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THE NATIONAL AGRICULTURAL NITROUS OXIDE RESEARCH PROGRAM (NANORP)

FINAL SUMMARY (PHASE 1)

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CANBERRA
14 JULY 2015

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N2O Network

THE NATIONAL AGRICULTURAL ‘NITROGEN USE EFFICIENCY’ RESEARCH PROGRAM

Carbon Farming Futures (DoA)

- Filling the Research Gap Round 1 – NANORP (2012-2015)
  - ***17 projects***
- Filling the Research Gap Round 2 – NANORP (2013-2016)
  - ***6 projects***

N2O Network

www.n2o.net.au

Australian Government

Queensland University of Technology

The University of Western Australia

The University of Queensland Australia | QAAFI Queensland Alliance for Agriculture and Food Innovation

UTAS

La Trobe University Australia

UNSW The University of New South Wales

State Government Victoria Department of Primary Industries

GRDC Grains Research & Development Corporation

Australian Government

Cotton Research and Development Corporation

tiar Tasmanian Institute of Agricultural Research

SARDI South Australian Research and Development Institute

NSW Government Primary Industries

Queensland Government

Charles Sturt University

CSIRO

The University of Melbourne

piccc Primary Industries Climate Challenges Centre

The University of Newcastle Australia

Incitec Pivot Fertilisers

The University of Sydney

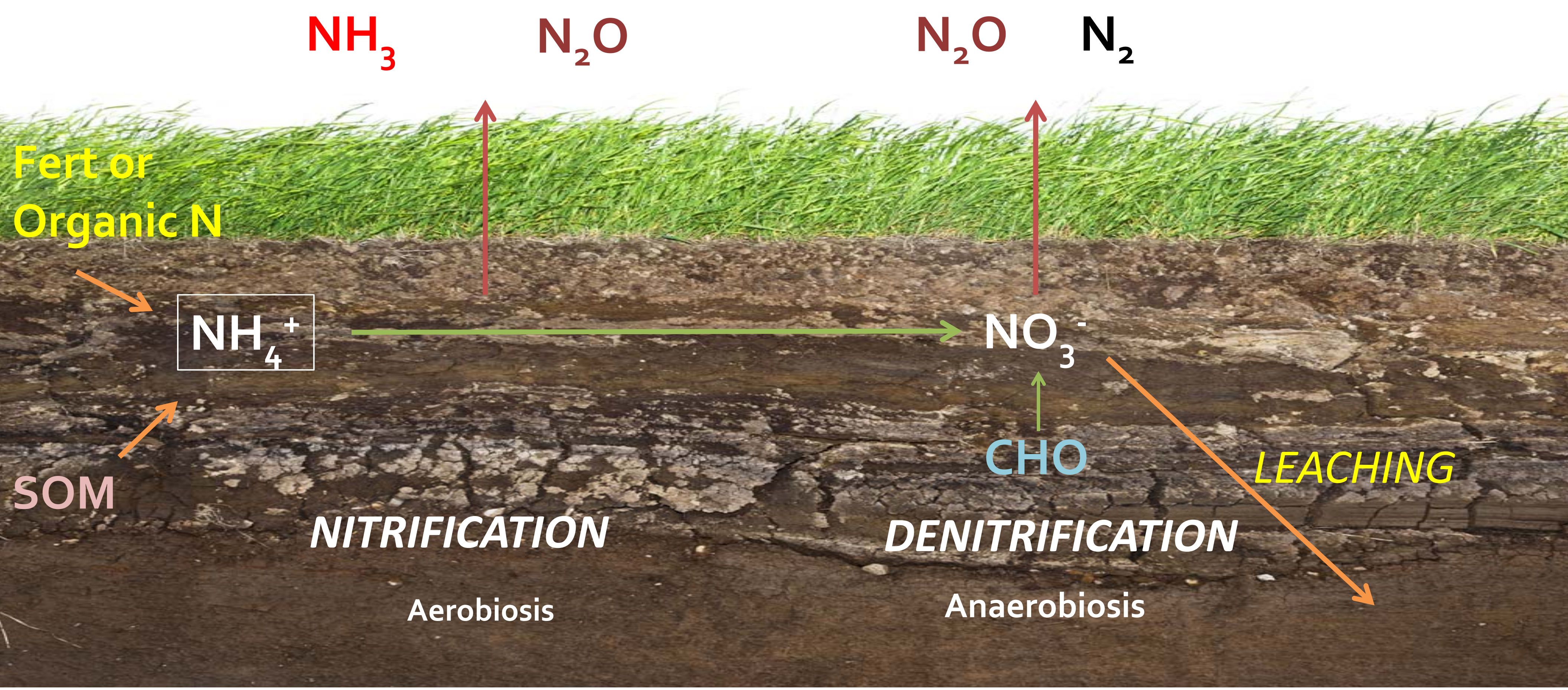
Dairy Australia

une University of New England

Nitrous Oxide…some facts

- Potent greenhouse gas (GWP = 298 CO_2)
- 8% of global GHG emissions
- Agricultural soils contribute 50% of global N_2O emissions
- Approx 1% of applied N fertiliser globally
- N_2O reductions are permanent
- Measurable indicator of NUIE (e.g. N_2/N_2O ratio = 1 – 50+)

Sources of N emissions



GHGs and Sustainable Agriculture

- GHGs - measurable indicators of resource use INEFFICIENCY & soil health
  - Low CO_2 (per unit SOC) = low microbial activity & C inputs
  - High N_2O = excess N and/or poor soil physical condition
  - High CH_4 = poor soil physical condition

- All of these factors = decreased production/profitability

Poorly managed, conventional cultivation, high GHG emissions

Well managed, reduced cultivation, low GHG emissions

NANORP Mission

Delivery of practical cost-effective management strategies that reduce N_2O emissions promote productivity and profitability in Australian agriculture.

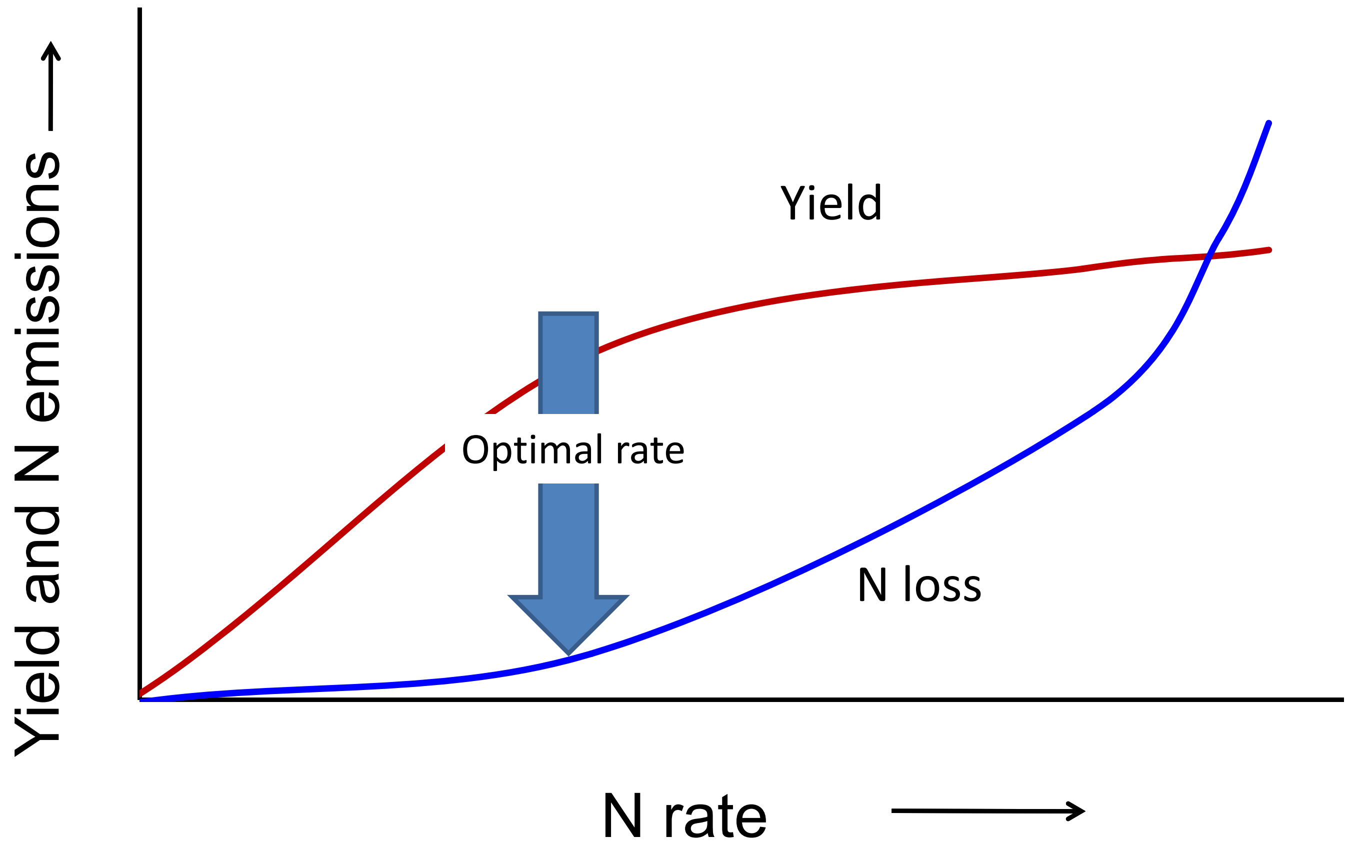
NANORP Core Research Hypothesis

- Nitrogen losses reduced and production increased by:
  - Matching fertiliser N supply with plant N demand
  - Reducing fert N inputs by increasing N supply from SOM/legumes
  - Enhanced Efficiency Fertilisers (EEFs)
  - Better soil structure/drainage

NANORP NUE / N_2O Mitigation Strategies

- <u>N Fertiliser Management</u>
  - Rate
  - Timing
  - Placement
  - Enhanced Efficiency Fertilisers (EEFs)
- <u>Rotations</u>

Improving Nitrogen Use Efficiency (NUE)



NANORP Research Themes

Nitrogen Use Efficiency (NUE)

Basic Processes

GHGs/Productivity

Soil C Interactions

Enhanced Efficiency Fertilisers (EEFs)

NANORP Theme x Industry

EEFs	Soil C interactions	NUE	Processes
Indirect emissions Suter (UM)	Sandy soil grains Barton (UWA)	Sub-tropical dairy Rowlings (QUT)	N_2O/N_2 partitioning Scheer (QUT)
Direct emissions Chen (UM)	Clay soil grains Bell (UQ)	Hot dry dairy Dougherty (NSW DPI)	Nitrification Farquharson (CSIRO)
Temperate dairy Kelly (Vic DPI)		Sugar cane Wang (DSITI)	Upscaling/spatial variability Adams (USyd)
		Dryland grains Schwenke/Li (NSW DPI)	NH_4^- charcoal complex Donne (UNew)
		High rainfall grains Harris/Armstrong (Vic DPI)	
		Irrigated cropping MIA Quayle (Deakin)	

NANORP – Network Structure

GHG reduction methodologies/NUE

National GHG inventory

<u>Coordination</u>

Simulation modelling

Data protocols

Database

<u>Automated 'core' sites (15)</u>

High temporal resolution

Multiple treatments

^{15}N mass balance

N_2/N_2O

Model calibration and validation

<u>Laboratory studies</u>

Basic processes

Temperature * H_2O * soil type

Fertiliser products

Model calibration

Model validation

<u>Manual 'satellite' sites (3-4/core)</u>

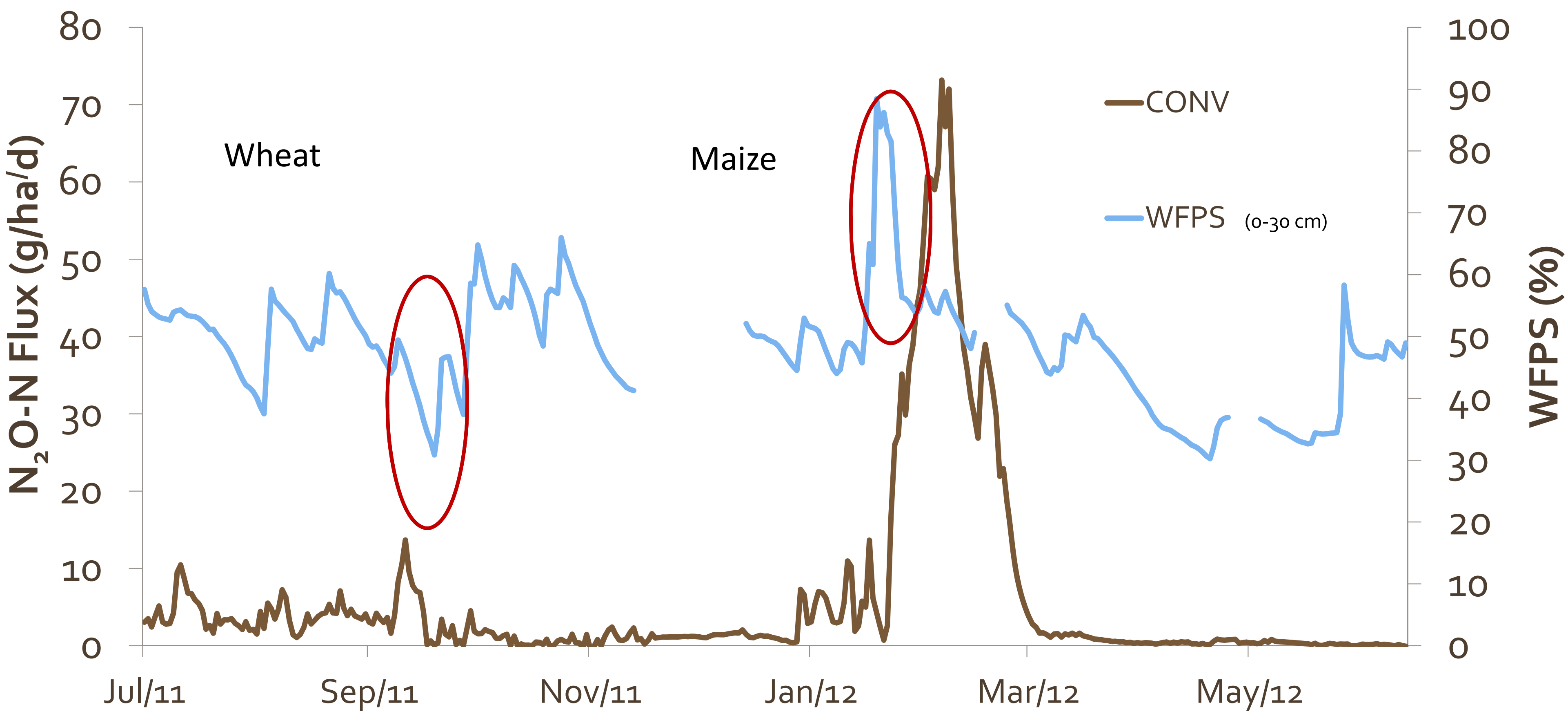
Medium temporal resolution

N response trials

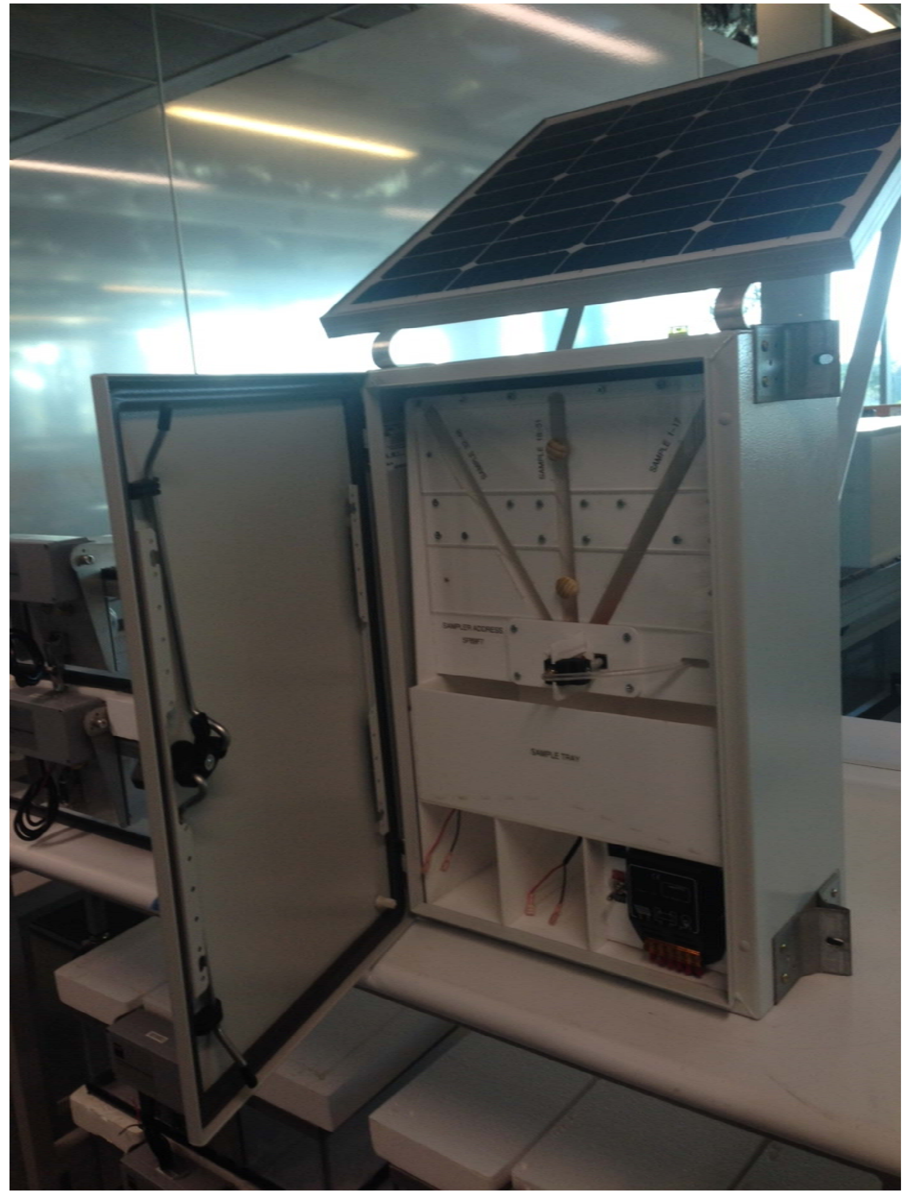
Limited treatments

Regional locations

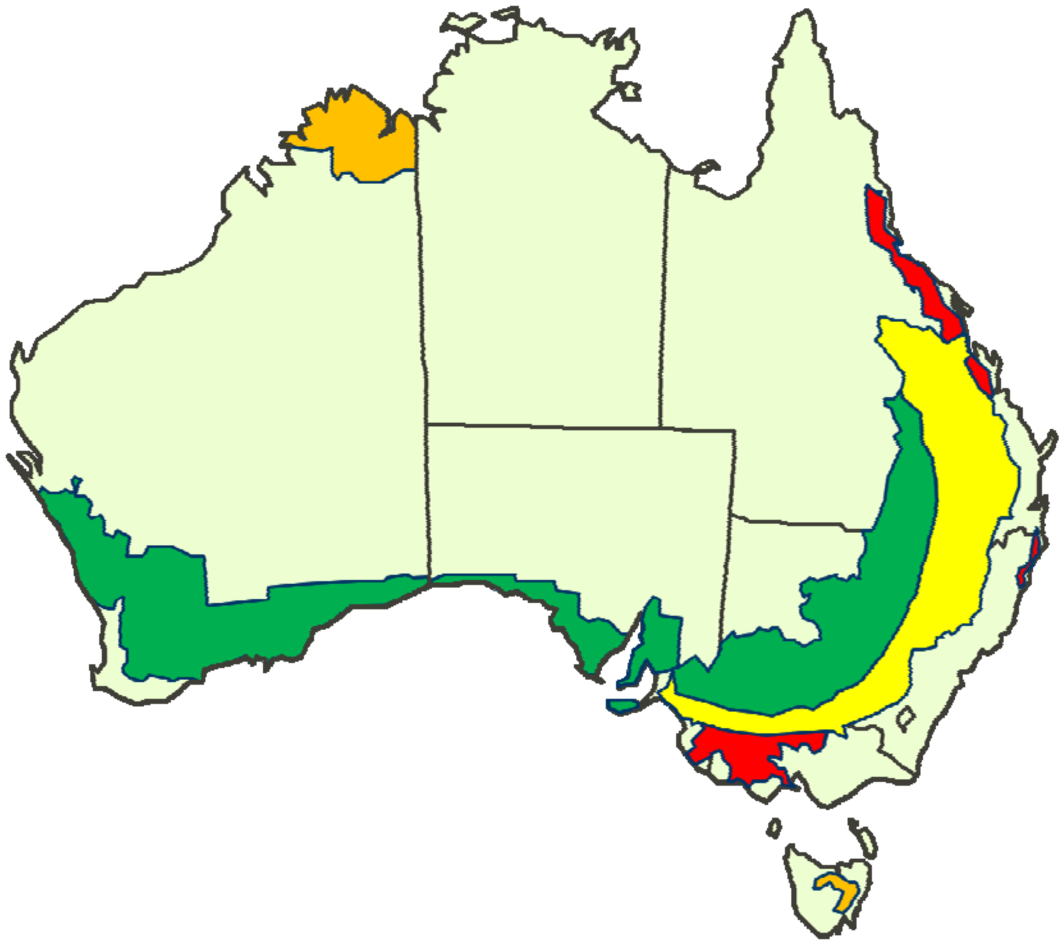

N_2O vs Water Content (WFPS) – Kingaroy (Ferrosol)



De Antoni Migliorati et al. (2014)


SAMPLER ADDRESS
SAMPLE TRAY

N_2O Emissions vs Agricultural Production Zones



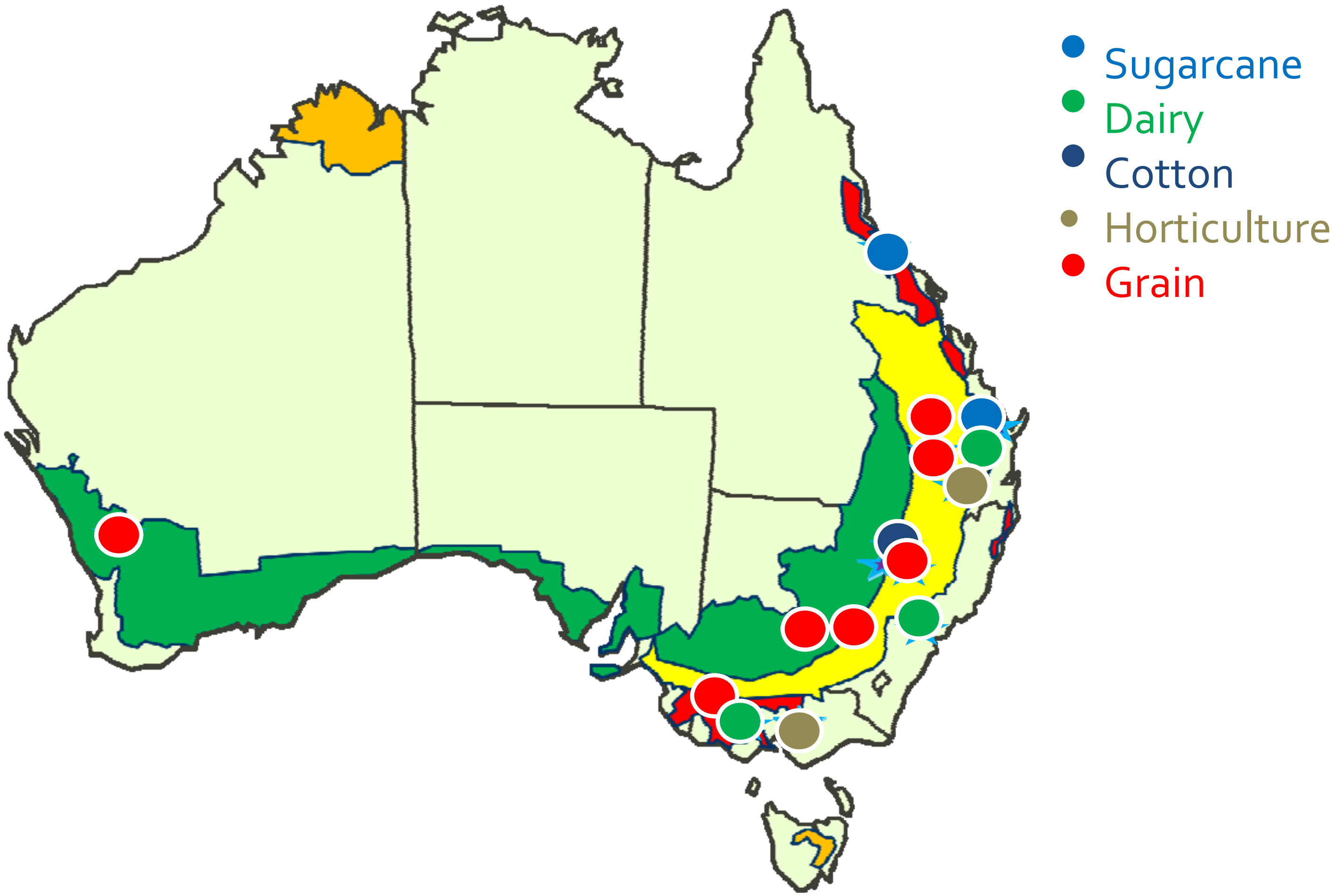
Low

Medium

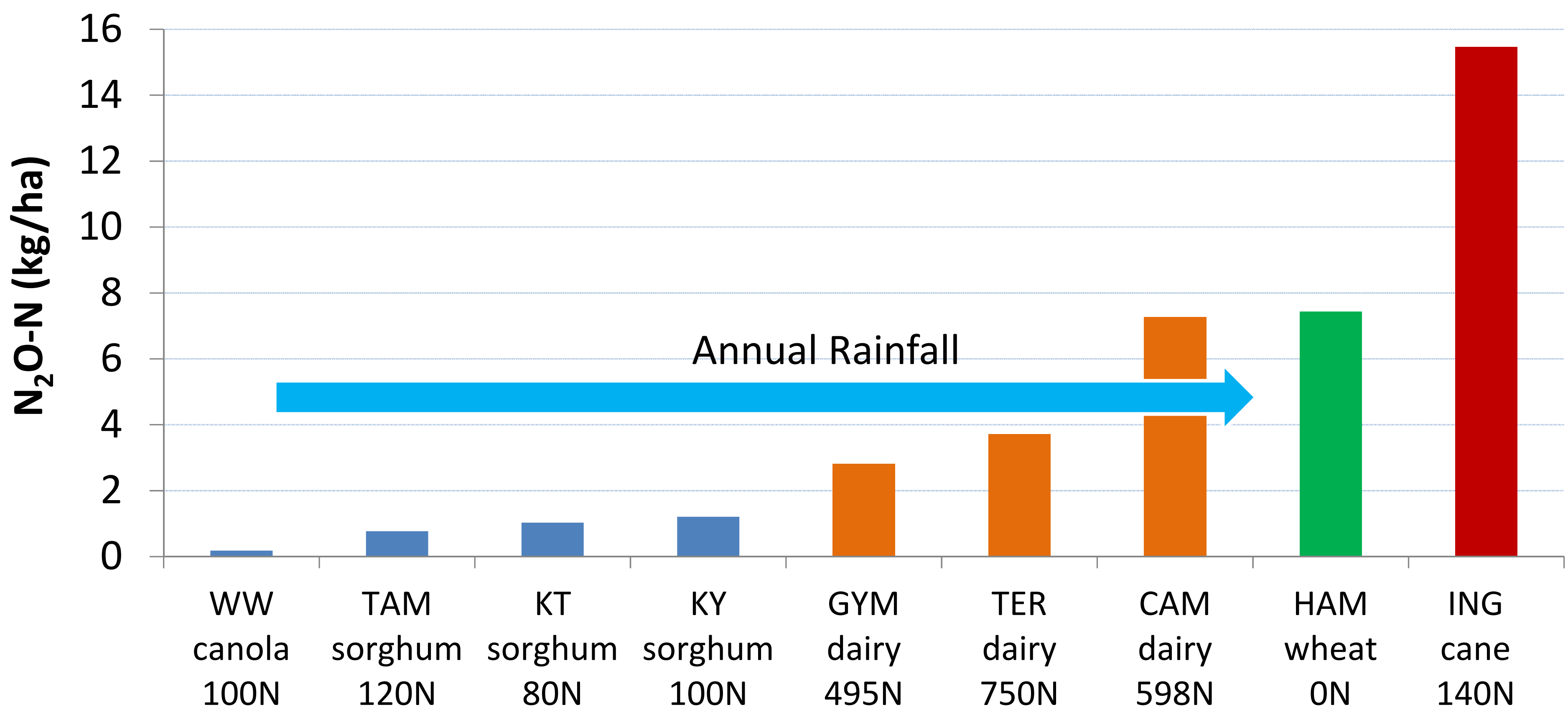
High

No data/uncertain

NANORP – Core (automated) sites



N_2O Emissions per Annum

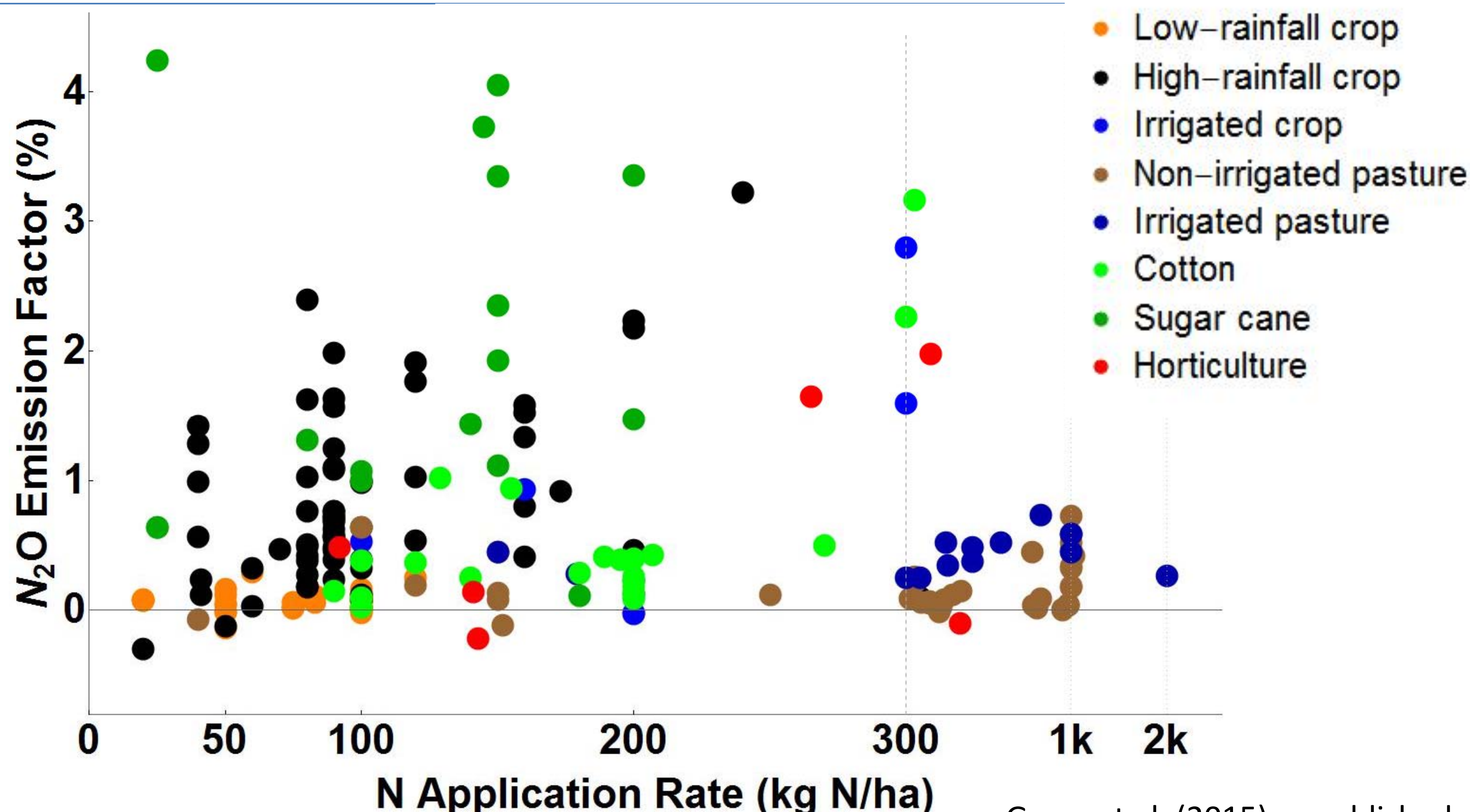


Grace et al. (2015) unpublished

Fertiliser Induced Emission Factor (EF%)

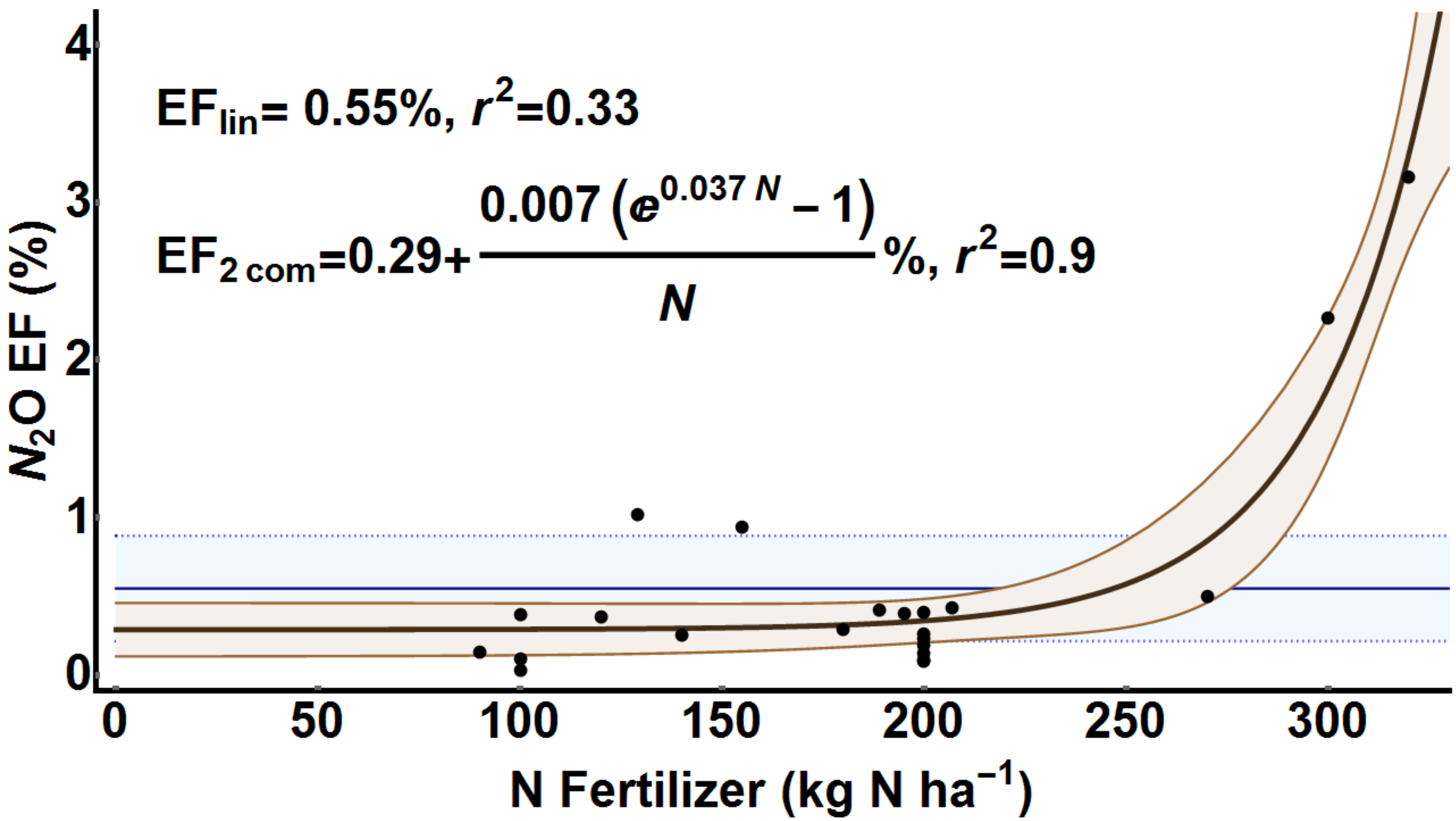
- N_2O emitted from fertilised soil (N_2Of)
- N_2O emitted from unfertilised soil (N_2Ouf)
- N applied (N)
- $EF = (N_2Of - N_2Ouf) / N * 100$

N_2O Emission Factors (% of applied N)



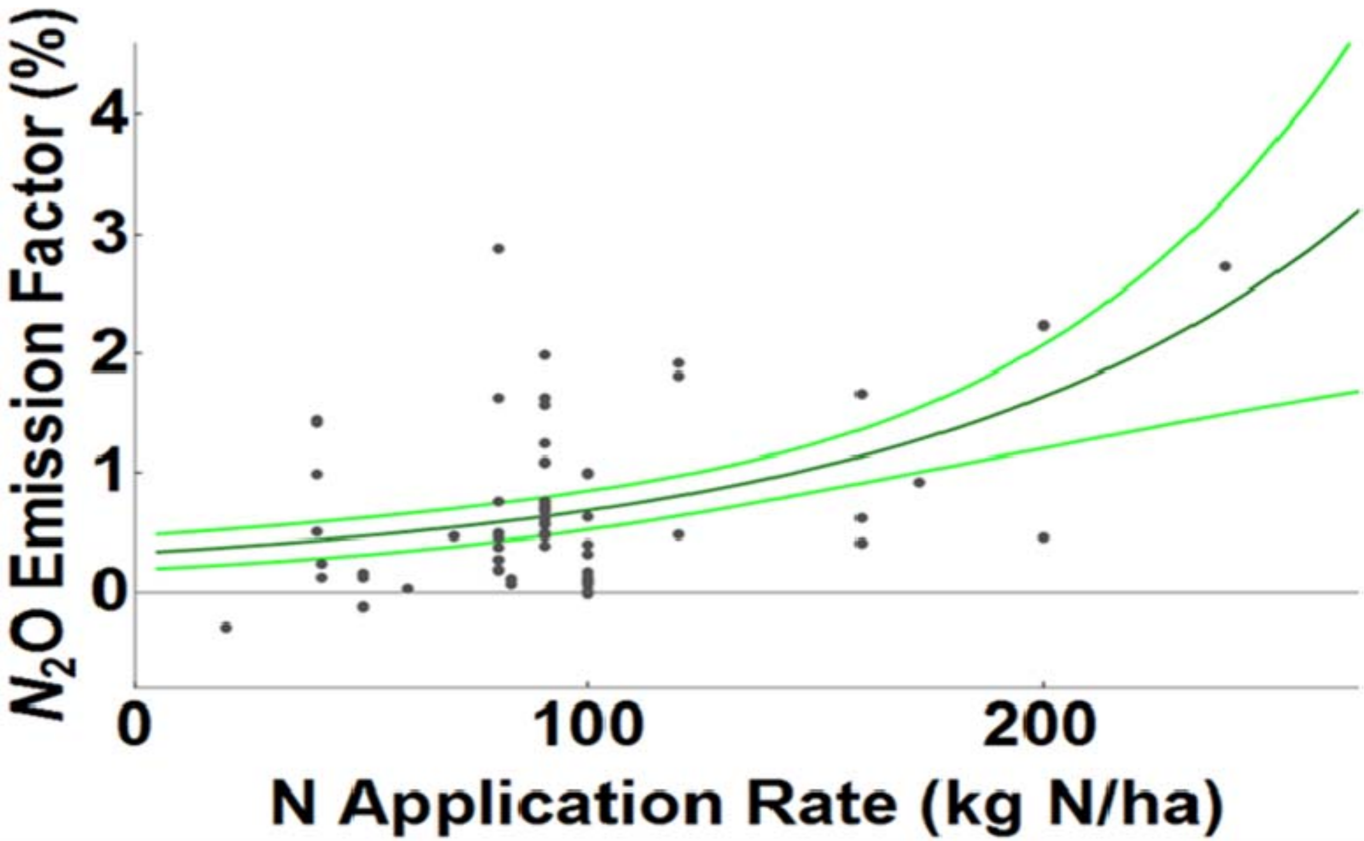
Grace et al. (2015) unpublished

Proposed Emission Factor - DoE Cotton Methodology



Grace, Shcherbak et al. (2016) Soil Research v54

Potential non-linear EF - Non-irrigated crop >600 mm



Grace & Shcherbak (2015)

N_2O Emission Factors (% of applied N)

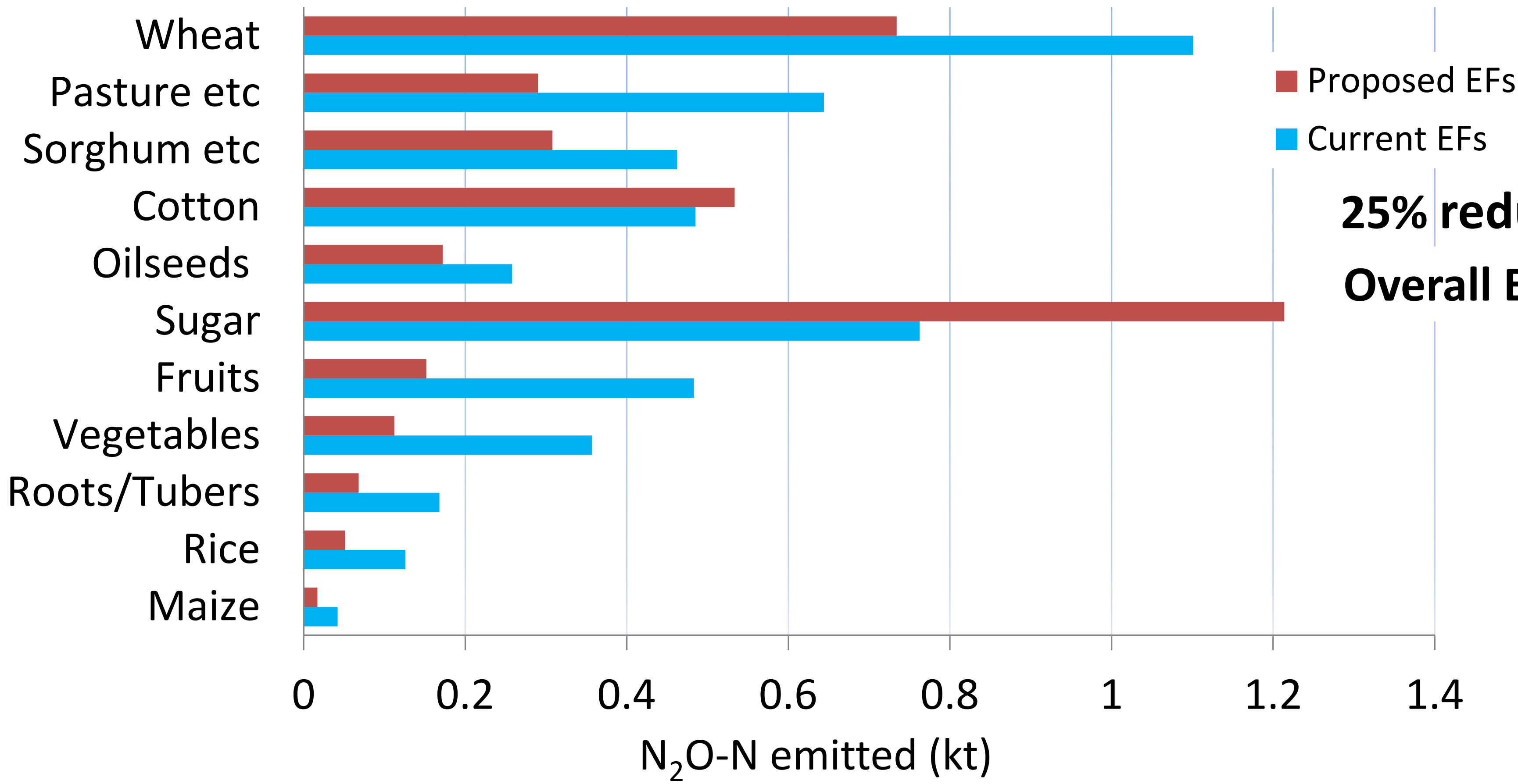
Land Use	Treatments #	Mean N rate (kg/ha)	Current EF (%)	NANORP Revised EF (%)[a]
Non-irrigated crop	104	93	0.3	0.2[b]
• *Low rainfall (<600 mm)*	*40*	*78*	*0.1*	*0.06*
• *High rainfall (>600 mm)*	*64*	*102*	*1.25*	*0.84*
Irrigated crop	7	209	2.1	0.85
Non-irrigated pasture	39	596	0.4	0.18
Irrigated pasture	15	622	0.4	0.42
Cotton	22	182	0.5	0.55
Sugar cane	16	123	1.25	1.99
Horticulture[c]	6	241	2.1	0.66

[a]Grace & Shcherbak (2015); [b] weighted EF - 81% low rainfall &19% high rainfall cropping; [c]based on irrigated cropping EF

Total N Applied National Basis – (IFIA, 2013)

Commodity	N applied (kt)
Wheat	367
Pasture etc	161
Sorghum etc	154
Cotton	97
Oilseeds	86
Sugar	61
Fruit	23
Vegetables	17
Roots/tubers	8
Rice	6
Maize	2
TOTAL	**982**

N_2O Emitted (Total N Applied National Basis - IFIA)



3.65 kt N

4.89 kt N

25% reduction

Overall EF = 0.37%

N_2O Emission Factors (% of applied N)

Land Use	Treatments #	Mean N rate (kg/ha)	Current EF (%)	NANORP Revised EF (%)	New NGGI EF (%)[a]
Non-irrigated crop	104	93	0.3	0.2[a]	0.2[b]
• *Low rainfall (<600 mm)*	*40*	*78*	*0.1*	*0.06*	*0.06*
• *High rainfall (>6*[illegible]	[illegible]	[illegible]	[illegible]	*[illegible]84*	*0.84*
Irrigated crop	[illegible]	[illegible]	[illegible]	[illegible]35	0.85
Non-irrigated pasture	39	596	0.4	0.18	0.2
Irrigated pasture	15	622	0.4	0.42	0.4
Cotton	22	182	0.5	0.55	0.55
Sugar cane	16	123	1.25	1.99	1.99
Horticulture[c]	6	241	2.1	0.66	0.85

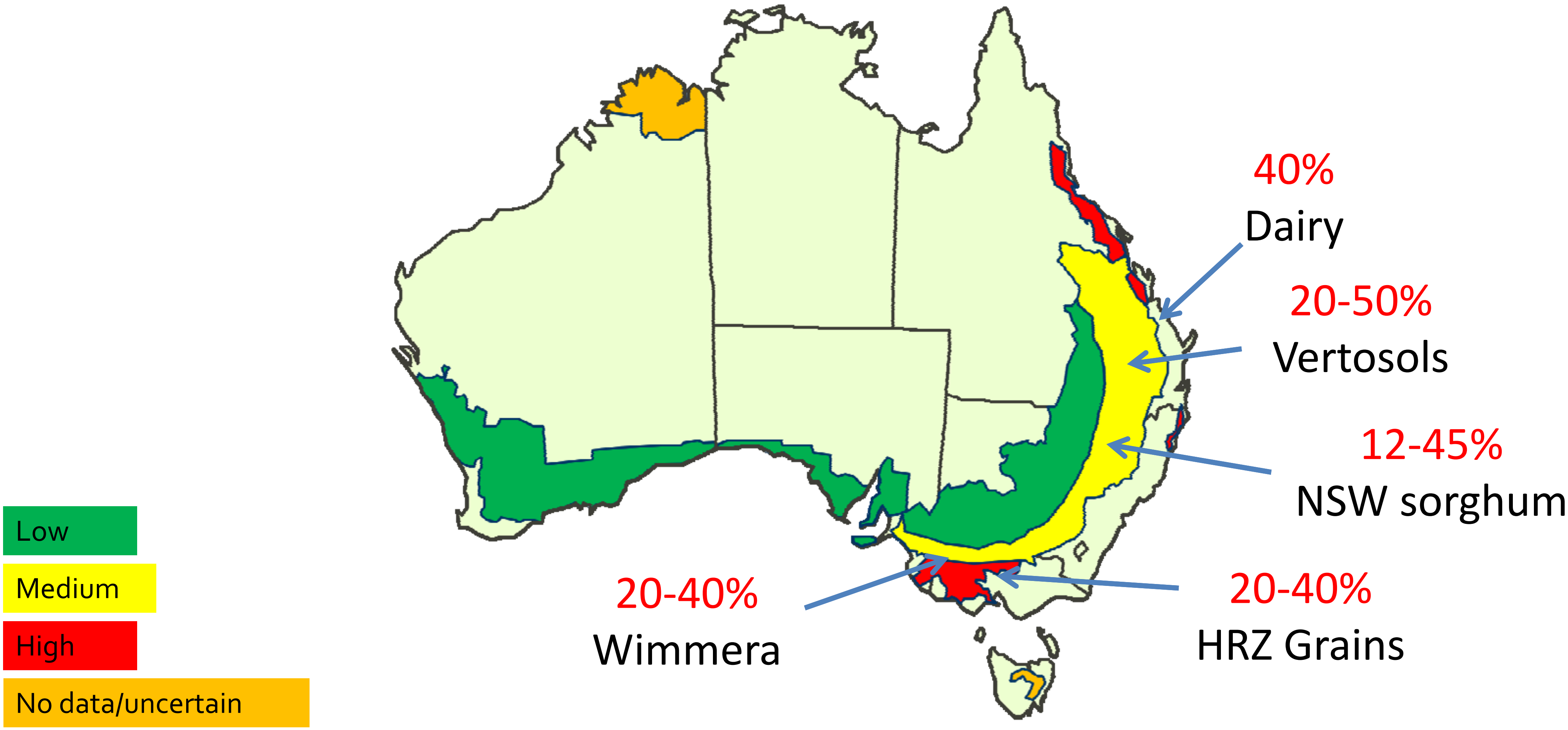
Saved 937, 000 t CO_2e

[a]Grace & Shcherbak (2015); [b] weighted EF - 81% low rainfall &19% high rainfall cropping; [c]based on irrigated cropping EF

NANORP NUE / N_2O Mitigation Strategies

- <u>N Fertiliser Management</u>
  - Rate
  - Timing
  - Placement
  - *Enhanced Efficiency Fertilisers (EEFs)*
    - *Polymer coated urea*
    - *Urease inhibitors*
    - *Nitrification inhibitors*
      - *DMPP*
      - *Nitrapyrin*
- <u>Rotations</u>

Nitrogen Use **Inefficiency** / ^{15}N Losses



Emissions Factors vs Enhanced Efficiency Fertilisers[1]

Land use	DMPP	DCD	nBTP	PCU	Nitrapyrin
Non-irrigated crop	28	0	6	5	1
Irrigated crop	1	0	0	0	0
Non-irrigated pasture	4	13	5	1	2
Irrigated pasture	4	2	2	1	0
Cotton	0	0	0	0	0
Sugar cane	5	0	0	4	0
Horticulture	4	0	0	0	2
Total # of treatments	46	15	13	11	5
Mean N rate	142	863	205	171	378
EF (%)	0.117	0.203	0.214	1.373	0.221
Standard Error	0.071	0.040	0.075	0.670	0.148

[1]Grace & Shcherbak (2015)

Emissions Factors vs Enhanced Efficiency Fertilisers[1]

Land use	Number	Mean N Rate	DMPP EF (%)	Regular EF (%)
Non-irrigated crop	28	96	0.163	0.2
--High-rainfall crop	18	112	0.181***	0.84
--Low-rainfall crop	10	66	0.131	0.06
Pasture	8	311	0.260*	0.3
Sugar cane	5	105	-0.089*	1.99
Horticulture	4	170	-0.269*	0.85

*statistical significance

[1]Grace & Shcherbak (2015)

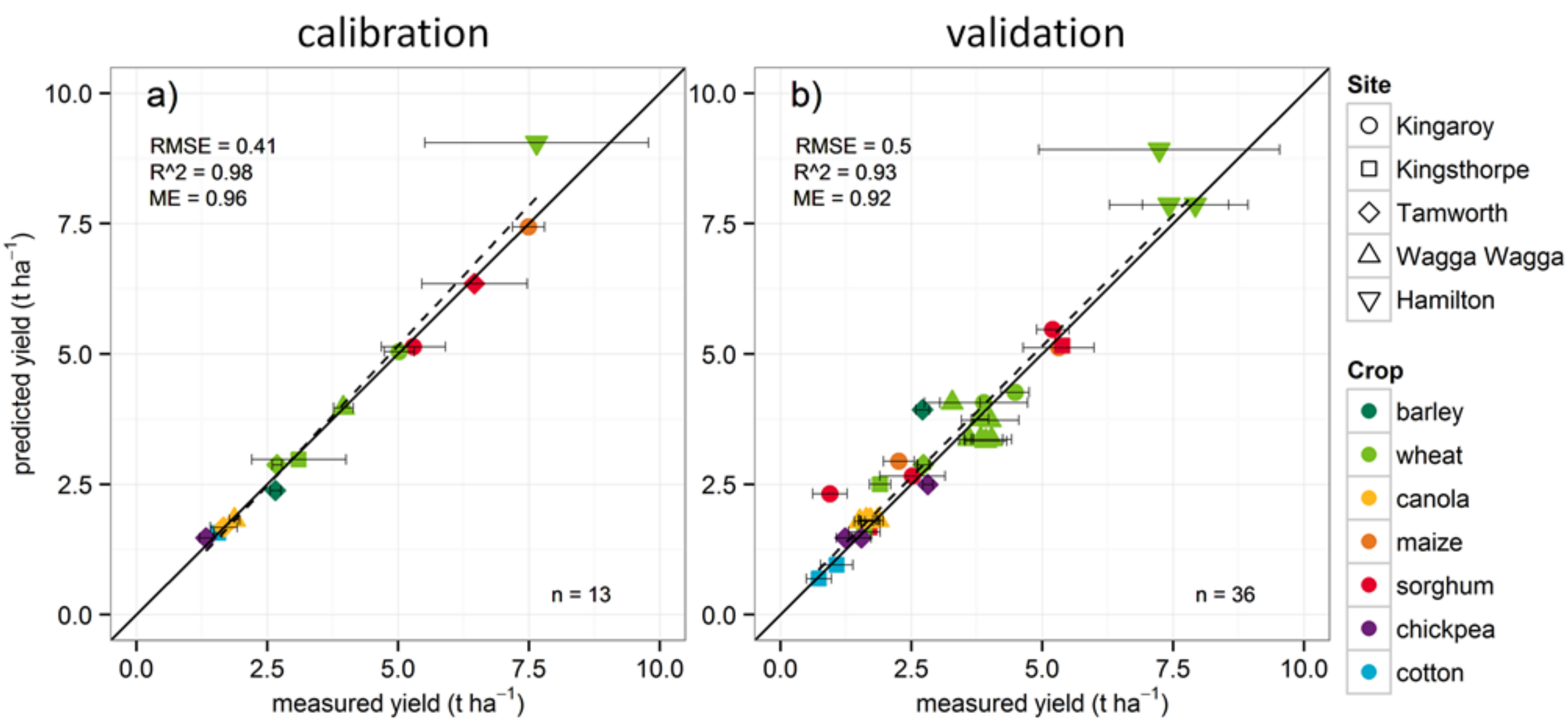
NANORP NUE / N_2O Mitigation Strategies / Simulation

- N Fertiliser Management
  - Rate
  - Timing
  - Placement
  - *Enhanced Efficiency Fertilisers (EEFs)*
    - *Polymer coated urea*
    - *Urease inhibitors*
    - *Nitrification inhibitors*
      - *DMPP*
      - *Nitrapyrin*
- Rotations

Response Curves for DSS/Methodology Development

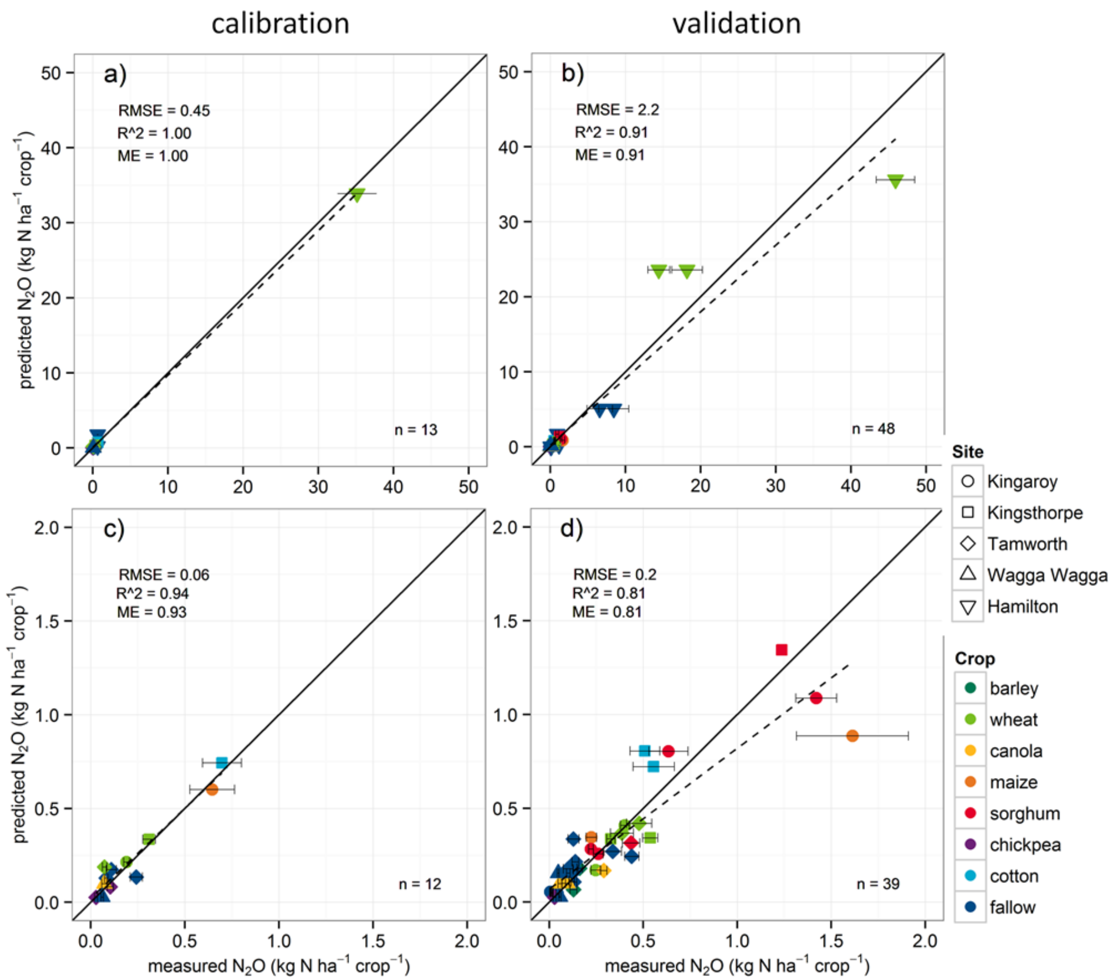
- APSIM
  - N management (including rotations) - Grains and sugar
- DayCent
  - N management - Dairy
  - EEFs - Grains, sugar and dairy

APSIM – Grain Yield - Calibration and Validation[1]



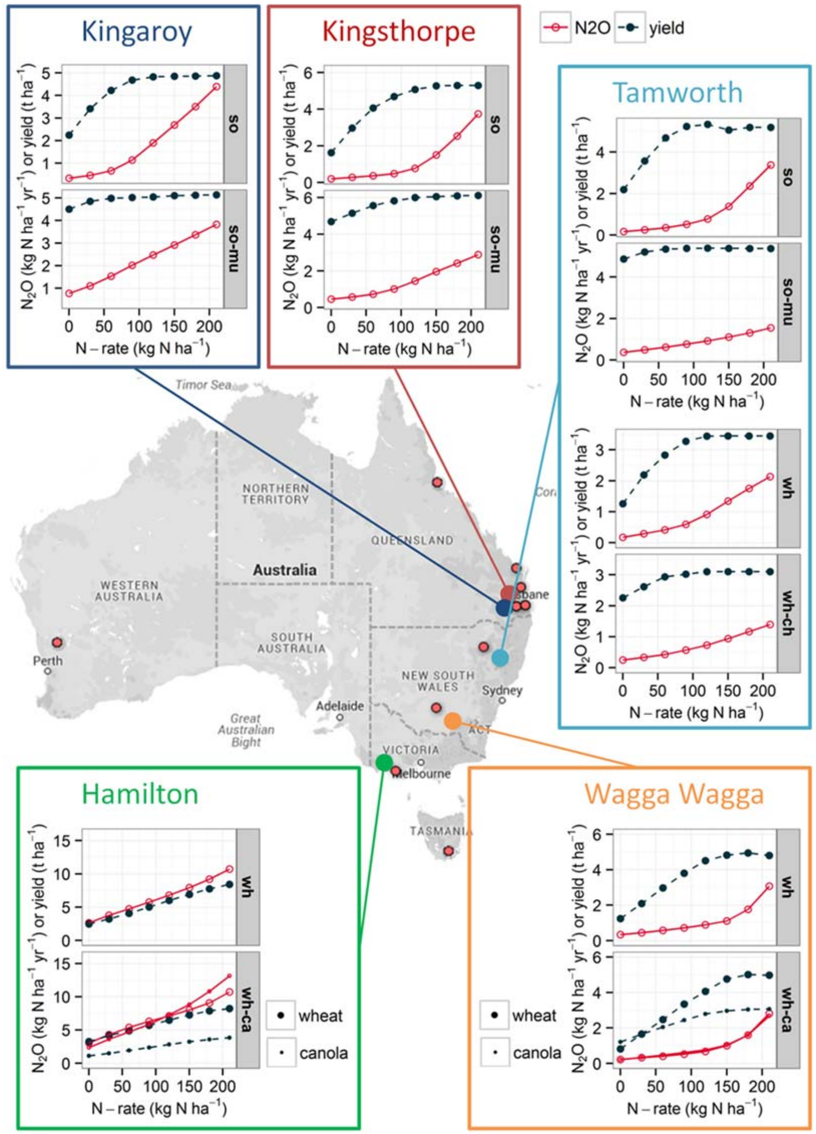
[1]Mielenz, Thorburn et al. (2016), Soil Research v54

APSIM – N_2O Emissions - Calibration and Validation[1]



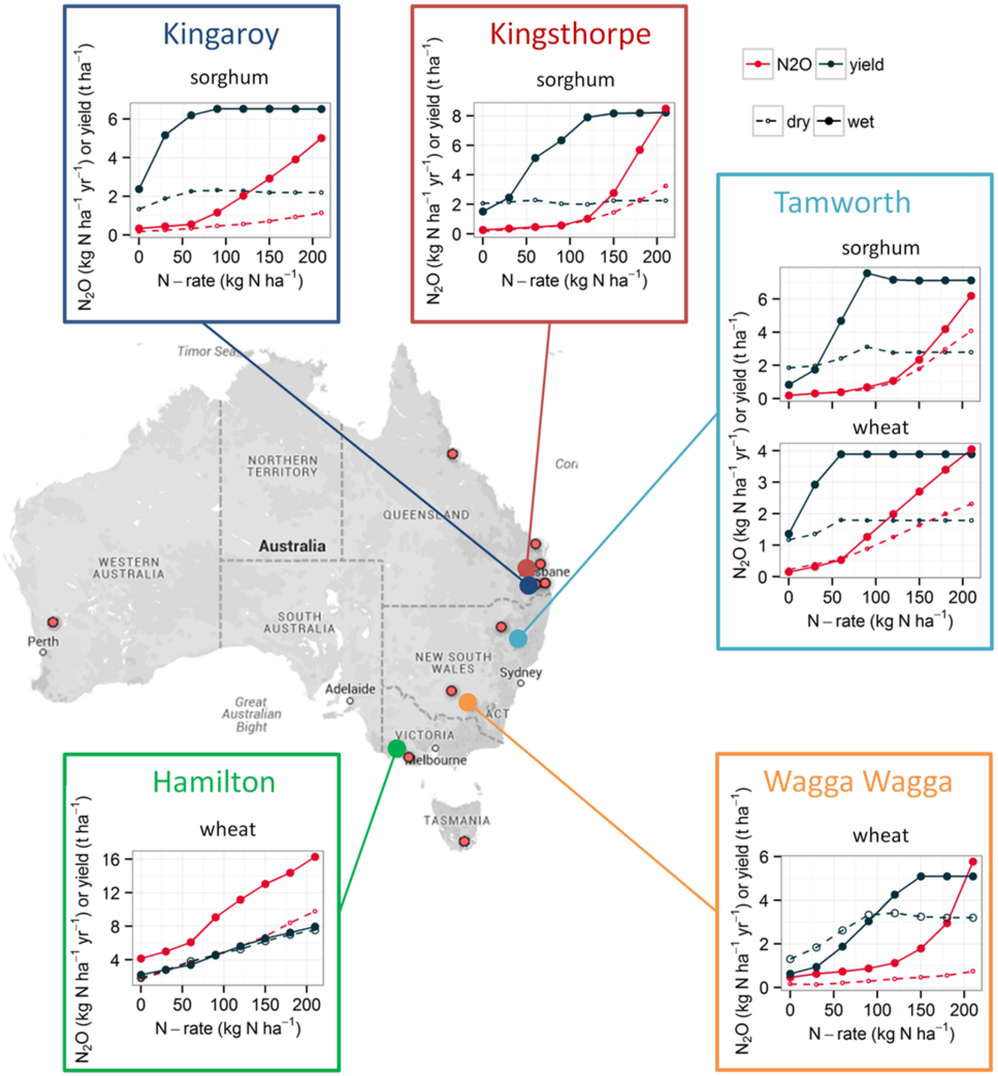
[1]Mielenz, Thorburn et al. (2016), Soil Research v 54

Grains industry: N_2O vs Yield (APSIM)[1]



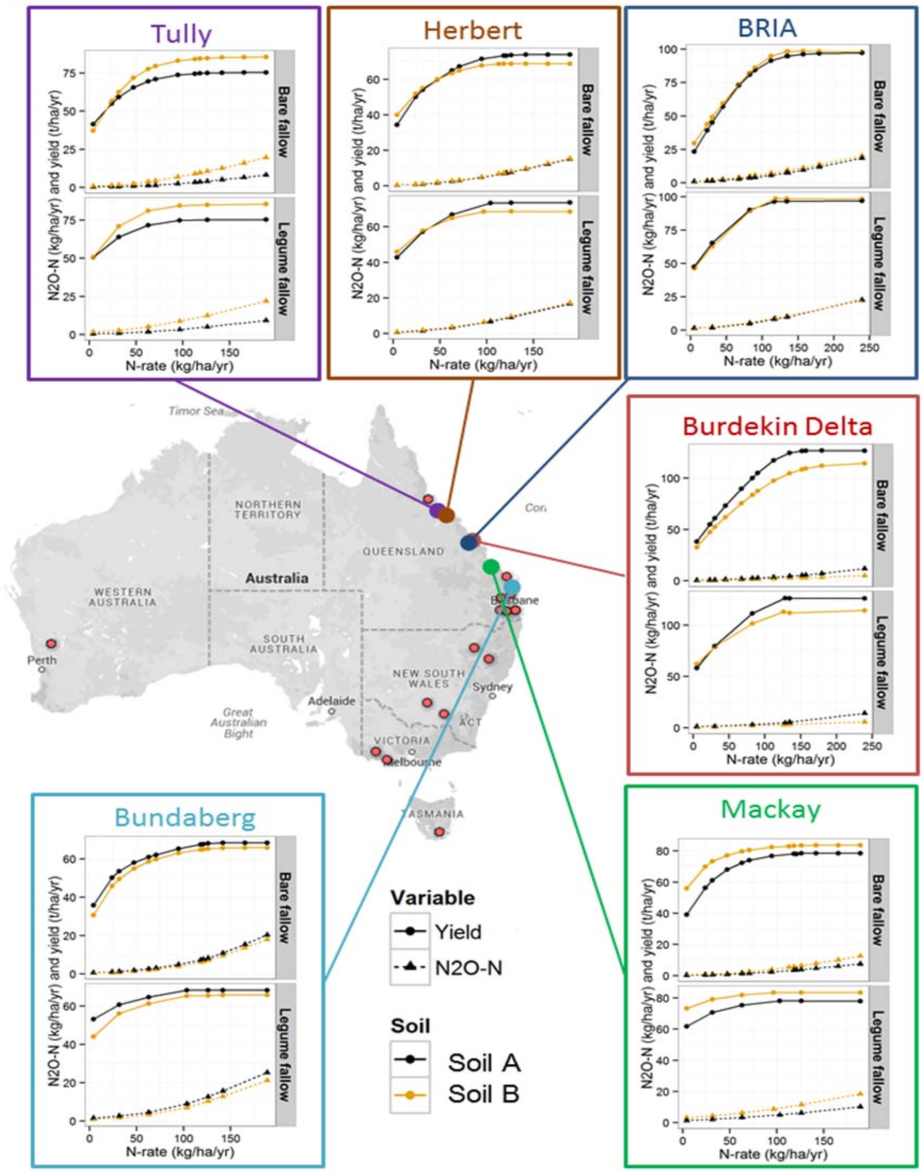
[1]Mielenz, Thorburn et al. (2016), Soil Research v54

Grains industry: N_2O vs Yield (APSIM)[1] Wet vs Dry year



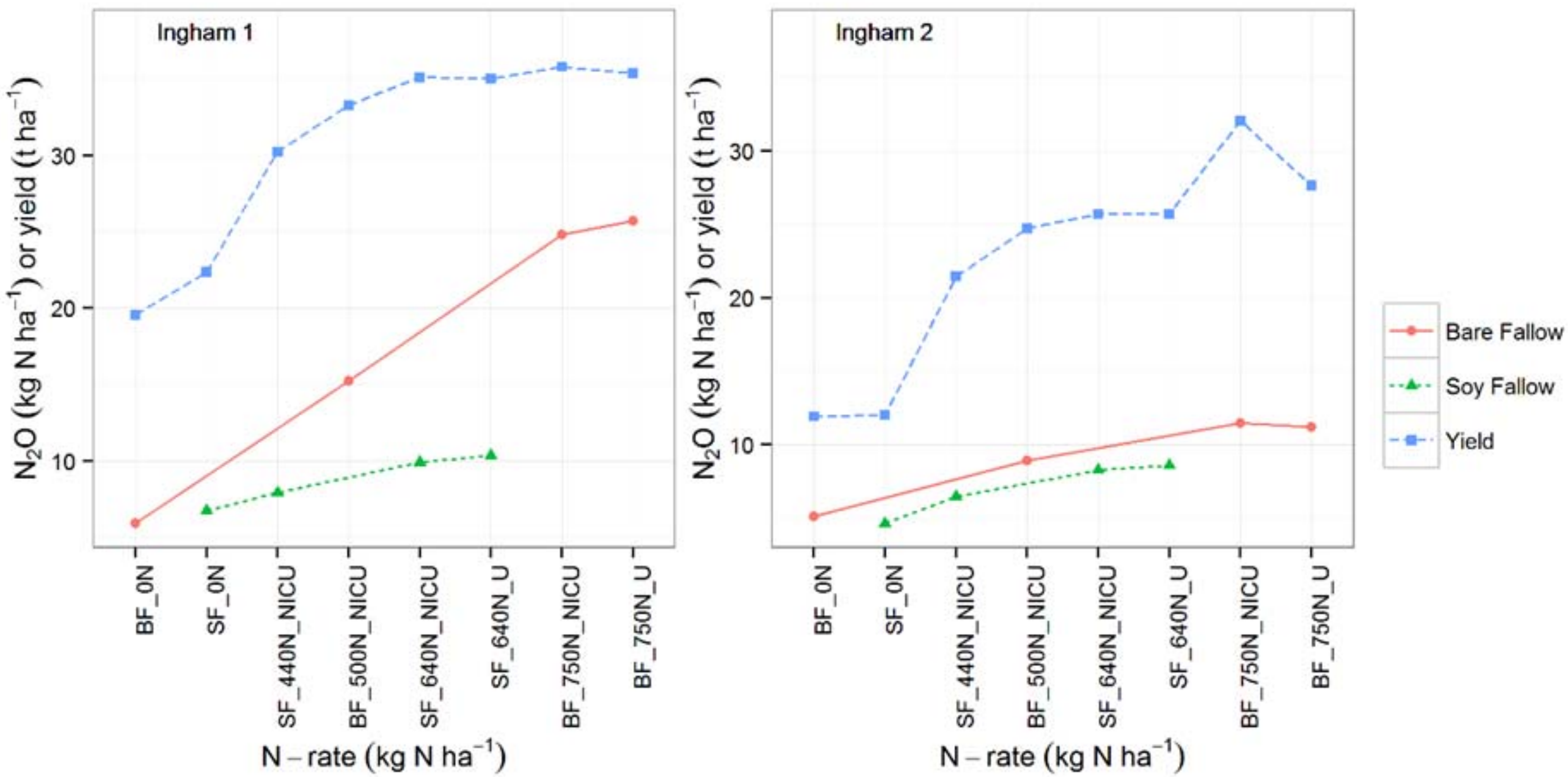
[1]Mielenz, Thorburn et al. (2016), Soil Research v54

Sugar industry: N_2O vs Yield (APSIM)[1]



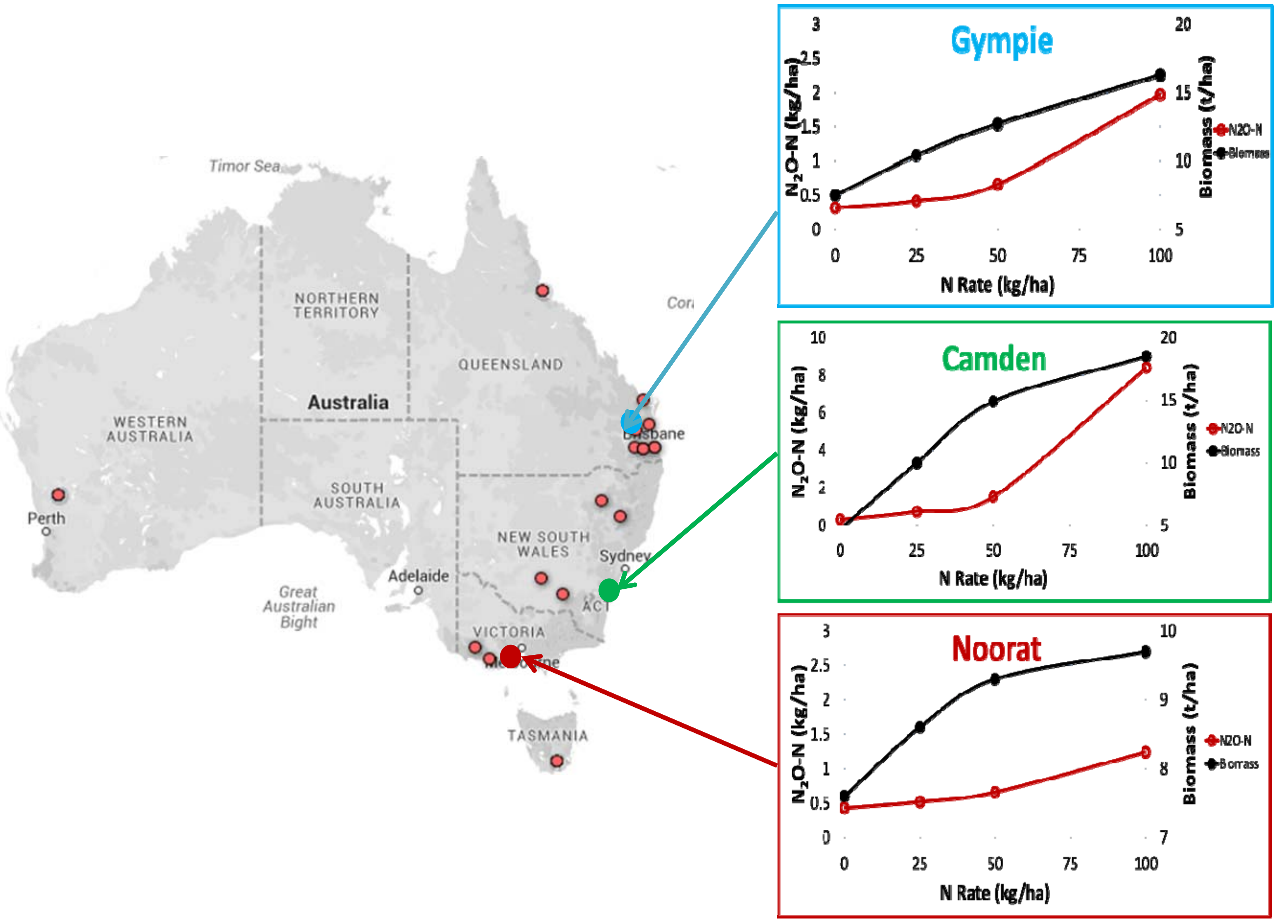
[1]Biggs et al. (unpublished)

Sugar industry: EEFs & Fallow vs N_2O & Yield (DayCent)[1]



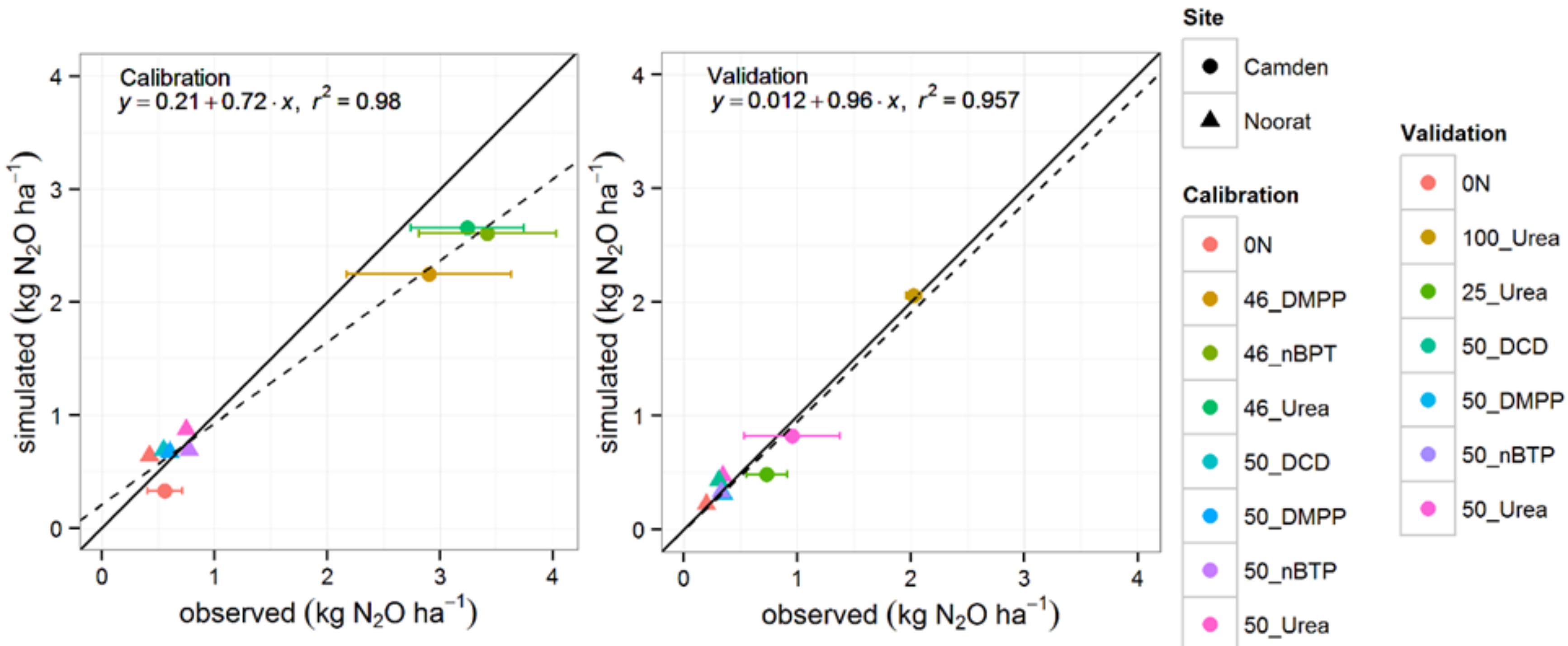
[1]Massimilano et al. (unpublished)

Dairy industry: N_2O vs Yield (DayCent)[1]



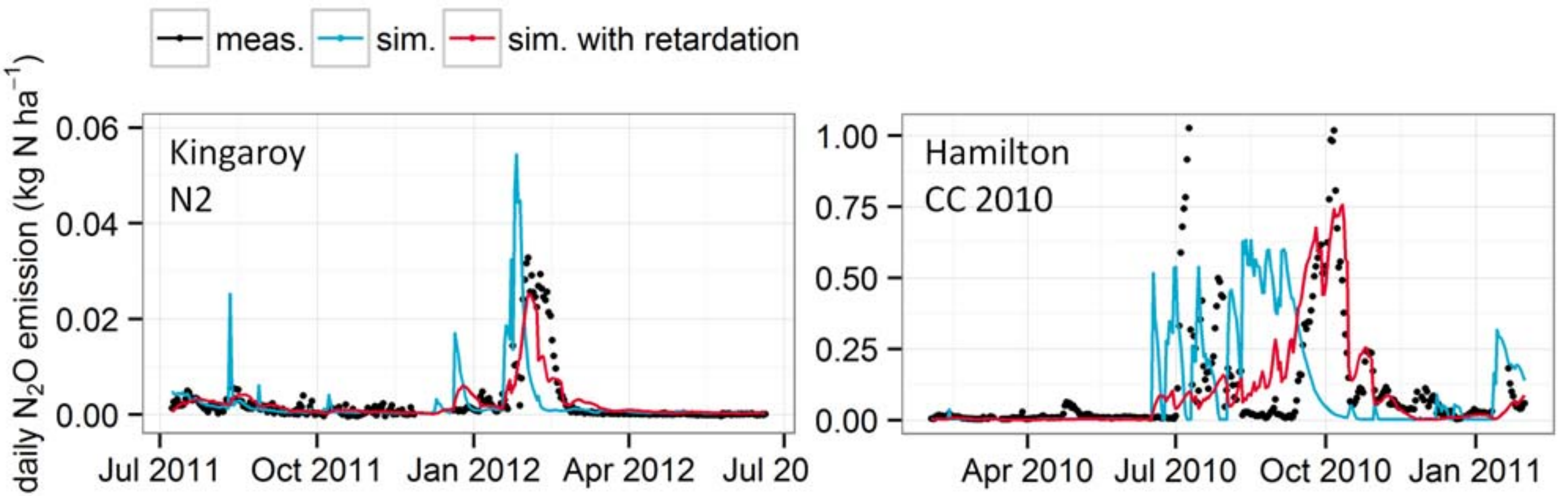
[1]Massimilano et al. (unpublished)

Dairy industry: EEFs vs N_2O (DayCent)[1]



[1]Massimilano et al. (unpublished)

APSIM – Gaseous Diffusion[1]



[1]Mielenz, Thorburn et al. (2017) EJA v32

NANORP Cost-benefit

Region/Industry	Area (1000 ha)	NUE Strategy	Benefit[1] $M	N_2O savings (1000 t CO_2e)	C credit[2] $1000
NGGI				937	13,118

[1]100% adoption; [2]$14/ tCO_2e

NANORP Cost-benefit per annum

Region/Industry	Area (1000 ha)	NUE Strategy	Benefit[1] $M	N_2O savings (1000 t CO_2e)	C credit[2] $1000
NGGI				937	13,118
Vic HRZ	150	< 25-50 kg N	5.6	22.1	309
Northern sorghum	750	< 8 kg N	6	23.6	330
Northern + legume	750	< 30 kg N	22.5		
Wimmera	350	+ 50 kg N	75	4	57
SMDB	20	Smaller irrigations		40.2	564
High rainfall grain		DMPP		356	5,000
Sugar		DMPP		485	6,800
Sub-tropical dairy	30	DMPP < 80 kg N	4.5		
			$113.6M	931	$13.1M

[1]100% adoption; [2]$14/ tCO_2e

Outputs

- 234 new datasets from 54 studies
- 66 multiple datasets in n2o.net.au
- 30 journal papers (excluding 20 additional papers in special issue of Soil Research)
- 76 Conference proceedings
- 37 Fact sheets
- 58 Field days

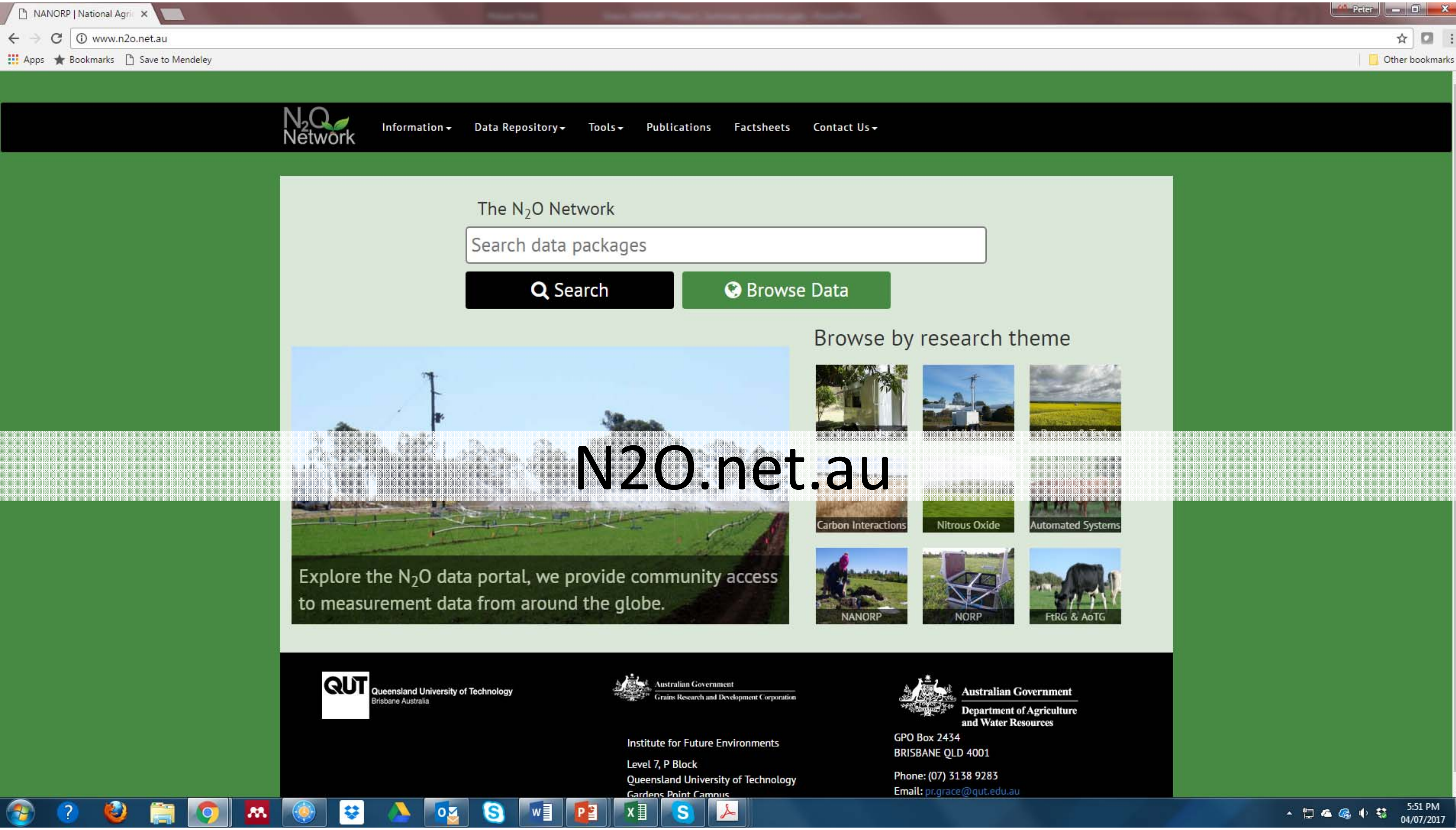
Key Findings

- Emissions Factors in NGGI Revised. **National Tier 2 EF = 0.37%**
- Fertiliser induced N_2O emissions **reduced by 937,000 t CO_2e**
- NUE continues to be low @ **40% lost** = **$400M/annum**
- Response curves for optimising N management now available for grains, sugar and dairy industries
- DMPP consistently reduces N_2O by 79% in high rainfall grains
- DMPP no consistent yield response to offset cost
- Seasonal N_2/N_2O = 40/1

Future Research Needs

- Translation of N response curves into viable ERF Methodologies
- Cost effective EFFs
- CH_4 uptake potentially offsets N_2O in coarse textured semi-arid soils
- Dynamic prediction of the N_2/N_2O ratio, NH_3 loss and EEFs
- Modelling the gaseous diffusion of N_2O
- Decision support

N2O.net.au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Explore the N2O data portal, we provide community access to measurement data from around the globe.
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04/07/2017

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