Will changed vegetation distribution and carbon cycling under climate change effect change in nutrient cycling?

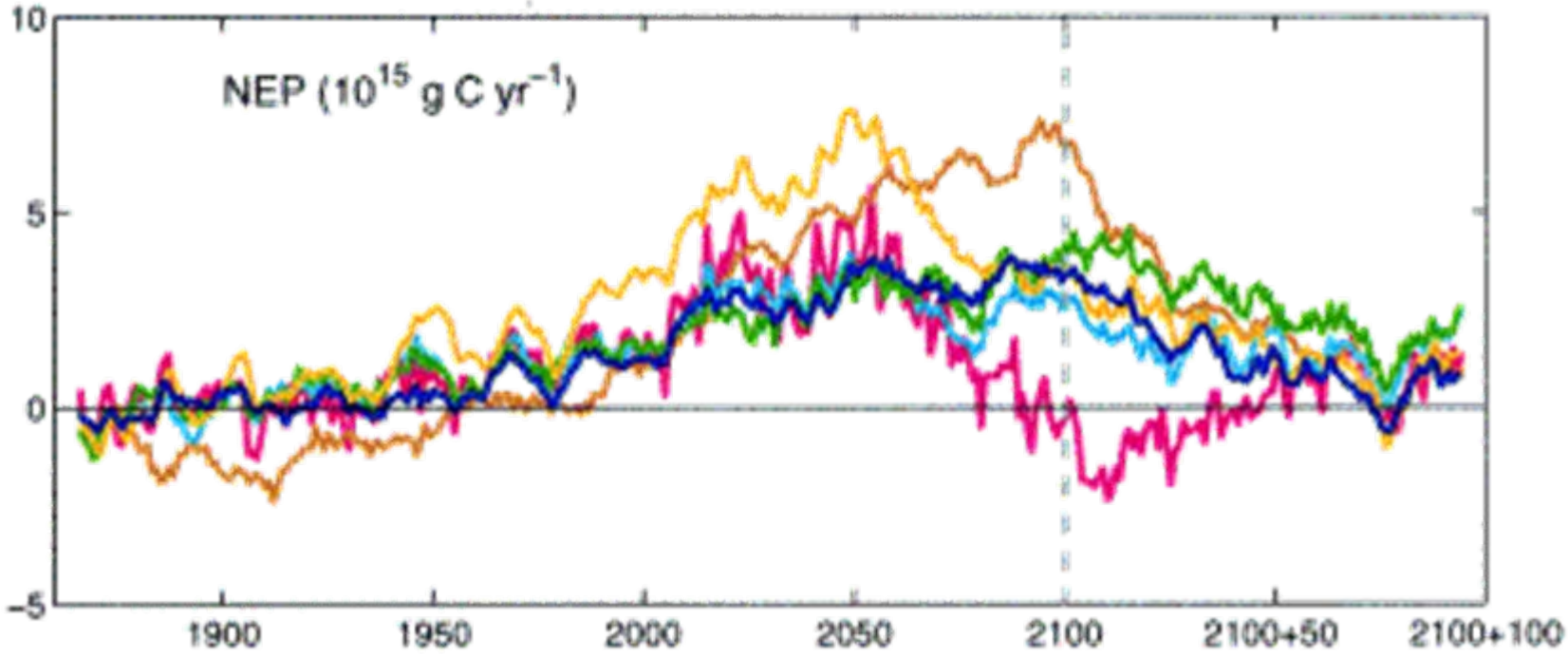
How does nutrient cycling modify responses to global change?

Or:

Will God Provide?

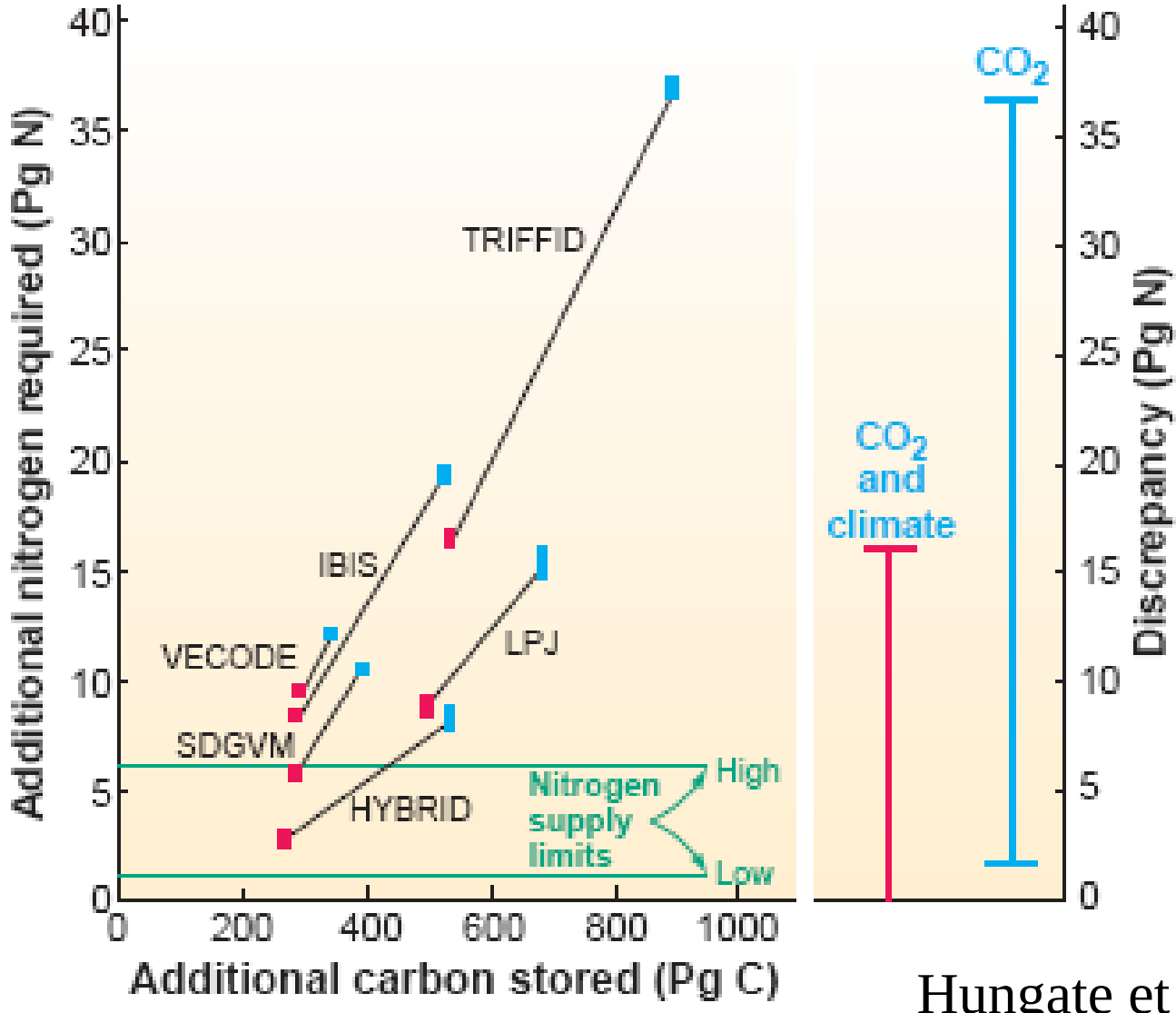
Belinda Medlyn, Macquarie University

Predicted Terrestrial C Sink



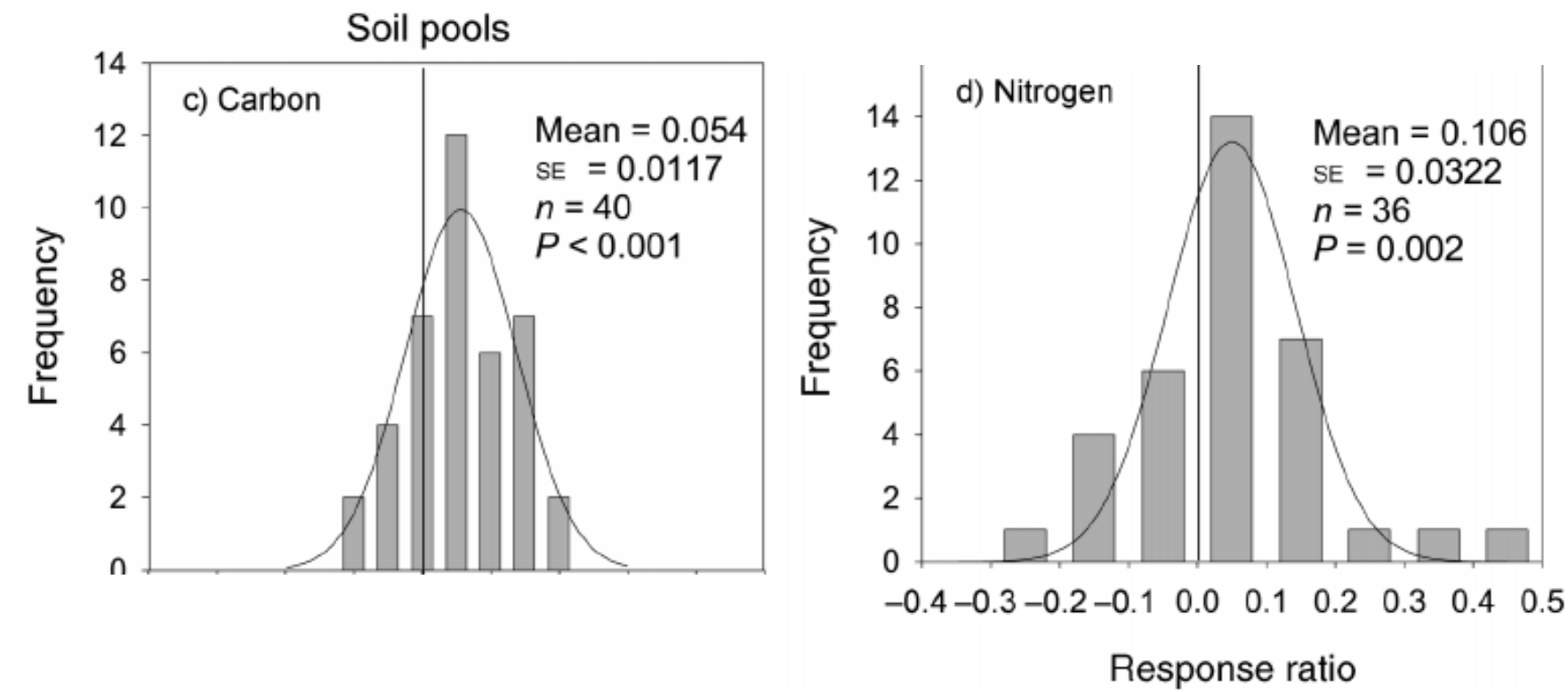
Cramer et al. 2001

Are These Predictions Possible?



Hungate et al. 2003

Do C & N plant & soil pools increase?



Plant C mean increase: 0.207

Plant N mean increase: 0.098

Luo et al. 2006

No N Limitation

- Oak Ridge FACE
- Sustained 25% increase in NPP
- Largely allocated to roots
- Increased N uptake via increased soil exploration

- Duke FACE
- Sustained 20-25% increase in NPP
- Largely allocated to stems
- Widening of ecosystem C : N ratio

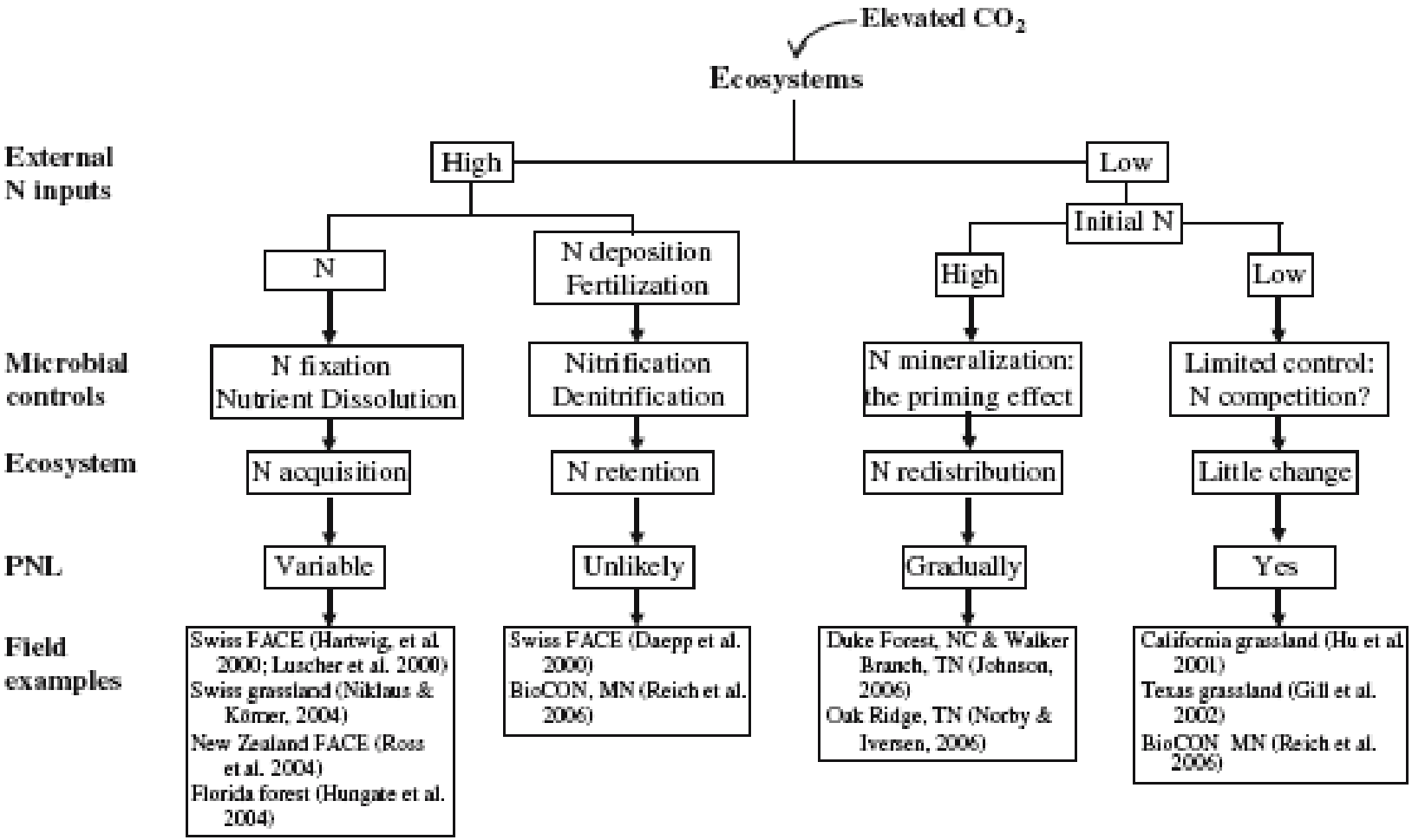
N Limitation

Texas grassland
- biomass increased, but
- soil N reduced
- transfer of soil N to pools with wider C:N ratios

Tasmanian grassland
- no biomass stimulation (ever)
- reduction in soil N availability after 4 years

Florida scrub-oak system
- stimulation of litterfall reduced after 4-5 years
- accumulation of N in forest floor

When does PNL occur?

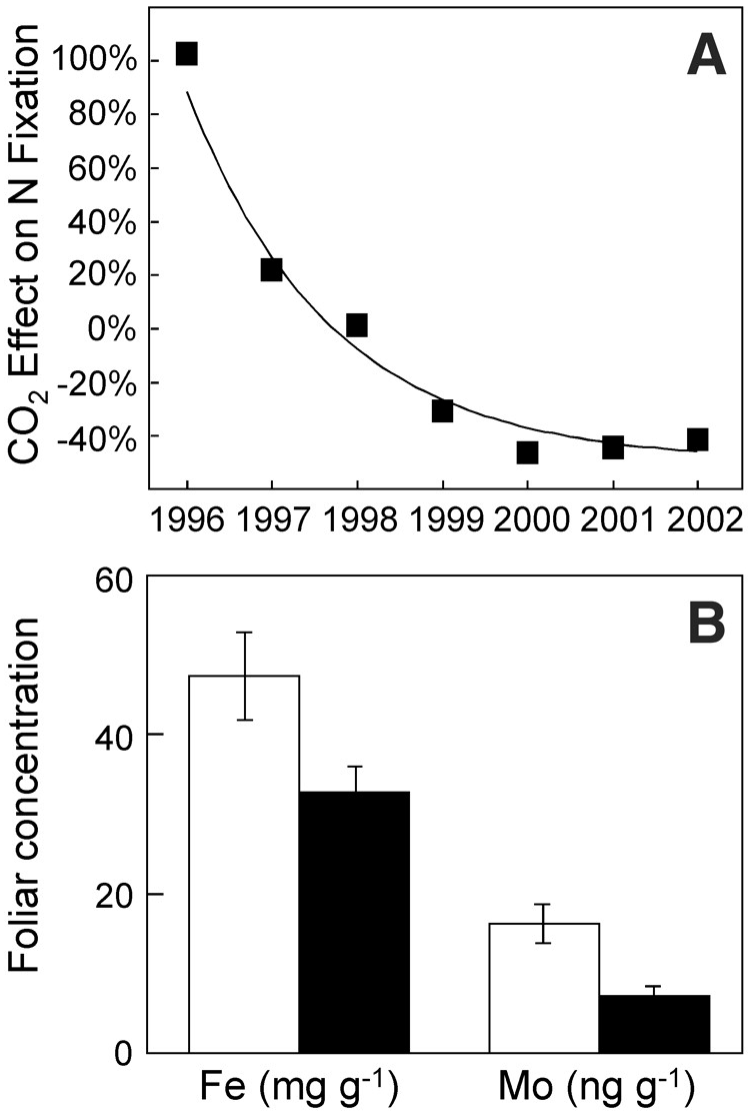


Progressive nitrogen limitation: a microbiological perspective (Hu et al. 2006)

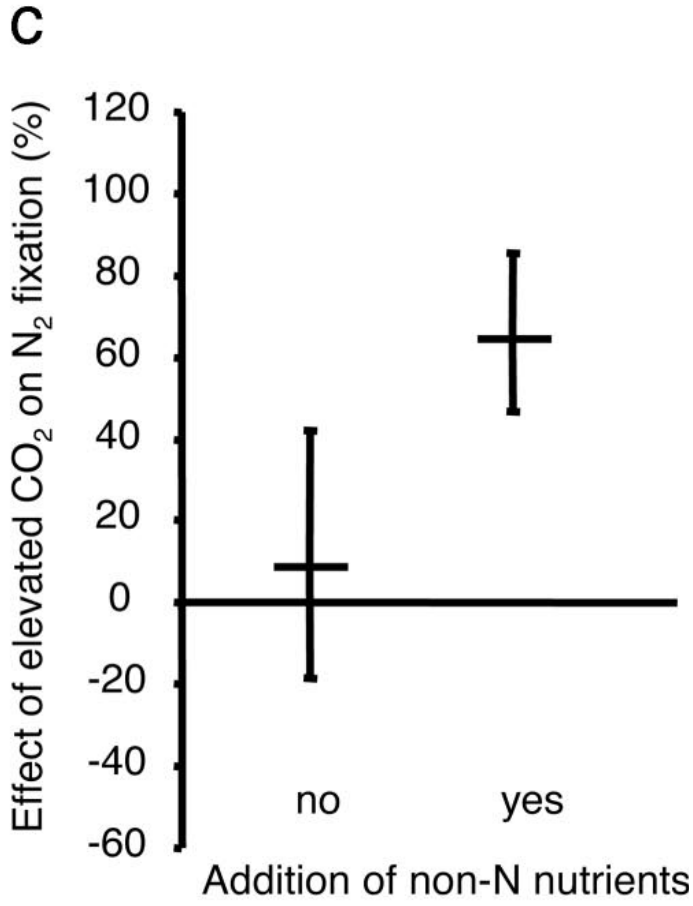
Key Questions: PNL

- Allocation
- Timescales: on what timescale do we expect PNL to be observable?
    - Flexibility of ecosystem C:N ratios
- Soil organic matter dynamics esp. slow pool turnover
- Inputs and outputs of N
    - Microbial community composition and activity
    - Ecosystem N retention
    - N fixation

N Fixation

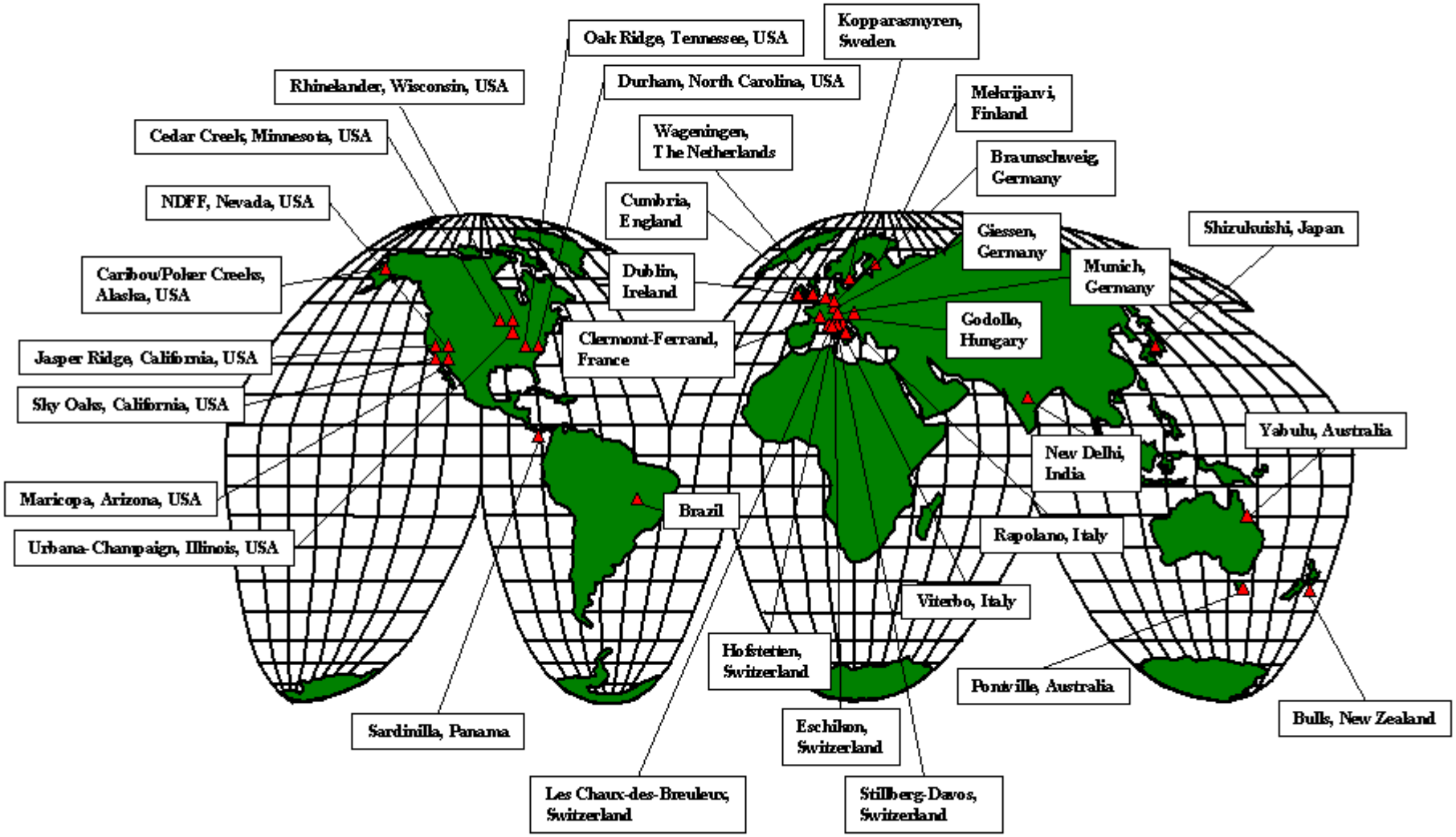


Hungate et al 2005

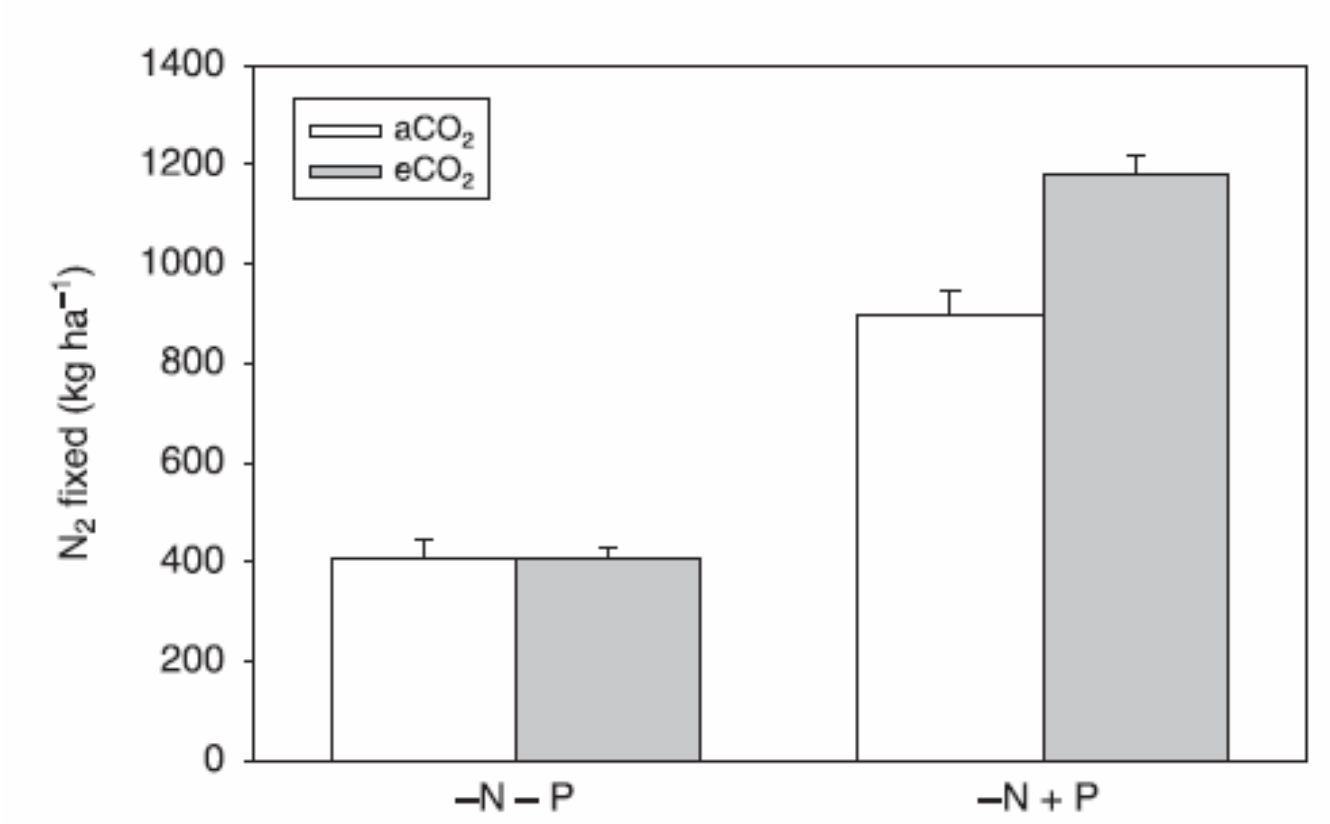


Van Groeningen et al 2006

Other Elements esp. P



N – P Interactions



Edwards et al. 2006

Global biological N2 fixation rate

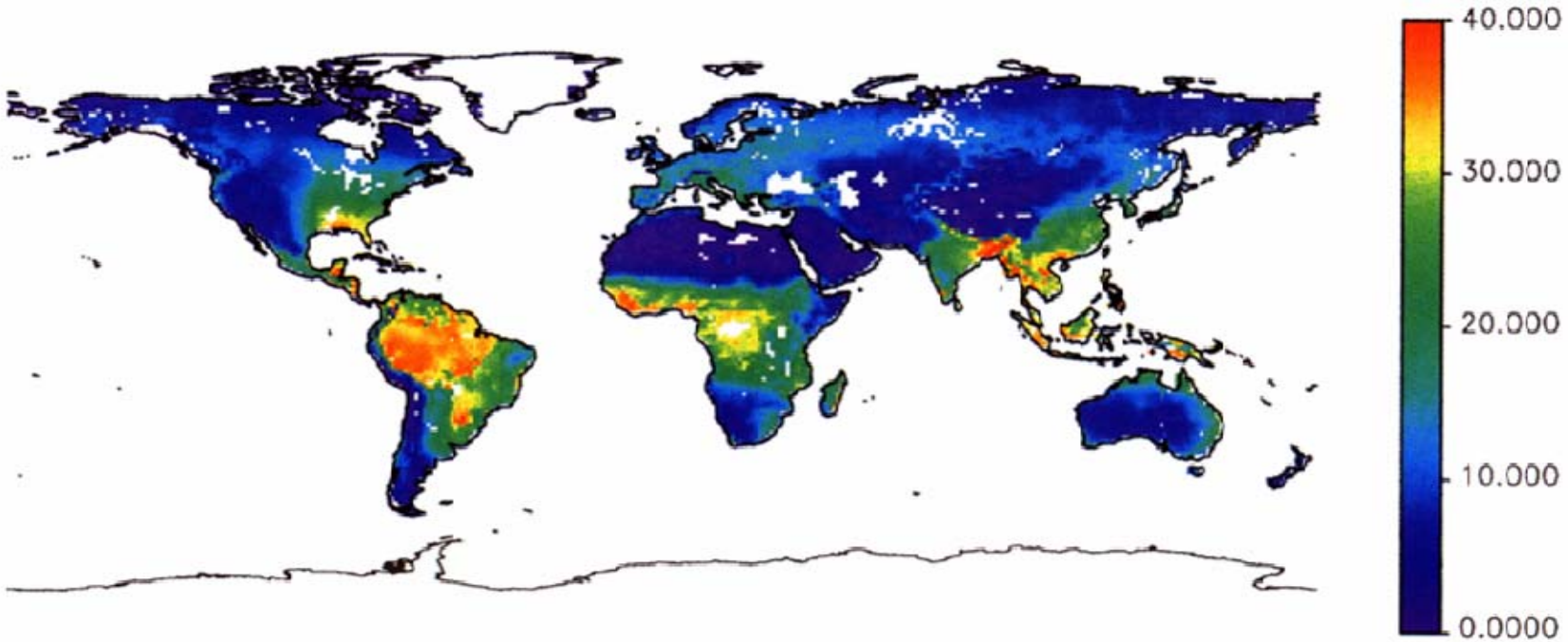
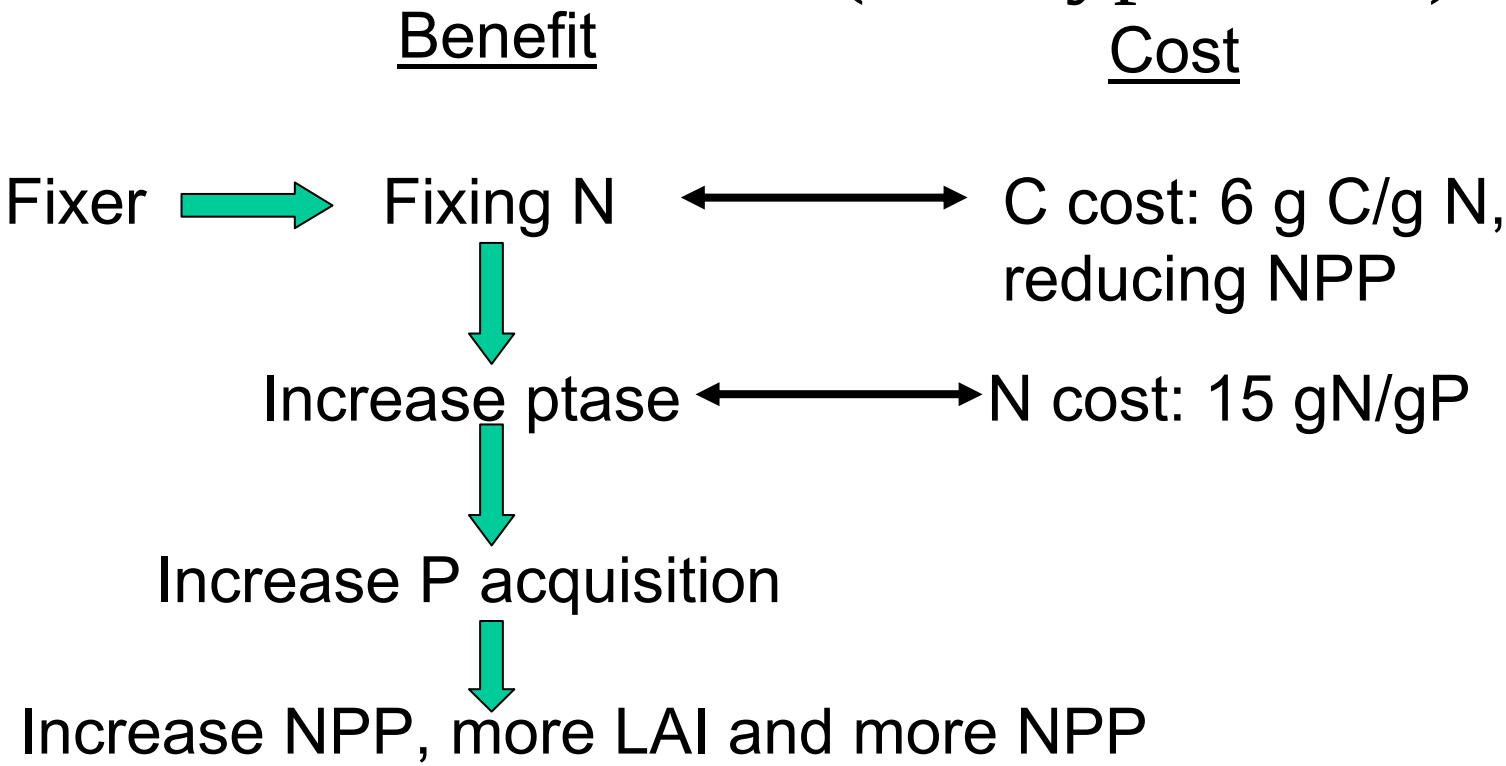


Plate 2. Mapped potential annual BNF by natural ecosystems based on the relationship between the central estimates of BNF (N fixation = 0.234(ET) - 0.172) and ecosystem ET. Values are kg N ha^{-1} yr^{-1}. White areas represent regions where modeled ET values are unavailable.

Source: Cleveland et al. 1999. GBC, 13:623-645

A strategy for N2 fixers in a P-limiting environment (our hypothesis)



Fixer will be successful only if benefit ≥ cost in NPP

(Ying Ping Wang)

N, P and Fire

‘many biological processes in ecosystems have little effect on stoichiometry (C:N, N:P, etc) ..

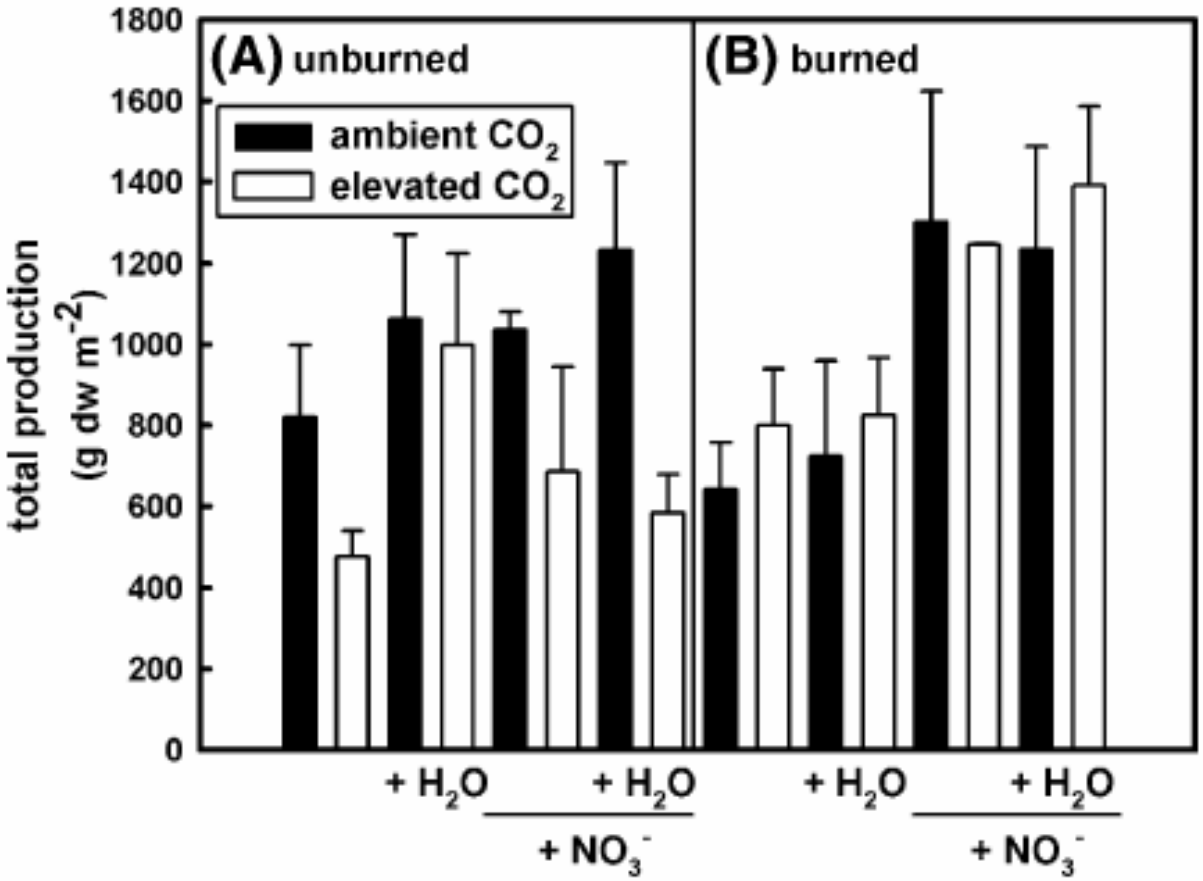
.. whereas fires change those ratios substantially owing to the differing volatility of the elements ..

.. widening N:P ratios without fire [is a] cause of large, even wholesale changes in diversity and productivity ..

Fire is essential to refresh P-cycling, species diversity and productivity.’

Adams 2007

CO_2 and Fire

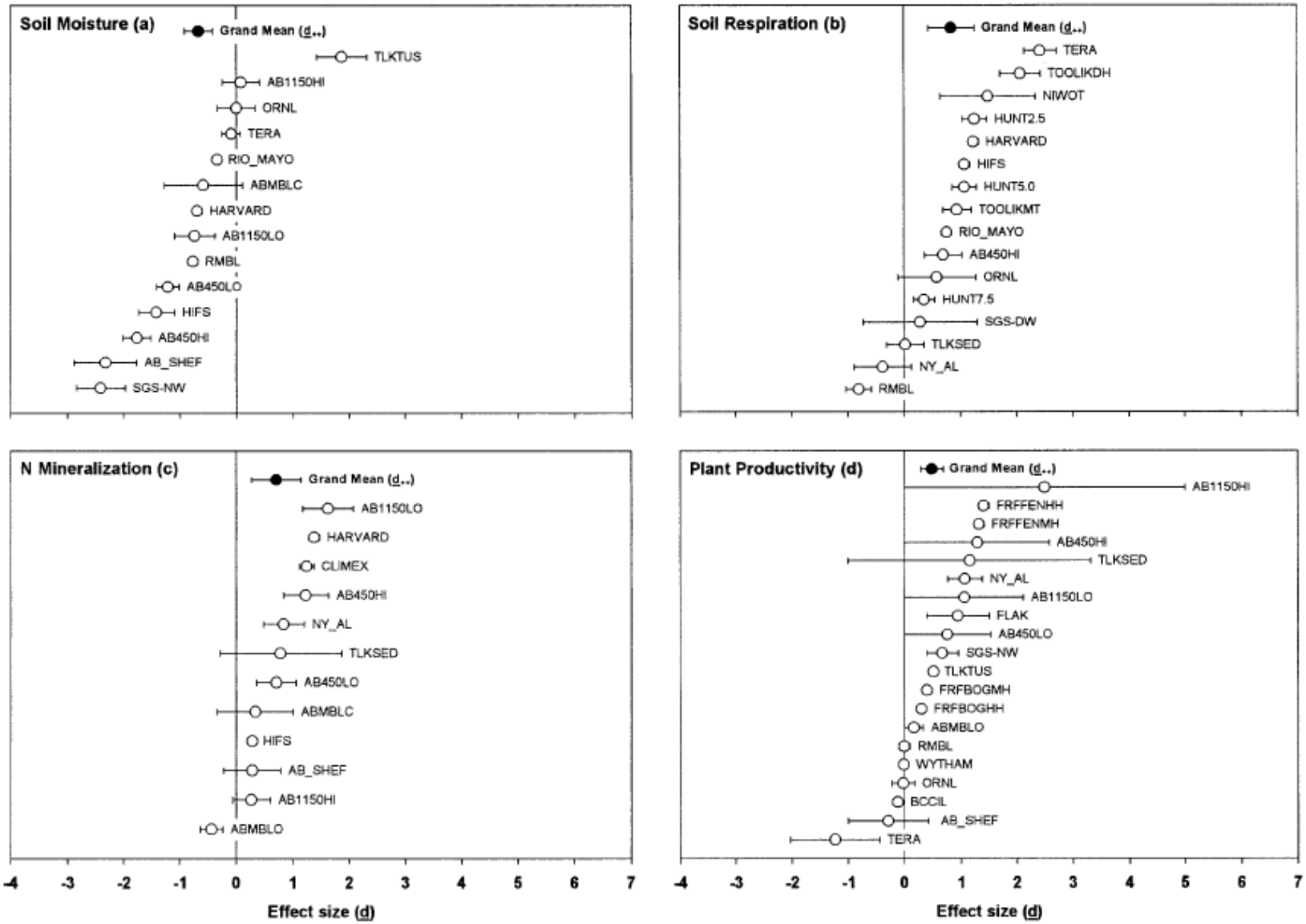


Henry et al. 2006

Key Questions: Other Elements

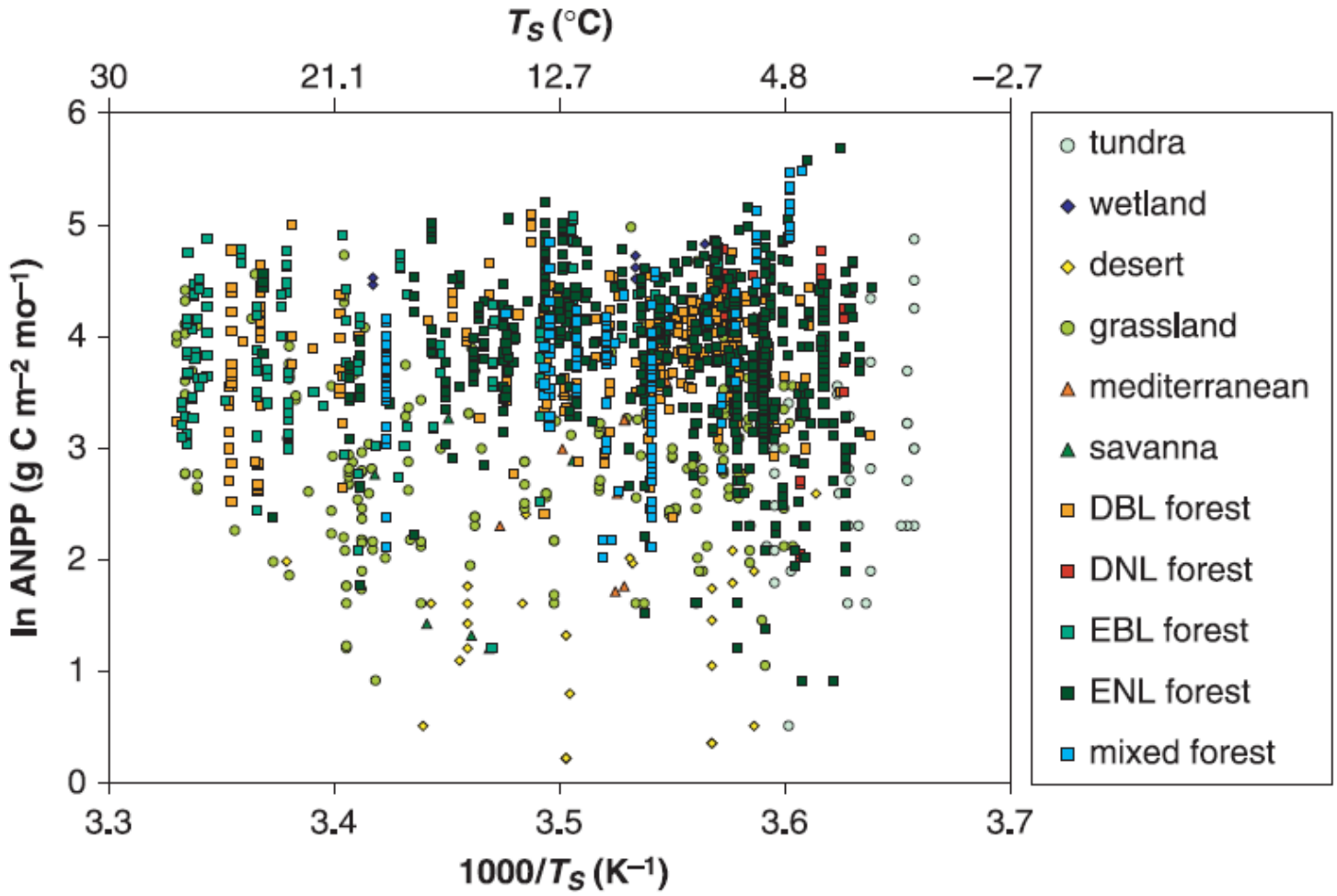
- Does P availability limit plant responses to CO_2?
- How does P availability influence N fixation?
- Does fire alter nutrient limitations?

Temperature and Nutrient Cycling I



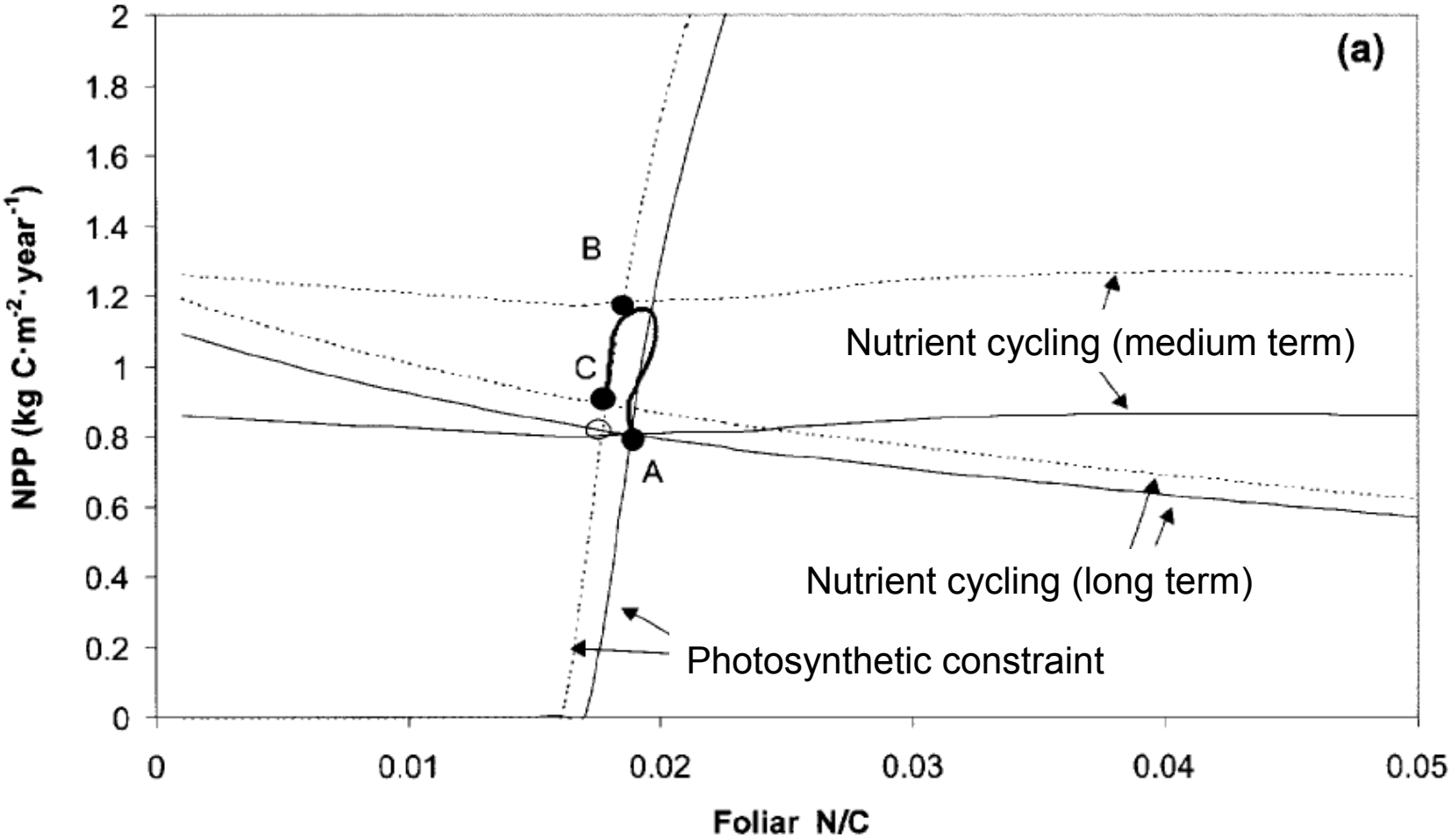
Rustad et al. 2001

Temperature and Nutrient Cycling II



Kerkhoff et al. 2001

Temperature and Nutrient Cycling III

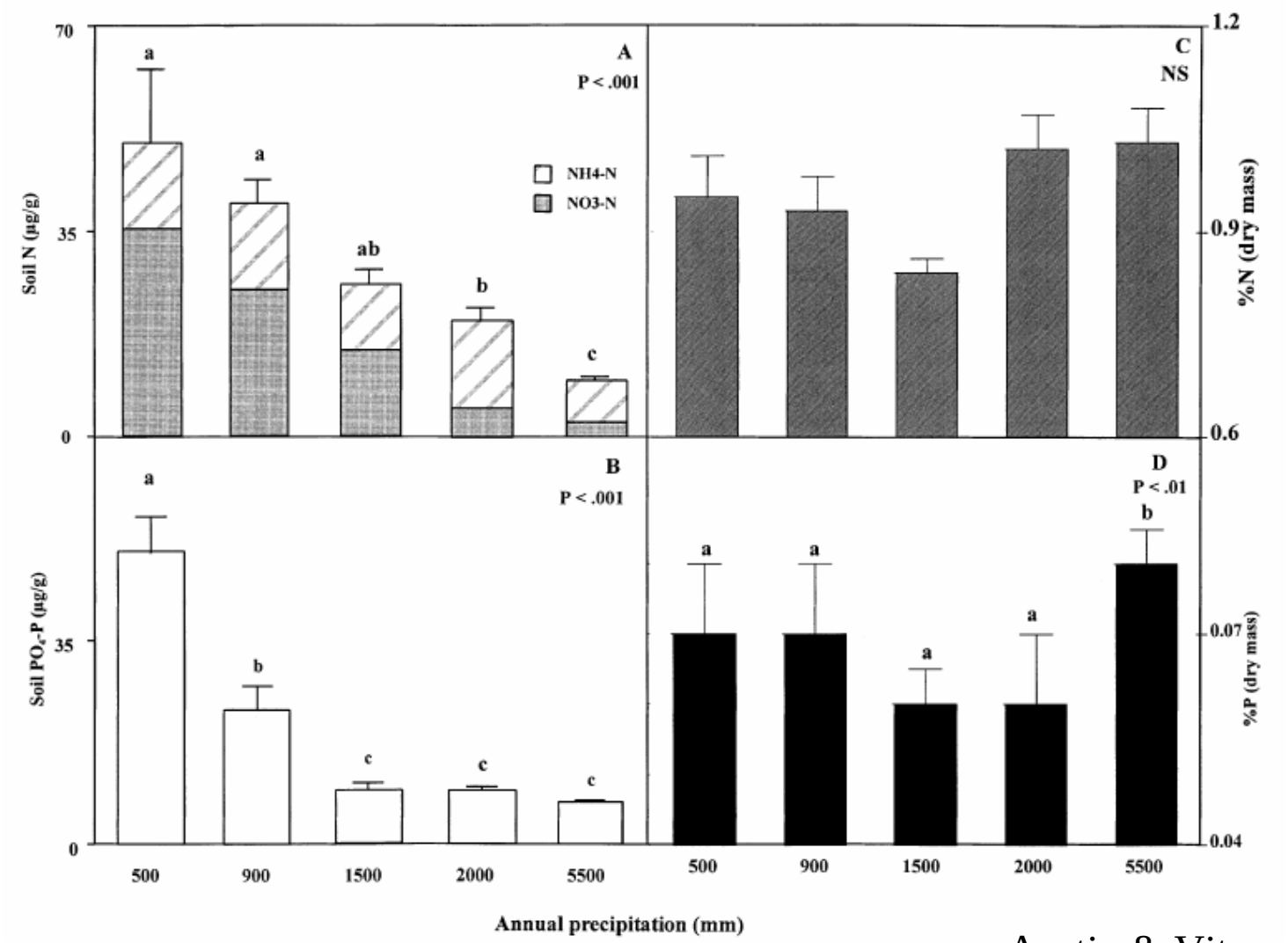


——— Ambient T

---------- T + 2°

Medlyn et al. 2000

Rainfall and Nutrient Cycling



Austin & Vitousek 1998

Key needs: T and rainfall

Experimental studies of NPP and nutrient cycling

- manipulative experiments (warming, rainfall timing and intensity)
- temperature and precipitation gradients

Such studies must be underpinned by a **modelling framework** that incorporates

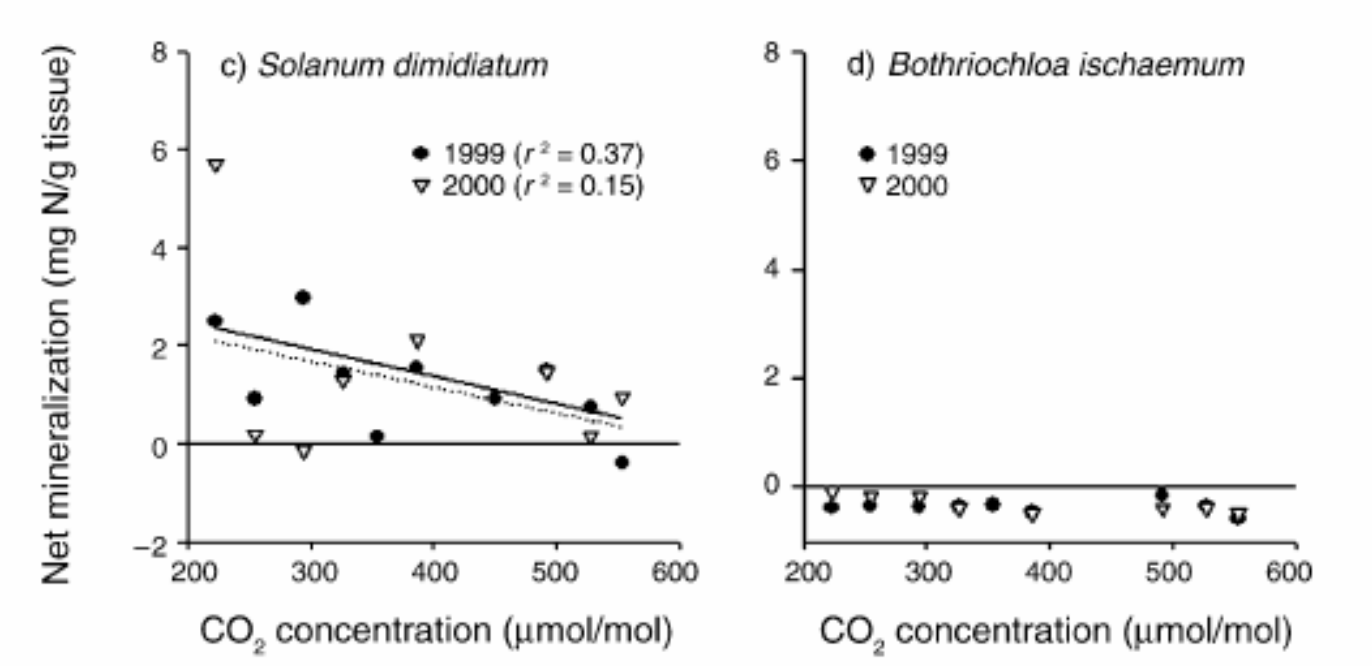
- nutrient cycling
- plant acclimation and adaptation to changes in nutrient availability
- and is able to simulate responses in different ecosystems

Community Composition

- Global change is likely to alter community composition

e.g. species shift detected in 5/7 high CO_2 grassland studies

- Potential consequences for nutrient cycling



Gill et al. 2006

Community Composition

Changes in functional type:

- N fixers vs non-fixers
- C_3 vs C_4
- Woody plants vs grasses

How does nutrient availability determine composition?

How do changes in species composition affect nutrient relations?

With Thanks To

Ross McMurtrie (UNSW)
David Ellsworth (UWS)
Mark Hovenden (U Tas)
Mark Adams (UNSW)
Charlie Warren (U Syd)
Ian Wright (MQU)
Ying Ping Wang (CSIRO DAR)
Colin Prentice (Bristol)
Miko Kirschbaum (over breakfast!)