Legumes in crop rotations reduce nitrous oxide emissions, compared to fertilized non-legume rotations

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Soil nitrous oxide (N_2O) emissions . . .

- N_2O comes from natural processes in the soil
  - nitrification and denitrification

- What matters is the extra nitrogen that humans add to soil
  - Fertiliser
  - Legume N_2-fixation by rhizobia

- Emission Factor (EF) = N emission / N input x 100%
  - 0.3% of fertiliser N for Australian dryland cereal crops
  - 1.0% of legume N for Australian dryland pulses

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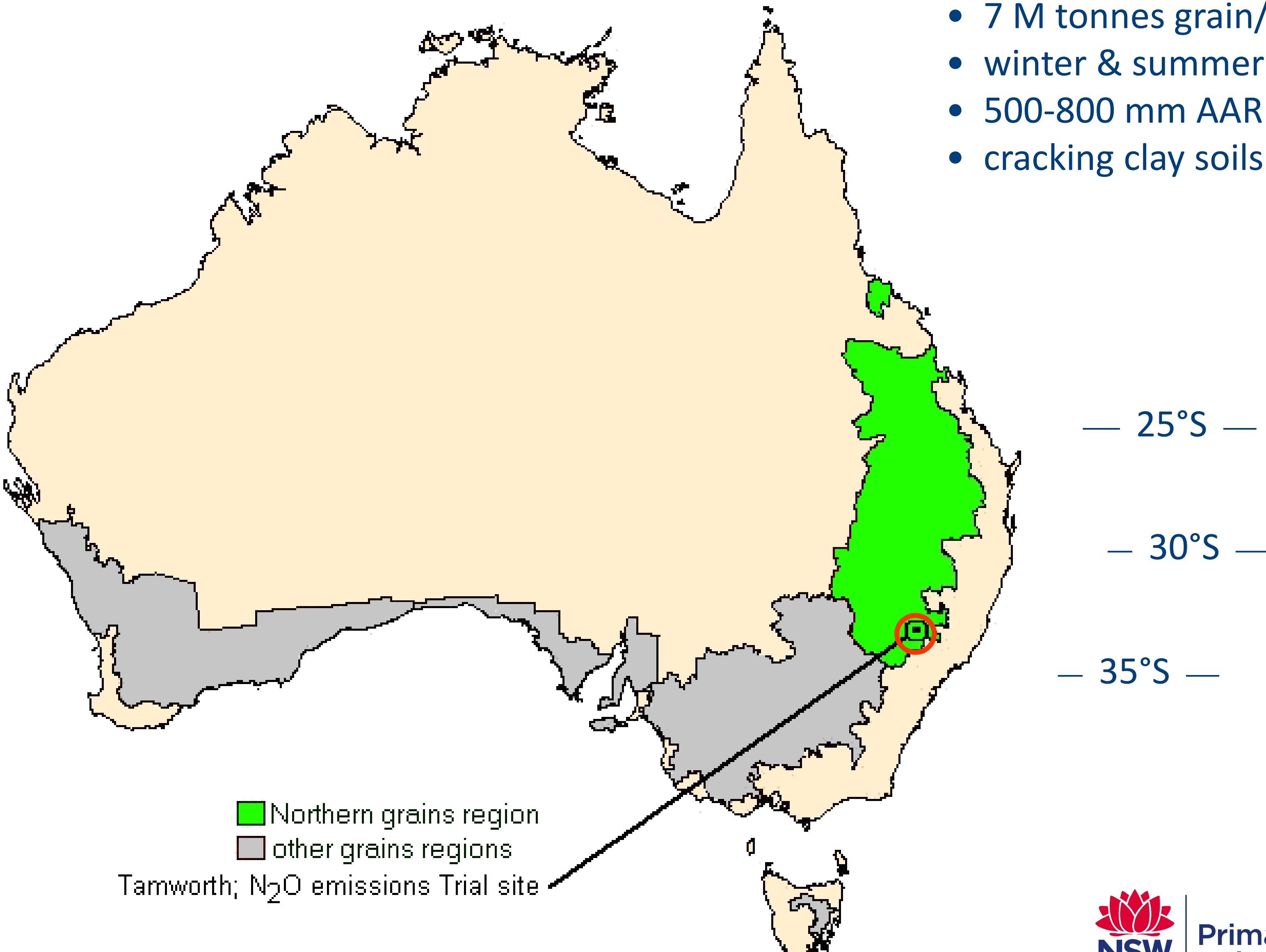
Australia's northern grains region

Northern grains region:

- 4 M ha cropping
- 7 M tonnes grain/yr
- winter & summer crops
- 500-800 mm AAR
- cracking clay soils



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Our Project Objectives

☑ Compare soil N_2O emissions during various crops

- *canola, chickpea, wheat, sorghum, barley*

☑ Compare soil N_2O emissions across crop rotations

- *canola-wheat-barley*
- *chickpea-wheat-barley*
- *chickpea-wheat-chickpea*
- *chickpea-sorghum*

☑ Derive soil N_2O emissions factors for legume/fertiliser N

- *chickpea (+ fababean and fieldpea in separate experiment)*
- *non-legume crops (canola, wheat, barley, sorghum)*

Project Methods

- *Treatments were crop rotations (dryland)*

2009		2010		2011
canola+N	→	*wheat+N*	→	*barley+N*
chickpea	→	*wheat*	→	*chickpea*
chickpea	→	*wheat+N*	→	*barley*
chickpea	→	*sorghum+N*	→	

(+N = urea fertiliser applied at sowing)

- *3 replications*
- *Zero-till, stubble-retained, chemical weed and disease control*
- *Plots were 12 m x 6 m*
- *Automatic air-sampling chambers (50 cm x 50 cm x 20 cm)*
  - *Air samples analysed in-field 7-8 times/day for N_2O, CH_4 & CO_2*

- *Legume N_2-fixation input measured by ^{15}N natural abundance*

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2009 ~ Air sample chambers in chickpea and canola

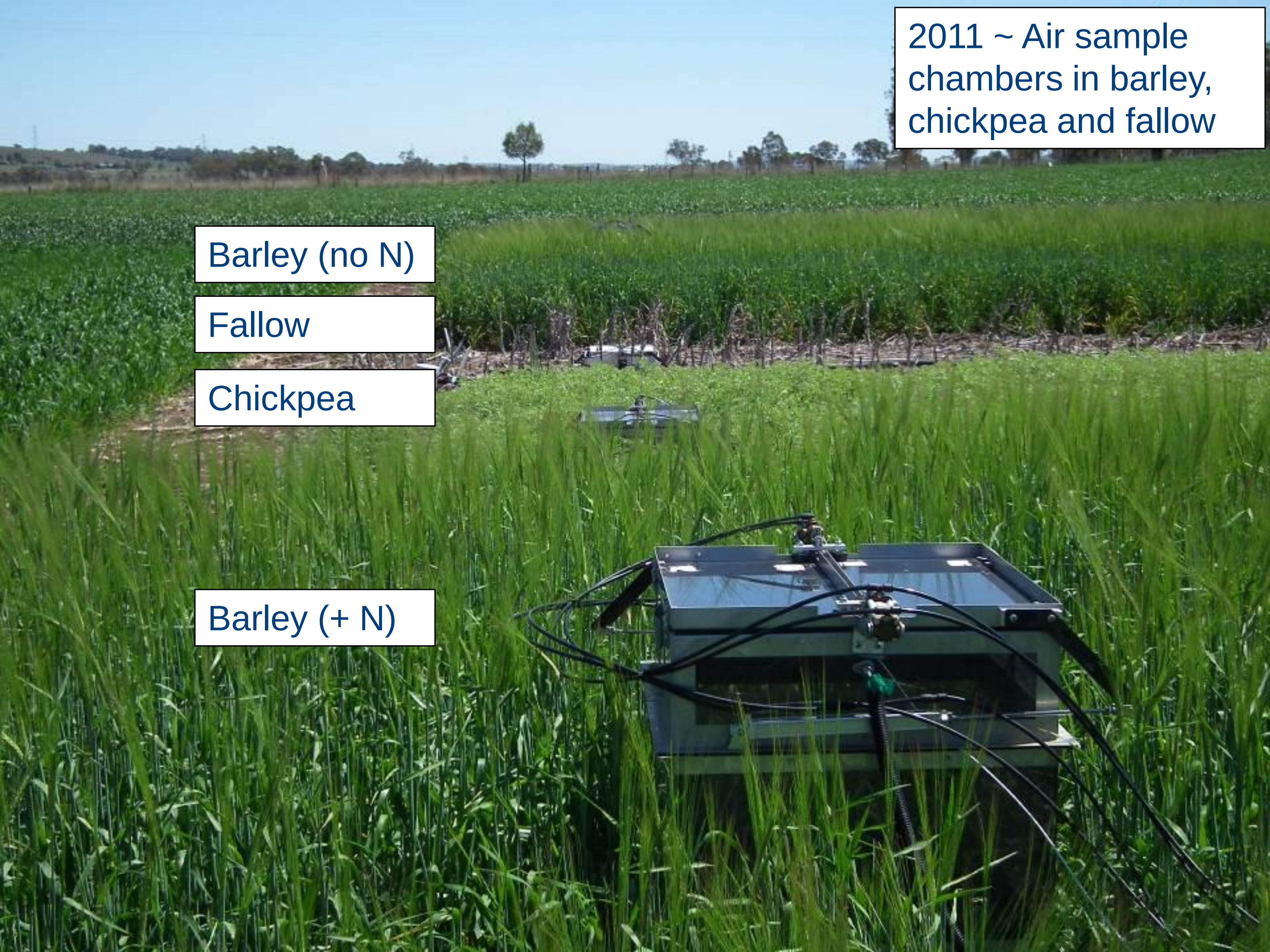
2010 ~ Air sample chambers in newly sown wheat and winter fallow plots

Gas chromatograph inside field lab

2010 ~ Air sample chambers in wheat and newly sown sorghum


2011 ~ Air sample chambers in sorghum


2011 ~ Sorghum ready for harvest, chamber in wheat fallow


2011 ~ Air sample chambers in barley, chickpea and fallow
Barley (no N)
Fallow
Chickpea
Barley (+ N)

Nitrogen inputs

- Urea mid-row banded at sowing;
  - canola (80 kg N/ha), wheat (80 kg N/ha), sorghum (40 kg N/ha), and barley (60 kg N/ha)

- Chickpea N_2-fixation (via ^{15}N natural abundance)
  - 2009
    - 18% Ndfa = 49 kg N/ha fixed from air
    - low in comparison to 41% Australian average
  - 2011
    - 37% Ndfa = 41 kg N/ha fixed from air
    - low plant biomass due to dry winter

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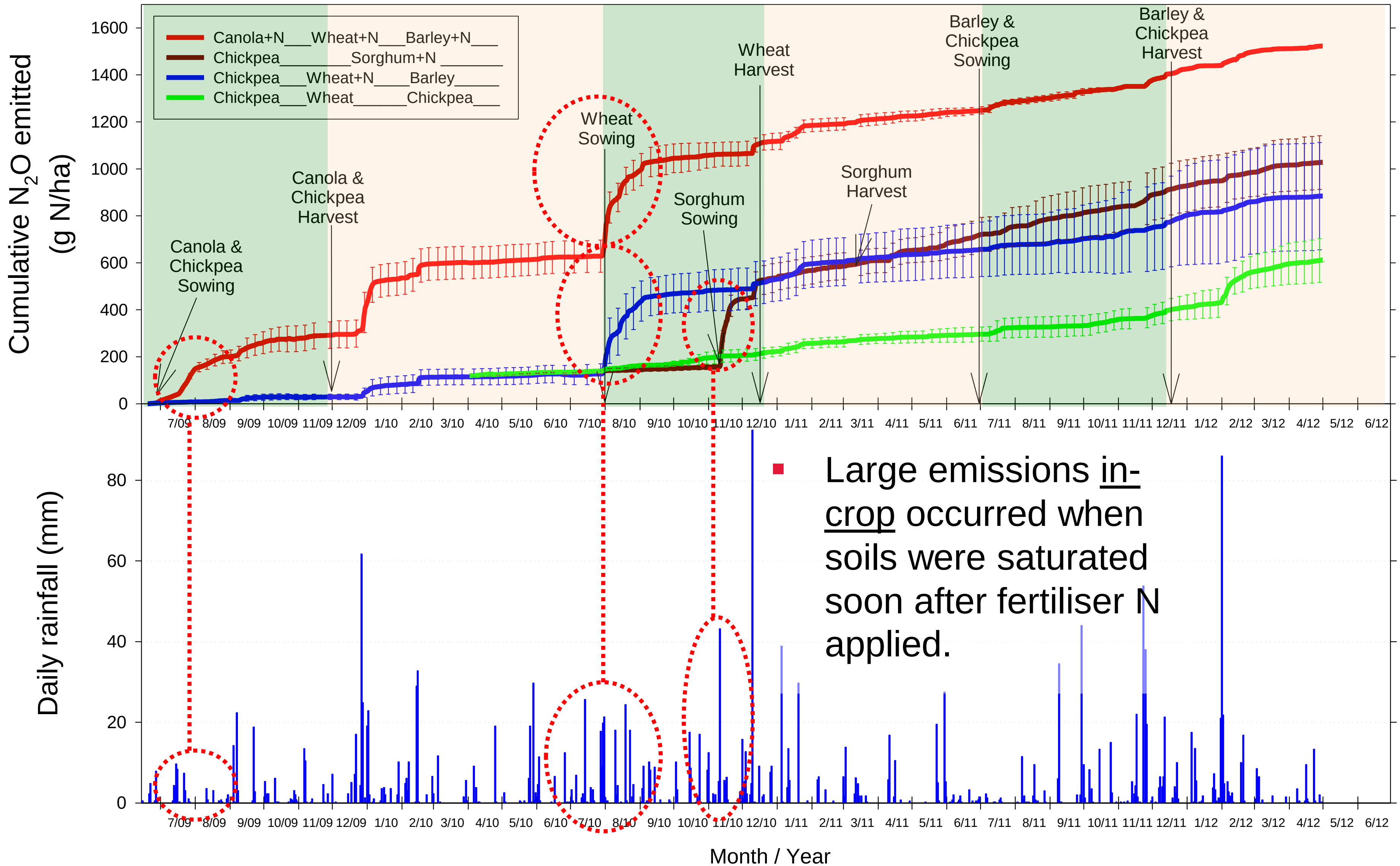
Cumulative N_2O emissions



- Large emissions <u>in-crop</u> occurred when soils were saturated soon after fertiliser N applied.

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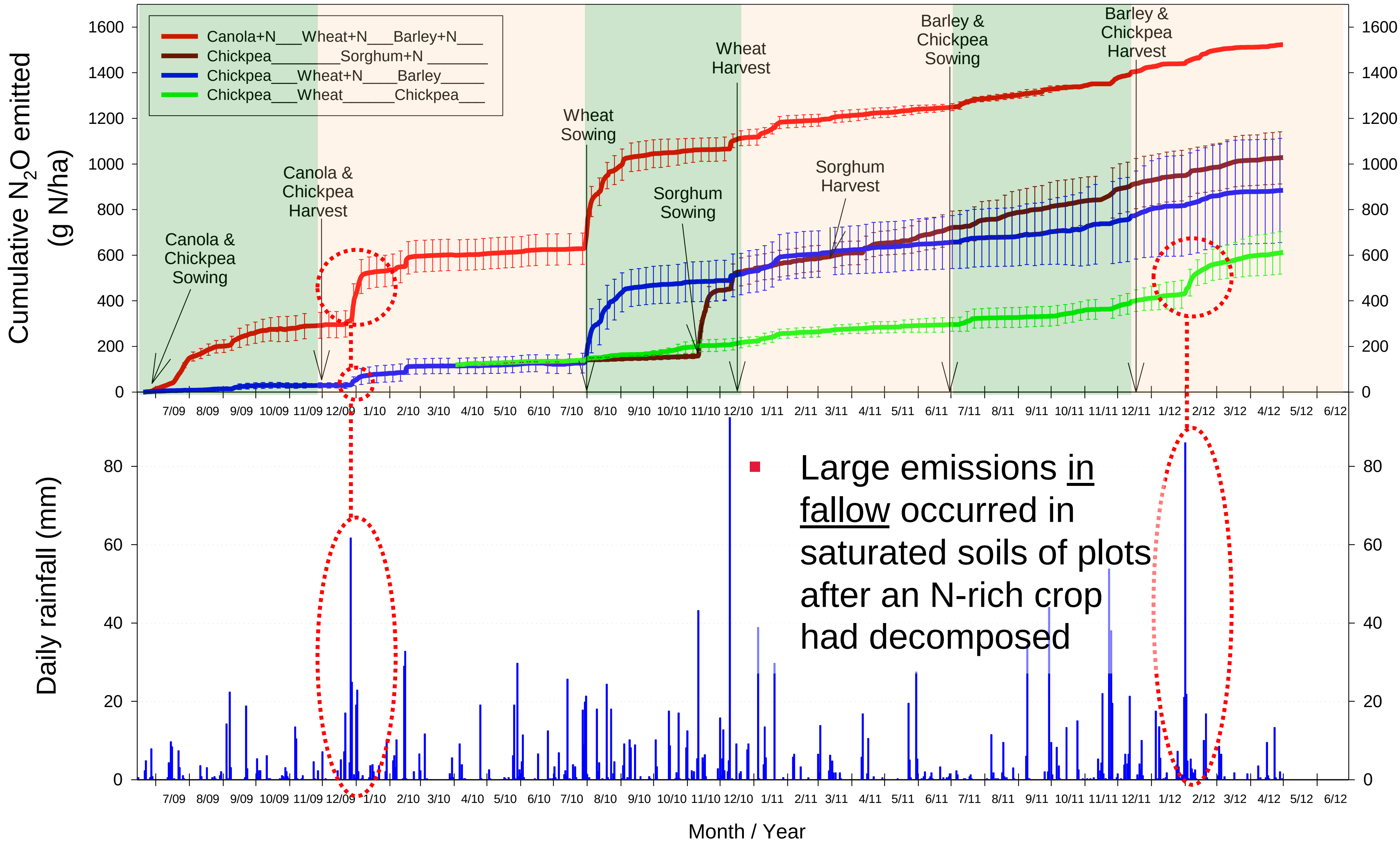
Cumulative N_2O emissions



- Large emissions <u>in fallow</u> occurred in saturated soils of plots after an N-rich crop had decomposed

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Emission factors (by crop)

Crop	Total N added (kg N/ha)	N_2O Emission Factor (%) (during crop growth)	(over 1 year)
Canola	80	0.37	0.78
Chickpea (2009)	49	0.06	0.26
Wheat (after canola)	80	0.51	0.59
Wheat (after chickpea)	80	0.39	0.46
Sorghum	40	0.92	1.31
Barley	60	0.07	0.08
Chickpea (2011)	41	0.25	0.78

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Emission factors (by rotation)

Crop rotation	Total N added (kg N/ha)	Total N_2O-N emitted (g N/ha)*	N_2O Emission Factor (%) *
canola+N_wheat+N_barley+N	80 + 80 + 60	1523	0.69
chickpea_wheat+N_barley	49 + 80 + 0	885	0.69
chickpea_wheat_chickpea	49 + 0 + 41	614	0.68
chickpea_sorghum+N_	49 + 40	1028	1.16

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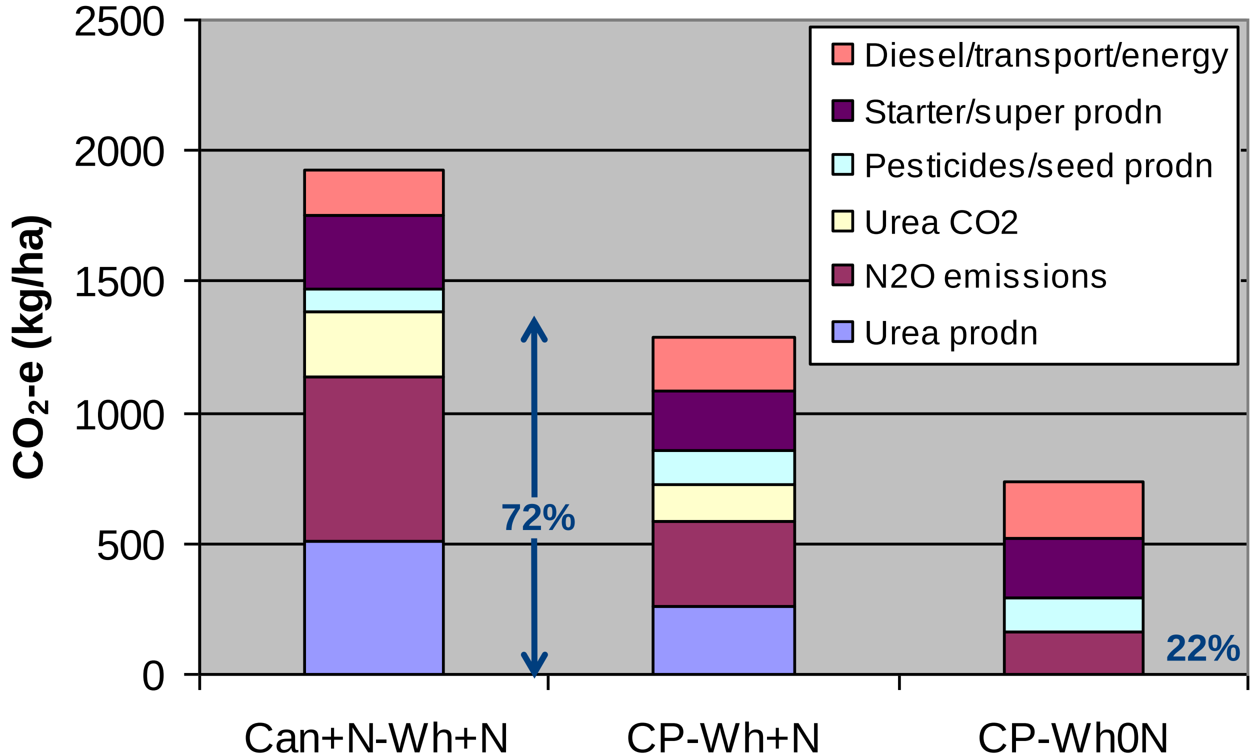
A lifecycle analysis of the first 2-year rotations . . .

- most greenhouse gas emissions were due to fertiliser N
- N_2O emitted directly from the soil accounted for up to 45% of total greenhouse gas emissions
- The remainder was associated with N fertiliser production, transport and application, and urea hydrolysis



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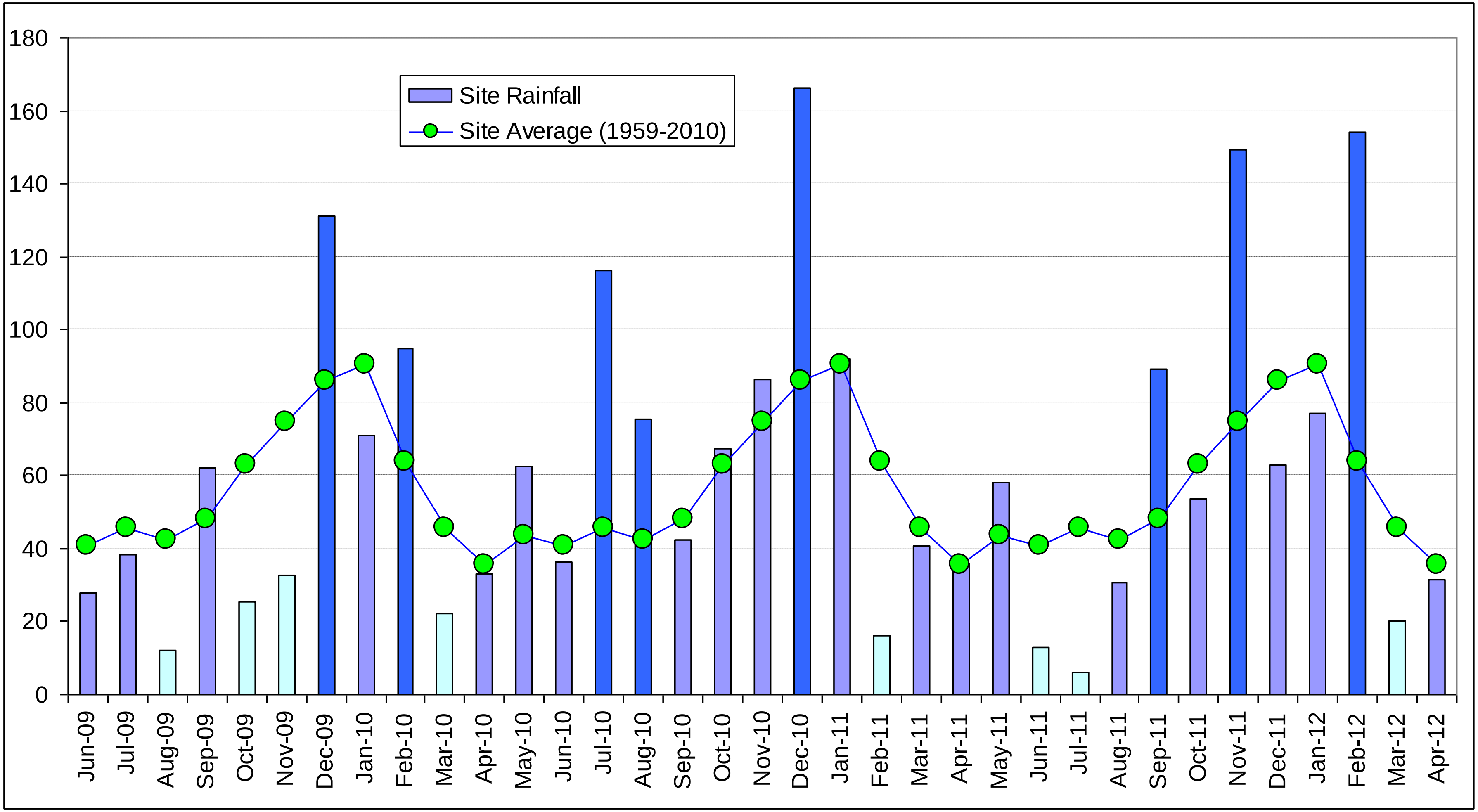
Conclusions

- N_2O emissions during legume growth were very low
- In-crop N_2O emissions during growth of fertilised crops can be significant if soil is saturated soon after fertiliser is applied
- N_2O emissions during post-harvest fallow can be significant if soil is saturated after residue decomposition of N-rich crops (chickpea, canola)
- Over a multi-year crop rotation, legumes reduced total N_2O emissions and <u>total greenhouse gas emissions</u>, but the loss as a proportion of N input was similar to N fertiliser.


Thank you!

Rainfall (mm) ~ Monthly Totals & Long-term Average



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