



Does Nitrogen Fertilizer Run Down Soil Organic Matter?

Rob Norton
Regional Director, ANZ
International Plant Nutrition Institute.

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Kingaroy, Dubbo, Bendigo, Adelaide

Carbon Speak

- Soil carbon concentration
 - percentage C of soil (%g/g) (eg 1% OC)

- Soil organic matter

- percentage of organic matter of soil
- Organic matter is about 58% C (eg 1% OC = 1.72% OM)

- Soil C stocks

**1.10% OC to 1.35% OC = + 3.3 t C/ha
(~\$7?)**

- quantity of C in the soil
- Percentage of C multiplied by the soil bulk density and depth
- eg 1% OC in top 10 cm of soil with 1.3 bulk density = 13 t C /ha

- Soil C for C trading (eCO₂) – *Global Warming Potential*

- eCO₂ is the unit traded / discussed in C markets.
- CO₂ is 27% C – so 13 t C/ha = 48 t eCO₂/ha



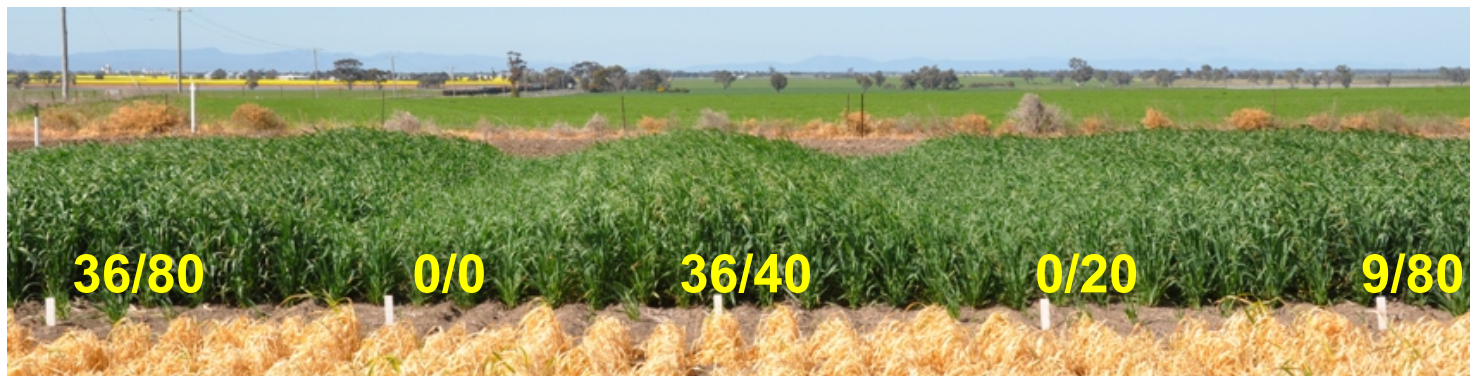
\$2.30/t
C



\$10/t
eCO₂

Soils 101

- When fertilisers are added
 - If nutrients are limiting plants grow better
 - Dead plants rot to organic matter
 - Soil organic matter increase/constant/decrease



Why is this being discussed?

Synthetic Nitrogen Fertilizers Deplete Soil Nitrogen: A Global Dilemma for Sustainable Cereal Production

R. L. Mulvaney,* S. A. Khan, and T. R. Ellsworth University of Illinois



- Suggest that N applications have resulted in a decline in soil organic N.
- Mechanism proposed that excess N stimulates microbes to break down OM faster than it could be produced or even supplied.
- Seen by several groups as evidence that “modern” agriculture is destroying the environment.

A 'New' Discovery – Soluble Nitrogen Destroys Soil Carbon

Compost, Economics, Fungi, News, Plant Systems, Society, Soil Biology, Soil Composition, Soil Conservation, Soil Rehabilitation, Structure — by Craig Mackintosh PRI Editor July 27, 2010

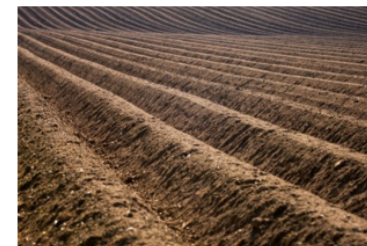
- Critiqued in other papers which indicated the effects were confounding changing rotations, cultivation and manuring meant no conclusions could be drawn.

(Grove et al, 2009, Better Crops)

New research: synthetic nitrogen destroys soil carbon, undermines soil health

By Tom Philpott

*“Fertilizer is good for the father and bad for the sons.”
—Dutch saying*

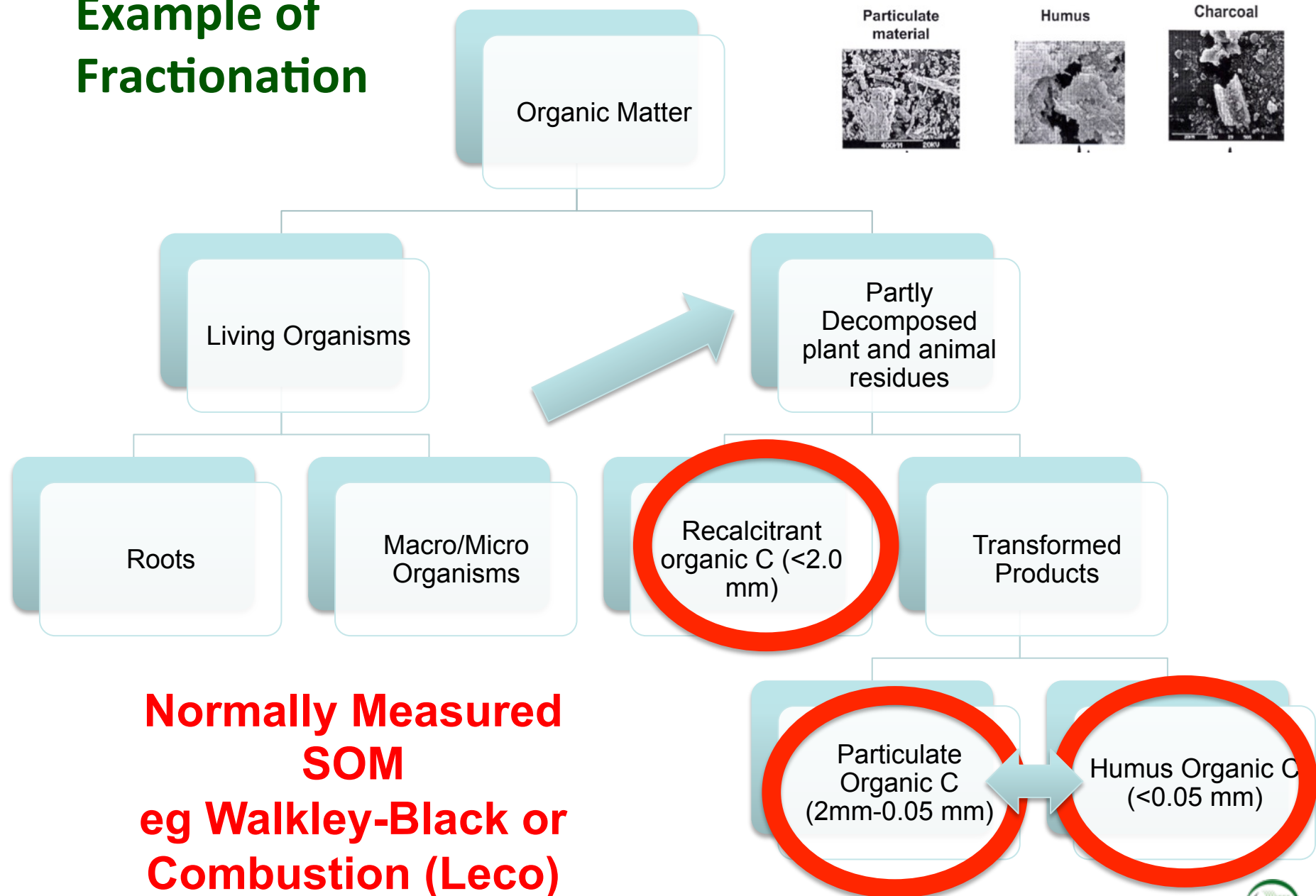


For all of its ecological

Just precisely what does all of that nitrogen fertilizer do to the soil?

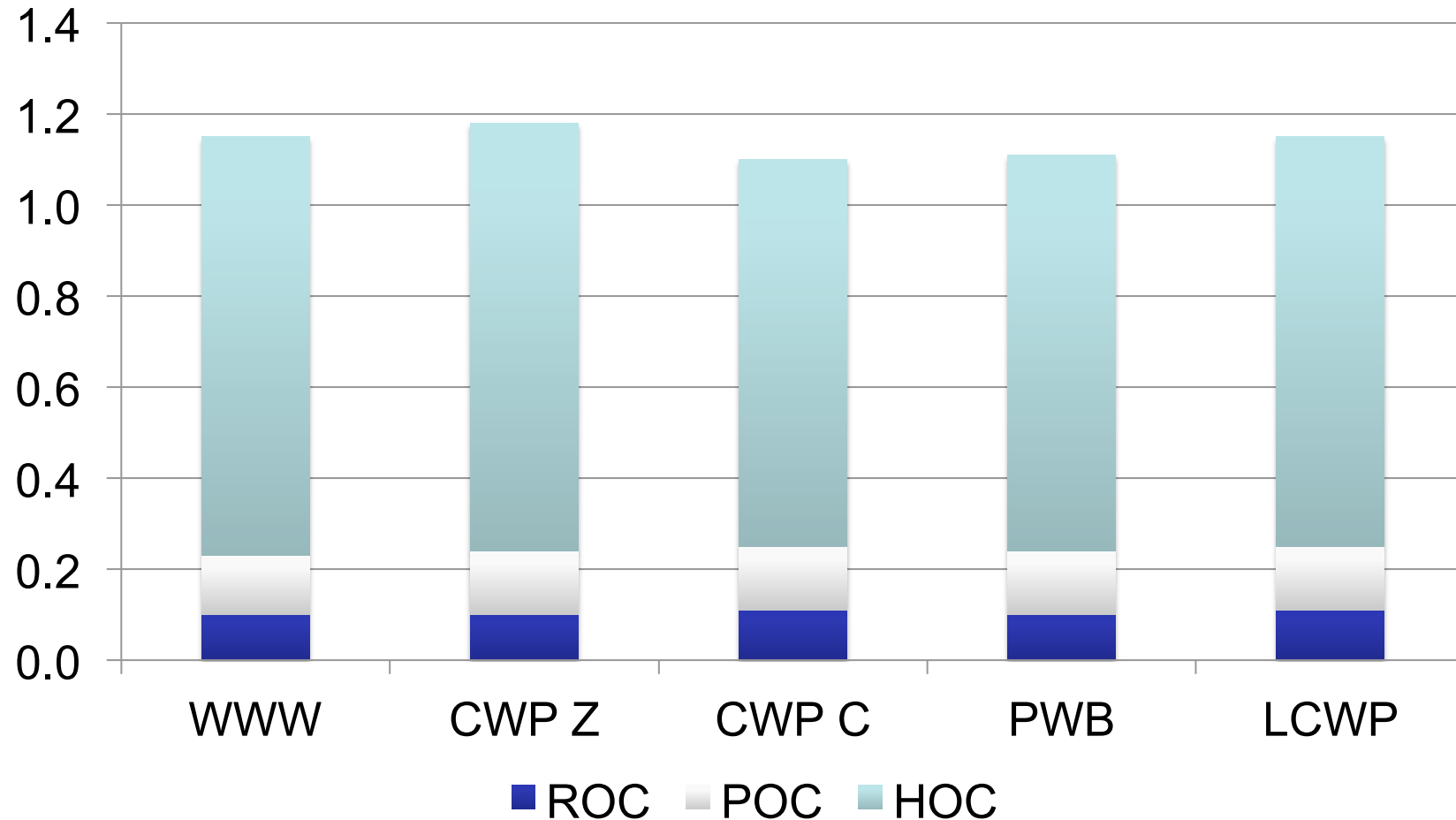


Example of Fractionation

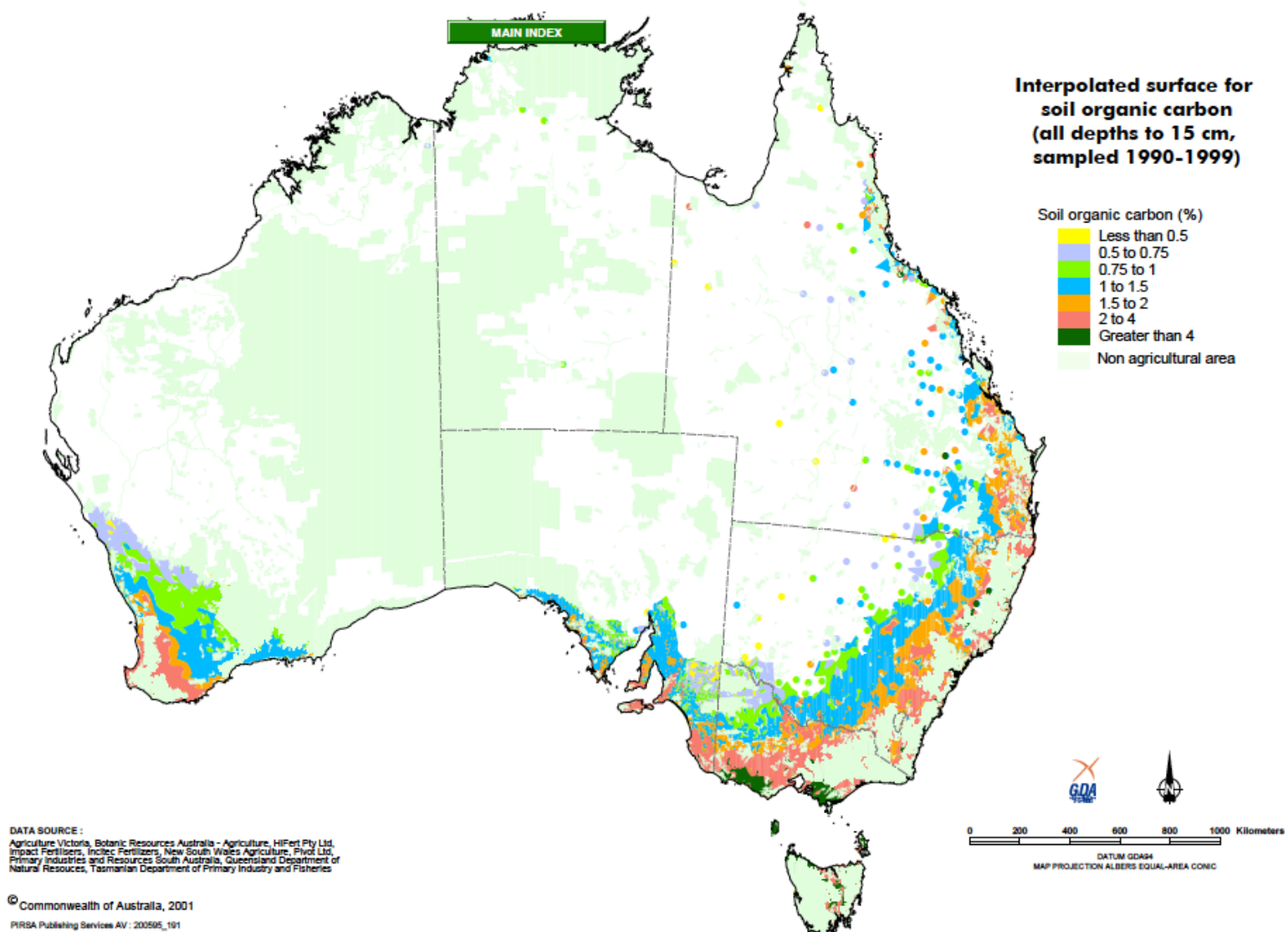


**Normally Measured
SOM
eg Walkley-Black or
Combustion (Leco)**

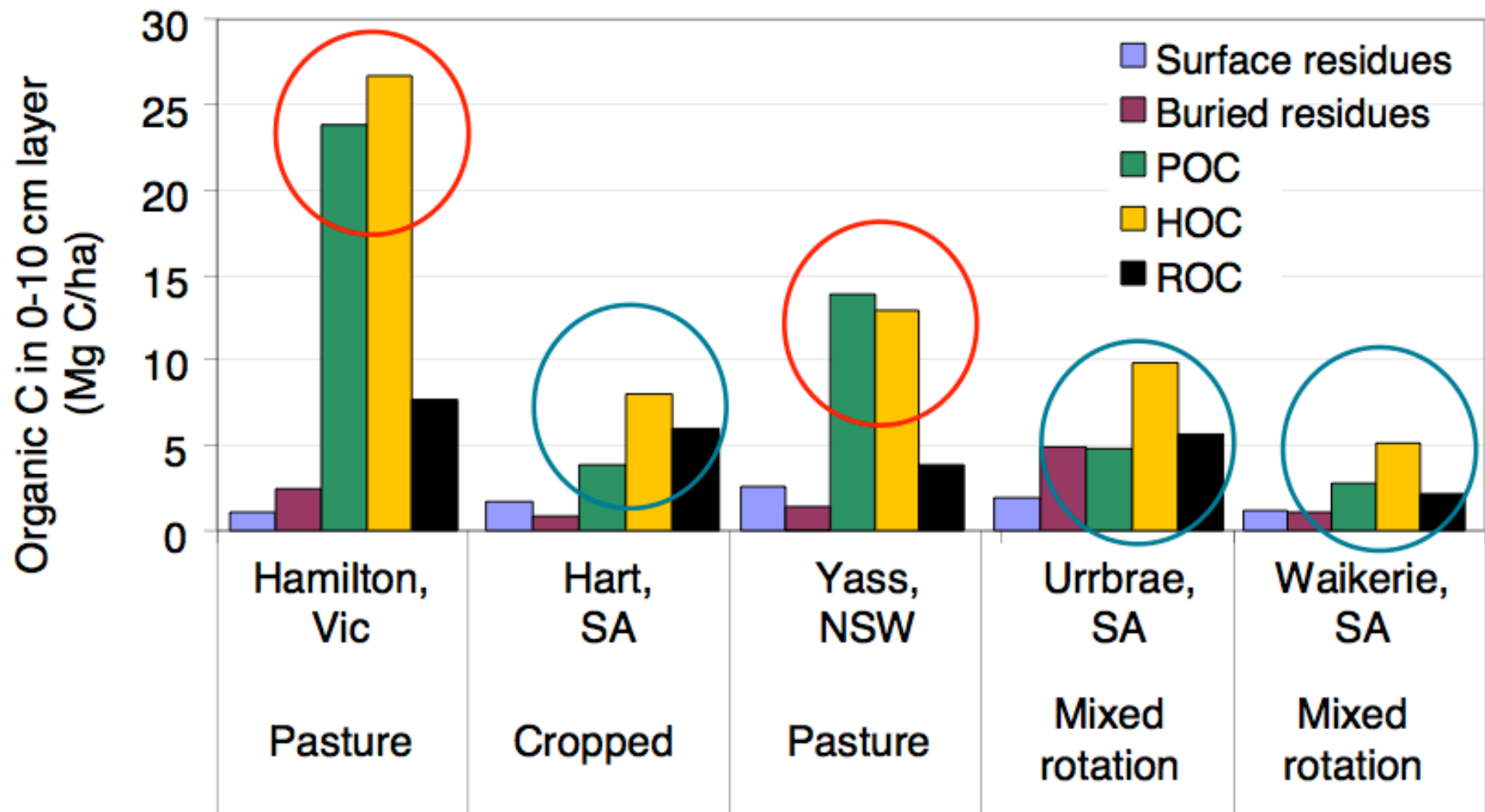
What is the relative importance fraction of OC?



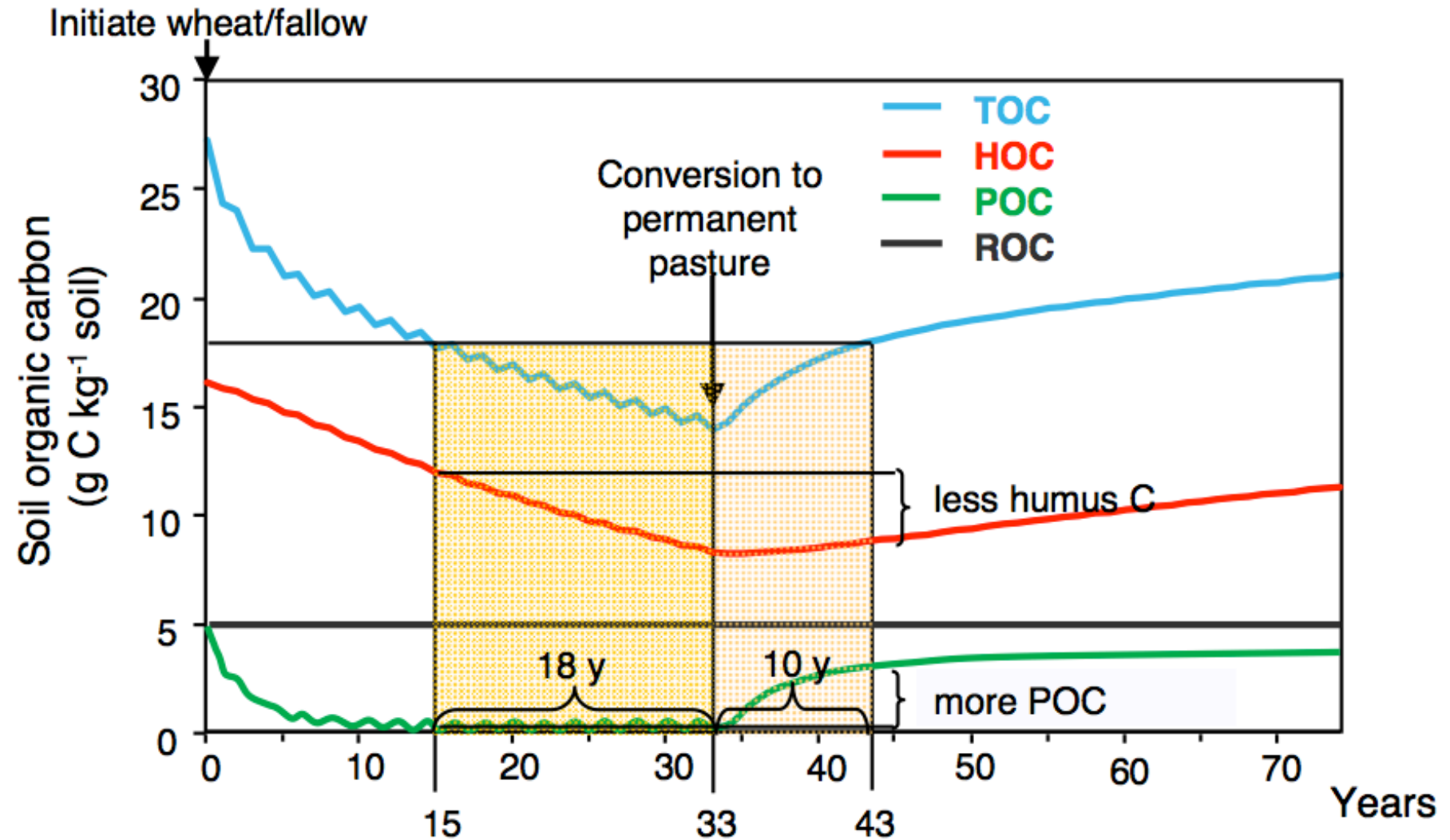
What determines Soil OC content?



Land use / location versus C stocks and fractions



The management impact on soil C?



Long term trial site – established 1996

- Four rates of P (TSP)
 - 0, 9, 18, 36
- Five rates of N (Urea)
 - 0, 20, 40, 80, 160
 - No N in legume phase
- N applied either
 - All at sowing/split 50:50
 - Now those plots with nil P since 2011
- Each year the site sown to a single crop.
- Soil samples, grain harvest, nutrient content.



Direct drilled,
zero cultivation,
stubble retained.

Average yields over time 1997-2012 - including nils

Average Grain Yield (t/ha)

N	0	9	18	36	
0	1.49	1.89	2.00	2.04	1.86
20	1.55	2.17	2.26	2.17	2.04
40	1.65	2.16	2.32	2.35	2.12
80	1.60	2.30	2.51	2.42	2.21
160	1.63	2.20	2.34	2.45	2.16
	1.58	2.14	2.29	2.29	

Does too much “burn” organic matter?

N	P	Mineral NO ₃ mg N/kg	Total Soil N %	Total Soil C %
1996 Values		9.6 ±0.7	0.096 ±0.008	1.14 ±0.18
0	0	12.5	0.098	1.08
0	18	15.7	0.113	1.23
80	0	13.2	0.108	1.10
80	18	25.2	0.133	1.37
160	0	13.0	0.122	1.10
160	18	20.0	0.127	1.33
LSD ($p=0.05$)		4.8	0.022	0.15

P also increased the OC level!

- Site more P limited.
- The increase in Total Soil N was due to P stimulating legumes and therefore N fixation.
- N fixation study on lentils in 2005

P Rate	Biomass	Yield	Nfixed kg/ha	kg/t
0	3.06	0.60	37.6	13
9	4.39	1.13	53.6	11
18	5.08	1.20	65.5	12
36	4.76	1.06	72.3	13
<i>LSD</i>	0.52	0.12	10.2	<i>ns</i>

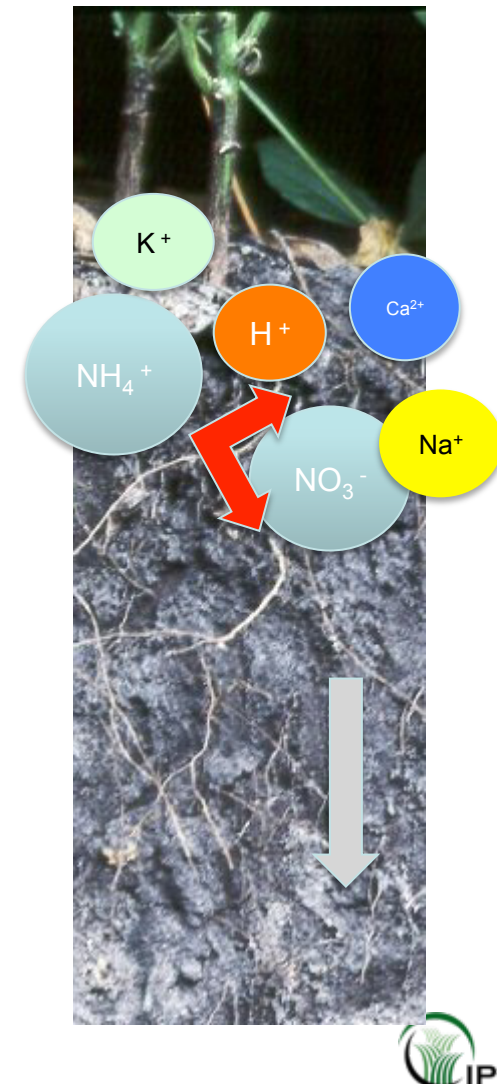
P	TSN%	%OC
0	0.108	1.089
9	0.116	1.249
18	0.124	1.330
36	0.125	1.290
<i>se</i>	0.003	0.027



How Nitrogen Affects Soil Acidity

- Nitrification - H^+ is released during the conversion of NH_4^+ to NO_3^-
- Leaching - NO_3^- carries basic ions with it. They are replaced by H^+
- Large Mineral N accumulation >60 cm.

N Rate	pH _{Ca}	Min N 60-150 cm (0P)	Min N 60-150 cm (18P)
0N	7.14	26	28
40N	7.12	-	
80N	6.97	301	70
160N	6.42	653	308
Isd	0.24	122	



What happens more generally?

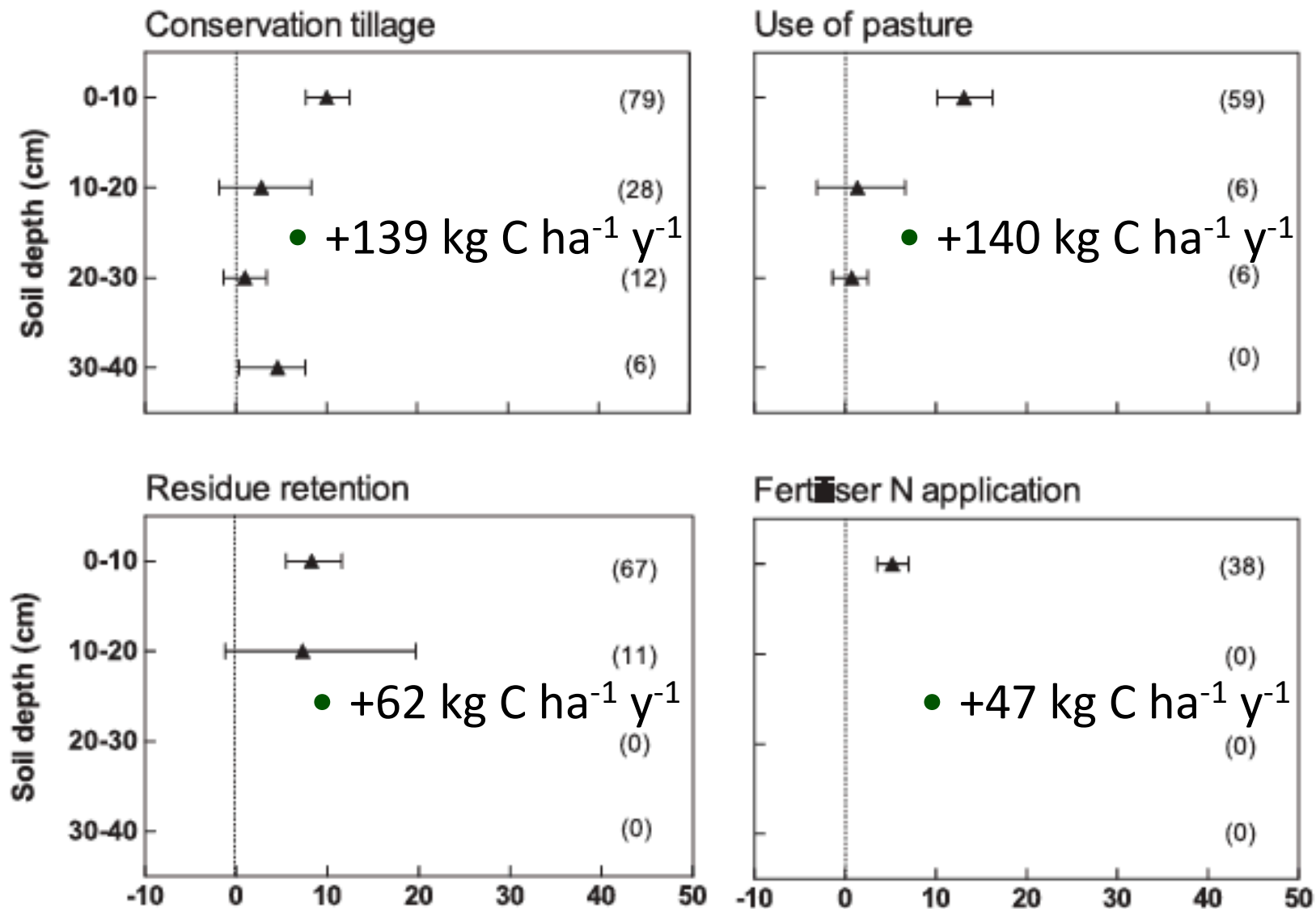
- Recent paper by SK Lam et al.
 - (Nature/Scientific Reports)
- Did a meta-analysis of the relative effects of management on soil C using Australian experimental data.
 - 56 Studies, 435 comparisons.



The potential for carbon sequestration in
Australian agricultural soils is technically
and economically limited

Shu Kee Lam, Deli Chen, Arvin R. Mosier & Richard Roush

Melbourne School of Land and Environment, The University of Melbourne, Victoria 3010, Australia.



Effect of improved management practice on soil C concentration (%)

**1700 kg
Carbon
Inputs**

~+250 kg C/ha/y

**Soil C content is a result of three
processes**
– capacity, rate of input & rate of
output

**Size of the Bucket
determined by the
soil and climate**

+ 0.25% in 16 years

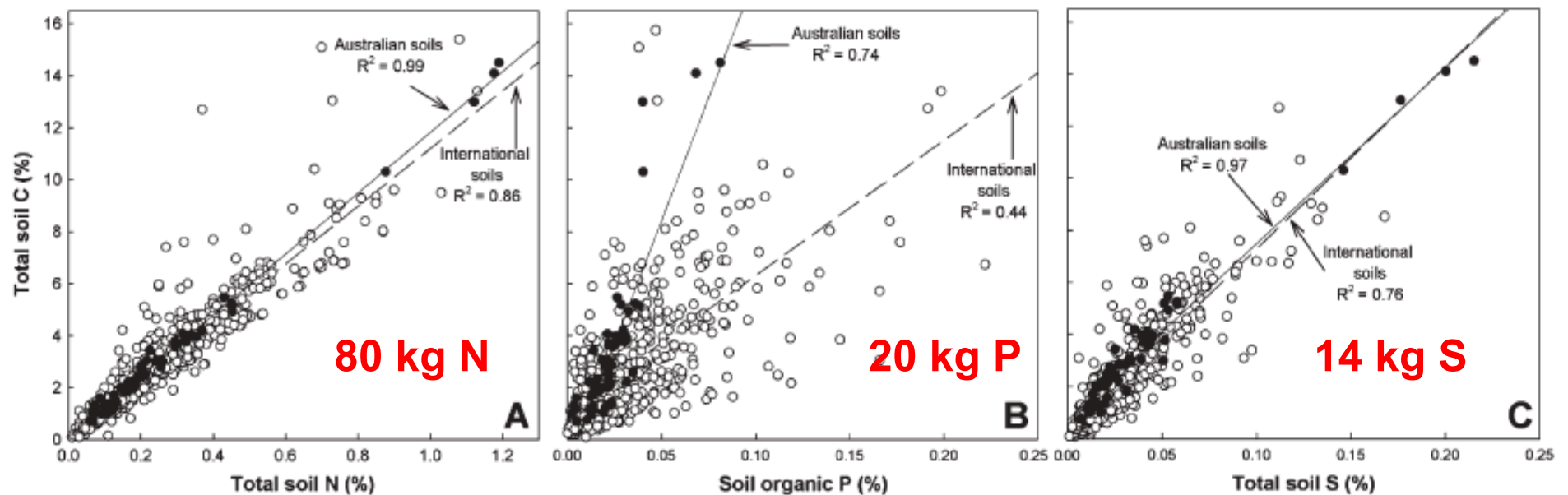
+200 kg C/ha/year

**2.2% OC in
“virgin soil”**

**1750 kg/ha/y
Carbon
Losses**

What else is in Organic Matter

- Discussed C – 58% OM = C
- Discussed N – N is about 1/10 of C C:N ratio ~ 10:1



- Add C needs N & P & S, loose C releases N & P & S

Summary

- Nitrogen does not run down soil organic matter
- Organic matter is more than C and N, and it is diverse
- The amount of OC in a soil is a result of balance between input and outputs
- Better crop growth promotes increased input of C (recycled N and P and S).
- The best way to build soil C is to grow good crops with zero tillage and stubble retention.