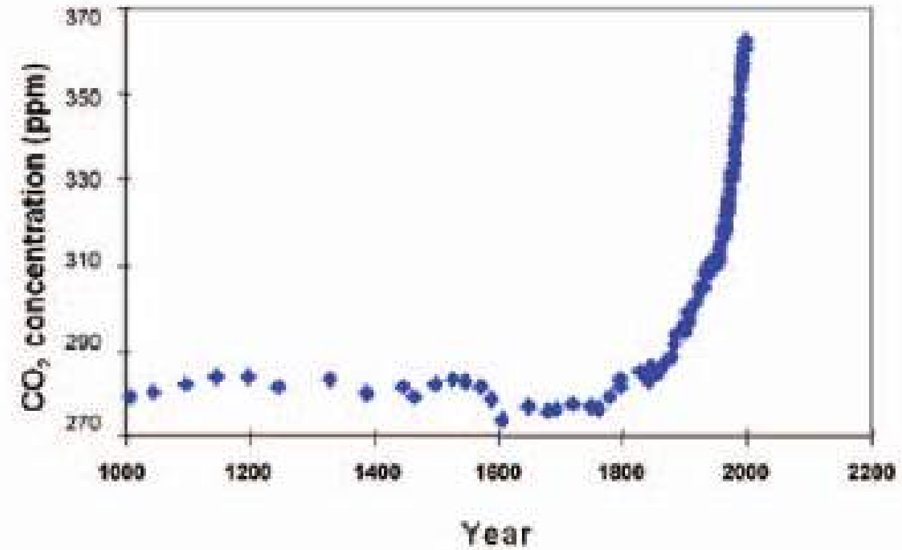
5th International Nitrogen Conference
3rd - 7th December, New Delhi, India

N DYNAMICS UNDER ELEVATED CARBON DIOXIDE IN THE AUSTRALIAN FACE EXPERIMENT



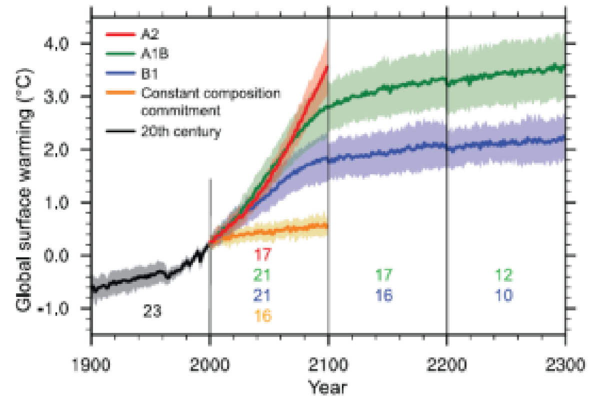
Robert M Norton
Regional Director IPNI, ANZ,

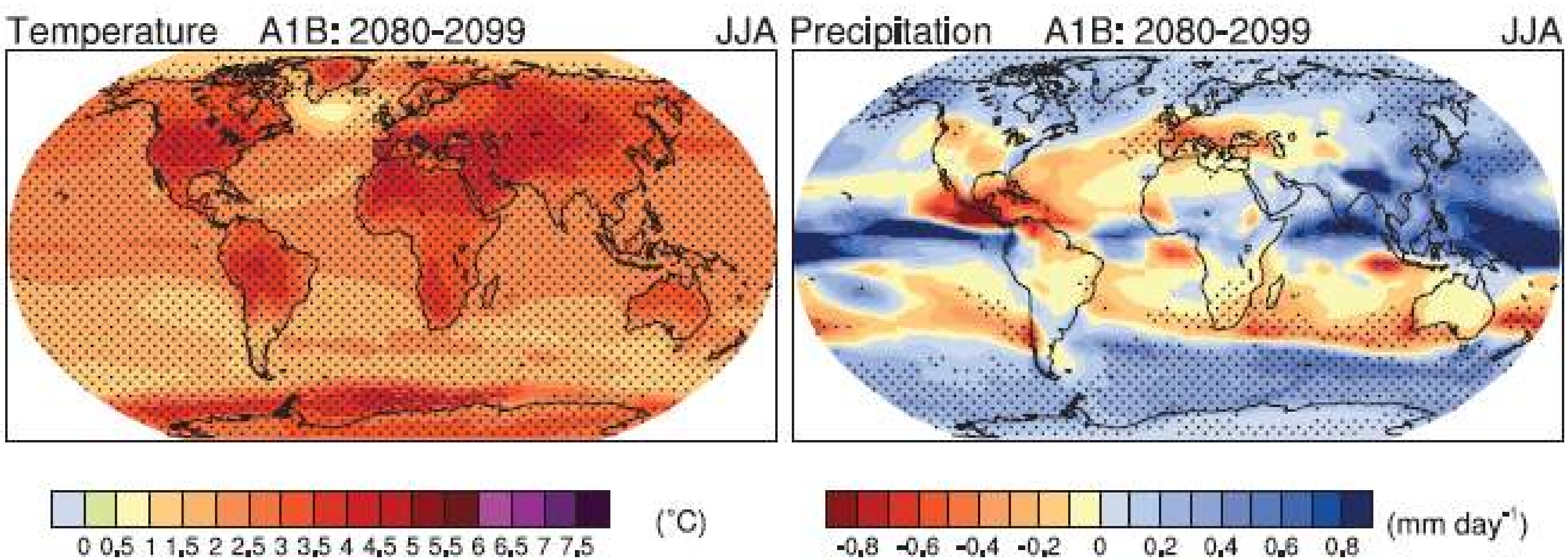
S K Lam, D Chen, G. Fitzgerald, R Armstrong

INI Conference, New Delhi, December 05, 2010

Global Climate Change Impacts

- A1B scenario – 2080-2099
- Generally 3-4^{o} warmer (JJA)
- Mid-latitudes generally drier





Mehel et al. 2007 – IPCC 4th Assessment – Ch 10.

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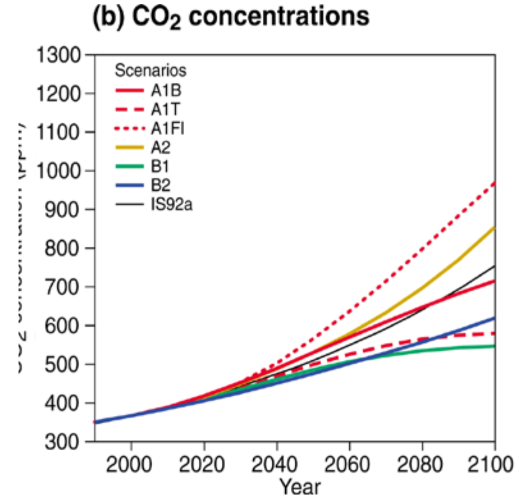
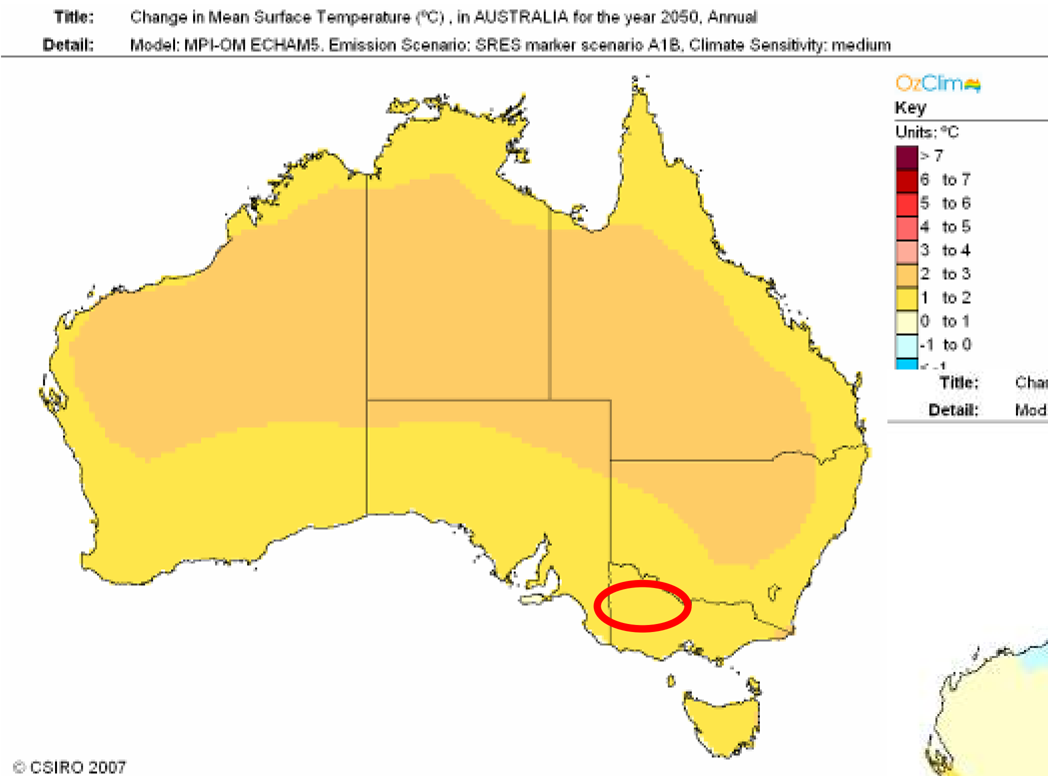
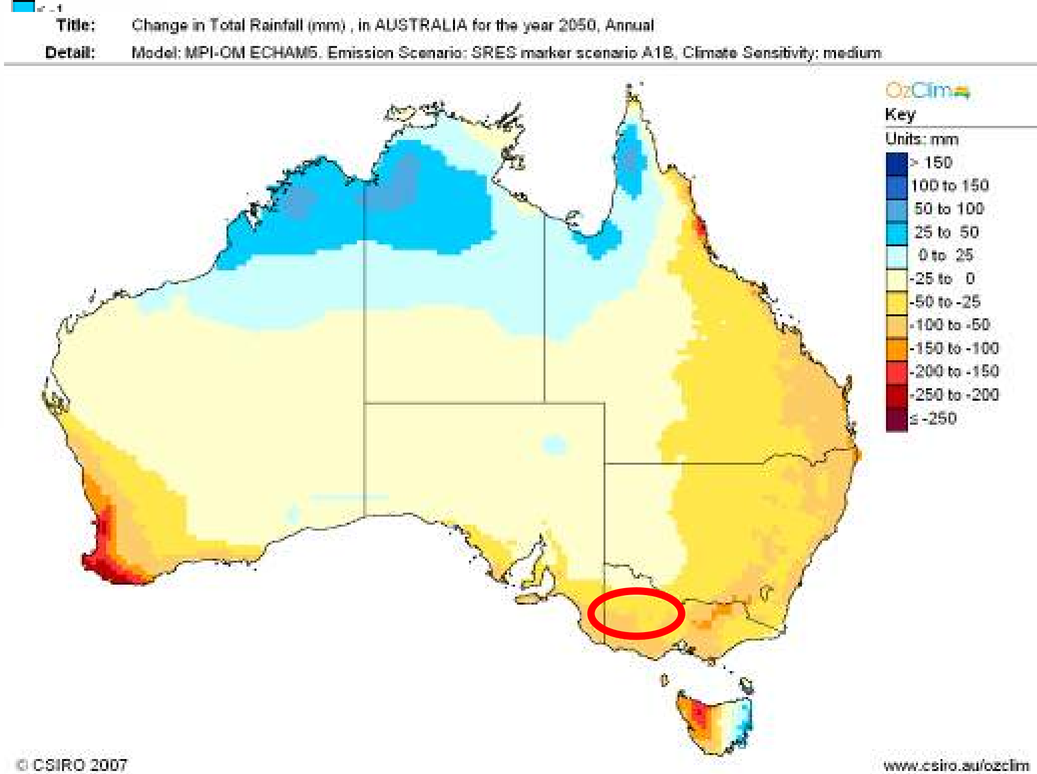
Projected climate – 2050 - A1B



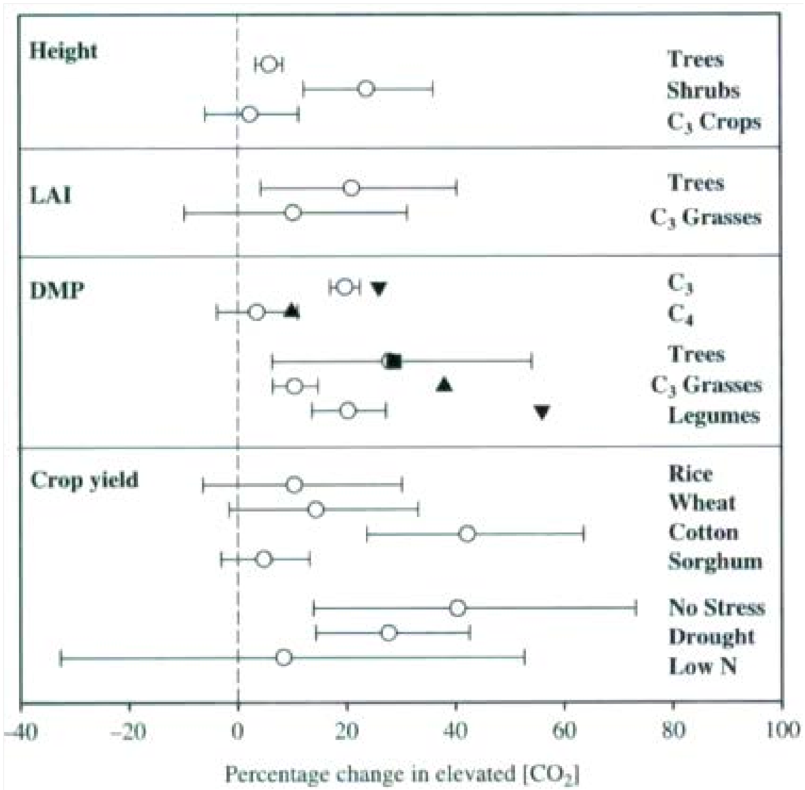




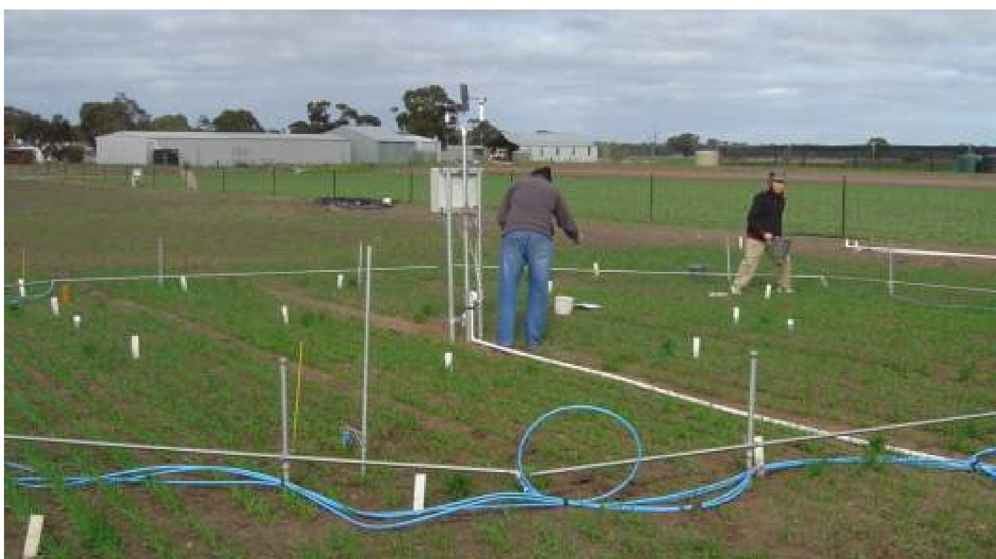
<u>by 2050</u>

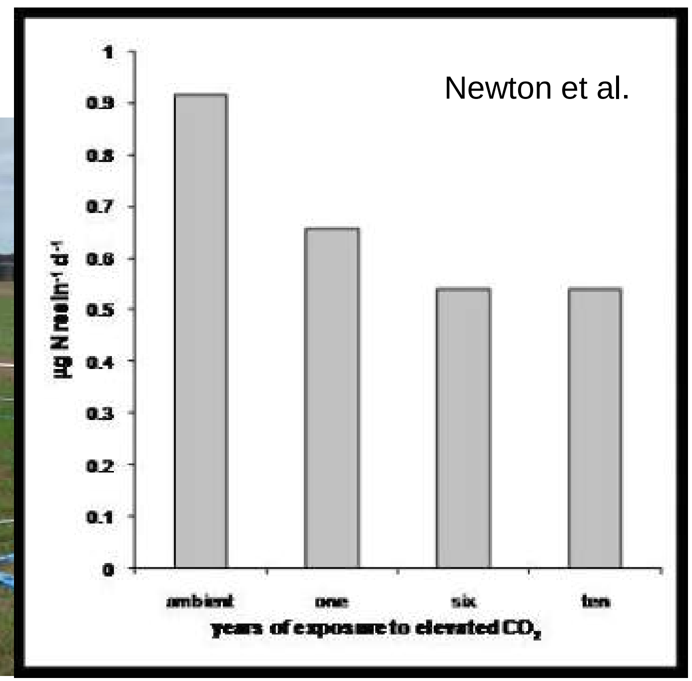
1-2°C warmer

50-100 mm drier



- Elevated [CO_2] increased dry matter production of trees (28%), legumes (24%), C_3 species (20%) but not much for C_4 species (Ainsworth and Long 2005).
- Change in N (& water) uptake and C input
- Consequent change in soil N dynamics

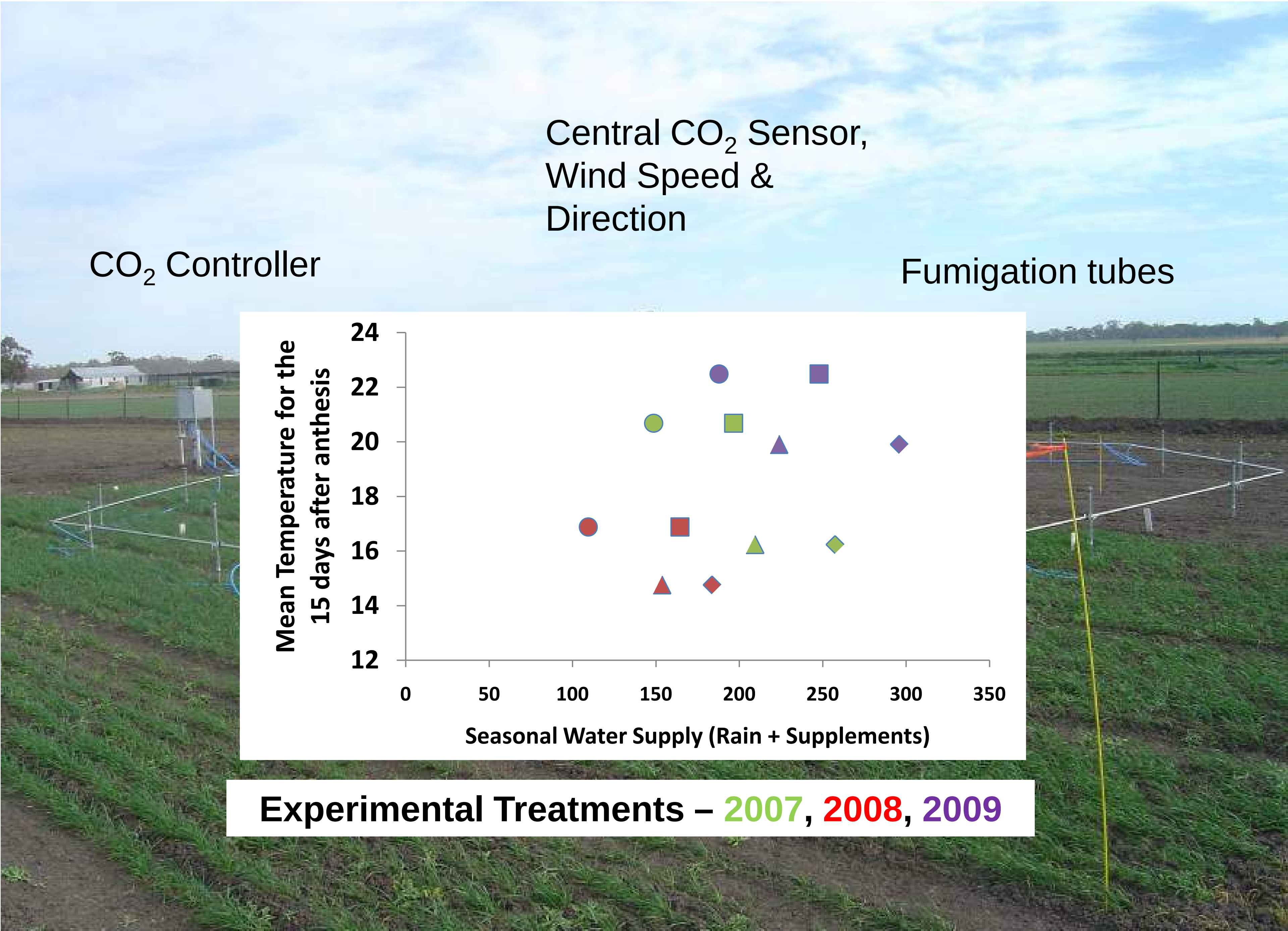




Central CO_2 Sensor, Wind Speed & Direction

CO_2 Controller

Fumigation tubes



Experimental Treatments – 2007, 2008, 2009

Carbon and nitrogen cycles – eCO_2

Change in the quantity and nature (C:N ratio) of OM inputs to soil

Rates of mineralisation

Changing root activity allowing better access to N from soil & fertilizer sources

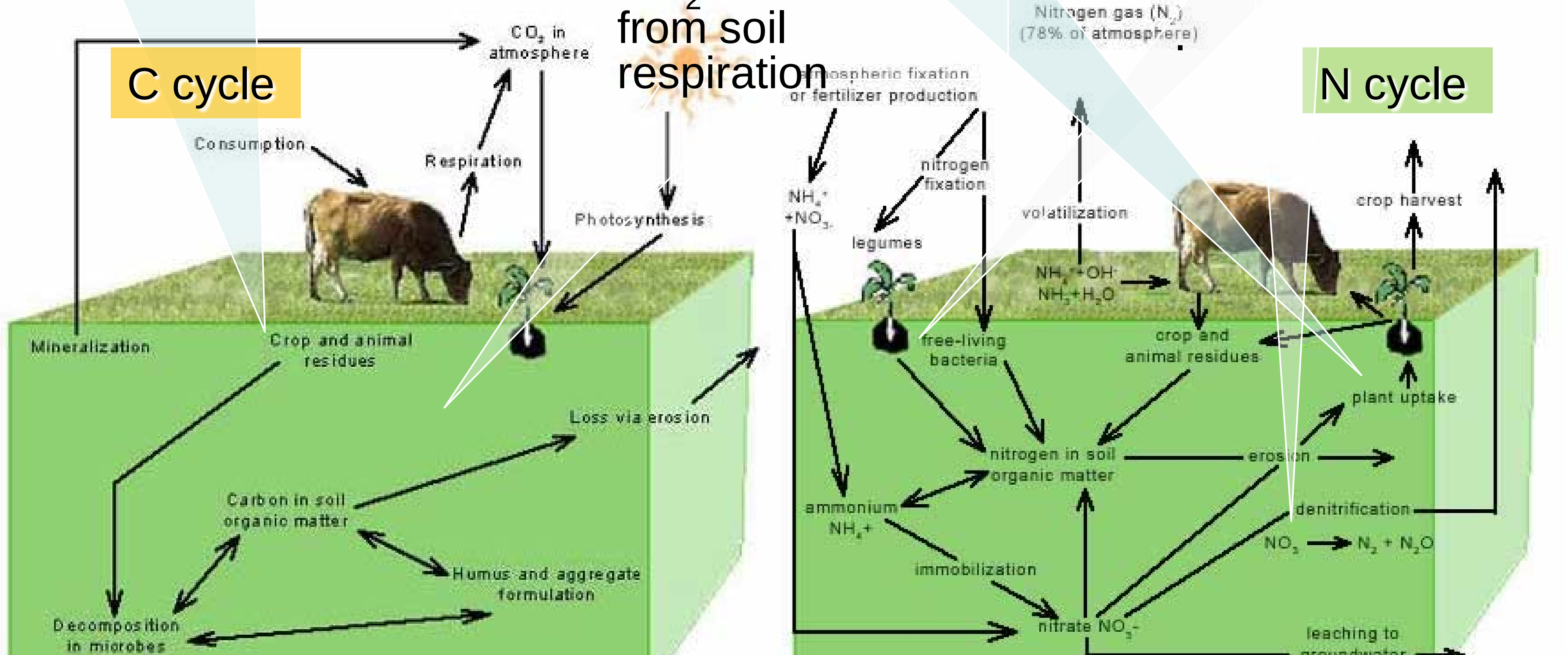
N_2O emissions

Rate of N fixed by legumes

CO_2 emissions from soil respiration

C cycle

N cycle



Adopted from National Sustainable Agriculture Information Service

Effect of eCO_2 on growth & N uptake

Factor	$[CO_2]$ (µmol/mol)	2007			2008			2009		
		GS30	GS65	GS90	GS30	GS65	GS90	GS30	GS65	GS90
Biomass (g/m^2)	380	51	**732**	**739**	**166**	**700**	**791**	88	**572**	**560**
	550	58	**852**	**910**	**208**	**915**	**1043**	100	**645**	**715**
Plant N (%)	380	**3.86**	**2.26**	**1.45**	3.77	**2.05**	**1.63**	4.80	**2.89**	**2.05**
	550	**3.63**	**2.12**	**1.34**	3.69	**1.90**	**1.56**	4.67	**2.62**	**1.97**
*N Uptake (g/m^2)	380	1.97	14.86	**10.64**	**6.11**	**14.28**	**12.73**	4.21	16.40	**11.48**
	550	2.11	14.91	**12.36**	**7.47**	**17.24**	**15.73**	4.67	16.72	**14.38**

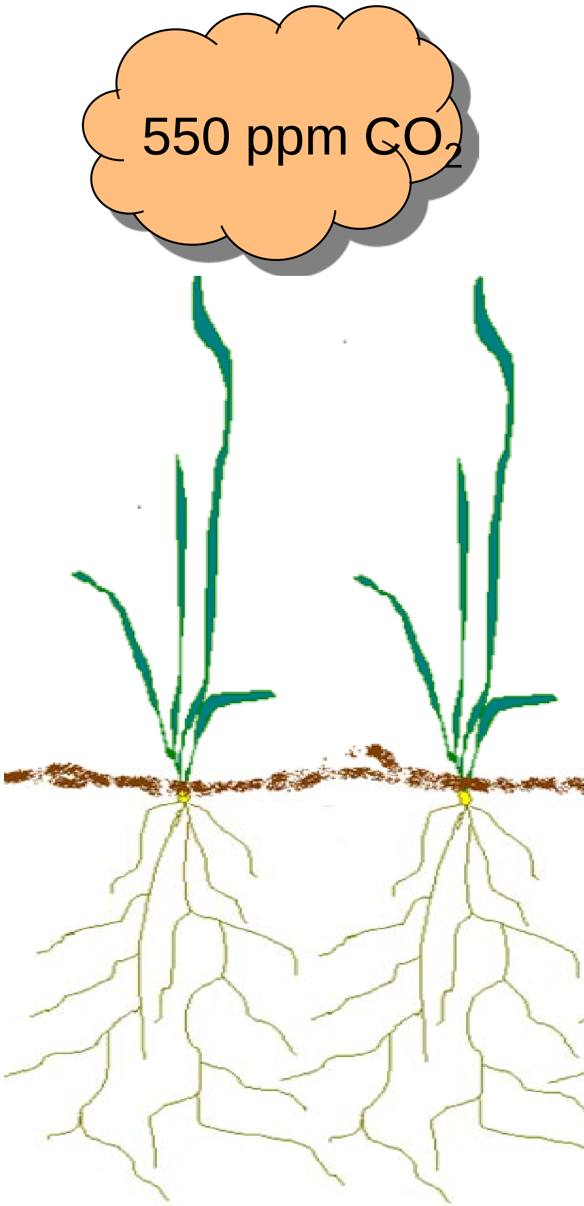
Biomass response appears temperature related (too cold = little response)
Plant N content declines – but at different times in different years.
Increase in N uptake apparent always at maturity
– loose less N during grain fill

Summary of N at GS65

- +21% Top Growth
- -7% Plant N content
- In 2007 & 2009 no change in N uptake
- In 2008 year, +20% N uptake

Root Length Density

Year	aCO_2	eCO_2
2007	**1.14**	**1.82**
2008	**2.45**	**3.00**
2009	0.86	0.96

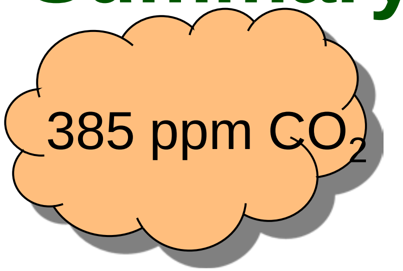


Grain Yield and N

Factor	$[CO_2]$ (µmol/mol)	2007	2008	2009
Grain yield (g/m^2)	380	**258**	**247**	**252**
	550	**323**	**310**	**332**
Grain N content (%)	380	**2.44**	**3.16**	**3.06**
	550	**2.33**	**3.04**	**2.81**

- Mean grain yield increase of 27% over three years.
- eCO_2 did not alter C:N ratio of straw from wheat crops
- Lower grain N
  - Acclimation of plants to eCO_2 typically shows a decline in leaf N content
  - Reduced Leaf/Plant N available for remobilization
    - 8% decline in leaf N% at GS65 over the three years

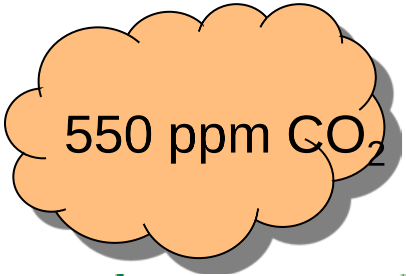
Summary of N at GS90

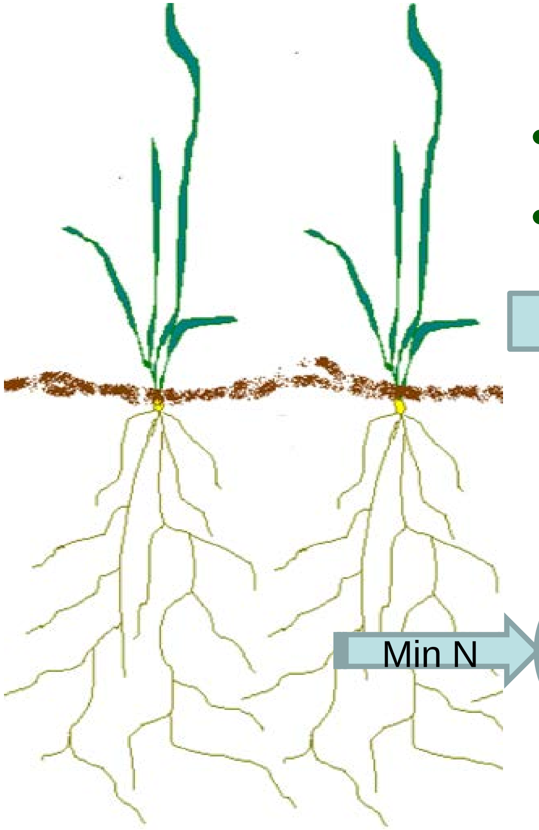


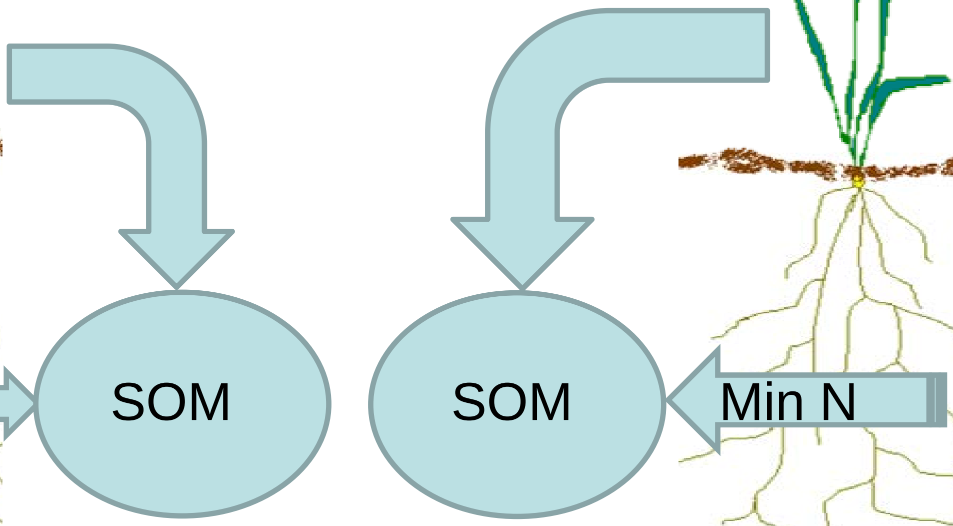
- +27% Top Growth

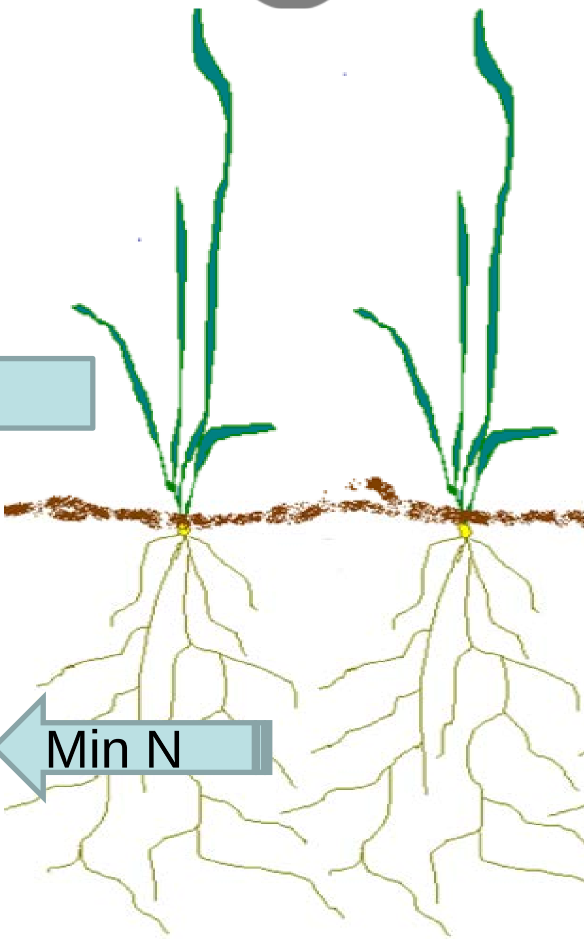
- -6% Plant N content
- Less N in grain

- 27% biomass to soil
- ~42 C:N in straw





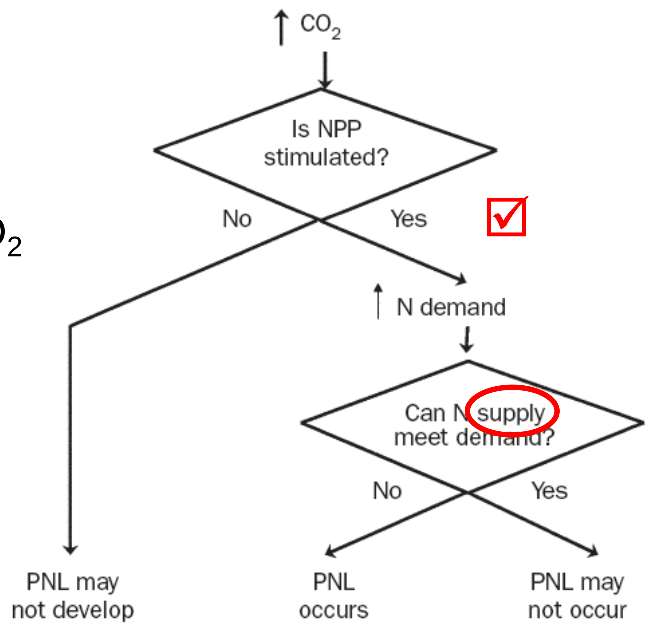




Conclusions about eCO_2 and soil N so far

- Supply capacity
  - No increased efficiency of accessing N from fertilizer
  - But higher root mass (+47%) and density with eCO_2 (+~70%)
  - Higher OM input but same C:N ratio
  - May lead to N immobilization – *likely that PNL can occur added N and/or increased frequency of legumes.*
- Current research
  - Symbiotic N fixation (Lam)
  - N_2O production (Lam)
  - Mineralisation rates

all under eCO_2



Integrate these processes using Water and Nitrogen Management Model (Li et al. 2006).

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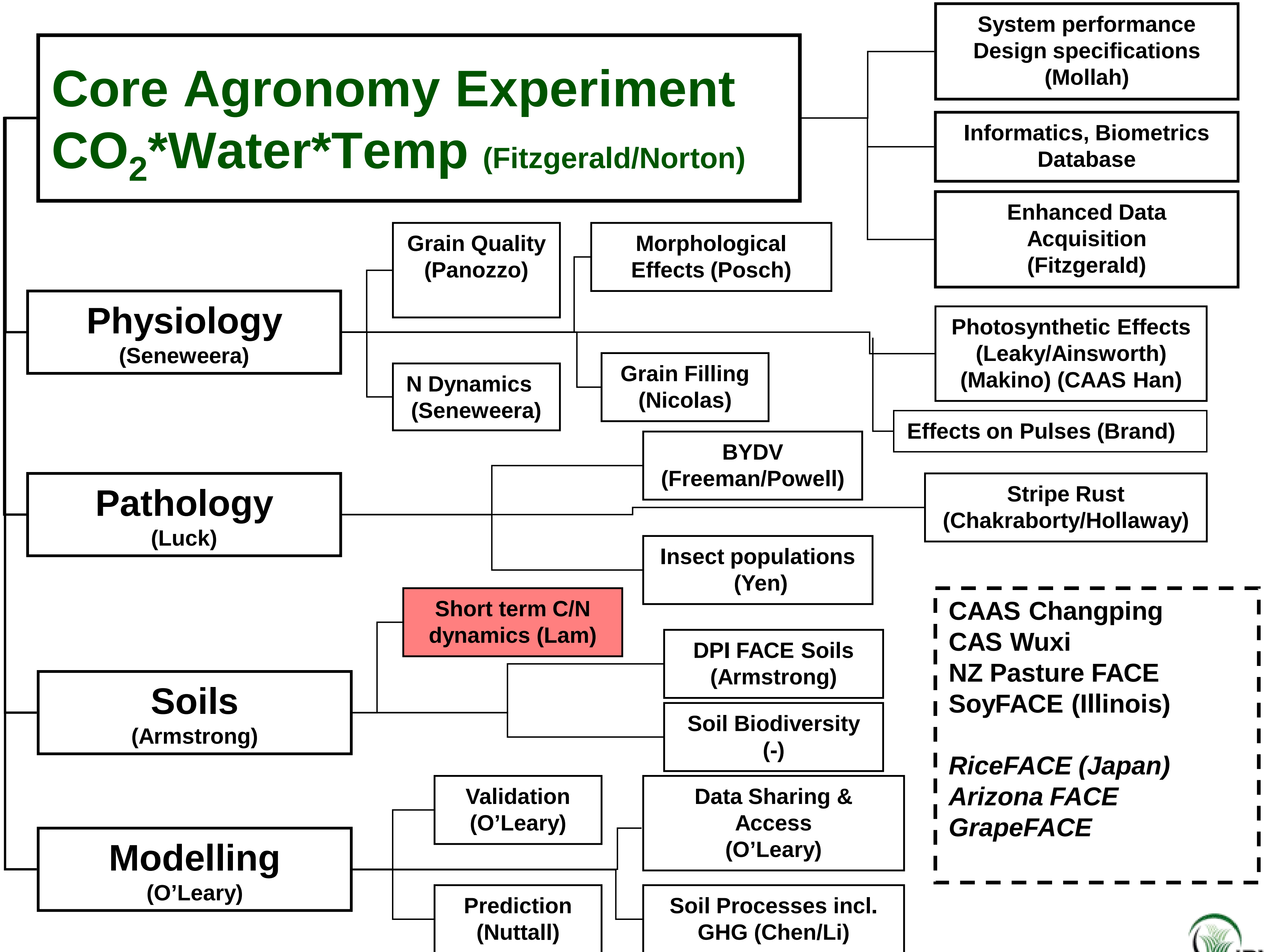
Core Agronomy Experiment
CO_2*Water*Temp (Fitzgerald/Norton)
System performance Design specifications (Mollah)
Informatics, Biometrics Database
Enhanced Data Acquisition (Fitzgerald)
Physiology (Seneweera)
Grain Quality (Panozzo)
Morphological Effects (Posch)
N Dynamics (Seneweera)
Grain Filling (Nicolas)
Photosynthetic Effects (Leaky/Ainsworth) (Makino) (CAAS Han)
Effects on Pulses (Brand)
Pathology (Luck)
BYDV (Freeman/Powell)
Stripe Rust (Chakraborty/Hollaway)
Insect populations (Yen)
Soils (Armstrong)
Short term C/N dynamics (Lam)
DPI FACE Soils (Armstrong)
Soil Biodiversity (-)
Modelling (O'Leary)
Validation (O'Leary)
Prediction (Nuttall)
Data Sharing & Access (O'Leary)
Soil Processes incl. GHG (Chen/Li)
CAAS Changping
CAS Wuxi
NZ Pasture FACE
SoyFACE (Illinois)
RiceFACE (Japan)
Arizona FACE
GrapeFACE

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