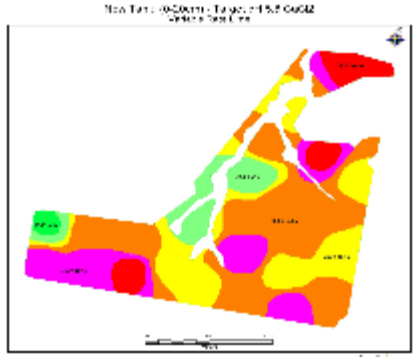
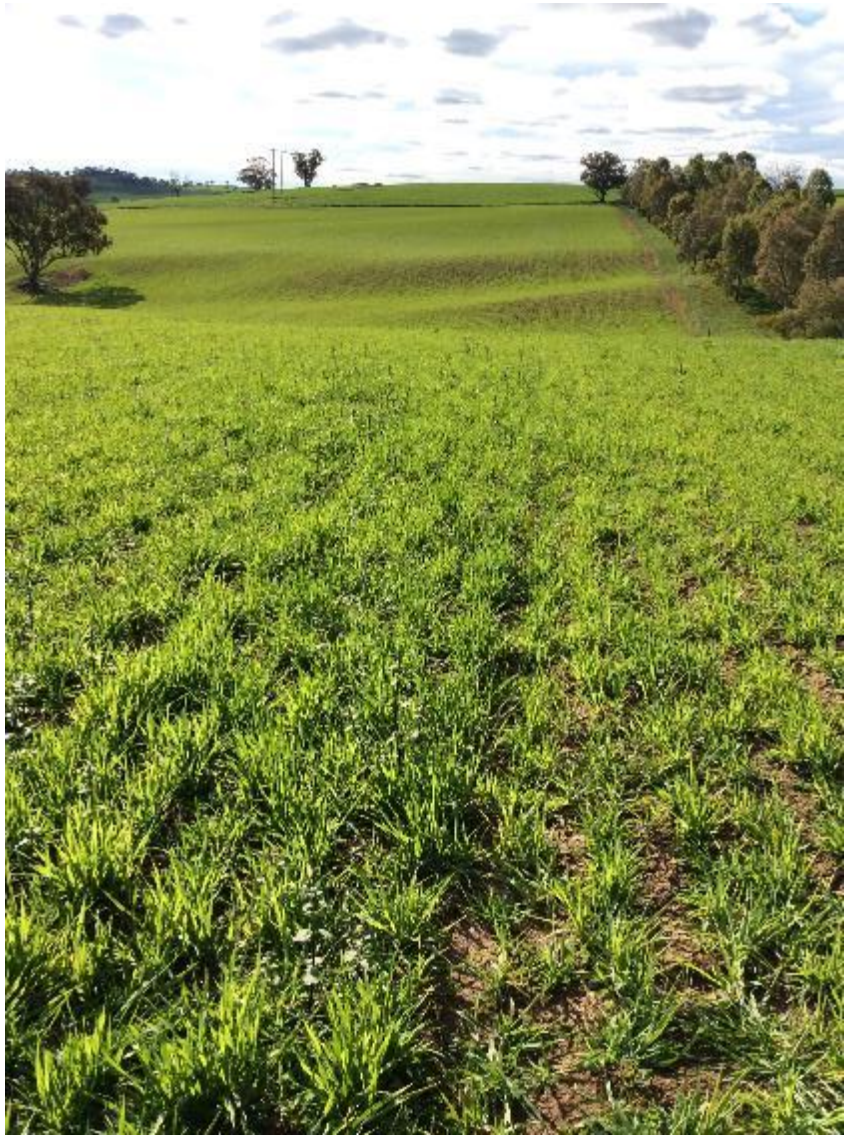
Farming Smarter –

a soils project for the next generation





Lisa Castleman &

Rebecca Waalkens

Ag Services Team

Riverina Local Land Services

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The project goals

To increase:

- awareness and understanding of soil acidification processes & **management options**
- the adoption of **targeted and strategic soil testing**
- the area of productive and **persistent perennial pastures**
- **groundcover** and better manage the risk of wind erosion and hillslope (water) erosion

To develop:

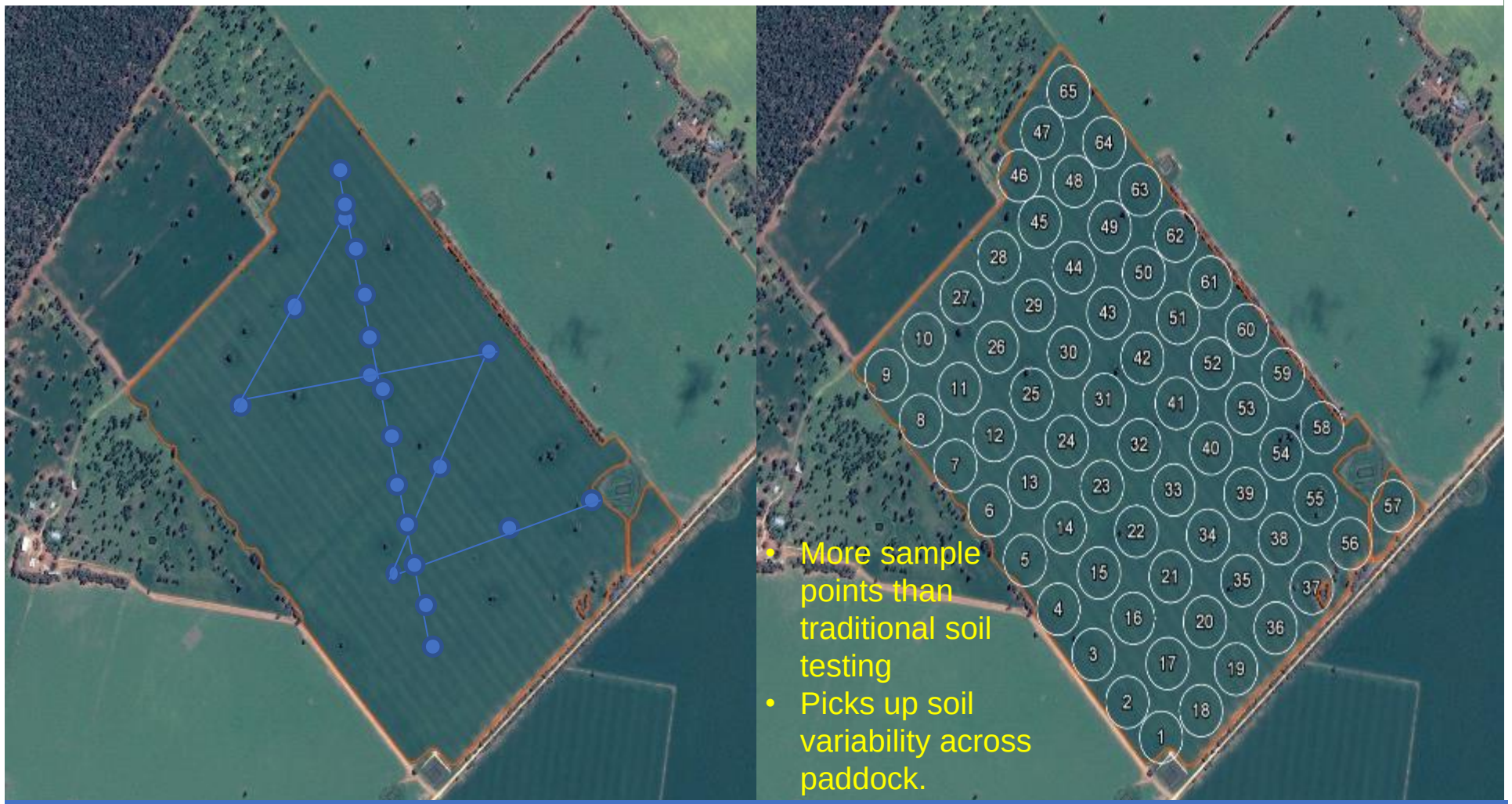
- Property Soil Nutrient and Liming Plans which result in lime use and **long-term amelioration** of soil acidity by land managers

Investigating soil pH – using dual depth sampling: Why?

- Acidic soils are a “major constraint to pasture and crop productivity in southern NSW with annual rainfall of 550-800mm (Scott et al., 2000)
- Historically, correction of soil acidity has focused on surface application of lime to treat the 0-10cm soil layer
- Less incorporation of lime due to min till and zero till systems
- Incorporation of lime - depth, implement and mixing effect varies. Use of blanket lime rates widespread, repeated over decades.
- Layer of 10-20cm is not commonly disturbed. Extent of amelioration depends on liming of topsoil & if any excess alkali remains for saturation of the acidity below

Traditional soil sampling (Transects)

Grid soil sampling-2 Ha grid



- More sample points than traditional soil testing
- Picks up soil variability across paddock.

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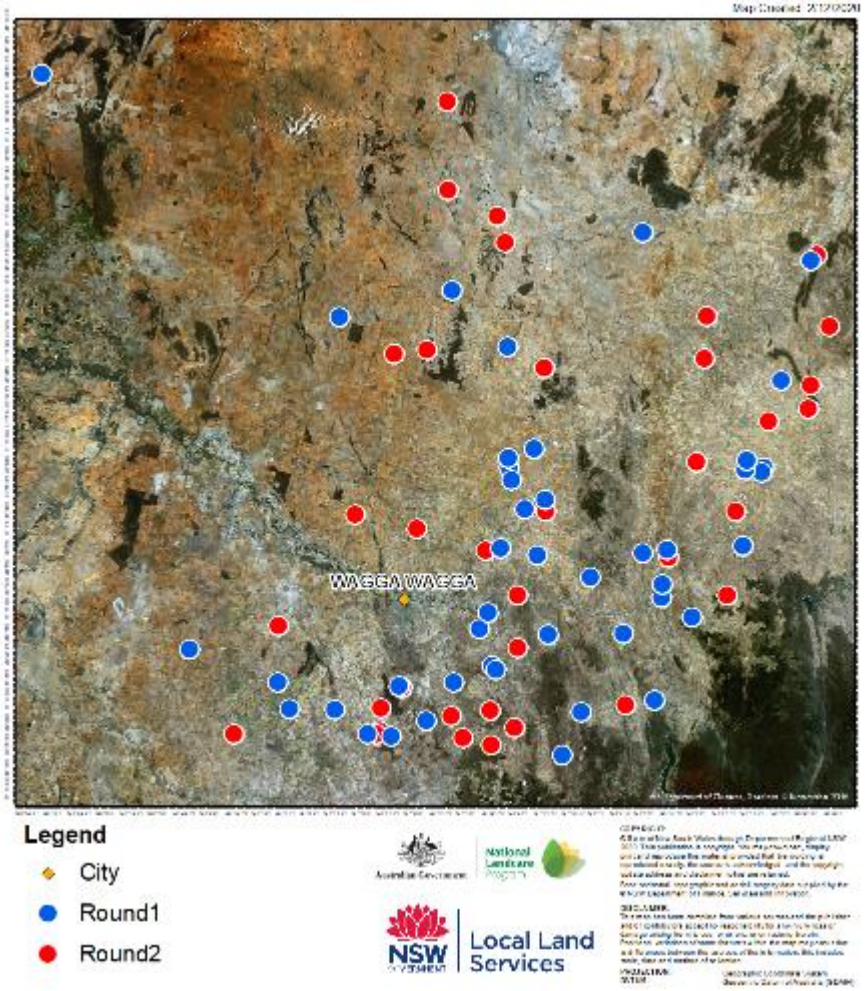
Equipment

Dual depth sampling (0-10cm, 10-20cm)
Soil sampling across a grid defines spatial variation

Locations of 2019 and 2020 properties

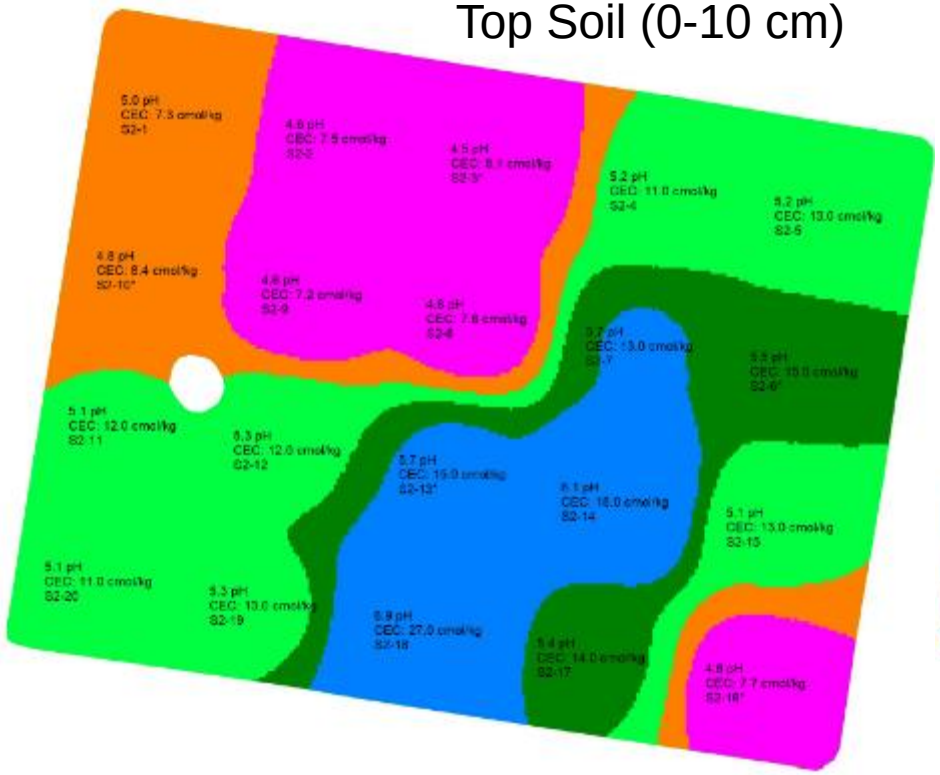


- 81 farms & participants
- 167 paddocks
- Southern and Eastern Riverina
- 500-800mm rainfall zone
- Mapping pH ($CaCl_2$) & Cation Exchange Capacity (CEC) from dual-depth sampling
- Selected points for Exchangeable acidity including Aluminium & Hydrogen

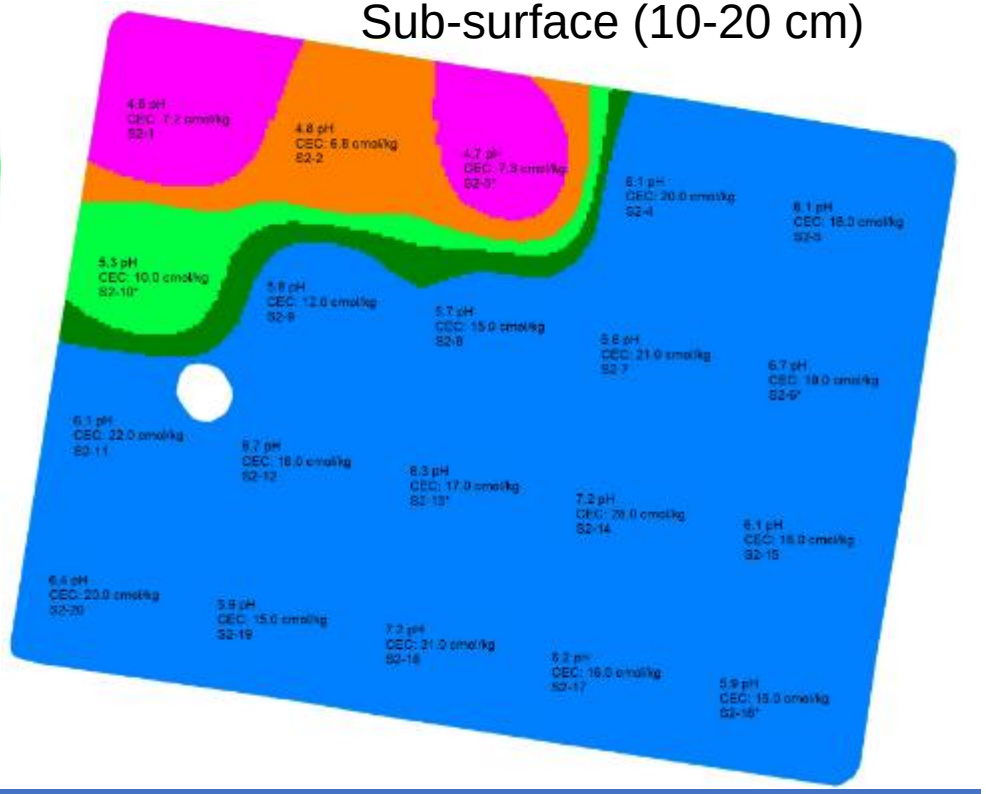
Distribution of soil pH

- 5.7 - 6.9 pH
- 5.4 - 5.6 pH
- 5.1 - 5.3 pH
- 4.8 - 5.0 pH
- 4.5 - 4.7 pH
- 4.2 - 4.4 pH
- Below 4.2 pH

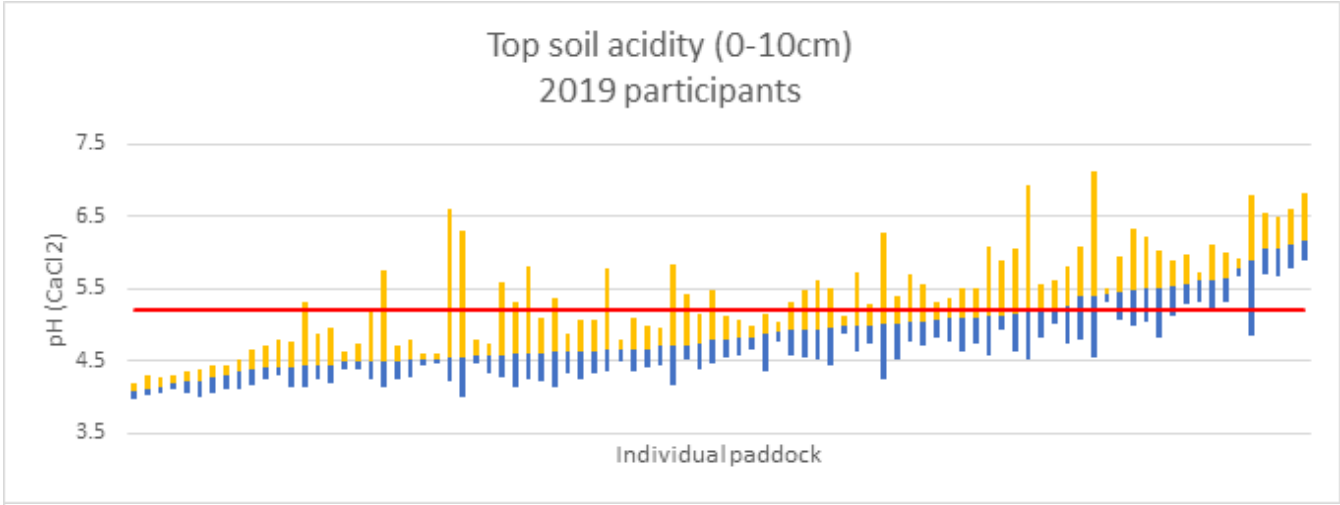
Top Soil (0-10 cm)

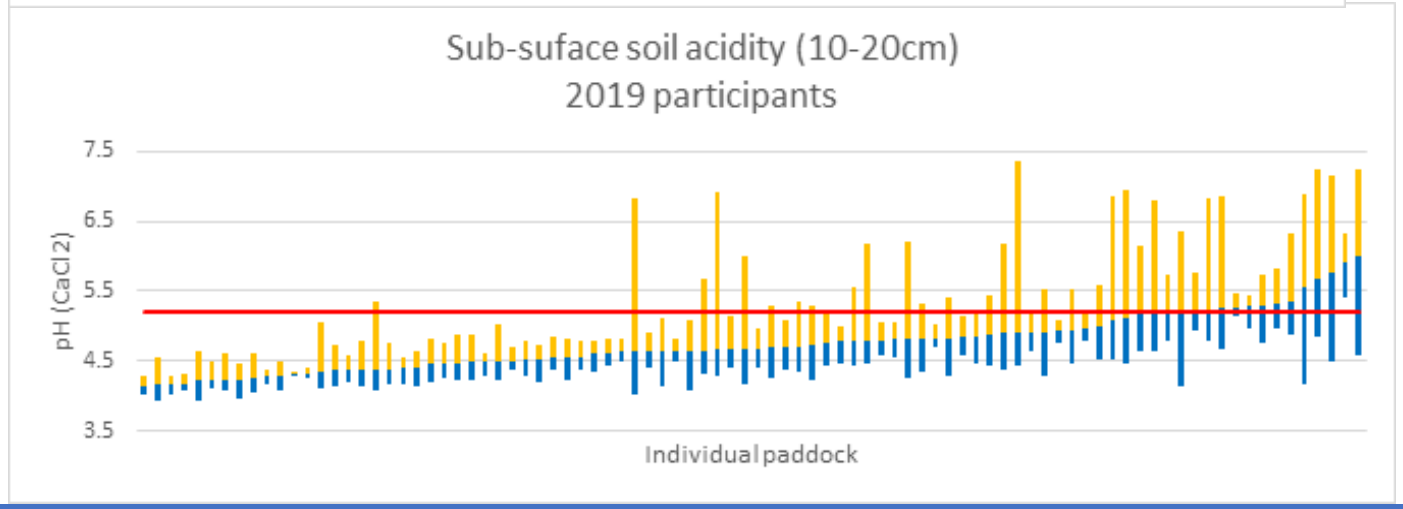


Sub-surface (10-20 cm)

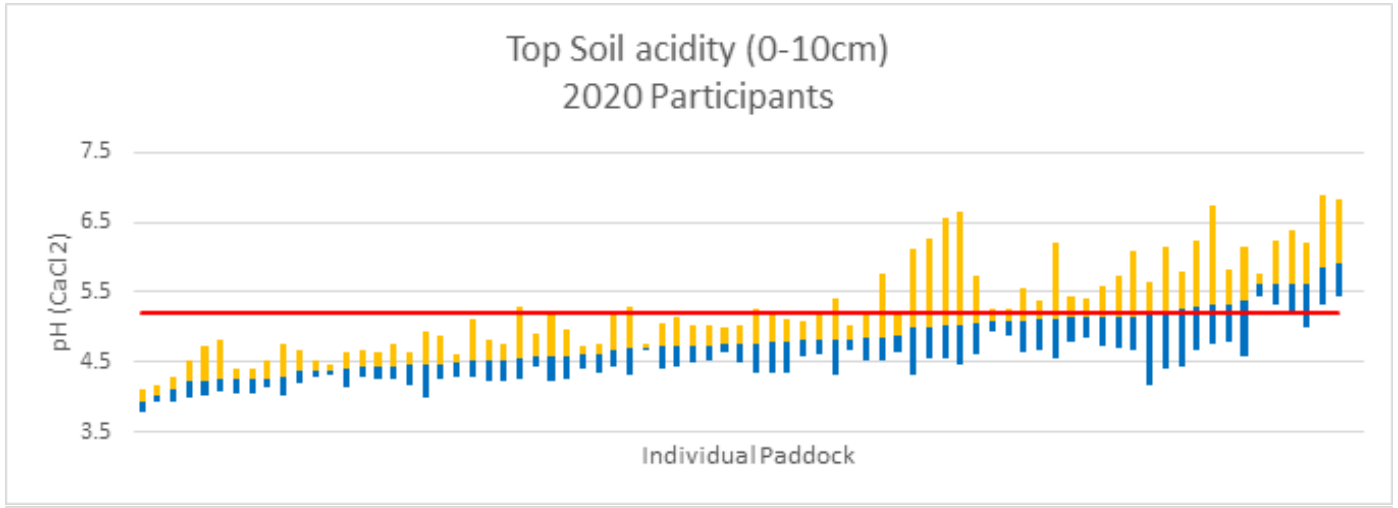


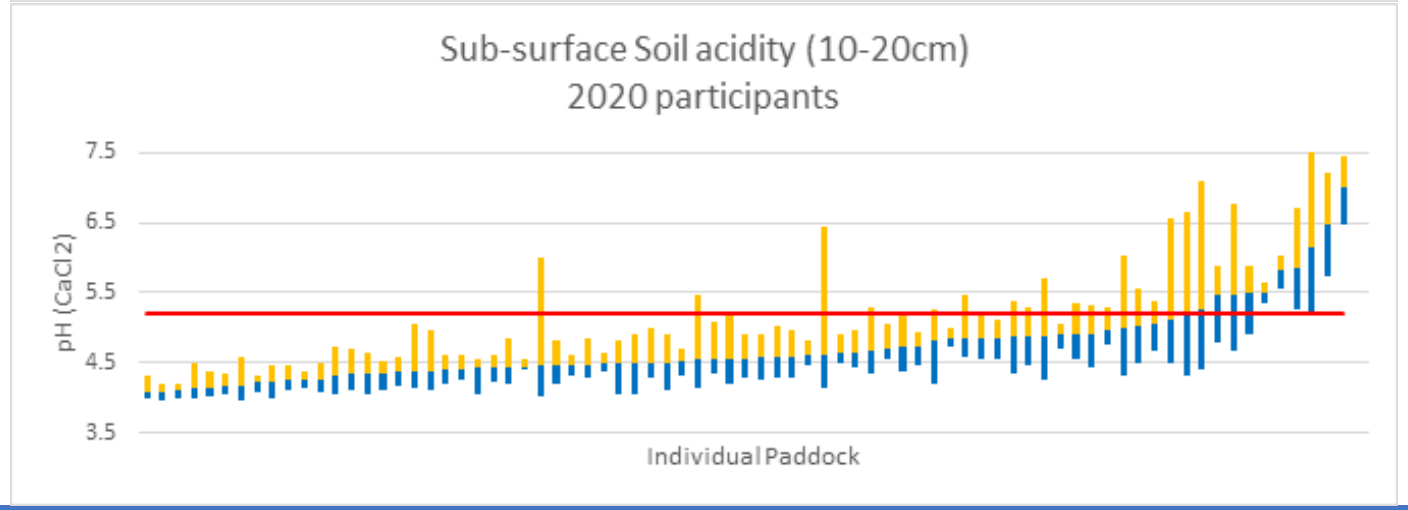
Round 1 in 2019 – soil pH ($CaCl_2$)





Round 2 in 2020 – soil pH ($CaCl_2$)



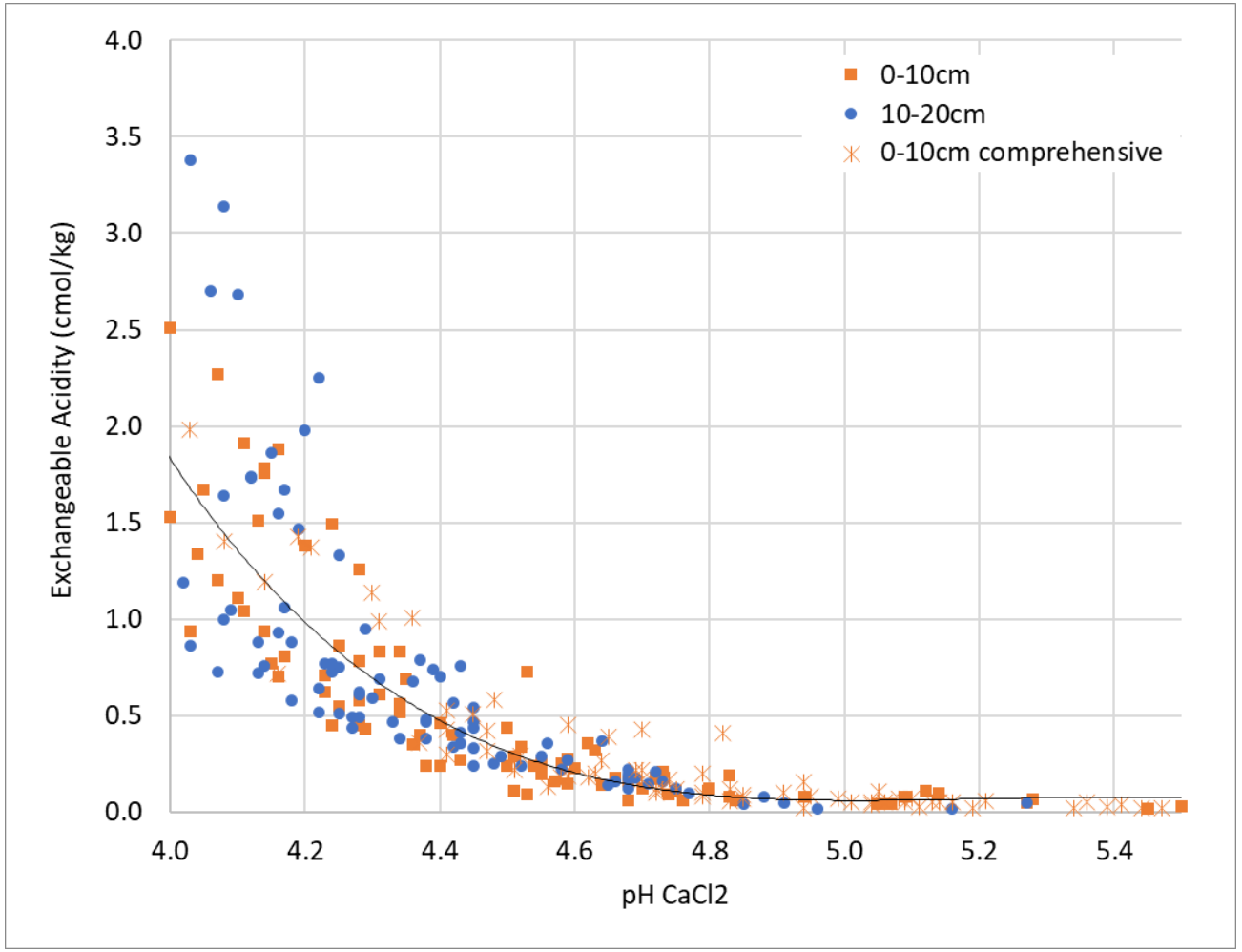


Soil pH data & trends from 81 farms

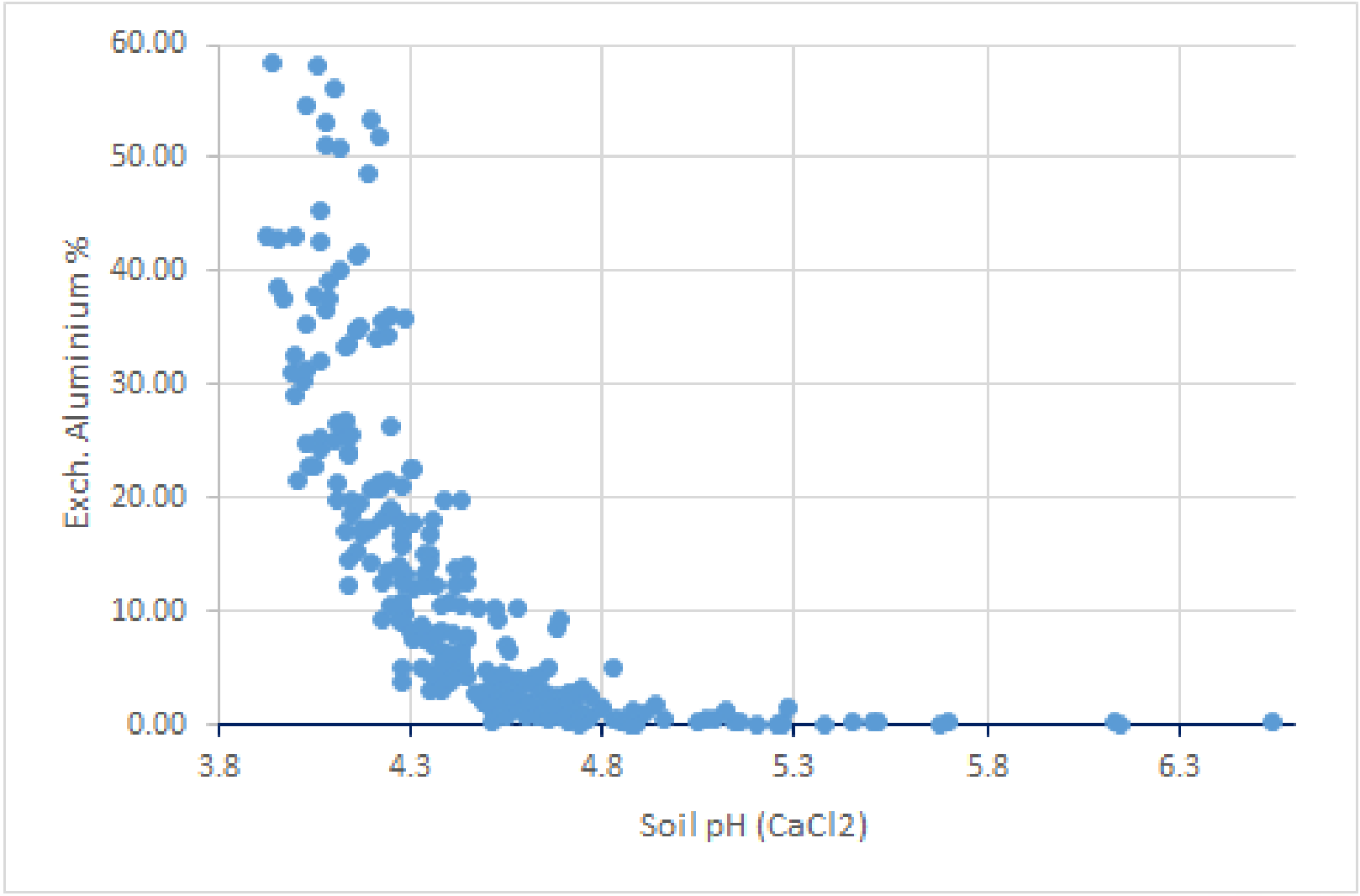
Baseline data

Statistics	pH ($CaCl_2$) 0-10 cm	pH ($CaCl_2$) 10-20 cm	Aluminium % 2019 0-10cm	Aluminium % 2020 0-10cm
Mean	4.84	4.77	Targeted areas	Targeted areas
Minimum	3.78	3.93	0.00	0.00
Maximum	7.11	7.53	60.00	57.80
Range	3.33	3.60	60.00	57.80
Standard Deviation	0.53	0.60	-	-
Optimum for plant growth	5.50	5.50	Limit <5%	Limit <5%

Exchangeable acidity is a function of pH



Exchangeable Aluminium - 2019 & 2020



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NUTRIENT STATUS REPORT

Riverina Local Land Services

Service Provider: Precision Agriculture Pty Ltd
Advisor/Contact:
Phone: 1800 773 247
Purchase Order:

Grower Name:	Riverina Local Land Services	Paddock Name:	- [illegible] - CS1	Sample Name:	- [illegible] - CS1 C01
Sample Number:		Sample Depth (cm):	0 To 10	Sampling Date:	[illegible]
Enterprise:	Beef/Sheep	Activity:	Pasture	Stocking Rate (dse/ha):	12
Annual Rainfall (mm):	550	Irrigation:			

Analyte	Unit	Value	Optimum	Low / Adequate / High
SOIL				
Organic Carbon (W&B)	%	1.6	2.0 - 5.3	
ACIDITY				
pH (1:5 Water)		5.4	6.0 - 7.0	Strongly acidic
pH (1:5 CaCl2)		4.7	5.2 - 7.3	Not ideal for lucerne
Aluminium (KCl)	cmol(+)/kg	0.[illegible]		
Aluminium % of Cations	%	2.4	< 5	There are no problems with Aluminium toxicity
SALINITY				
Electrical Conductivity (1:5 water)	dS/m	0.12		Salinity assessment depends on soil texture
Chloride	mg/kg	11		Not chart referenced
Sodium (Amm-acet.)	cmol(+)/kg	0.0[illegible]	< 1.7	Low risk of being harmful to plant growth
Sodium	mg/kg	[illegible]		
STRUCTURE				
Calcium % of Cations	%	[illegible]	[illegible]	Satisfactory for soil structure, check sodicity
Magnesium % of Cations	%	[illegible]	< 25	Stable soil structure likely, check sodicity
Sodium % of Cations (ESP)	%	0.67	< 6.0	Non sodic soil, stable soil structure likely
Potassium % of Cations	%	21.00		
Calcium/Magnesium Ratio		4.6	> 2.0	Stable soil structure likely, check sodicity
ELEMENTS				
Nitrate Nitrogen	mg/kg	25.0		
Ammonium Nitrogen	mg/kg	2.8		
Phosphorus (Colwell)	mg/kg	11	29 - 38	
Potassium (Colwell)	mg/kg	410		
Sulphur (KCl40)	mg/kg	5	9 - 12	
Calcium (Amm-acet.)	cmol(+)/kg	3.0	3 - 5	
Calcium	mg/kg	[illegible]		
Magnesium (Amm-acet.)	cmol(+)/kg	0.7	1 - 2	

ASPAC

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NUTRIENT STATUS REPORT

Riverina Local Land Services

Service Provider: Precision Agriculture Pty Ltd
Advisor/Contact:
Phone: 1800 773 247
Purchase Order:

Grower Name:	Riverina Local Land Services	Paddock Name:	[illegible] - CS1	Sample Name:	[illegible] CS1 C01
Sample Number:		Sample Depth (cm):	0 To 10	Sampling Date:	[illegible]
Enterprise:	Beef/Sheep	Activity:	Pasture	Stocking Rate (dse/ha):	12
Annual Rainfall (mm):	550	Irrigation:			

Analyte	Unit	Value	Optimum	Low / Adequate / High
Potassium (Amm-acet.)	cmol(+)/kg	0.99		
Potassium	mg/kg	385.00		
Zinc (DTPA)	mg/kg	1.10	0.4 - 5	
Copper (DTPA)	mg/kg	0.82	0.3 - 5	
Iron (DTPA)	mg/kg	[illegible]		
Manganese (DTPA)	mg/kg	62.0	20 - 50	
Boron (Hot CaCl2)	mg/kg	0.5	1 - 4	
ADDITIONAL				
Phosphorus Buffer Index		52		Low phosphorus fixation capacity
Phosphorus Environmental Risk Index		0.21		Low risk of P loss to the environment
Cation Exch. Cap. (ECEC)	cmol(+)/kg	[illegible]		
Grass Tetany Risk Index		0.27		

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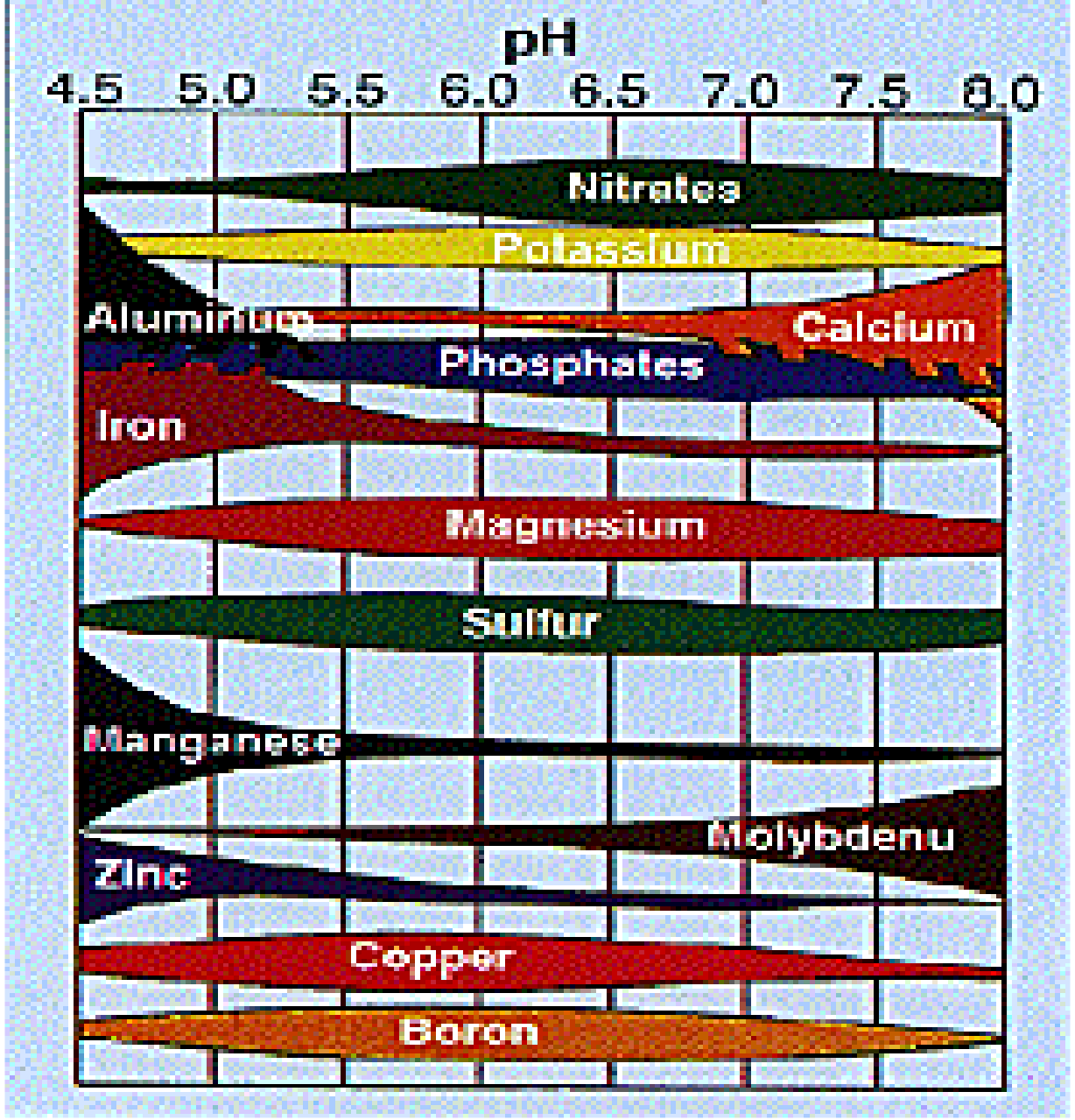


Ensuring a healthy pasture

Management factors include:

- ameliorating soil pH
- underlying soil fertility and the addition of inputs
- disease and pest management
- species & cultivar selection
- grazing management

Seasonal factors such as climate-rainfall, temperature, length of season.

Soil fertility data & trends from 81 farms

Statistics	Phosphorus (mg/kg)	Phosphorus Buffering Index (PBI)	Potassium (mg/kg)	Sulfur (mg/kg)
Mean	48	61	300	17
Minimum	6	25	98	3
Maximum	120	136	640	39
Range	114	111	542	36
Standard Deviation	25	23	110	9
Recommended	>25	<140	>120	>5 (High>8)

Soil fertility data & trends from 81 farms

Statistics	Organic Carbon (W & B) %	Nitrate-N (mg/kg)	Ammonium- N (mg/kg)
Mean	2.02	51.34	8.91
Minimum	0.55	3.70	1.20
Maximum	5.64	190	58
Range	5.09	186.30	56.80
Standard Deviation	0.80	32.06	7.93
Desirable range	NSW DPI Benchmark 2.00%	APAL laboratory Desired level 10-50	APAL laboratory Desired level 1-10

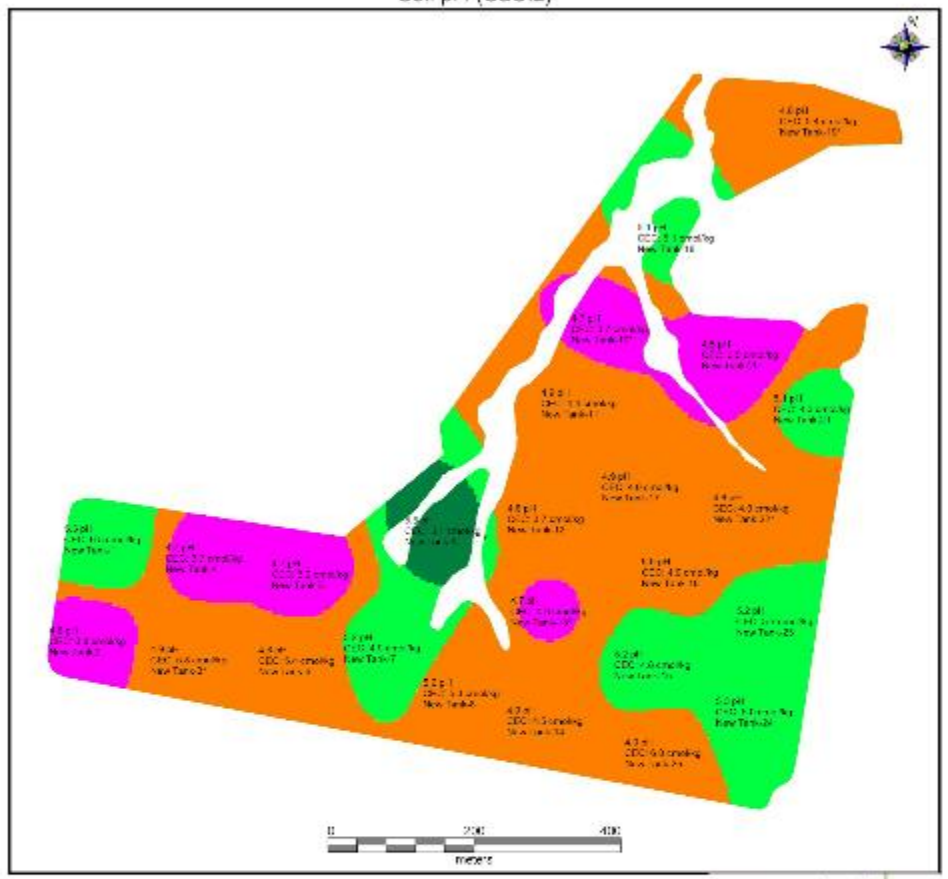
Organic Carbon levels and Nitrogen levels were highly variable between paddocks and participants

Soil fertility data & trends from 81 farms

Statistics	CEC (base cations) (cmol/kg)	Ca: Mg 0-10 cm	Ca: Mg 10-20 cm	Sodium % 0-10 cm	Sodium % 10-20 cm
Mean	5.89	4.95	4.03	2.20	2.89
Minimum	0.37	0.40	0.30	0.20	0.20
Maximum	34.00	31	23	23.90	28.20
Range	33.63	30.60	22.70	23.70	28.00
Standard Deviation	4.30	2.93	2.79	2.24	3.07
Desirable range	ECEC 5-25	>2.00 (2-8)	>2.00 (2-8)	<6%	<6%

- Range in CEC across soil types was expected. Variable-rate lime maps calculated using measured soil data (targeted and strategic).
- Paddocks were seldom sodic. Major constraint was acidity.

New Tank: (0-10cm)
Soil pH (CaCl2)



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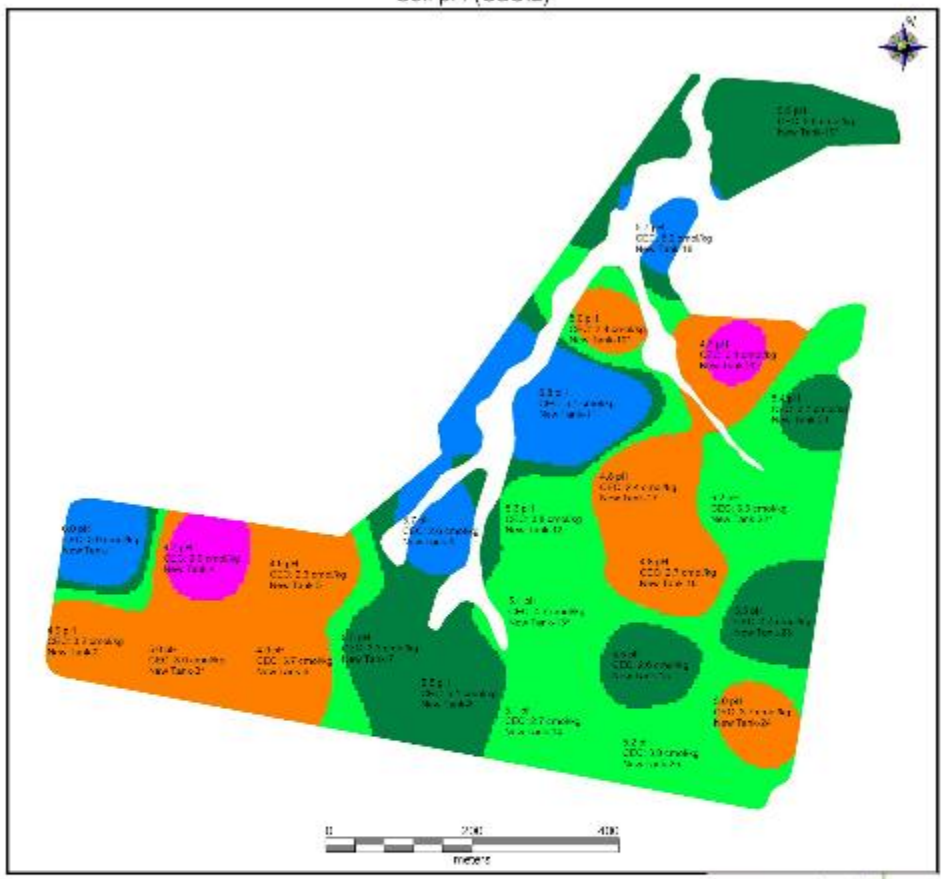
Above 5.5 pH	0.00 ha	
5.4 - 5.6 pH	1.27 ha	
5.1 - 5.3 pH	12.27 ha	
4.8 - 5.0 pH	29.20 ha	
4.5 - 4.7 pH	7.80 ha	
4.2 - 4.4 pH	0.00 ha	
Below 4.2 pH	0.00 ha	

Paddock: New Tank
Name: New Tank (0-10)
Type: (0-10cm)
Date: 5/28/2018
Min: 4.5 pH
Max: 5.5 pH
Avg: 4.9 pH

New Tank: (10-20cm)
Soil pH (CaCl2)



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5.7 - 6.8 pH	5.66 ha	
5.4 - 5.6 pH	12.60 ha	
5.1 - 5.3 pH	16.38 ha	
4.8 - 5.0 pH	13.86 ha	
4.5 - 4.7 pH	1.72 ha	
4.2 - 4.4 pH	0.00 ha	
Below 4.2 pH	0.00 ha	

Paddock: New Tank
Name: New Tank (10-20)
Type: (10-20cm)
Date: 5/28/2018
Min: 4.7 pH
Max: 6.8 pH
Avg: 5.3 pH

Goal setting for changing the soil pH

- The project identifies two target pH's of 5.2 and 5.8, while the ultimate goal is to ameliorate soil pH to 5.5 in $CaCl_2$.
- First target pH of 5.2 aims to remove Aluminium toxicity for a more successful pasture establishment.
- Second target pH allows for both layers of soil to be ameliorated.
- Third target aims to raise the soil pH above 5.5, allowing for re-acidification at 0.05 pH units/year.
- Lime is relatively insoluble. Chemical reactions take place around the lime particle. Lime applications need to generate excess alkali.
- Time taken for amelioration will depend on rate of alkali movement driven by sufficient rainfall to move the excess alkali.
- Participants choose to achieve higher pH targets in consultation with their agronomist or consultant.

Calculating variable-rate lime application rates

- NSW DPI Lime recommendations
- Calculation used measured soil pH and CEC for each 2 Ha grid
- Recommendations use ECEC which is CEC plus the exchangeable acidity (hydrogen and aluminium)
- Estimated exchangeable acidity (based on historic PA data)
- Validated pH: exchangeable acidity relationship using 2 grid samples on every farm, selected for lowest pH in topsoil and lowest pH in sub-surface

TABLE 3.

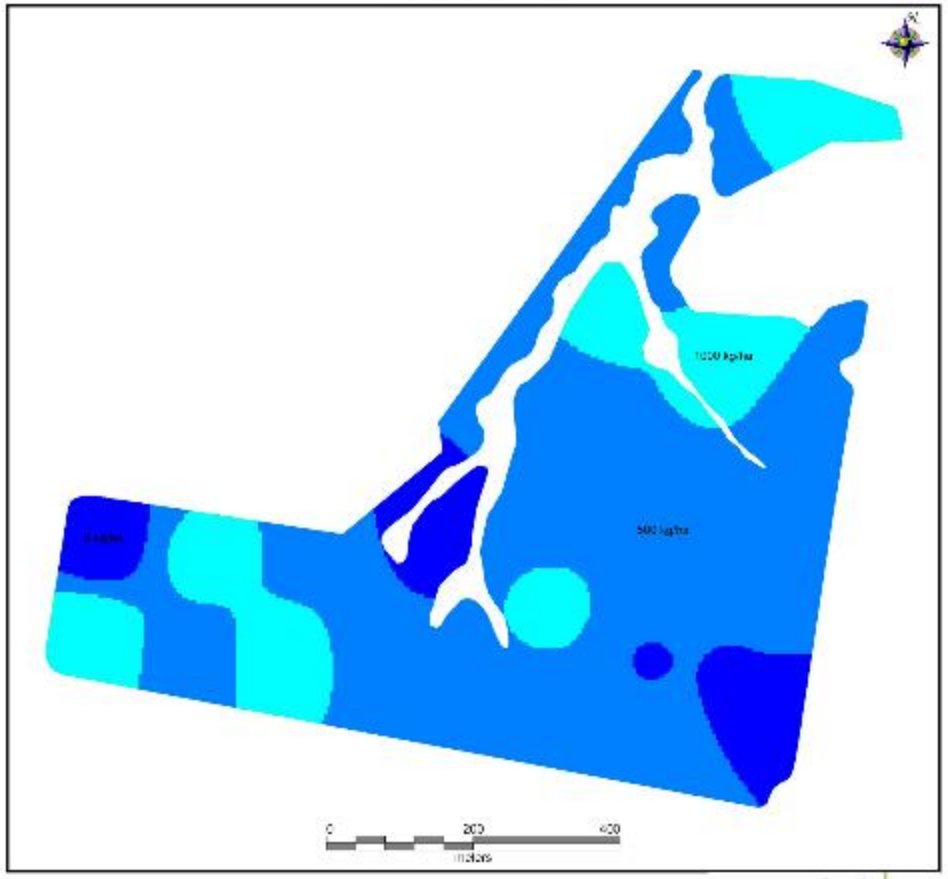
Lime required (superfine and NV>95) to lift the pH of the top 10cm of soil to 5.2 for a range of Cation Exchange Capacities and pH normally encountered when making liming recommendations. The additional lime required to lift the pH from 5.2 to 5.5 is given in the right hand column.

ECEC (meq/100gm)	Lime required (t/ha) to lift the pH of the top 10 cm: from 4.0to 5.2	from 4.3 to 5.2	from 4.7to 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

Assumptions: bulk density of soil is 1.4 and 70 per cent lime dissolves in one year. Note: For cracking clays this table will give an over estimate of lime required. *It is recognised that low rates of lime are difficult to apply but over-liming can cause nutrient deficiencies, particularly in these light soils.

Upjohn, Fenton and Conyers (2005) Soil acidity and liming. NSW DPI AgFact 19 3rd Edition

New Tank: (0-10cm) - Target pH 5.2 CaCl2
Variable Rate Lime



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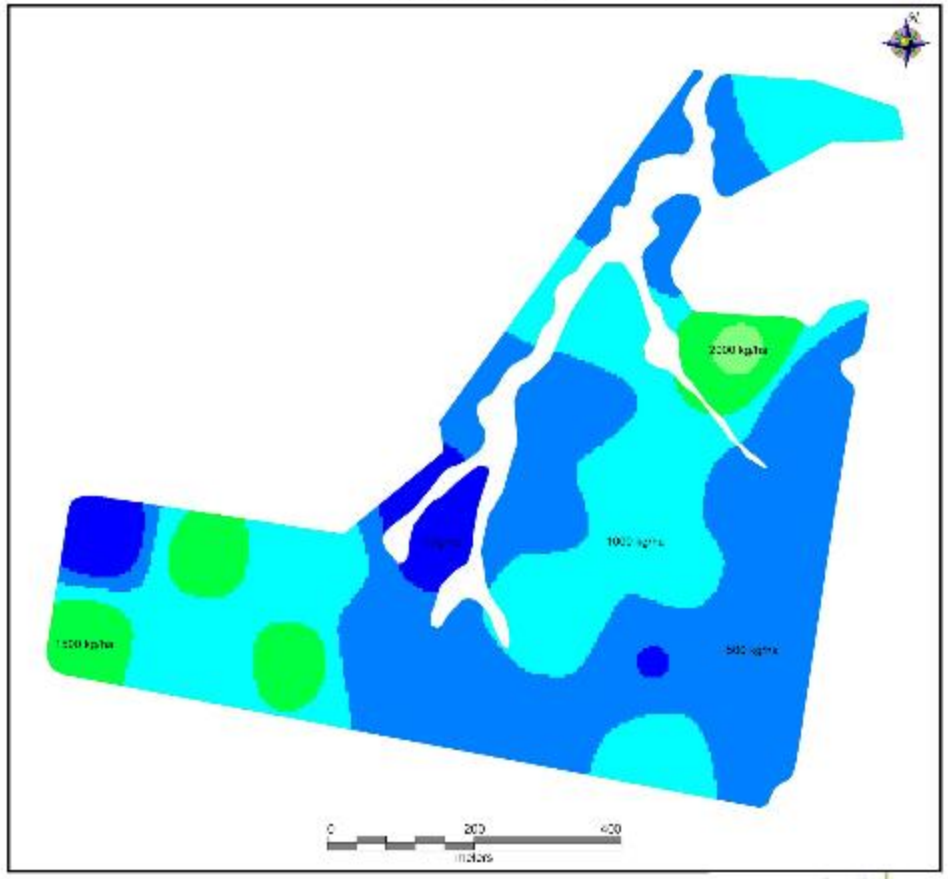
1000 kg/ha 11.24 ha
500 kg/ha 33.58 ha
0 kg/ha 5.42 ha

Paddock: New Tank
Name: New Tank - (0-10cm) Target
Type: (0-10cm) - Target pH 5.2 Ca
Date: 5/28/2019
Variable Rate Lime: 25.193 tonnes
Applied Area: 45.124 ha
Minimum Rate Applied: 0.000 kg/ha
Maximum Rate Applied: 1000.000 kg/ha
Average Rate Applied: 557.807 kg/ha

New Tank: (0-20cm) - Target pH 5.2 CaCl2
Variable Rate Lime



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2000 kg/ha 0.38 ha
1500 kg/ha 4.81 ha
1000 kg/ha 16.57 ha
500 kg/ha 24.21 ha
0 kg/ha 2.77 ha

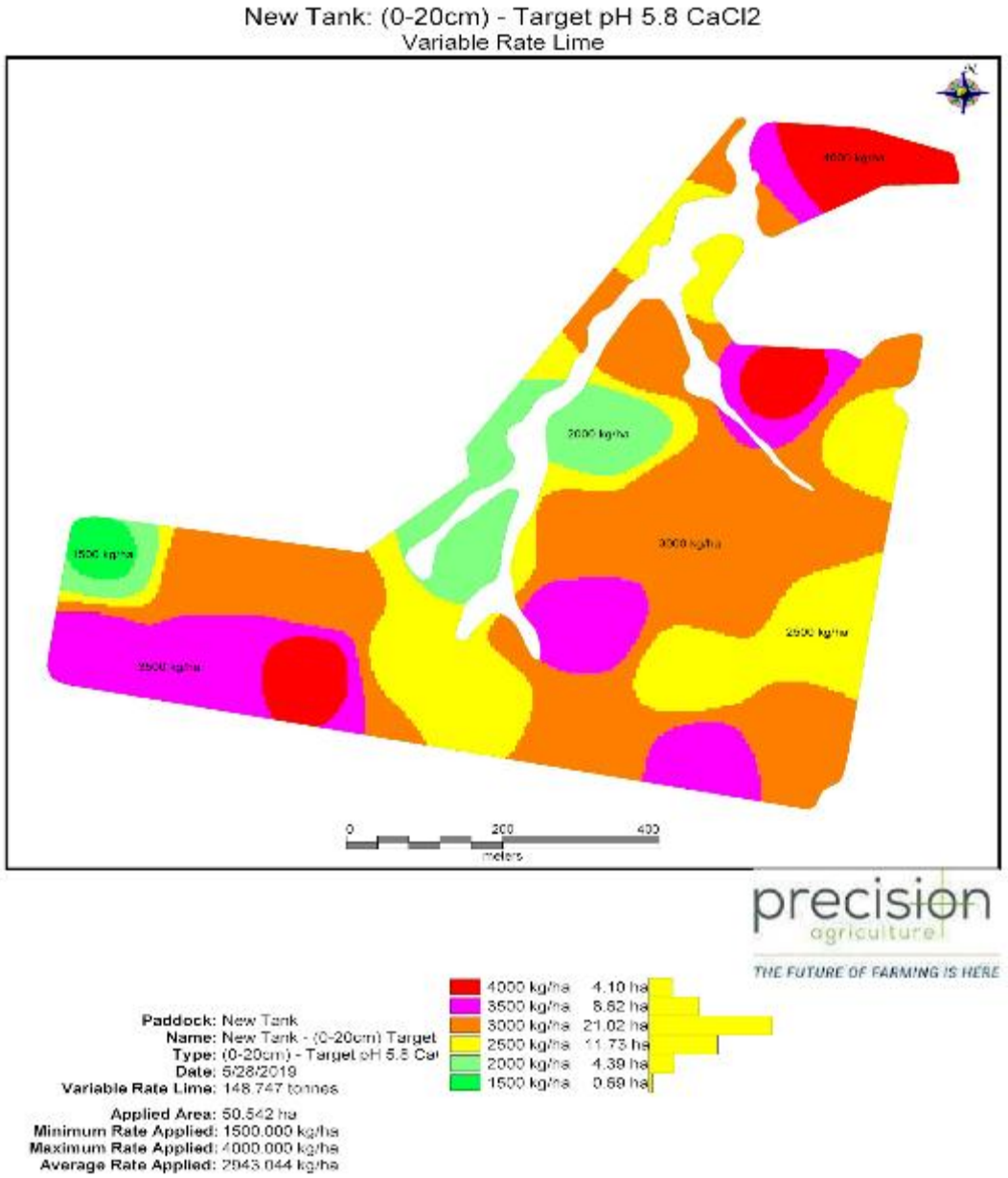
Paddock: New Tank
Name: New Tank - (0-20cm) Target
Type: (0-20cm) - Target pH 5.2 Ca
Date: 5/28/2019
Variable Rate Lime: 38.343 tonnes
Applied Area: 47.758 ha
Minimum Rate Applied: 0.000 kg/ha
Maximum Rate Applied: 2000.000 kg/ha
Average Rate Applied: 758.638 kg/ha

Reach the aspirational pH target of 5.8 after multiple lime applications

Setting a target pH helps to narrow the range in pH across the paddock

Reallocates lime to more acidic areas through VR lime application

The sub-surface soil is the next most significant soil layer we have influence over



What about stratification in soil pH?

- Increasing awareness of pH stratification in soil profile from researchers (Burns, Condon), investigating 0-5cm, 5-10cm, 10-15cm & 15-20cm layers and pH trends in the profile.
- Dual depth control of sampling ensured the full volume of soil for each layer was sampled. Soil samples are mixed thoroughly before testing.
- Lime rates are calculated on a 10cm volume of soil for each layer, using the measured pH and CEC for each 10cm layer.
- Stratification of soil pH in project paddocks tested is very likely. This could be confirmed by additional sampling and testing. However, it is unlikely to change the quantity of lime required to ameliorate a known volume of soil.
- The method of incorporation of lime could be changed (depth-cm), where practicable, once stratification can be described.
- Every participating landholder makes their own assessment of soil erosion risk and potential benefit from the incorporation of lime.

The newly established perennial pasture

Lucerne, Sub, Arrowleaf, Balansa, Chicory

The pasture mix in the photo

- Stamina GT5 lucerne 5kg/ha
- Bindoon Sub clover 1.5 kg/ha
- Dalkeith Sub clover 1.5 kg/ha
- Arrowleaf clover 0.5 kg/ha
- Taipan Balansa clover 0.5 kg/ha
- Puna Chicory (herb) 0.25 kg/ha

Total Sowing rate of 9.25 kg/ha

See Pasture Budget on next page

Budget for Pasture establishment		(excluding lime)	
Preparation-weed control	**$/Ha**	**Sowing**	**$/Ha**
Summer spray 1 Feb		Seeder	$50.00
Roundup CT 2L/Ha	$10.00	MAP 80 kg/Ha	$60.00
Boom	$10.00	Pasture seed	$90.00
Summer spray 2 March		Post sow Pre-emergent	
Roundup CT 2L/Ha	$10.00	Dual Gold 250ml/Ha	$3.00
Boom	$10.00	Talstar 80ml/Ha	$2.50
Pre sow knock		Boom	$10.00
Roundup Argo 2L/Ha	$14.00		
Boom	$10.00	Post-emergent weeds	
Double knock		Status 500ml	$6.20
Gramoxone 2L/Ha	$14.00	Factor 180g/Ha	$25.00
Moly 150g/Ha	$4.00	Broadstrike 25g/Ha	$8.25
Triflur 3L/Ha	$18.00	Super charge elite 0.75%	$5.00
Boom	$10.00	Boom	$10.00
Subtotal	**$110.00**	**Subtotal**	**$269.95**

What successful establishment in the 2020 season looked like

Feedback from land-holders

- "The investment in my new pasture is considerable. I had 2 failures in dry seasons. I really want it to persist without being held back by soil acidity. " ***Junee***
- "We thought the VR lime maps would tell us to use more lime. We needed less lime." ***Murringo***
- "Using a blanket rate of lime won't address the worst part of the paddock." ***Tumblong***
- "What was the best soil in the paddock has produced the most and is now the most acidic." ***Tarcutta***
- "The sub-surface layer was even worse than we suspected." ***Harden***
- "I am going to use a combination of blanket rates and vari-rate lime now, split over time." ***Coolac***

THANK YOU

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