



Department of  
Primary Industries



Charles Sturt  
University

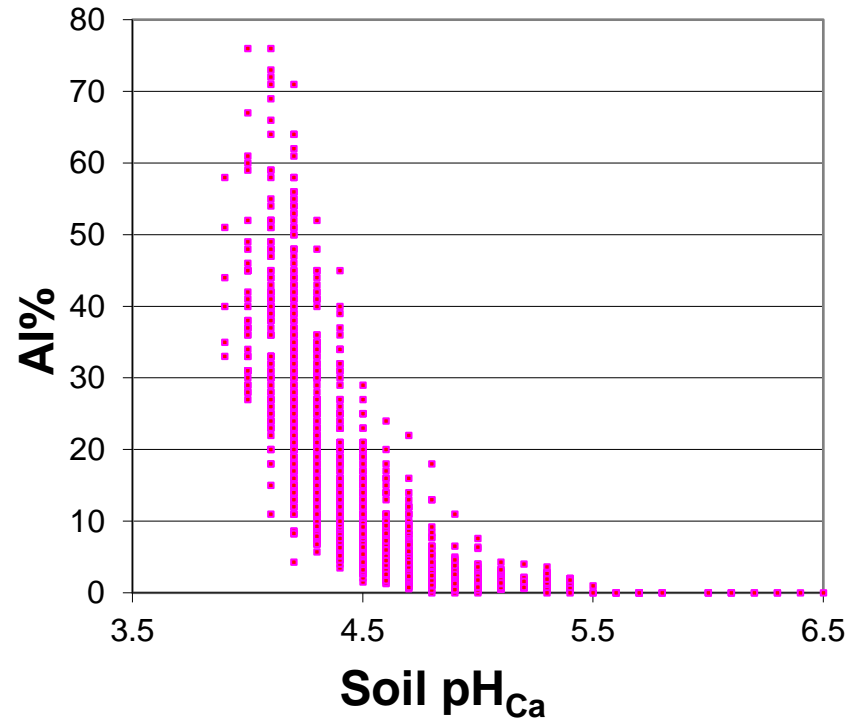
# Future proofing agricultural production through effective management of soil acidity

Dr Jason Condon and Helen Burns  
NSW DPI- Wagga Wagga

# Acidity

Affects plant growth

Aluminium toxicity



Source: Karl Andersson

# Acidity

Affects plant growth

Aluminium toxicity

Root growth decreased

Nodulation decreases



# Acidity

Affects plant growth

Aluminium toxicity

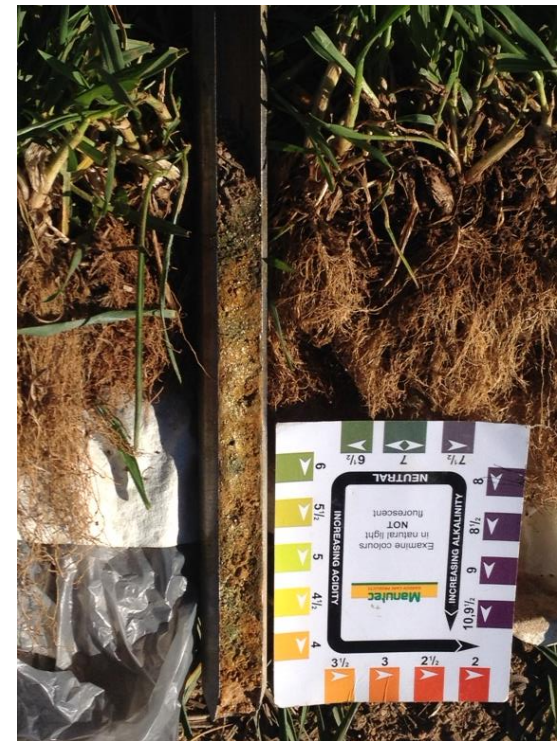
Root growth decreased

Nodulation decreases

Magnesium and calcium can move down profile

Phosphate binds with aluminium = decreased P for plants

Plants susceptible to attack (pest and disease)

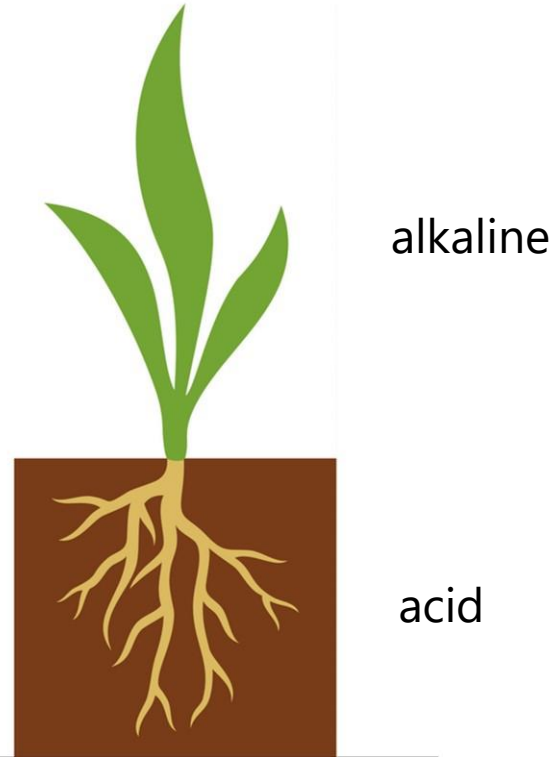


# Productive agriculture is acidifying

Product removal:

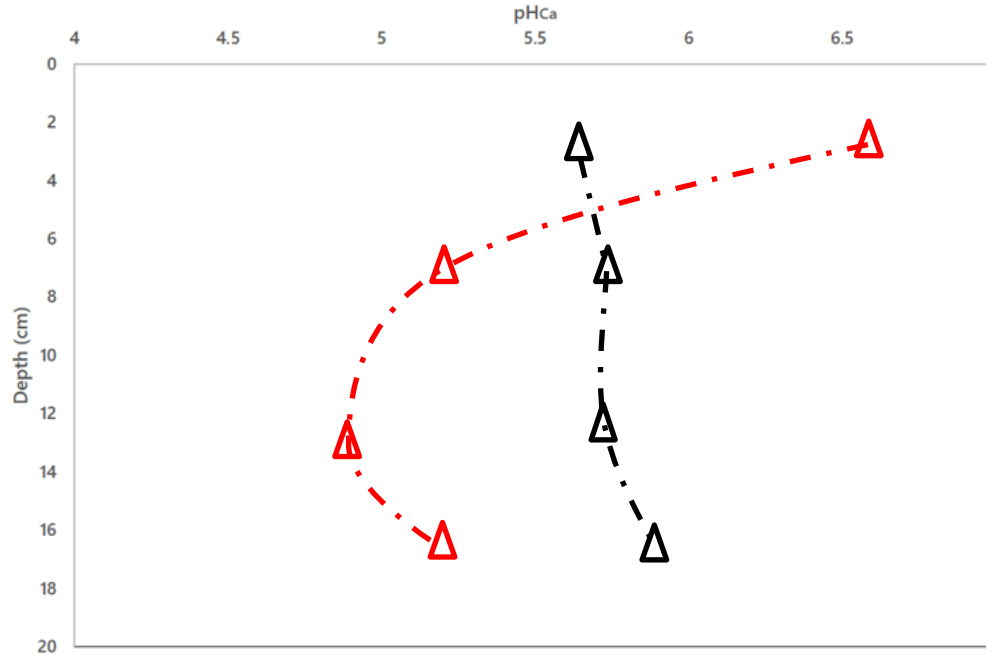
Nitrogen inputs:

Urea, ammonium, legumes



# Productive agriculture is acidifying: paired 'paddocks'

**CEC ~ 10**



## **Black triangle:**

Undisturbed native pasture  
- cemetery

## **Red triangle:**

Highly productive  
crop/legume-based pasture  
rotation.

Lucerne hay cuts

Yields up to:

7.5 t/ha wheat

2.8 t/ha canola

2.8 t/ha lupins

3 lime applications

@ 2.5t/ha

1994, 2003, 2018

Source: Helen Burns

# Building soil C

3 Long term trials

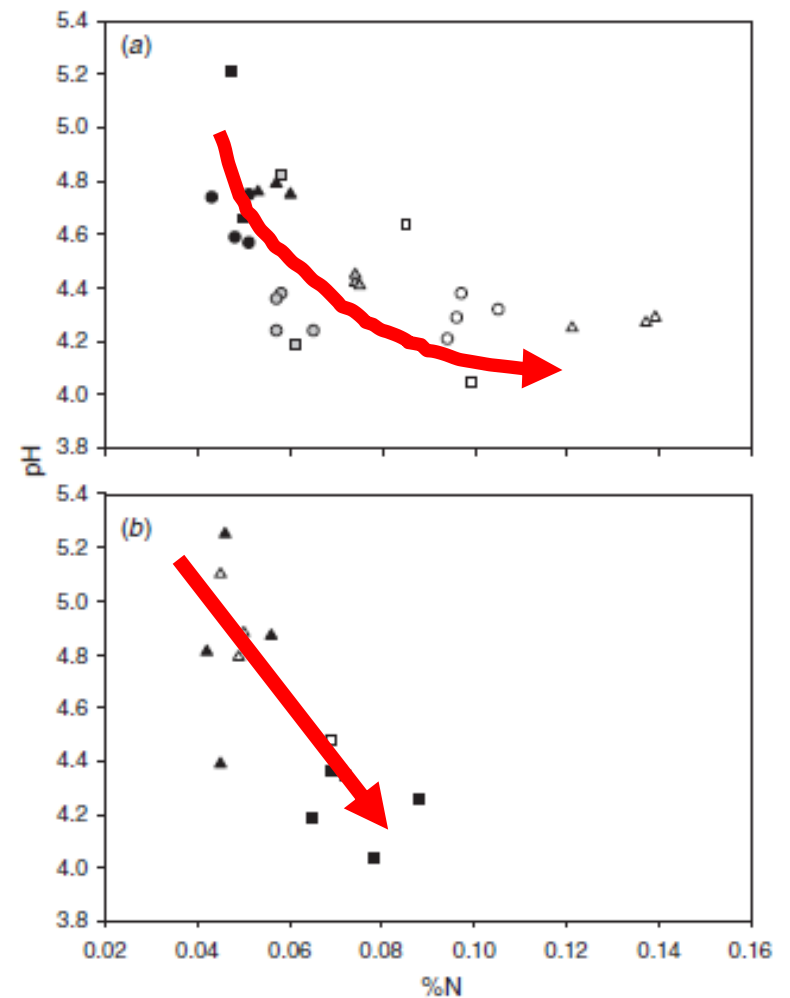
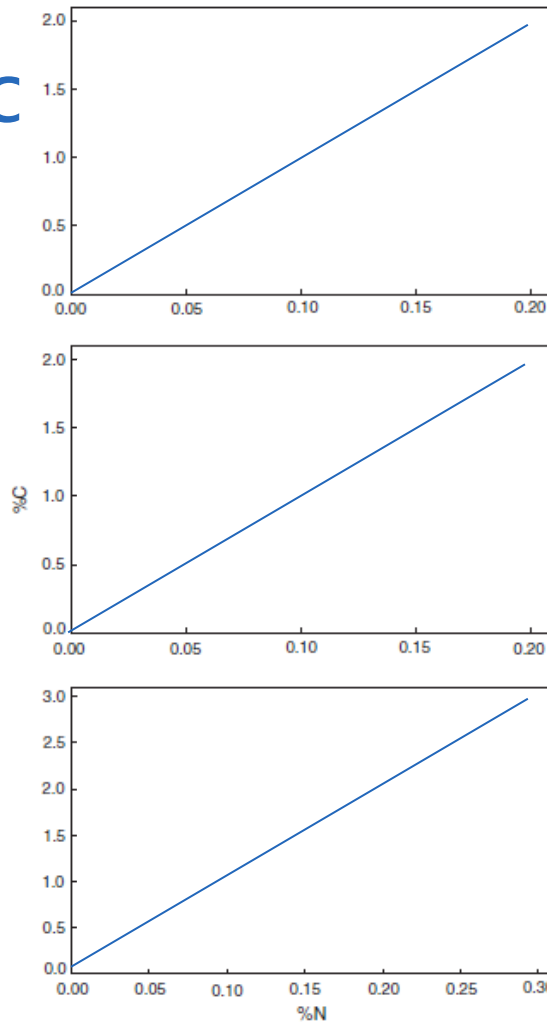
Different rotations

C and N linked

N and pH linked

Building Soil C,  
acidity is a cost

Conyers et al. 2012

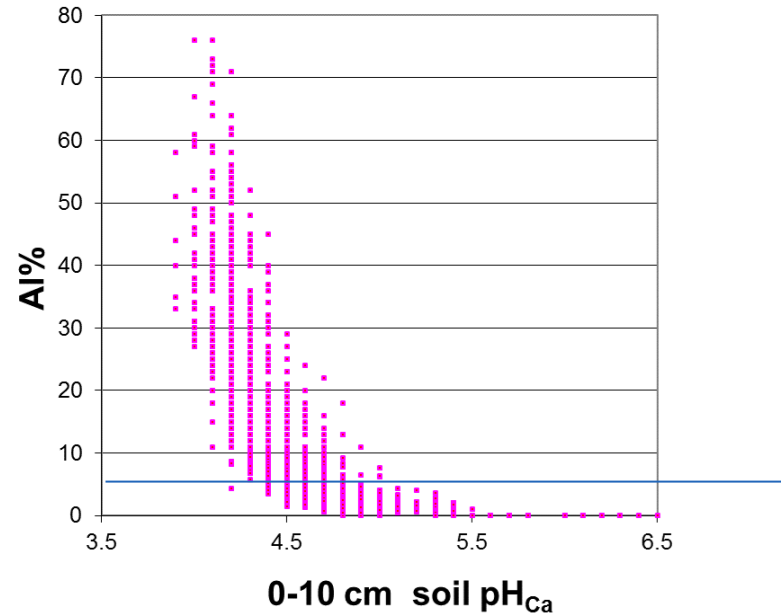


# Current management of acidity

Sample for pH 0-10cm (maybe 10-20 cm)

Apply lime when pH is below  $\text{pH}_{\text{Ca}}$  4.8

Apply enough lime to bring  $\text{pH}_{\text{Ca}}$  just above 5 (remove  $\text{Al}^{3+}$ )



# Current management of acidity

Rate of lime = “rule of thumb”      “2.5 t/ha every 10 years”

or Agfact table (Upjohn et al. 2005)

Soil test ECEC (meq/100 g)	Lime required (t/ha) to lift the pH of the top 10 cm:			
	from 4.0 to 5.2	from 4.3 to 5.2	from 4.7 to 5.2	from 5.2 to 5.5
1	1.6	0.8*	0.3*	0.2*
2	2.4	1.2	0.5*	0.4*
3	3.5	1.7	0.7	0.5*
4	3.9	2.1	0.9	0.6
5	4.7	2.5	1.1	0.7
6	5.5	3.0	1.2	0.8
7	6.3	3.3	1.4	1.0
8	7.1	3.8	1.6	1.1
9	7.9	4.2	1.8	1.2
10	8.7	4.6	1.9	1.3
15	12.5	6.7	2.8	1.9

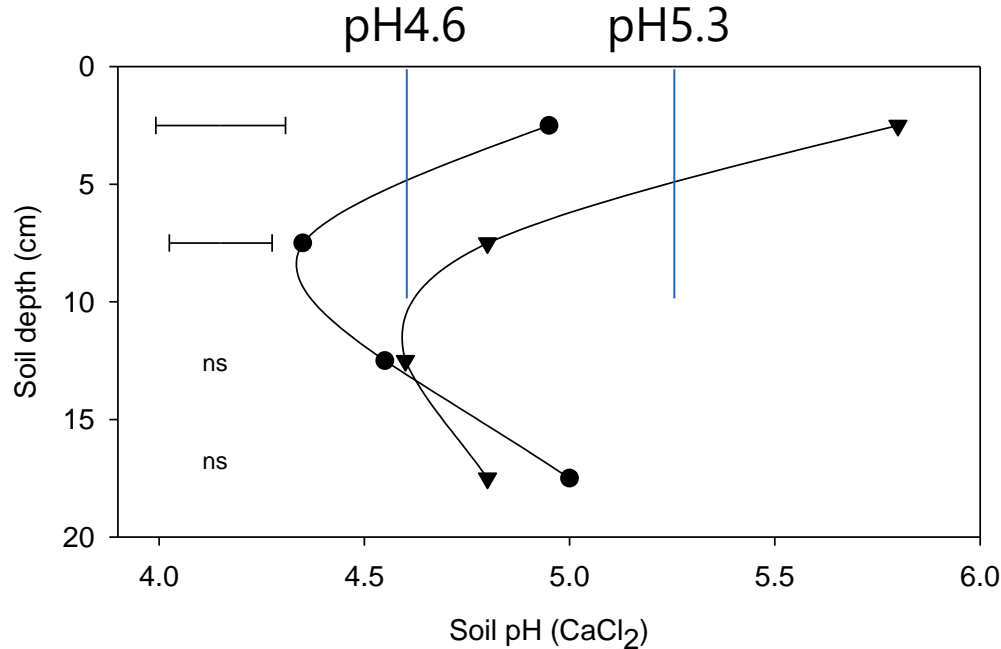
\*It is recognised that low rates of lime are impractical to apply, but over-liming can cause nutrient imbalances, particularly in these light soils.

KEY: Limestone rates per hectare

0.5 t/ha	1.0 t/ha	1.5 t/ha	2.0 t/ha	2.5 t/ha	3 to 4 t/ha	Split applications advised
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# Current management of acidity

Outcome?



No pH impact below 10cm

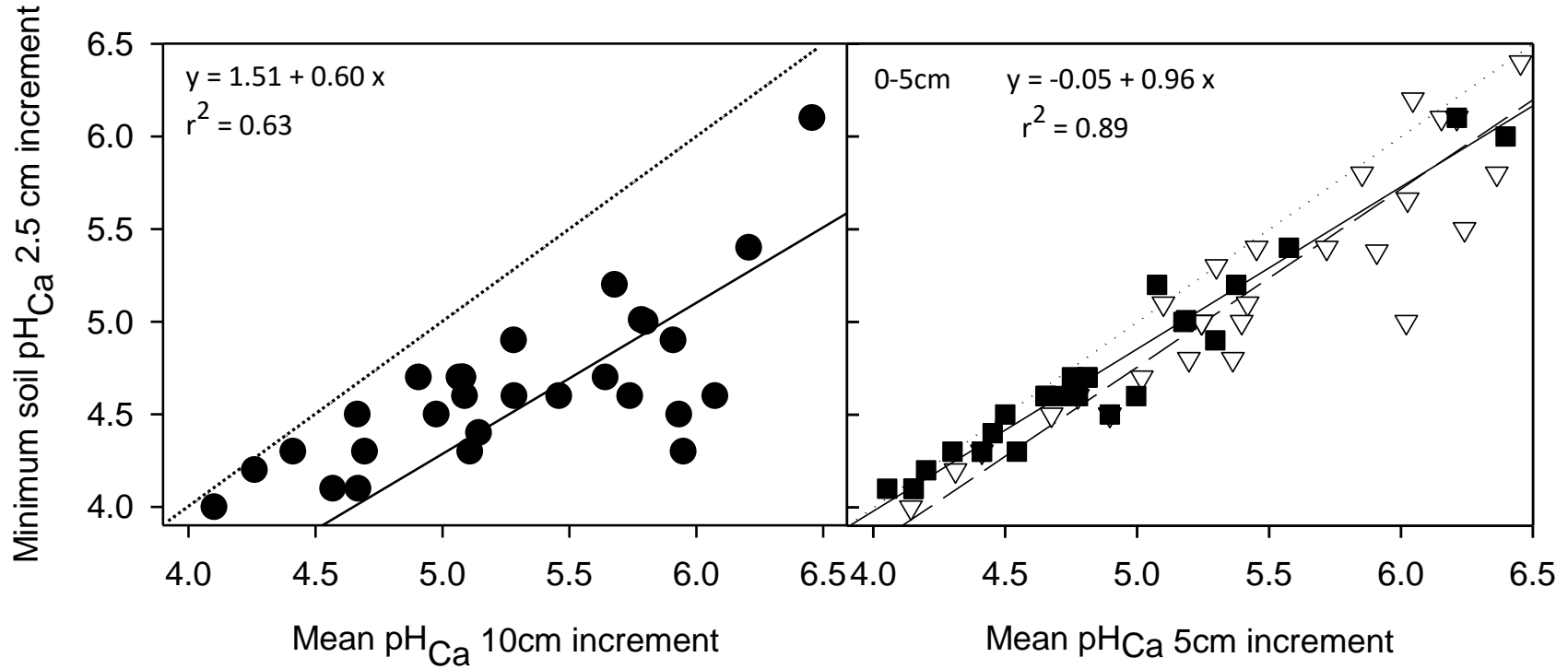
Acidity still be a problem

Even though \$ spent

▼ Lime < 5 yrs (n = 33)

● Lime > 5 yrs (n=15)

# Identifying acid subsurface layers

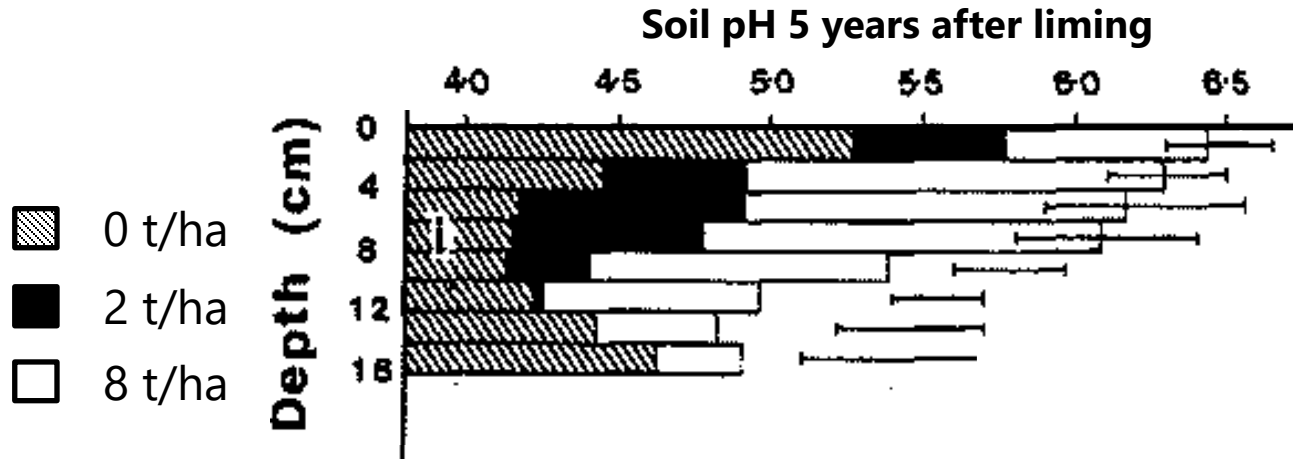


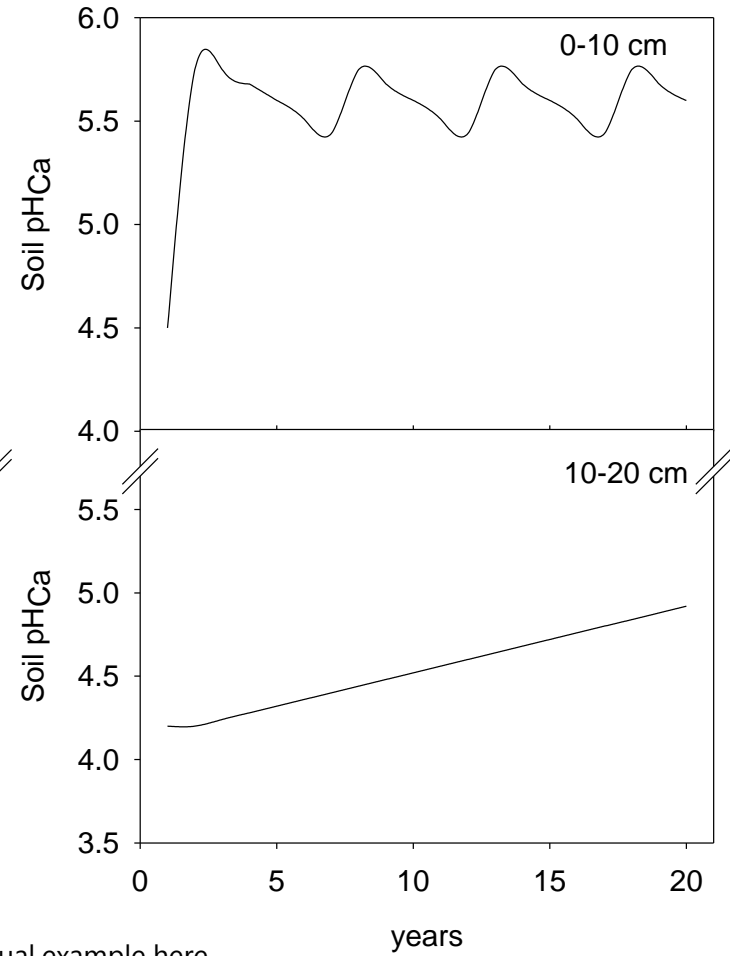
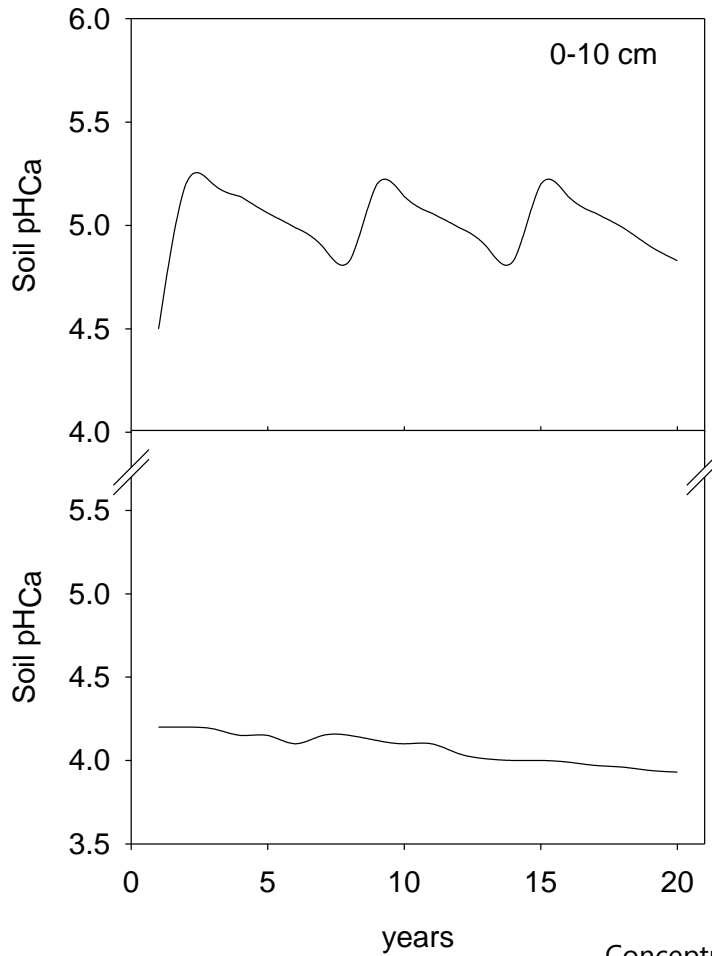
# Dealing with subsurface acidity

Rely on lime movement

Liming to remove  $\text{Al}^{3+}$   
doesn't move alkali

But high rates do ( $\text{pH} > 5.5$ )

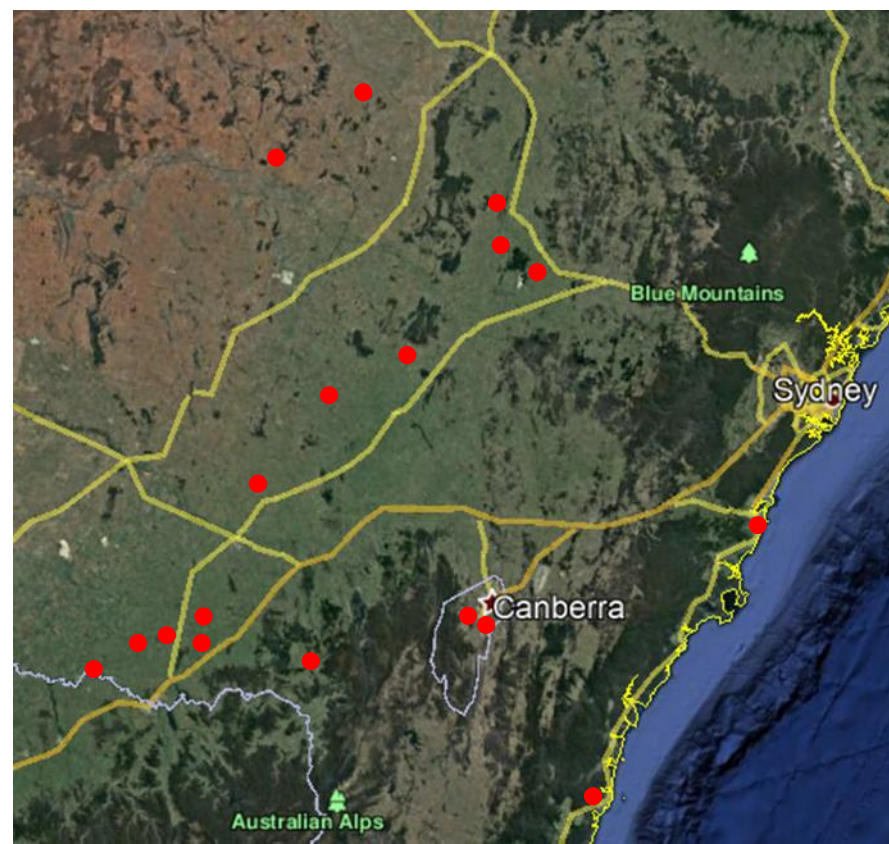




# New acid soil management

Liming to maintain  $\text{pH}_{\text{Ca}}$  above 5.5

But what is the best way to get there?



National  
Landcare  
Program



Local Land  
Services  
South East



# New research

## Replicated trials

- control
- lime to pH 5.2
- lime to pH 5.9 (maintain pH > 5.5)

- lime to pH 5.9 (maintain pH > 5.5) only 5cm (less lime, more often)
- incorporation (where possible)
- once in a generation (deep incorporation)



## Lime Rate x Incorporation Sites

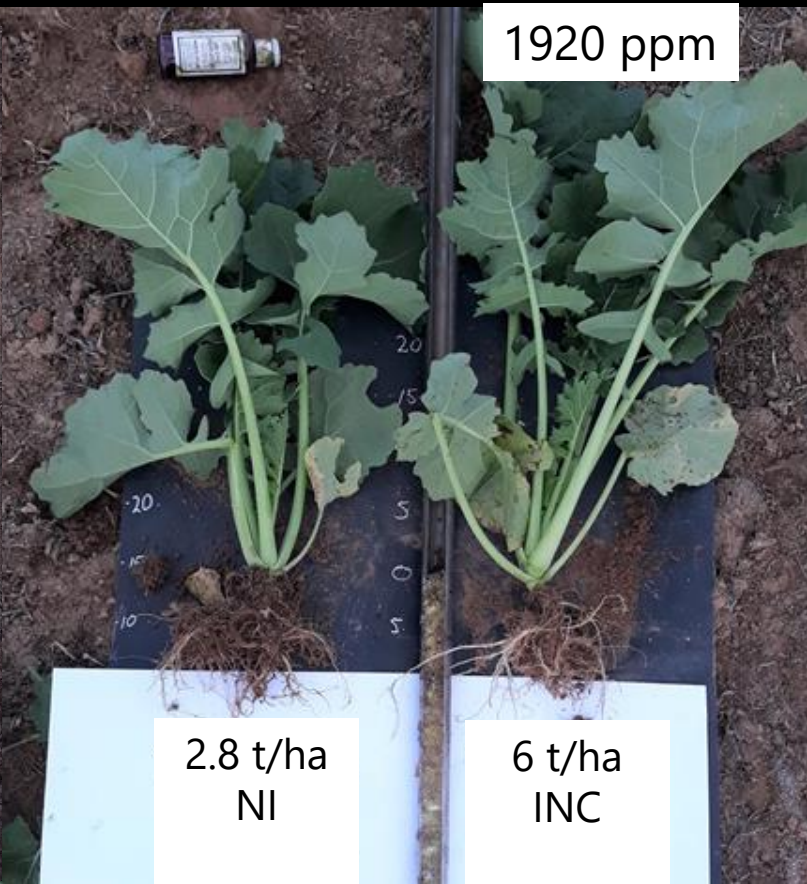
	Lyndhurst	Morven	Toogong
pH <sub>Ca</sub> @ 5-15 cm	3.9 to 4.1	4.0 to 4.3	4.8 to 4.9
Lime rate targeting >5.2	4.7 t/ha	3 t/ha	1 t/ha
Lime rate targeting >5.5	5.9	4	2.8
Lime rate targeting >5.5 (in 0-5 cm surface layer)	2.9	2	1.4
'Once-in-a generation'	7	6	3.8

# Morven – April 2020

350 ppm



1920 ppm



1470 ppm



Nil Lime

4t/ha Inc



Nil lime plots – more , smaller plants, smaller leaf size, more weeds

# Is it worth doing? - NSW production outcomes of liming

Location (Region) years	Enterprise/Pasture	Response to lime	Average annual gross margin (\$/ha c.f no lime)	Reference
Wagga Wagga (SE slopes) 1992-2004	Sheep/Perennial	+3.8 DSE	+\$25	Li and Conyers (2006), Brennan and Li (2006)
Ebor (Northern TL) 1999-2002	Cattle/Improved	+16% more beef production	+\$89	Duncan (2003)
Binalong (Southern TL) 1999-2004	Sheep/Perennial	+2.4 DSE (+5.6 DSE annual SSP)	-\$4 (+\$46)*	Leech (2006)
Laggan (Southern TL) 2015-2020	Sheep/Perennial	+2.9 DSE	+ \$181	Lieschke (2021)

Note gross margins are those at the time of research and does not account for current commodity prices

# Residual benefit





## Scenarios

- Liming topsoil targets too low and won't stop subsurface acidity forming
- But liming is expensive – is it worth applying if there are other limiting factors?
- Doesn't look like lime is moving, so is it worth it?
- Are targets just good for country – what should we do with poor pastures & hills
- Already acid? Live with it or fix it? – aren't they naturally acid anyway?



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## Many thanks to

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The many land managers that host our trial sites



## References

Burns H and Norton M (2018) Legumes in Acidic Soils: maximising production potential in south eastern Australia. GRDC and NSW DPI.

<https://grdc.com.au/resources-and-publications/all-publications/publications/2018/legumes-in-acidic-soils>

Condon J, Burns H, Li G (2020) The extent, significance and amelioration of subsurface acidity in southern New South Wales, Australia. *Soil Research* 59, 1-11.

Conyers M, Scott B (1989) The influence of surface incorporated lime on subsurface soil acidity. *Australian Journal of Experimental Agriculture* 29, 201-207.

Conyers M, Newton P, Condon J, Poile G, Mele P, Ash G (2012). Three long-term trials end with a quasi-equilibrium between soil C, N and pH: an implication for C sequestration. *Soil Research*, 50, 527–535

Li G, Conyers M, Heylar K, Lisle C, Poile G, Cullis B (2019) Long-term surface application of lime ameliorates subsurface soil acidity in the mixed farming zone of south-eastern Australia. *Geoderma* 338, 236–246.

Upjohn B, Fenton G and Conyers M (2005) Liming and soil acidity. Agfact AC. 19 NSW Department of Primary Industries. [https://www.dpi.nsw.gov.au/\\_data/assets/pdf\\_file/0007/167209/soil-acidity-liming.pdf](https://www.dpi.nsw.gov.au/_data/assets/pdf_file/0007/167209/soil-acidity-liming.pdf)

