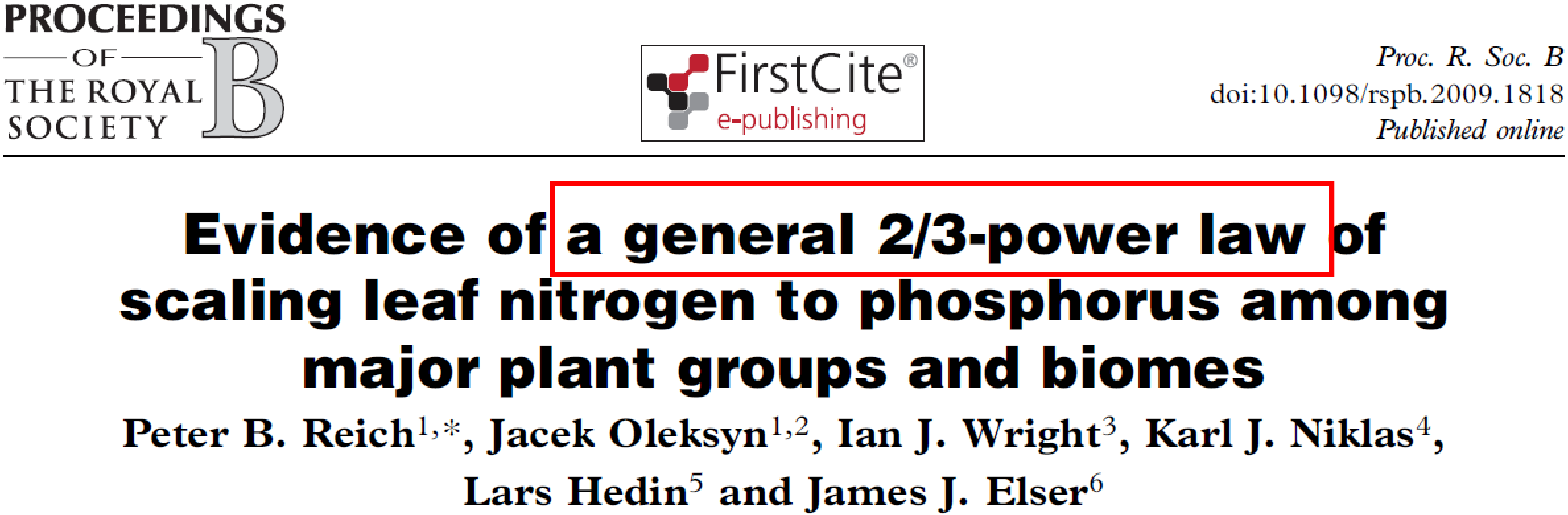
nature
International journal of science

articles

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]

…We now have wide-ranging and convincing evidence that feasible leaf investment strategies are to a great extent arrayed along a single spectrum, with the same patterning of trait correlations seen globally and in species grouped by growth form, biome or climate…


PROCEEDINGS OF THE ROYAL SOCIETY B

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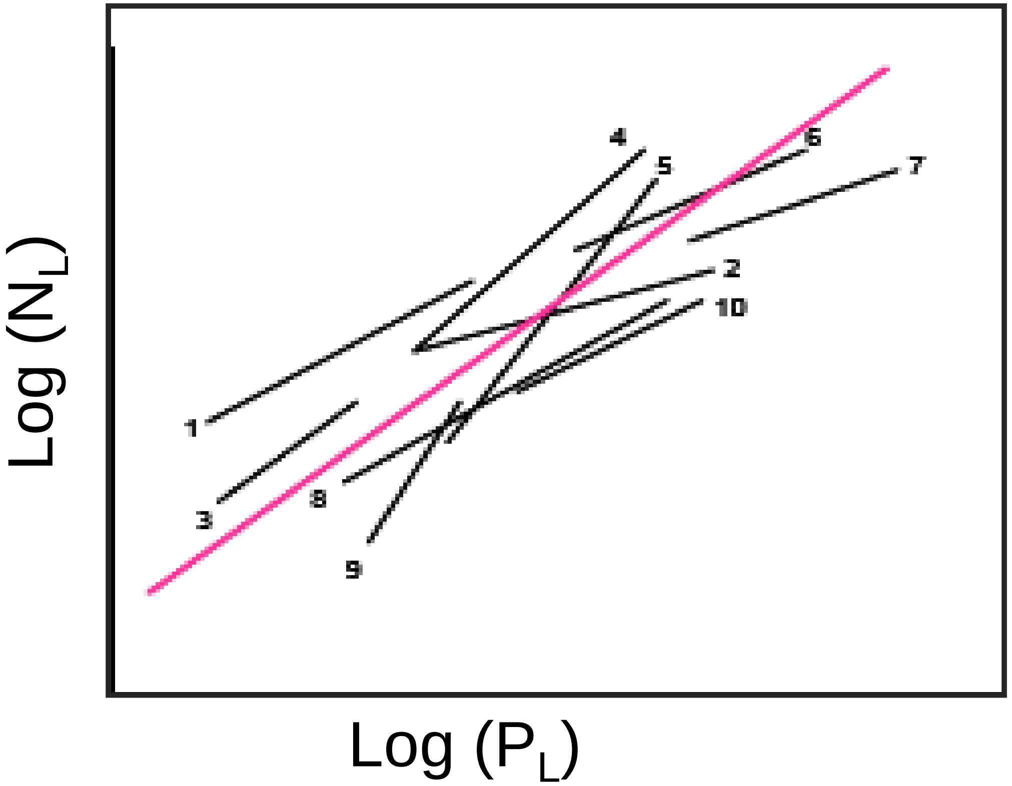
doi:10.1098/rspb.2009.1818

Evidence of a general 2/3-power law of scaling leaf nitrogen to phosphorus among major plant groups and biomes

Peter B. Reich[1,*], Jacek Oleksyn[1,2], Ian J. Wright[3], Karl J. Niklas[4],
Lars Hedin[5] and James J. Elser[6]

…Power law exponents derived from log–log scaling relations were near 2/3 for all observations pooled, for angiosperms and gymnosperms globally, and for angiosperms grouped by biomes, major functional groups, orders or families…

Are we focusing too much on the generality of leaf traits across scales (e.g. N & P stoichiometry here)?



Does leaf N vs P scaling constant (invariant)

Table 1. Exponents values reported in references

Reference	**α**	**Data Resources**
Wright *et al*. 2004	0.66 (~2/3)	Pooled data (Glopnet, *n* = 745)
McGroddy *et al*. 2004	1.00	Woody plants (data from literatures, *n* = 55)
Niklas & Cobb 2005	3/4	*Eranthis hyemalis* (cultivated , *n* = 17)
Niklas & Cobb 2006	2/3 and 3/4	Woody and herbaceous plants (*n* = 112, 131)
Niklas 2006	3/4	Pooled data (*n* = 7,445)
Han *et al*. 2005	0.65 (~2/3)	Pooled data of China (*n* = 2,094)
Kerkhoff *et al*. 2006	0.73/0.70/0.79 (~3/4)	Pooled data/ woody/ herbaceous plants (*Not Given*)
Reich *et al*. 2010	2/3	Pooled data/ angiosperm/ gymnosperm/ trees/ shrubs/ forb/ graminoid (*n* = 9,356)
Zhao *et al*. 2016	0.78	224 woody species (*n* = 269)

Hypotheses: inconstant exponent

The scaling exponent at each site should reflect site-specific N vs. P stoichiometric relationships, because plants growing at the same site represent the characteristics shaped by the combination of local climatic conditions, geological processes, soil nutrient availabilities, and other environment factors.

Global data set

- **Dataset information**

12,055 records

222 families, 3441species, 486 sites

Leaf N and P concentrations

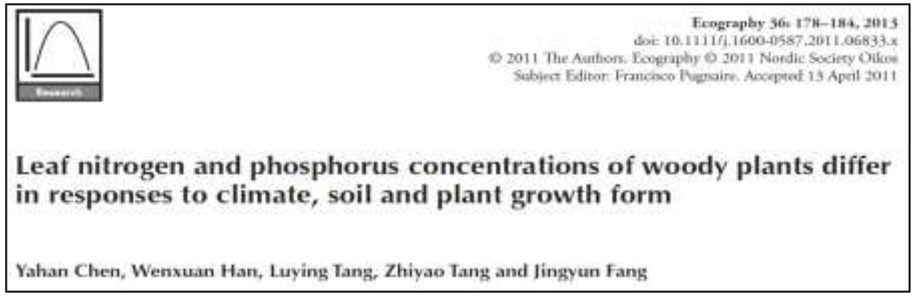
- **Data Resources**

TRY-data Kattge et al. 2011 ；

Han et al. 2005; He et al. 2006;

Chen et al. 2011; Tang et al. 2018;

Own field sampling


Ecography 36: 178–184, 2013
doi: 10.1111/j.1600-0587.2011.06833.x
© 2011 The Authors. Ecography © 2011 Nordic Society Oikos
Subject Editor: Francisco Pugnaire. Accepted 13 April 2011

Leaf nitrogen and phosphorus concentrations of woody plants differ in responses to climate, soil and plant growth form

Yahan Chen, Wenxuan Han, Luying Tang, Zhiyao Tang and Jingyun Fang

Patterns of plant carbon, nitrogen, and phosphorus concentration in relation to productivity in China's terrestrial ecosystems

Zhiyao Tang[a,1], Wenting Xu[b,1], Guoyi Zhou[c,1], Yongfei Bai[b], Jiaxiang Li[b,d], Xuli Tang[c], Dima Chen[b], Qing Liu[e], Wenhong Ma[f], Gaoming Xiong[b], Honglin He[g], Nianpeng He[g], Yanpei Guo[a], Qiang Guo[a], Jiangling Zhu[a], Wenxuan Han[h], Huifeng Hu[b], Jingyun Fang[a,b,2], and Zongqiang Xie[b,2]


ECOLOGY LETTERS

Ecology Letters, (2011) doi: 10.1111/j.1461-0248.2011.01641.x

LETTER

Biogeography and variability of eleven mineral elements in plant leaves across gradients of climate, soil and plant functional type in China

Statistic analysis

Reduced Major Axis regression (RMA):

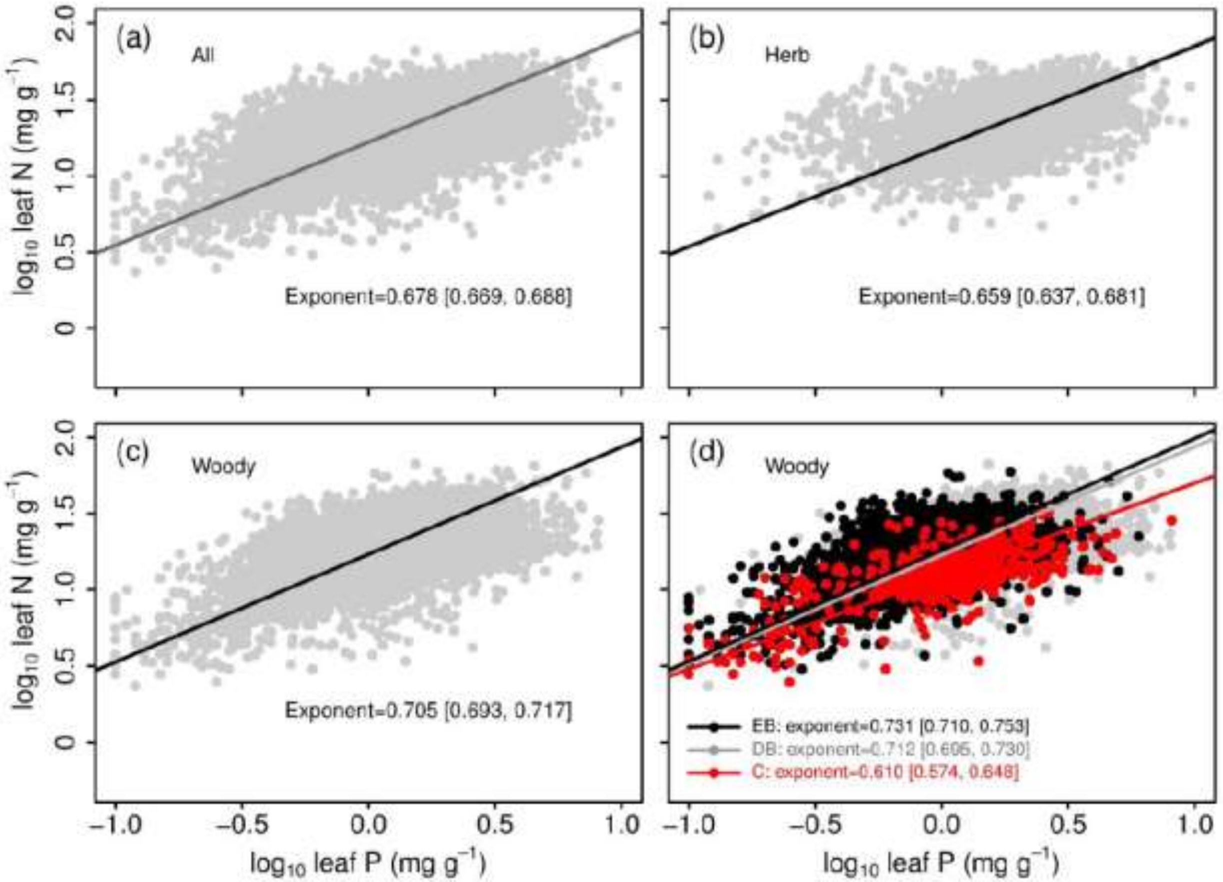
- **Functional groups:** herbaceous & woody species (coniferous, deciduous broad-leaved and evergreen broad-leaved woody species)
- **Latitudinal zones**: tropical (0-25°), temperate (25-50°) and boreal (>50°)
- **Ecoregions (six continents):** North America, Europe, Asia, Oceania, Africa and South America.
- **Individual sites:** n≥10 and n≥20 records

Results

- Exponents differ with plant functional groups

Table 2. Statistic results of RMA

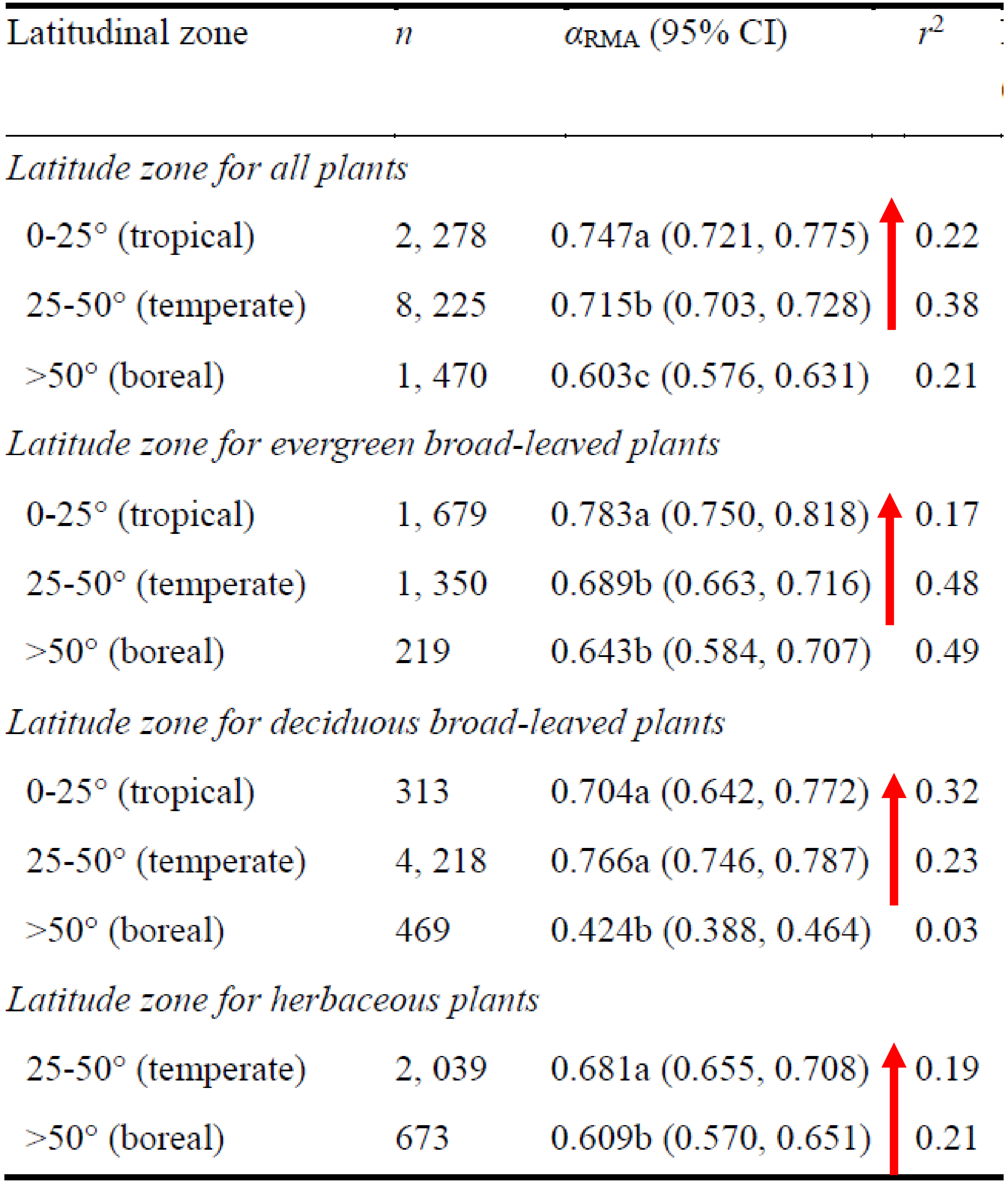
Functional group	*n*	α_{RMA} (95% CI)	r^2
All	12, 055	0.678b (0.669, 0.688)	0.33
Functional group			
Herb	2, 776	0.659bc (0.637, 0.681)	0.20
Woody	8, 888	0.705a (0.693, 0.717)	0.34
Conifer woody	526	0.610c (0.574, 0.648)	0.50
Deciduous broadleaf	5, 035	0.712a (0.695, 0.730)	0.22
Evergreen broadleaf	3, 267	0.731a (0.710, 0.753)	0.29



Results

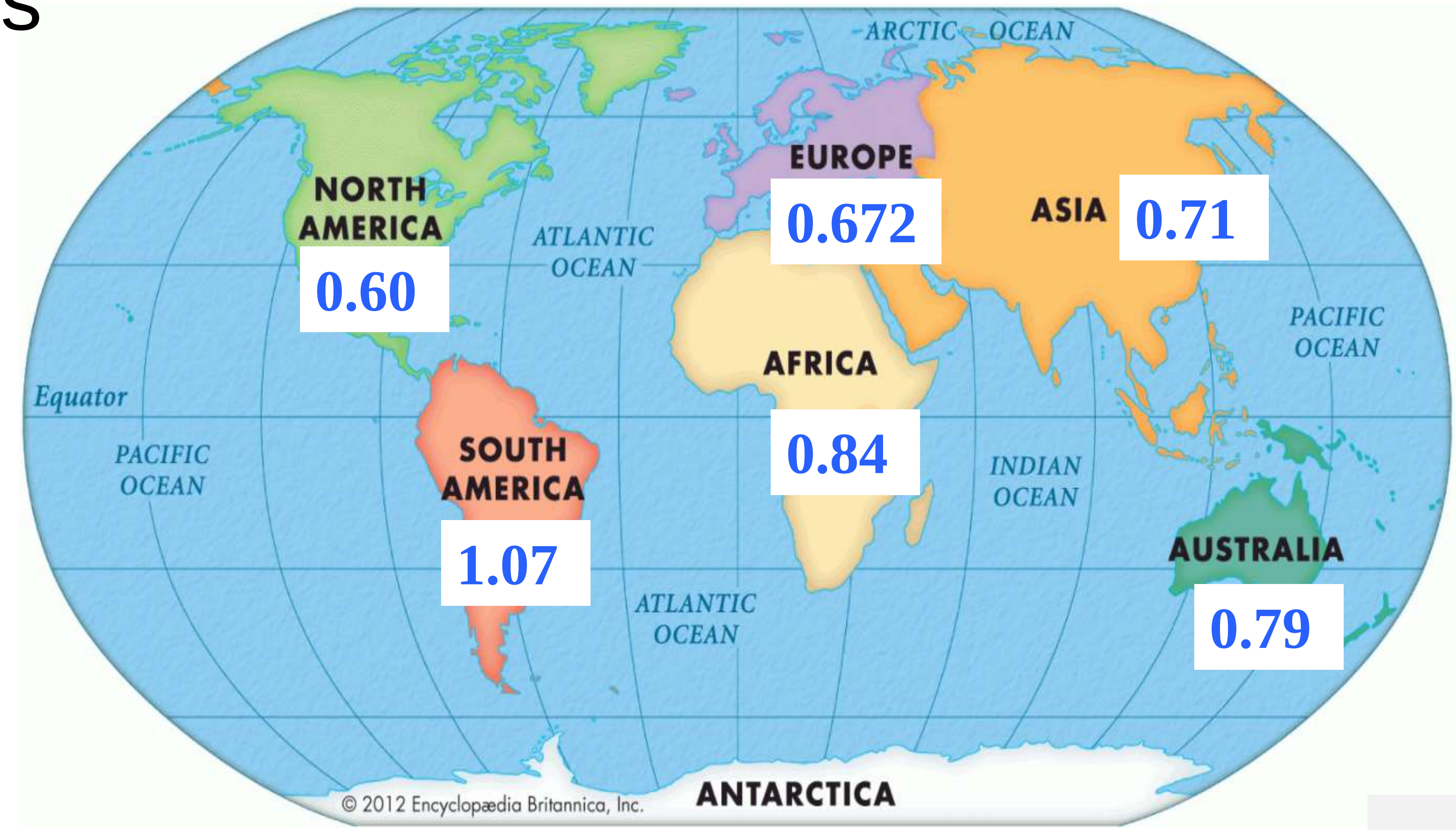
- Exponents showed significant latitudinal differences

Increase from boreal to tropical zones



Latitudinal zone	n	α_{RMA} (95% CI)	r^2
Latitude zone for all plants			
0-25° (tropical)	2, 278	0.747a (0.721, 0.775)	0.22
25-50° (temperate)	8, 225	0.715b (0.703, 0.728)	0.38
>50° (boreal)	1, 470	0.603c (0.576, 0.631)	0.21
Latitude zone for evergreen broad-leaved plants			
0-25° (tropical)	1, 679	0.783a (0.750, 0.818)	0.17
25-50° (temperate)	1, 350	0.689b (0.663, 0.716)	0.48
>50° (boreal)	219	0.643b (0.584, 0.707)	0.49
Latitude zone for deciduous broad-leaved plants			
0-25° (tropical)	313	0.704a (0.642, 0.772)	0.32
25-50° (temperate)	4, 218	0.766a (0.746, 0.787)	0.23
>50° (boreal)	469	0.424b (0.388, 0.464)	0.03
Latitude zone for herbaceous plants			
25-50° (temperate)	2, 039	0.681a (0.655, 0.708)	0.19
>50° (boreal)	673	0.609b (0.570, 0.651)	0.21

Results



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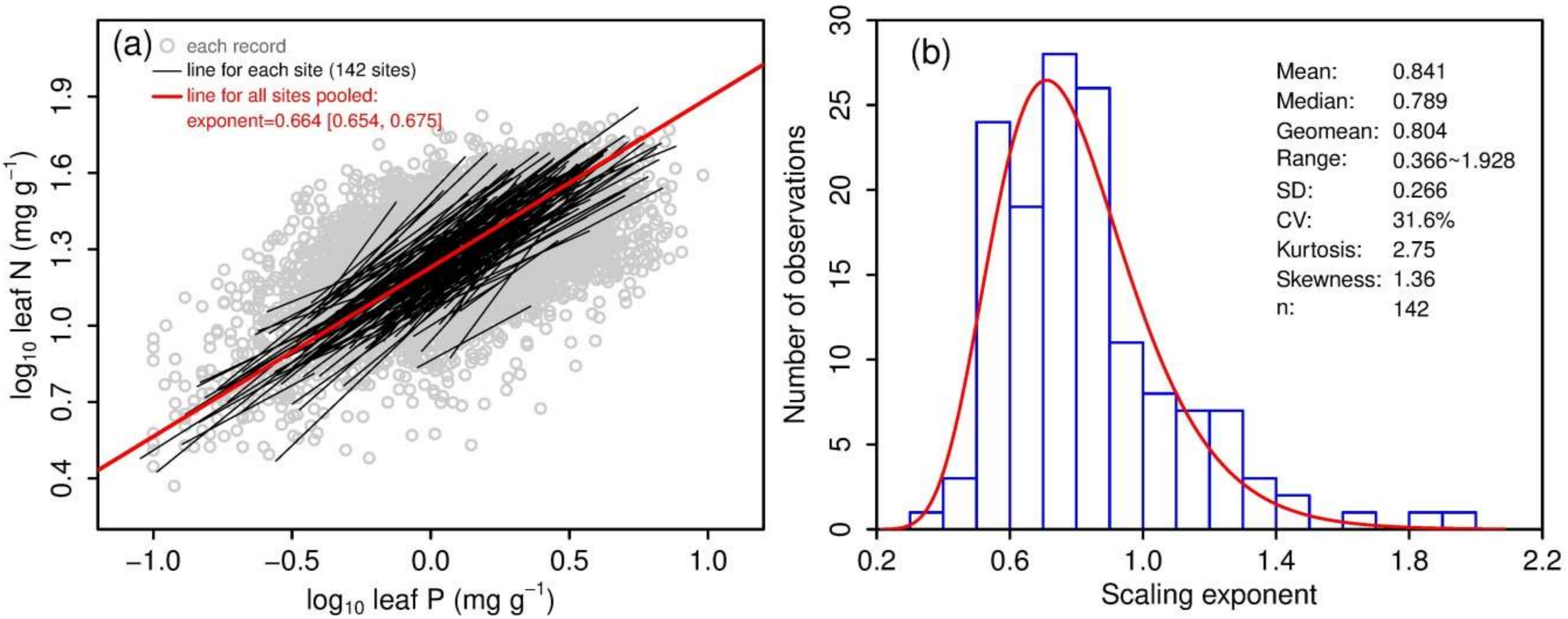
- Significant differences across continents:

North America < Europe < Asia < Oceania < Africa < South America

Results

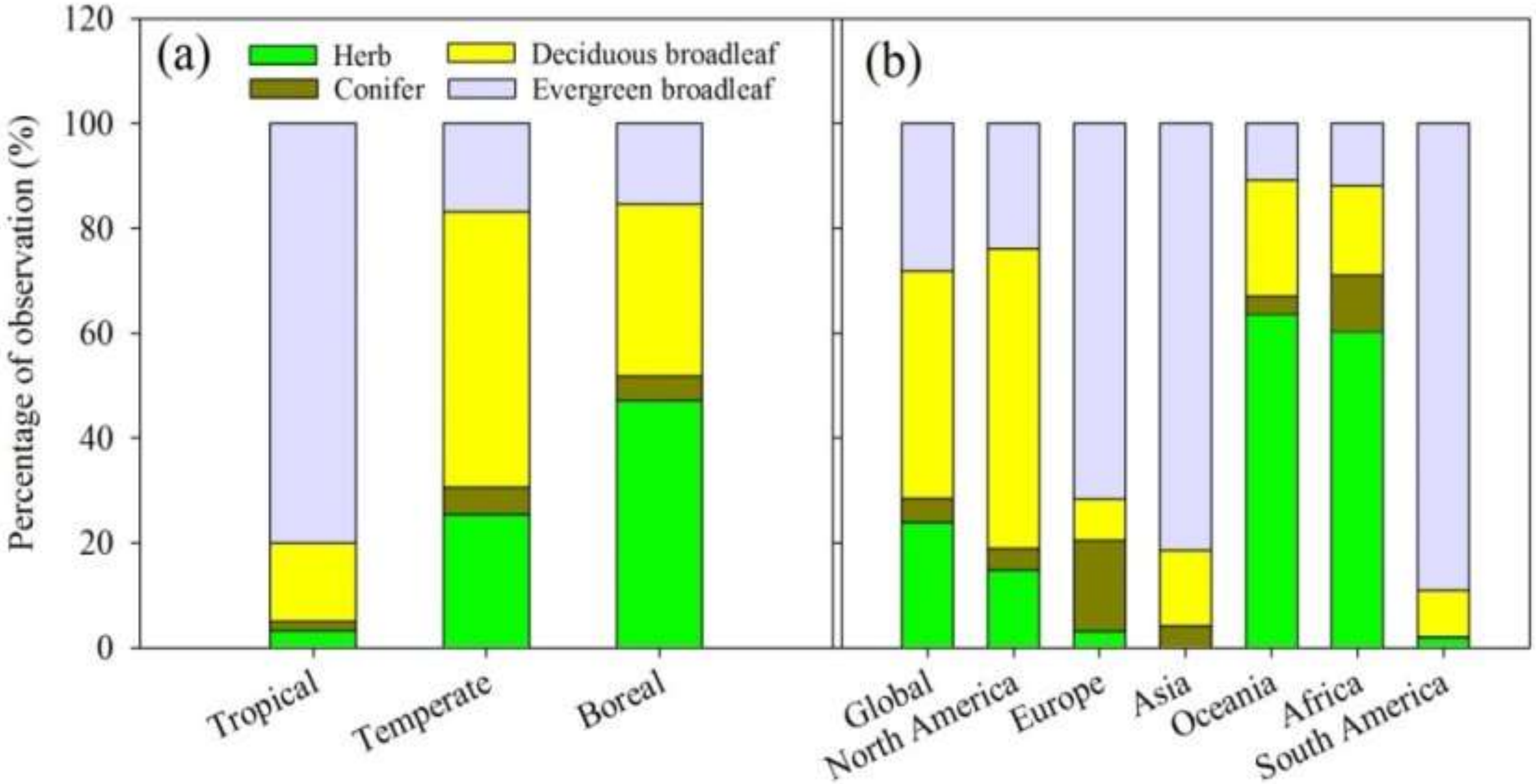


- Significant differences across continents:

Sample size >10, α ranges from 0.37 to 1.93

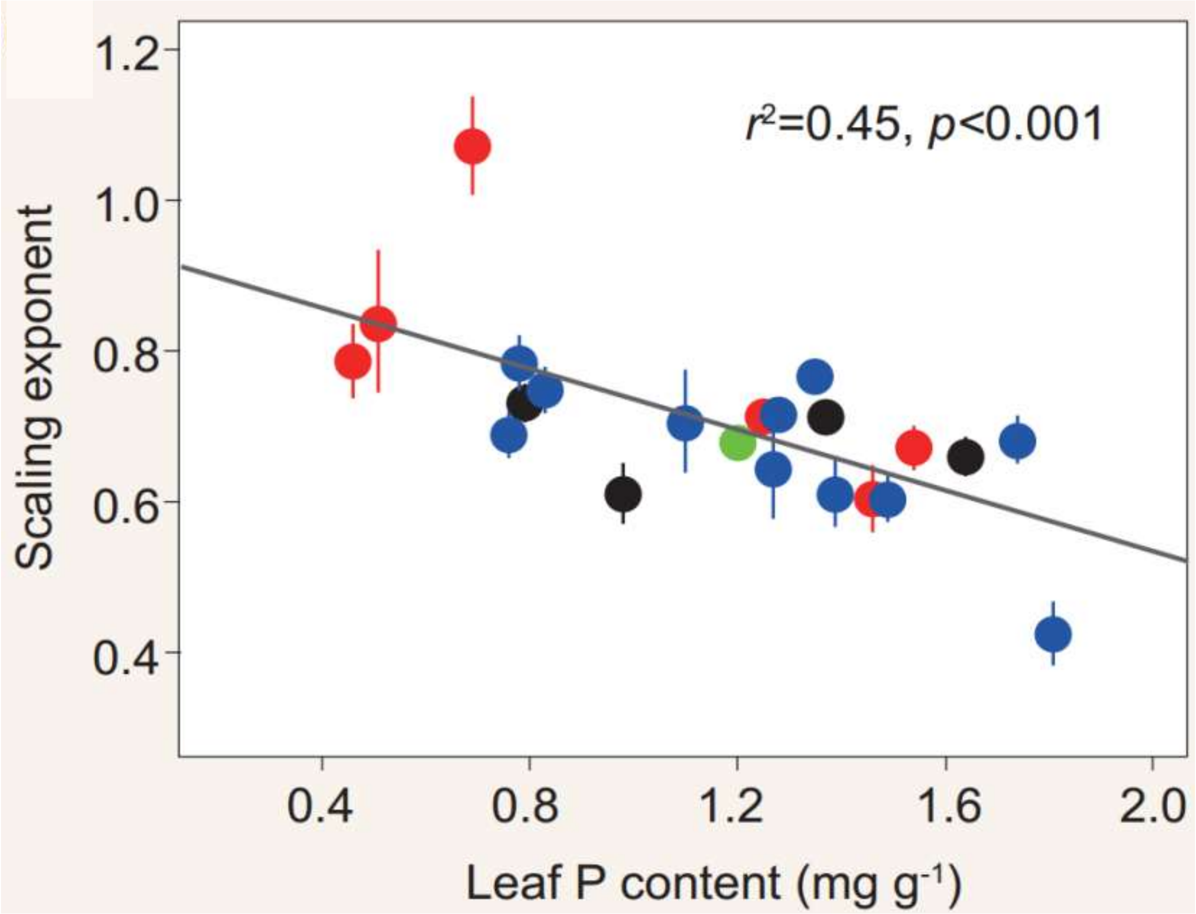
Possible mechanisms

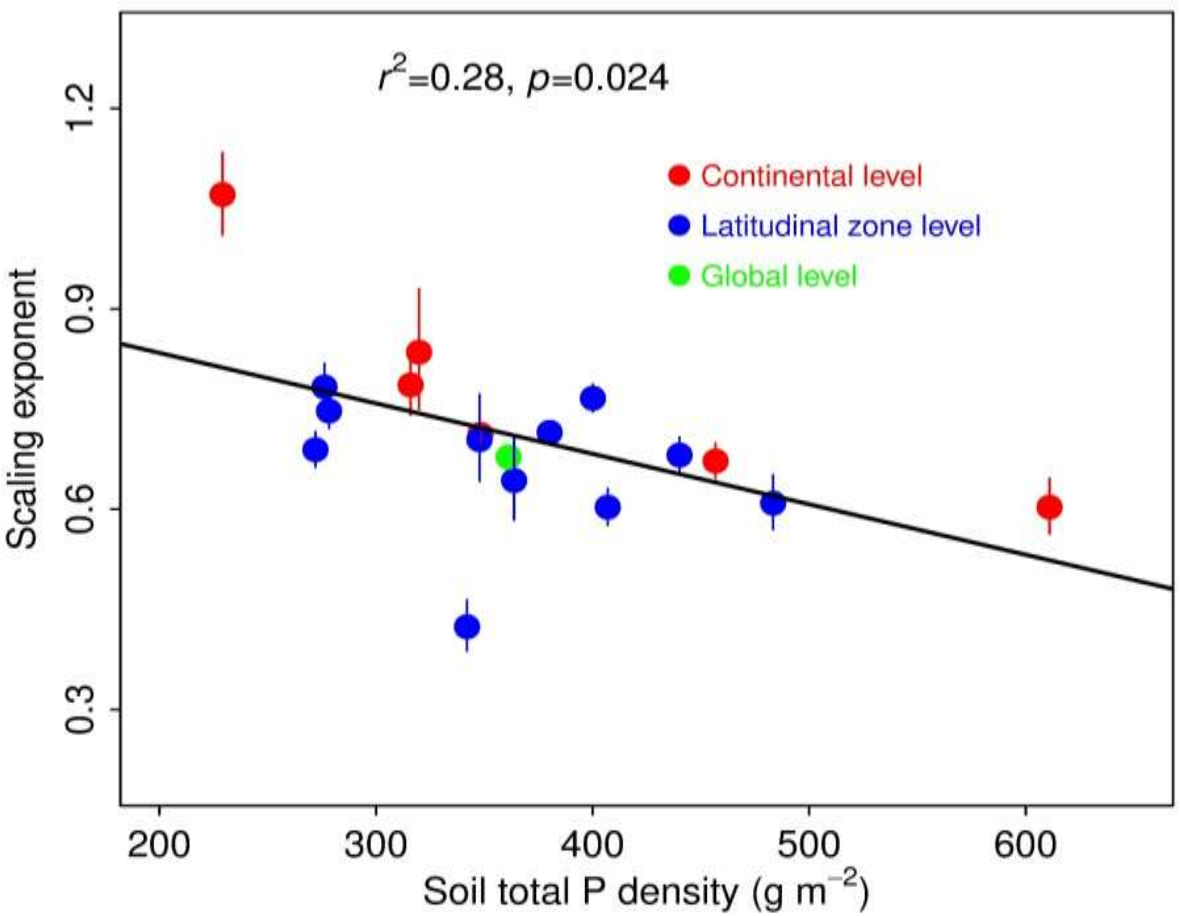
- Composition of plant life forms (the relative growth rate hypothesis) (Sterner & Elser, 2002)



Possible mechanisms

- P-related growth rate and N ~ P stoichiometry.





Conclusions

- There is no canonical numerical value for the N~P scaling exponent.
- The analysis of pooled data for the N~P scaling relationship may hide biologically and ecologically significant variation.

Future research

- Nutrient stoichiometry, plant traits and functioning.
- Biogeochemical cycles of elements and ecosystem functions.
- Global changes and their effects on ecosystems…

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Ian J. Wright
Bernhard Schmid

Jens Kattge


TRY
Plant Trait Database

National Natural Science Foundation of China

Thank you for your attention!

Danke schön !