Due to Covid you _must RSVP by September 7th_ to PIRSA Struan

Ph: 8762 9100

WESTERN FLAT FIELD WALK

WEDNESDAY 9 SEPTEMBER
1-5pm

Meet at 1pm

@ Funke's gateway
opposite
1785 Naracoorte Road
Bordertown South
(Western Flat)

Followed by BBQ tea
@ Paxton Stud
942 Broadview Road

BYO BBQ refreshments

PROGRAM

Irrigation induced salinity

Greg Funke, Nathan Tink & Mel Fraser

- Visit a lucerne pivot that developed a patch of salinity in the 2019 summer
- Learn about the causes and impacts of salinity on this site
- Explore the strategies used to fix the problem

Cover cropping on sandy soils

Hamish Verco & Mel Fraser

- Inspect and compare the impact of clay spreading and delving on an acidic sandy soil
- Discuss and see the benefits of a mixed species fodder crop in a paddock amended this year

Monitoring local weather and soil moisture

Martin Harvey, Felicity Turner & Shane Oster

- Visit a recently installed weather and soil moisture monitoring station
- Learn how to access the data here and understand what all the number mean

This event is brought to you by the **Western Flat Ag Bureau** in collaboration with:

Australian Government
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Tatiara
the good country

Coorong Tatiara Local Action Plan

Government of South Australia
Limestone Coast Landscape Board

LANDSCAPE SOUTH AUSTRALIA LIMESTONE COAST

Western Flat Field Walk
Wednesday 9th September 2020

1-5pm – Finish over BBQ tea

Stop	Item	Speaker	Organisation	Location	Time	Page n#
1	**MEETING POINT** Funke's Gateway *Welcome, COVID safe,* *Around the group, what soil info would you like to explore today?* **Irrigation Induced salinity** -Visit a lucerne pivot that developed a patch of salinity in the 2019 summer -Learn about the causes and impacts of salinity on this site -Explore the strategies used to fix the problem	Greg Funke Nathan Tink Mel Fraser Felicity Turner	PIRSA Rural Solutions Independent Adviser	Opposite 1785 Naracoorte Road Bordertown South / Western Flat	**1pm – 2.30pm**	**Page 3** Measuring Salinity **Page 6** Saltland Tips & Tools **Page 16** Introduction to soil sodicity
2	Hamish Verco's *Afternoon Tea* **Cover cropping on sandy soils** -Inspect and compare the impact of clay spreading and delving on an acidic sandy soil -Discuss and see the benefits of a mixed species fodder crop in a paddock amended this year	Hamish Vercoe Mel Fraser	PIRSA Rural Solutions	402 Broadview Road Western Flat	**2.45pm** – *4.15pm*	**Page 20** Clay Development Work
3	Martin Harvey's *Visit the Tatiara District Council – Drought Communities Program weather station and soil probe in the paddock, back to the shed for the presentation* **Monitoring local weather and soil moisture** -Visit a recently installed weather and soil moisture monitoring station -Learn how to access the data and understand what all the number mean	Martin Harvey Felicity Turner Shane Oster	Independent Adviser Alpha Group	Paxton Stud 942 Broadview Road Western Flat	**4.30am** – *followed by BBQ tea*	
4	**BBQ TEA & FINISH**			Paxton Stud 942 Broadview Road Western Flat		

Measuring salinity

Salinity is the accumulation of salt in soil and water. High salt levels can adversely affect plant growth, soil structure, water quality and infrastructure.

High salt levels occur naturally in many parts of the Australian landscape but in many cases have been exacerbated where human activities accelerate the mobilisation and accumulation of salt.

Methods for measuring salinity

It is important to identify saline areas so they can be appropriately managed. There are a range of methods for measuring salinity. Two common ways are by using an electrical conductivity (EC) meter or by measuring how much salt is in a solution of soil or water.

An EC meter measures how much electricity moves through a solution—the saltier the solution, the more electricity moves through it and the higher the conductivity reading. EC can be easily measured in the field or in a laboratory. A wide range of EC meters are available, ranging in price and size.

Electrical conductivity can be expressed in different units—for soil, EC is measured in dS/m (deci-Siemens/metre), while water is measured in µS/cm (micro-Siemens/centimetre). It is important to always calibrate the EC meter before use.

Another way to detect salinity is by measuring how much salt is in a solution—this measurement is called total dissolved solids (TDS) or total dissolved ions (TDI). It is measured in units of mg/l (milligrams/litre) or ppm (parts per million). Higher readings mean more salt is present in the solution.

Measuring salinity in water

Salinity in surface water and groundwater can be easily measured in the field by collecting a water sample, inserting an EC probe into the sample and reading the value shown on the meter.

Alternatively, a water sample can be collected and forwarded to a laboratory for testing of salinity and chemical composition. The container should be entirely filled with the water sample to exclude air. Samples for laboratory analysis should be forwarded as quickly as possible. Delays and high temperatures will change the composition of salts in the sample, affecting the results. Typical salinity values for water are given in Table 3.

Measuring salinity in soil

EC is usually measured in the field using a 1:5 soil:water suspension (EC1:5), or in a laboratory using a soil saturation extract EC (ECse) or a 1:5 solution.

To measure EC1:5 in the field, put approximately 10 millilitres of distilled water, rainwater or tank water into a jar, container or tube. Add small soil particles until the contents of the container increase by 5 millilitres to bring the volume to 15 millilitres. Add additional water to bring the total volume to 30 millilitres. Shake intermittently for five minutes and allow it to settle for five minutes. Dip an EC probe into the solution and take a reading. Remember to wash the EC probe after using it.

The interpretation of EC values to determine soil salinity levels depends on the texture of the soil. Salts are readily dissolved out of sandy soils whereas salts are more tightly held by clay soils. This means that the same amount of salt will have a greater impact on sandy soils then it will on clay soils. As a guide, sandy or loamy soils are moderately saline if EC1:5 is above 0.3 deci- Siemens/metre, and clay soils are moderately saline if EC1:5 is above 0.6 deci- Siemens/metre.

As the EC1:5 is measured on a diluted sample, a more realistic measurement of the actual salt levels that a plant will encounter can be measured on a saturated extract (ECse). This can be done by some laboratories. As a guide, soils are generally considered saline if their ECse is greater than 2– 4 deci- Siemens/metre.

Salinity tolerance ratings for soils are usually based on ECse values, rather than EC1:5. To convert EC1:5 to ECse, identify the texture of the soil, and use the guide in Table 1

Table. 1. Conversion of EC1:5 to ECse for a range of soil textures

Soil type	Multiply EC1:5 by
Sand	23
Sandy loam	14
Loam	10
Clay loam	9
Light clay	7.5
Heavy clay	6

For example, sand with an EC1:5 of 0.3 dS/m is equivalent to an ECse of 6.9 dS/m, while a heavy clay with an EC1:5 of 0.3 dS/m is equivalent to an ECse of 1.8 dS/m. Soil salinity classes are shown in Table 2.

Table 2. Approximate soil salinity classes

Salinity rating	EC_{se} (dS/m)	
Slightly saline	1.5—2	Salinity effects usually minimal
Moderately saline	2—6	Yield of salt sensitive plants restricted
Highly saline	6—15	Only salt tolerant plants yield satisfactorily
Extremely saline	>15	Few salt tolerant plants yield satisfactorily

Salinity tolerance of crops

As a general guide, salt tolerant crops include barley, canola, cotton, beetroot, soybean, wheat, olives and sorghum. Moderately salt tolerant crops include lucerne, tomato, cabbage, potato and carrots. Low salt tolerant crops include maize, sugar cane, celery, lettuce and pumpkin.

Table 3. Guide to typical salinity limits for waters. It is important to also check other water quality parameters (e.g. chemical composition, sodium adsorption ration, metals etc) before use.

		Electrical conductivity (EC)		TDS
		(µS/cm)	(dS/m)	(mg/l or ppm)
Distilled water		1	0.001	0.67
Rainfall		30	0. 03	20
Sewage effluent		840	0.84	565
Freshwater		0-1500	0-1.5	0-1000
Great Artesian Basin Water		700-1000	0.7-1.0	470-670
Brackish water		1500-15000	1.5-15	1000-10050
Upper limit recommended for drinking		1600	1.6	1070
Tolerances of livestock to salinity in drinking water (at these values, animals may have an initial reluctance to drink, but stock should adapt without loss of production)	Beef cattle	5970-7460	5.9-7.5	4000-5000
	Dairy cattle	3730-5970	3.7-5.9	2500-4000
	Sheep	7460-14925	7.5-14.9	5000-10000
	Horses	5970-8955	5.9-8.9	4000-6000
	Pigs	5970-8955	5.9-8.9	4000-6000
	Poultry	2985-4475	2.9-4.4	2000-3000
General limits for irrigation	Salt sensitive crops	650	0.65	435
	Moderately salt sensitive crops	1300	1.3	870
	Salt tolerant crops	5200	5.2	3485
	Generally too saline for crops	8100	8.1	5430
Salt water swimming pool		5970-8955	5.9-8.9	4000-6000
Seawater		55000	55	36850
Dead sea		110000	110	73700

Note: To convert from µS/cm to dS/m, divide by 1000. To approximately convert from µS/cm to mg/l, multiply by 0.67.

References

- ANZECC (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. ANZECC and ARMCANZ.
- Charman PEV and Murphy BW (2007). Soils: Their Properties and Management, 3rd Edition. Oxford University Press, South Melbourne.
- Foth HD (1990). Fundamentals of Soil Science, 8th Edition. John Wiley & Sons, New York, USA.
- Price G (ed) (2006). Australian Soil Fertility Manual, 3rd Edition. CSIRO Publishing and Fertilizer Industry Federation of Australia, Collingwood.
- Salcon (1997). Salinity Management Handbook. Department of Natural Resources, Indooroopilly.

Further information

This and other science notes are available from the Queensland Government website www.qld.gov.au – search 'science notes'. For further information about this science notes series phone **13 QGOV** (13 74 68) – ask for science notes – Land series L137.

For further information about salinity visit < http://www.qld.gov.au/environment/land/soil/salinity/> or email soils@qld.gov.au.

Saltland Pasture Redemption

Tips and Tools for Identifying and Dealing with Saline Soils

REPORT PREPARED BY FELICITY TURNER FOR THE COORONG TATIARA LAP

Key Outcomes

- **Maintain groundcover at all costs; reduces evaporation, capillary rise of salt, and provides opportunities for micro-climates and plant colonisation.**

- **Know your soil salinity levels and choose an appropriate salt tolerant mix of species for remediation (some crops and pastures handle waterlogging, some don't).**

- **Seeding after a rainfall event that flushes the salt through the soil profile is important when remediating salinity affected sites.**

- **Diversity in the mix of pasture species being sown is important as it provides an opportunity for multiple species to find their fit on sites that can be highly variable in their levels of soil salinity and waterlogging.**

- **Neptune Messina was found to be a suitable species in the local environment (as part of a salt land pasture mix), providing the soil salinity threshold didn't exceed recommended levels (30 dS/m ECe).**

- **Prevention of dryland salinity is better (and often easier) than remediation.**

Background

The Coomandook Saltland Pasture Redemption Project was initiated by the Coomandook Ag Bureau in 2015 to investigate the application of new developments in the productive use of saline land across Coomandook / Cooke Plains area. The initial focus of the project was to assess the suitability of the salt tolerant pasture legume Messina as a potential species to remediate saline scalds and reduce the level of wind erosion and recharge to groundwater in these areas. The 'Saltland Pasture Redemption Project' broadened the scope to look at a range of species, methods and timing of establishment, the

PROJECT DETAILS

Project ID: 4-9GS7FPL

Funding Body

This project is supported by the National Landcare Program – Smart Farms Program, an Australian Government Initiative

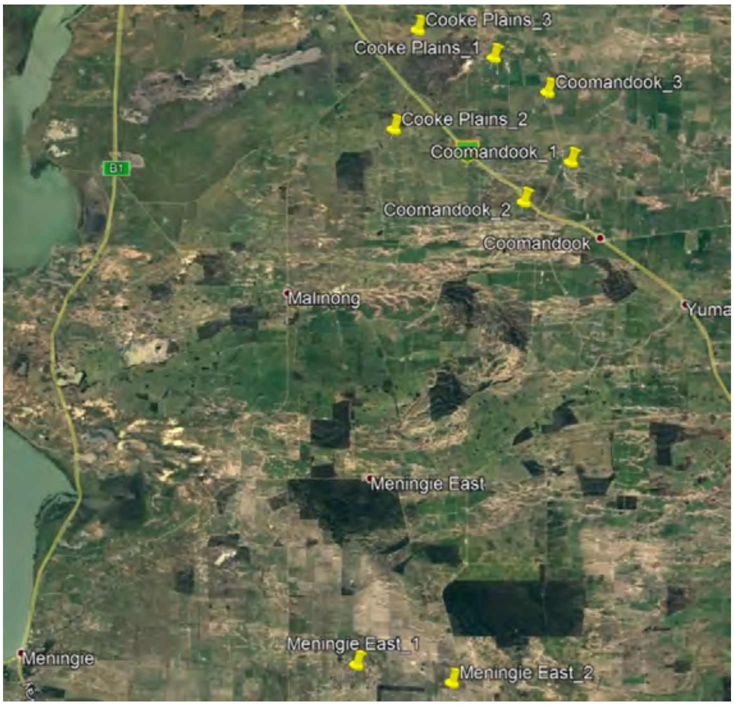
Project Duration

2018-2020

Site Locations

Coomandook, Cooke Plains and Meningie East, South Australia

(Various site locations)



use of groundcover and mechanical intervention methods to try and assist in the remediation of saline soils across the Coorong Tatiara Local Action Plan project area.

Sites were established in key areas where dryland salinity was occurring and have been monitored as either short term strategic sites, or longer-term demonstration sites. The location of these is shown in Figure 1.

Figure 1. Location of saltland redemption sites (2016-2020)

The local landscape

Parts of the Coorong Tatiara Local Action Plan project area have a high potential for dryland salinity formation due to being low lying in nature, and its proximity to the regional unconfined groundwater system drainage point into the River Murray Lower Lakes and Coorong. This is shown in the Digital Elevation Model (DEM) in Figure 2 where the red and orange areas are those that are less than 11.6m above sea level. Monitoring of piezometers within this localised area have found that groundwater levels respond strongly to changing rainfall patterns.

More information can be found in the 'Coorong Dryland Salinity Review: Improving Salinity Understanding – June 2019' which can be accessed here http://www.coorong.sa.gov.au/salinityreview

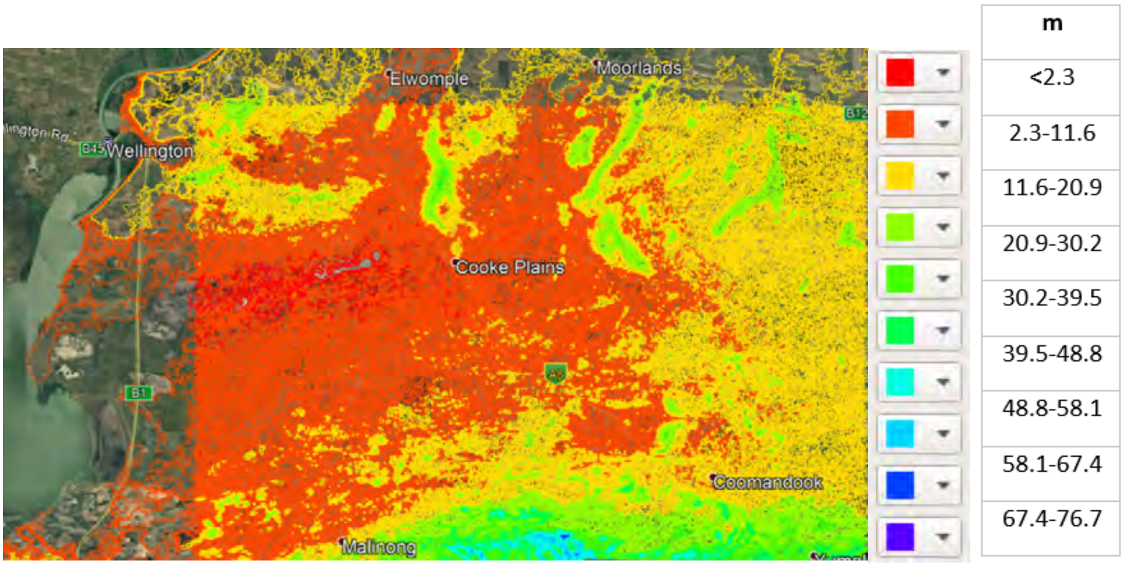


Figure 2. DEM of the Cooke Plains/Coomandook region (m above sea level)

Identifying areas that may be prone to salt scalds

As the water table below the surface rises, it brings with it dissolved salts to the root zone of crops, pastures, and native vegetation and potentially the soil surface. The first areas affected are often the low-lying areas within paddocks.

There appears to be two main processes occurring across the region leading to soil salinity;

- **Discharge -** where the water table intercepts with the ground surface creating an area that becomes waterlogged over a period of time
- **Capillary action** ('wicking') - where evaporation at the soil surface draws the water up through the soil. Capillary action is strongly influenced by soil type with water moving most easily through clay soils and less so through sandy soils making clay soils with a similar water table level more prone to salinity scalding.

Throughout the life of the project, various observations have been made by farmers around those areas that become saline over recent years. These include;

- **Annual Ryegrass (ARG) appearing in low lying areas**. This has largely been observed in cropping paddocks. ARG is much more tolerant of waterlogging than crop species and will often outcompete crops in wet conditions. The appearance of large patches in low lying areas (Fig.3) suggests that groundwater has risen within the plant root zone. If the ARG is controlled, it can leave the area largely bare and exposed increasing evaporation potential over the summer months. This is likely to result in an increase in the accumulation of salts at the plant root zone and soil surface.

Figure 3. ARG in a waterlogged area of a paddock

- **High biomass production in the year prior to dryland salinity appearing**. This has been observed in both crop and pasture situations (including Dryland Lucerne – Fig.4). The increase in biomass is thought to be due to the increase in available fresh water within the root zone (without the water actually reaching the surface) in that season. Fresh water is lower in density than saline water. Fresh water can sit in a lens on top of the saline groundwater. However once this fresh water source has been exhausted, the saline water is left behind. If the plants aren't tolerant to this saline water, they then die leaving bare exposed areas with the potential for increased wicking to occur.

Figure 4. Increased Lucerne growth in a low-lying area

Understanding Soil Salinity Levels

Knowing the soil salinity level of your soil is critical; particularly if you are looking to try and remediate the site by establishing pasture species.

Soil salinity is usually referred to as either EC 1:5 (where 1 part soil is mixed with 5 parts de-ionised water) or as ECe (dS/m) – an estimated amount of salt in the soil accounting for soil type.

Full methods for measuring soil salinity are available at:

https://www.publications.qld.gov.au/dataset/05c87bc5-6048-4767-85c8-36e660c38b1d/resource/6205ff5f-92b6-444b-95b7-f195fe4a64d6/fs_download/sn-l137-measuring-salinity.pdf

Soil sampling through a laboratory analysis is the most accurate way to determine soil salinity levels. Soil salinity levels across a paddock can vary greatly (Fig 5). In this instance it is probably worth conducting multiple tests.

The time of sampling can also impact results, with a sample taken at the end of summer most likely to show the maximum level of soil salinity. A winter sample is likely to show a lower result due to the flushing of salts through the profile from natural rainfall (see time of sowing below).

Figure 5. Variations in soil salinity across Coomandook site, 2018

Management options for Saltland Remediation

1. Varietal selection

There is a wide range of tolerance of different crop and pasture species to soil salinity as shown in Figure 6. The recently released salt tolerant legume Neptune Messina is adapted to winter-waterlogged areas where soil salinity in the top 10cms is 8-30 dS/m ECe in summer-early autumn. (https://www.agric.wa.gov.au/neptune)

Farmer demonstrations from 2017-2019 largely focused on the new salt tolerant (and waterlogging tolerant) pasture legume Neptune Messina (Figure 7a-c). It was assessed in different soil types and situations as both a stand-alone salt tolerant pasture, and as part of a saltland pasture mix where it's role was to add protein to the feed mix and to provide nitrogen to the system (all seed was inoculated with the salt tolerant Rhizobium strain for Messina).

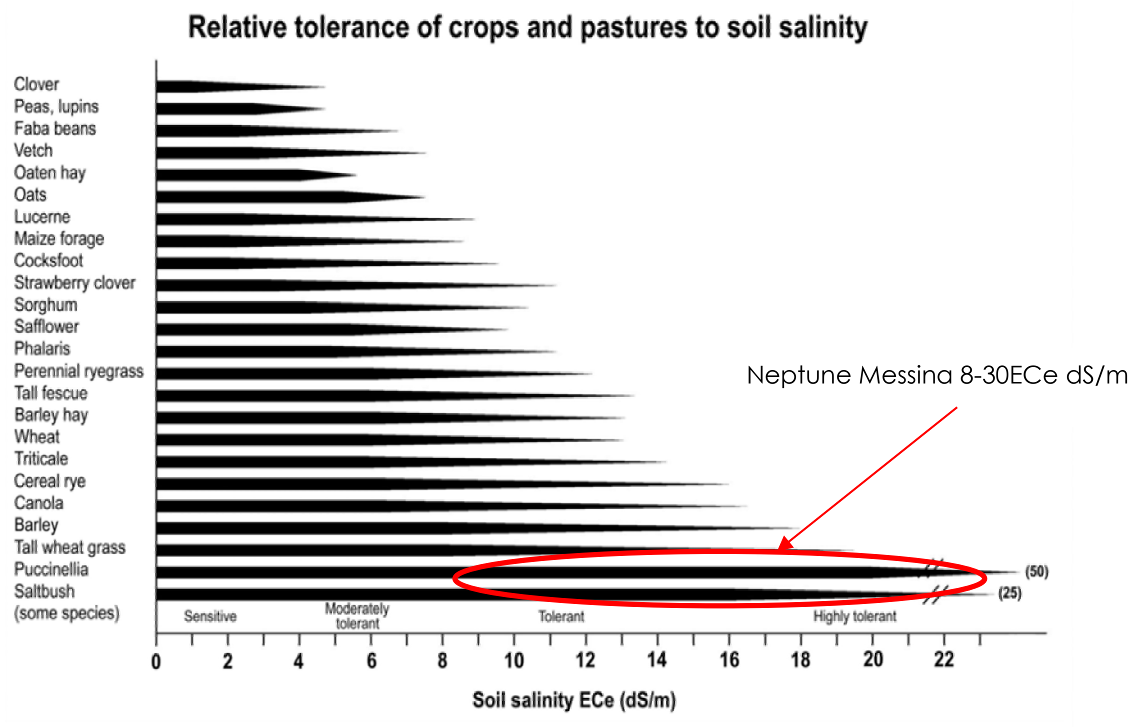


Figure 6. Relative tolerance of crops and pastures to soil salinity (Hermann, 1995)

Figure 7a – Messina establishment, Cooke Plains 2019

Fig 7b – Messina growing in waterlogged conditions, Meningie East 2017

Fig 7c – Seedling Messina, Coomandook 2018

Feed quality samples were taken from the Cooke Plains_2 site in 2017. This testing found that the Messina was comparable in feed quality to other legume species (Figure 8), however farmer experience has been that in larger paddocks with a mixture of soil types and pasture species the Messina can remain largely ungrazed but still provide valuable groundcover. In the absence of other feed sources, the stock will graze it.

Test	Messina	Nitro Persian	Balansa
Dry Matter (DM) (%)	12.3	10.9	7.8
Moisture (%)	87.7	89.1	92.2
Crude Protein (% DM)	32.7	26	25.3
Acid Detergent Fibre (% DM)	19.6	18.5	20
Neutral Detergent Fibre (%DM)	25	31	34.3
Digestibility (DMD % of DM)	82.9	80.5	78.1
Digestibility (DOMD) (Calculated % of DM)	77	75	73
Est. Metabolisable Energy (Calculated MJ/kg DM)	12.6	12.2	11.8
Fat (% of dry matter)	4.8	4.5	4.7
Ash (% of dry matter)	13.7	13.5	12.9

Figure 8. Feed test data (summarised), Cooke Plains_2, 2017.

Nodulation of the root system of Neptune Messina (Fig 9) was still evident in 2019 in a four-year old stand showing the ability of the rhizobia to survive in the hostile soils in the district.

The persistence of the Messina and Rhizobia over four years has shown the role that the Messina is likely to play in saltland pastures;

- As part of a diverse species mix (as opposed to a monoculture).
- As part of a mixed salt tolerant pasture sward providing maximum levels of groundcover and water extraction across the saline area.
- Providing the vital role of a salt tolerant legume (other than Balansa or Persian Clover) to provide nitrogen fixation in a salt tolerant pasture mix.

Figure 9. Nodulation of Messina, Coomandook, September 2019

2. Time of sowing

The time of sowing is critical in trying to remediate saline country. To improve the chances of plant germination, a 'flush' is thought to be required. In 2017-2018 this 'flush' wasn't received and there was poor germination across all sites. In 2019, exceptional germinations were observed on hostile, saline soils and the late time of sowing after the salts had flushed through the soil was thought to be the key difference driving this success.

Figure 10 shows the effectiveness of the rainfall events received 12-June 2019 at a nearby Coomandook soil moisture probe in pushing water down through the profile (taking salts with it).

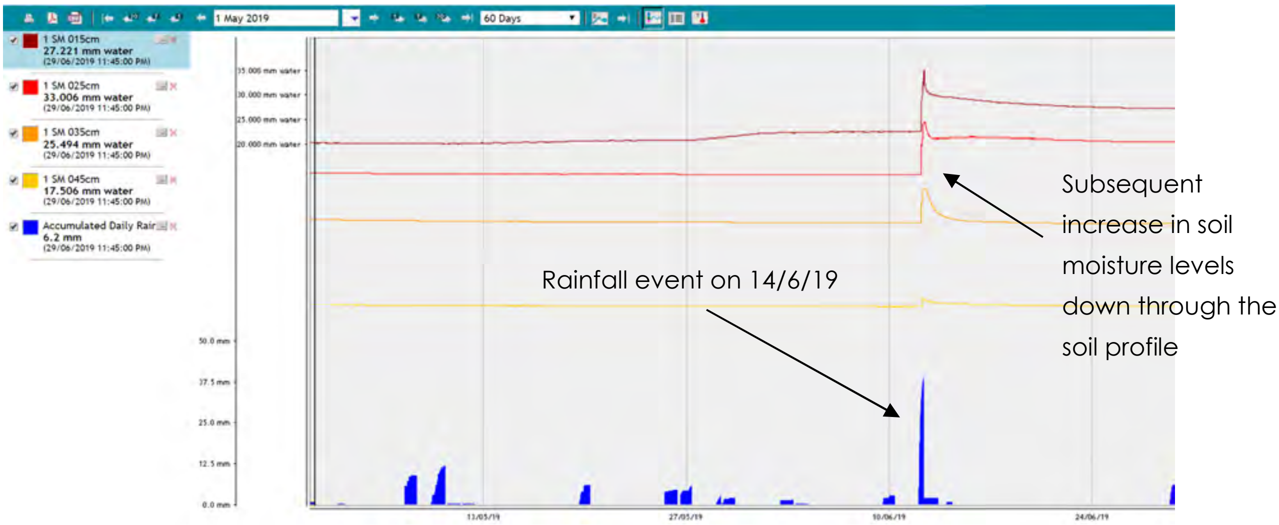


Figure 10. Coomandook soil moisture probe 1-May to 1-July 2019 (Data courtesy of SAMDB NRM Soil moisture probe network)

This is further supported by the Moorlands soil moisture probe data where the 2018 and 2019 data can be compared. In 2018 (Fig 11a) there was very little change in soil moisture levels from the 25-May to 25-June 2018, with the 50cm zone actually drying out further. This is in contrast to 2019 (Fig 11b) where there was an increase in the soil water through the profile down to 50cms.

Sensor depth	25-May	25-Jun	**CHANGE**
(cms)	mm water		
20	12.97	13.66	**0.69**
30	14.82	15.23	**0.41**
40	15.04	15.08	**0.03**
50	13.84	13.73	**-0.11**

Sensor depth	25-May	25-Jun	**CHANGE**
(cms)	mm water		
20	11.27	15.42	**4.15**
30	12.62	17.68	**5.07**
40	12.94	16.96	**4.03**
50	11.53	12.98	**1.46**

Fig 11. Moorlands soil moisture levels (a) 2018 (b) 2019
(Data courtesy of SAMDB NRM Soil moisture probe network)

3. Use of groundcovers and providing micro-climates

Throughout the life of the project, the areas where successful establishment of pastures occurred were those where there was evidence of groundcover (green or dead plant material) or areas where the surface was slightly elevated.

It is thought that retaining some level of groundcover over the summer period may assist in shading the area and reducing the evapoconcentration of salts in the soil over the summer period. In 2019-20, three sites were monitored to see if groundcover/shade over the summer period assisted in reducing the evapoconcentration. Soil samples were taken on 30-Jan 2020 prior to a rain event. The results are shown in Figure 12 where it can be seen that the groundcover appeared to reduce the soil surface salinity levels across all sites both at the soil surface further emphasising the importance of trying to retain groundcover to reduce the level of salt scalding.

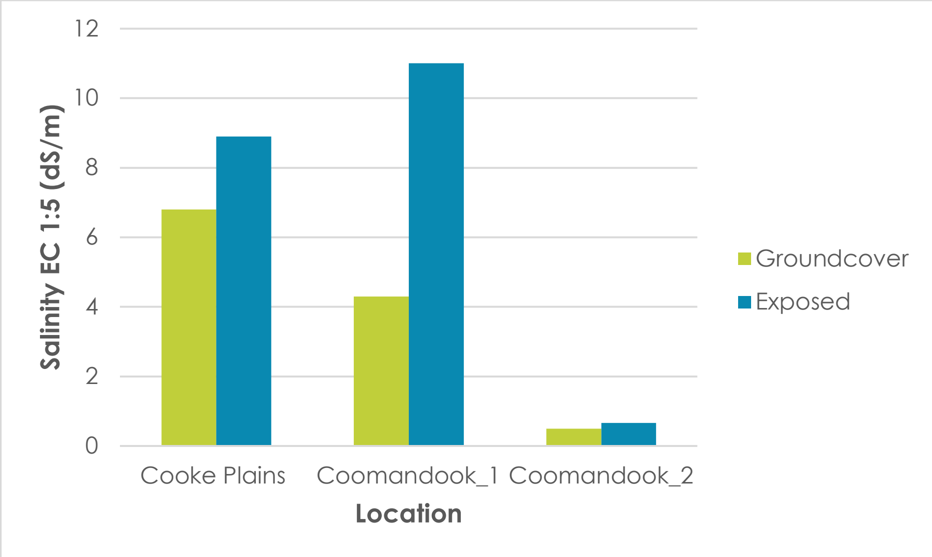


Figure 12. Impact of groundcover on soil surface salinity (0-10cms), 2020

This groundcover is also thought to provide a micro-climate for germinating plants. It not only provides an area that is lower in salinity levels, often the soil deposits lodge at the base of these areas providing a mounded area that appeared to be less hostile (thought to be due to reduced evapotranspiration, and more rapid leaching of salts when rainfall occurs). The natural colonisation of plants in areas where there was groundcover was evident across all sites throughout the life of the project (Figure 12). This prompted the thought of using mounds or organic matter to simulate what was being observed in nature.

4.Mechanical intervention

Throughout the project, different seeding techniques were used with varying success. The common method of seeding into the furrow and then providing a furrow with the press wheel was found to be detrimental to establishment of pastures in saline soil as the press wheel tended to create soil surface sealing impacting on germination. Those seeds that weren't placed in the base of the furrow rather on the sides of the furrow were those that germinated more effectively (and were more likely to survive).

The paddocks that were very roughly worked were those that appeared to have improved establishment. Mounding of a site at Coomandook in 2019 did not appear to improve establishment, however the time of sowing was very delayed at this site and the site may require rainfall to flush the salts out of the mounded area. This site will continue to be monitored as future opportunities allow.

In 2018 at the Cooke Plains_1 site the application of organic matter was demonstrated to see if this mulch effect provided a micro-climate to improve establishment of the Messina. Straw was chopped up through a Tomohawk bale shredder (Figure 13 a-b) and then incorporated with a chopper chain increasing the amount of organic matter in the soil. Germination in 2018 at this site was minimal, however the presence of the straw assisted in reducing wind erosion in 2018 and the summer/autumn of 2019. In 2019 good pasture establishment occurred across this (and all other sites). This has mainly been attributed to the rainfall 'flush' events, but areas where the straw had been incorporated appeared to visually have improved ground cover in 2019.

Figure 13 (a) Tomohawk Bale Shredder **(b) Straw on surface at site (August 2018)**

In 2019, a paddock at Cooke Plains that had been impacted by salt since 2013 was deep ripped to 400mm in a series of strips to see if cracking open the soil or reducing a hard pan layer had an impact on the soil salinity levels and establishment of pasture species. A mixture of crop and pasture species was then sown 11th June 2019 across the site.

The ripping was very successful in improving the pasture production and overall health of the plants (Fig 14). Establishment of the small seeds in the mix was reduced (thought to be due to seeding depth on the soft ripped area). Ripping was also effective in decreasing the salinity levels in the treated area, both at the surface, and at the 10-30cm layer (Fig 15).

Figure 14. Ripped (LHS) vs Unripped (RHS), Cooke Plains 2019

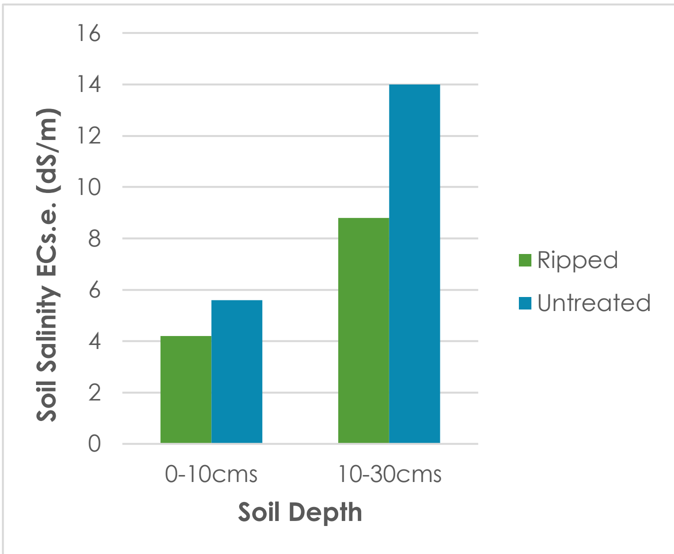


Figure 15. Soil Test Results, Cooke Plains 2019

Conclusion:

Throughout the life of the project, various saltland remediation techniques were demonstrated to improve farmer understanding of their effectiveness in remediating salt scalds. Varying success was achieved depending on the technique being demonstrated and the seasonal conditions being experienced.

Key Lessons learned;

- Maintain groundcover
- Wait until the soil has been 'flushed' before sowing
- Use a mixture of salt tolerant species

Gathering the following information will also assist in decision making in regard to the best way to manage a salinity impacted site;

- Knowing the soil salinity levels
- Is there a hardpan?
- The depth and seasonal variation of the saline water table

The use of mechanical interventions needs further exploration to improve understanding of the effect of different ripping techniques across a range of soils and the impact that it has on the movement of salts within the season.

There also needs to be a continued focus on prevention of saline areas (as opposed to cure). Further work needs to be done around suitable land use, the water use of different crops, pastures and other perennial vegetation to reduce the recharge of ground water across the landscape.

Australian Government | National Landcare Program

COORONG DISTRICT COUNCIL

Coorong Tatiara Local Action Plan

Tatiara the good country

This project is supported by the National Landcare Program – Smart Farms Program, an Australian Government Initiative

Technical note 1

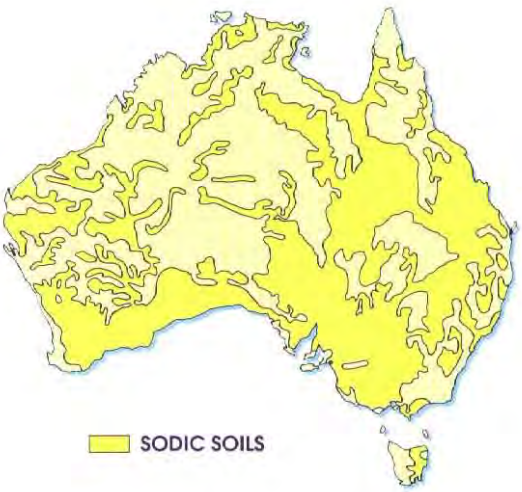
Introduction to soil sodicity

June 1994

Land managers with paddocks that are prone to waterlogging, poor crop or pasture emergence, gully erosion or tunnel erosion may be experiencing the effects of sodicity. Sodicity becomes a problem when there is sufficient sodium attached to the clay in the soil to affect soil structure. These soils are referred to as sodic and are often regarded as poorly structured and difficult to manage, and are susceptible to soil degradation such as erosion.

In Australia about 30% of the agricultural land is sodic. That is about five times the area of land that is estimated to be saline.

Not all poorly structured soils are sodic. Land managers need to distinguish between poorly structured non-sodic soils and sodic soils as management differs for each situation.



Distribution of sodic soils in Australia

Sodicity and salinity

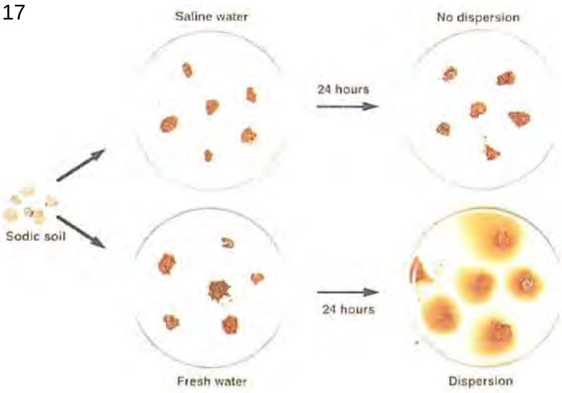
Both sodicity and salinity are caused by too much salt (usually sodium chloride) in the soil but sodic and saline soils have quite different problems and require different management techniques to maintain productivity.

Sodicity is caused by the presence of sodium attached to clay in soil. A soil is considered sodic when the sodium reaches a concentration where it starts to affect soil structure. The sodium weakens the bonds between soil particles when wetted resulting in the clay swelling and often becoming detached. When this happens the clay particles spread out or disperse making the soil water cloudy. This process is called **dispersion** and occurs in sodic soils without any disturbance of the soil. The dispersed clay particles can then move through the soil clogging pores. Both swelling and dispersion reduce infiltration and drainage. Once the sodic soil is broken down into very fine particles it can easily be moved by water or wind.

Most of the sodium in **saline soils** is in the form of soluble salts (mainly sodium chloride or common table salt) which can be easily dissolved and moved in soil water. Soluble salts reduce the availability of water to plants. The symptoms of salinity are commonly known and the severity can be easily measured. Sodicity is more common in Australian soils but its symptoms are not as well known and it is more difficult to recognise.

Salt, sodium and soil structure

A saline or salty soil will often not show the symptoms of sodicity even when sodium is present on the clay. The salt prevents the clay particles from dispersing.



Salt prevents clay dispersion but is detrimental to plant growth

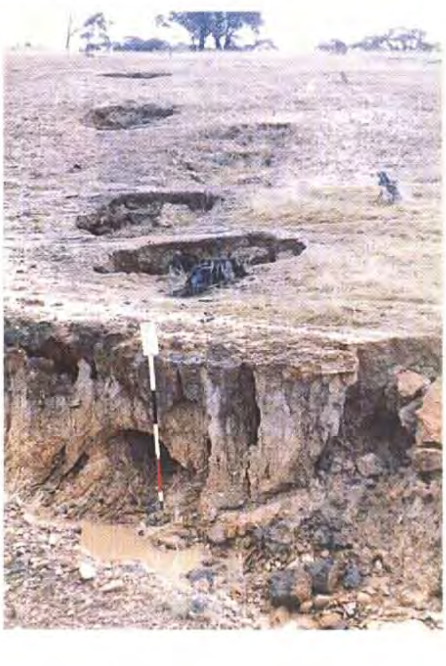
Sodium weakens the bonds between soil particles on wetting resulting in swelling and dispersion

Effects of saline and fresh water on swelling and dispersion

> **Exchangeable sodium**
>
> The sodium attached to soil particles is referred to as exchangeable sodium whereas the free sodium found in salt (eg. sodium chloride) remains unattached. The exchangeable sodium is moved out of the root zone by displacing it with calcium or subsequent leaching. The salt is moved by leaching alone.

Waterlogged sodic soil

Gully erosion of a sodic soil



Tunnel erosion of a sodic soil

If the soil is reclaimed by leaching the salt out of the affected soil layer, then symptoms of sodicity will start to appear. Temporary leaching of salts from surface soils, such as occurs after a rain storm, can also result in sodicity symptoms being observed.

Symptoms of sodicity

Sodicity can occur at any depth in the soil. A sodicity problem within a metre of the surface is more easily recognised than a problem deeper in the soil. In many soils that are agriculturally very productive, a sodic layer commonly exists below the rooting zone of the plants. This may have impact on crops or pastures if it is on flat land and could result in tunnel erosion if it is on a slope in a high rainfall climate. Symptoms are therefore a reflection of where the sodicity is a problem in the soil (topsoil, subsoil or both), climate (particularly rainfall) and slope (hilly country more susceptible to tunnel erosion).

Symptoms that are typical of a sodicity problem in the rooting zone of plants (ie. down to 60 - 100cm) include poor infiltration and drainage resulting in waterlogging, increased runoff and poor water storage, surface crusting, poor emergence of crops and pastures, problems with cultivation and erosion. The soils are often regarded as difficult to manage and have low productivity.

In irrigation areas the sodicity problem may occur in the topsoil as a result of sodic subsoil clay being brought to the surface or exposed by land forming.

Soils that are sodic below the rooting zone of plants often go unnoticed by land managers because there is frequently no obvious impact on farm management, especially in low rainfall regions. In some high rainfall areas, irrigation regions and where there have been high rainfall events, drainage can be reduced by sodicity resulting in waterlogging. This may not always be obvious by looking at the surface soil.

Visual symptoms of sodicity may occur in hilly country and where mole drains, interceptor drains and dams have been installed. Mole drains installed in sodic soil are susceptible to collapse. Interceptor drains and channels into and out of dams are susceptible to being eroded.

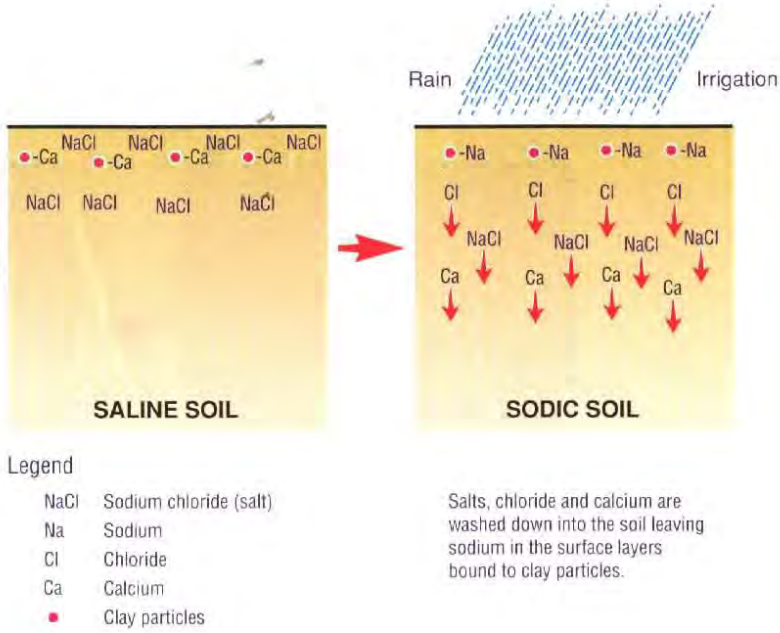
The effects of sodicity may also be seen in hilly country. Tunnel erosion can be a problem where the force of water moving down the hill can wash out soil, leaving cavities which eventually collapse to form gullies.

How do soils become sodic

A saline soil becomes sodic through the leaching of salt (eg. sodium chloride). This process may have occurred in the last 20 years or 10,000 years ago. As salt is washed down through the soil it leaves some sodium behind bound to clay particles displacing more useful substances such as calcium. This sodium builds up in the soil and interferes with soil structure.

The adjacent diagram highlights the steps in the formation of a sodic soil.

The amount of sodium and salt left determines whether the soil is non-sodic (very little sodium), sodic (a lot of sodium) or saline and sodic (a lot of salt and sodium).



Saline soil being leached with fresh water from rain or irrigation to form a sodic topsoil

Sources of salt and sodium

Soils can become saline due to rising watertables that bring the salt closer to the surface, through the use of saline irrigation water (eg. bore water, effluent), weathering of rocks containing salt or rainfall, and when paddocks are close to the sea or exposed to sea winds. In some regions, salt blown in from the sea has caused salinity several hundred kilometres from the ocean.

The additions of salt from rainfall and weathering rocks are very slow processes that take thousands of years before the concentration of salt in the soil becomes a problem.

Some soils are naturally saline due to trapped marine salts from land being inundated by the sea many thousands of years ago.

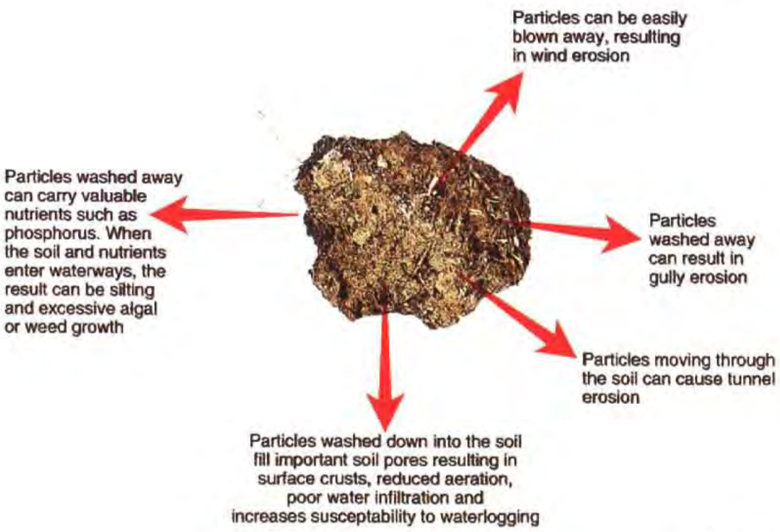
Not all dispersion is caused by sodicity

Erosion, waterlogging, poor emergence and a range of other symptoms can also be observed without sodicity being a problem.

Tillage and the impact of rainfall can cause sodic and non-sodic soils to disperse whereas in sodic soils dispersion occurs spontaneously. This means that when a lump of soil is put into water, it will disperse without any disturbance of the soil. Many soils will not disperse until disturbed by tillage or other mechanical operations. The presence of large amounts of sodium in the soil aggravate these problems and in many instances exert a considerable impact on plant productivity.

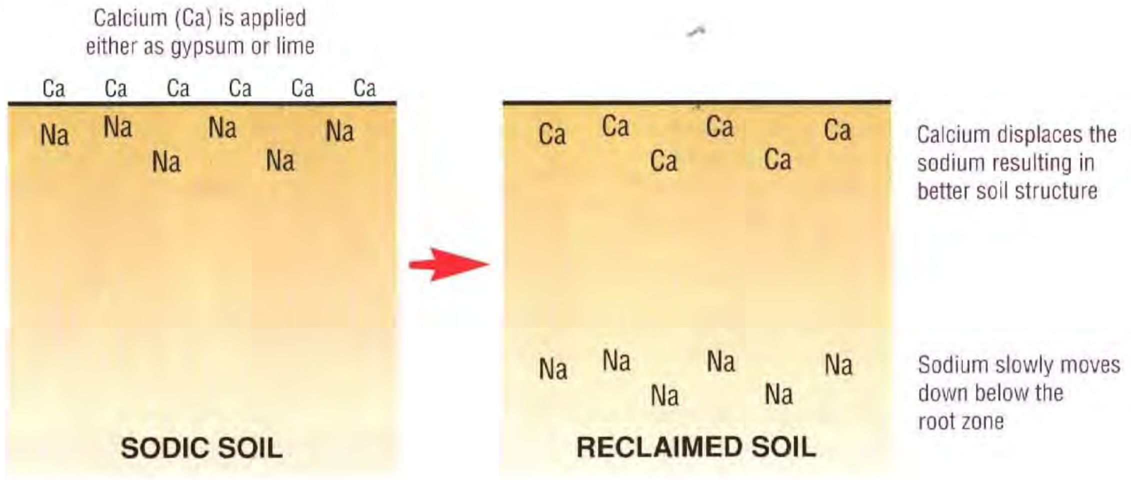
Soil testing for sodicity

Land managers can determine whether sodicity is a problem by sending soil samples to a reputable laboratory for analysis.



Movement of fine soil particles

Managing sodic soils



Reclaiming a sodic soil

To increase productivity of sodic soils, land managers need to apply gypsum or, in the case of acidic sodic soils, lime or a combination of both. The gypsum and lime have three important effects that contribute to better soil structure and increased plant productivity.

Firstly, the calcium in the gypsum and lime displaces the sodium which can then be leached deeper into the soil. This is a very slow process with the low rates that land managers can usually afford to apply.

Secondly, gypsum and lime act like common salt in that they help prevent the clay from swelling and dispersing. Unlike common salt , they are not detrimental to plant growth.

The land manager can therefore gain the benefits of better soil structure even though the sodium attached to clay is only partially displaced by the use of small amounts of gypsum or lime.

Thirdly, the higher plant production from the use of gypsum or lime will also result in more plant residues. If these are not removed or burnt they will aid in building up organic matter. The additional organic matter improves soil structure adding to benefits of using gypsum or lime.

Where sodicity is not a problem, but soils exhibit the symptoms mentioned above, organic matter alone will improve soil structure

For further assistance contact your local adviser

This leaflet has been compiled by Dr Pichu Rengasamy and Mr Leigh Walters, CRC for Soil and Land Management in consultation with the following state representatives:

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CRC AUSTRALIA Soil & Land Management

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Western Flat Field Walk

Clay Development Work

Hamish Verco

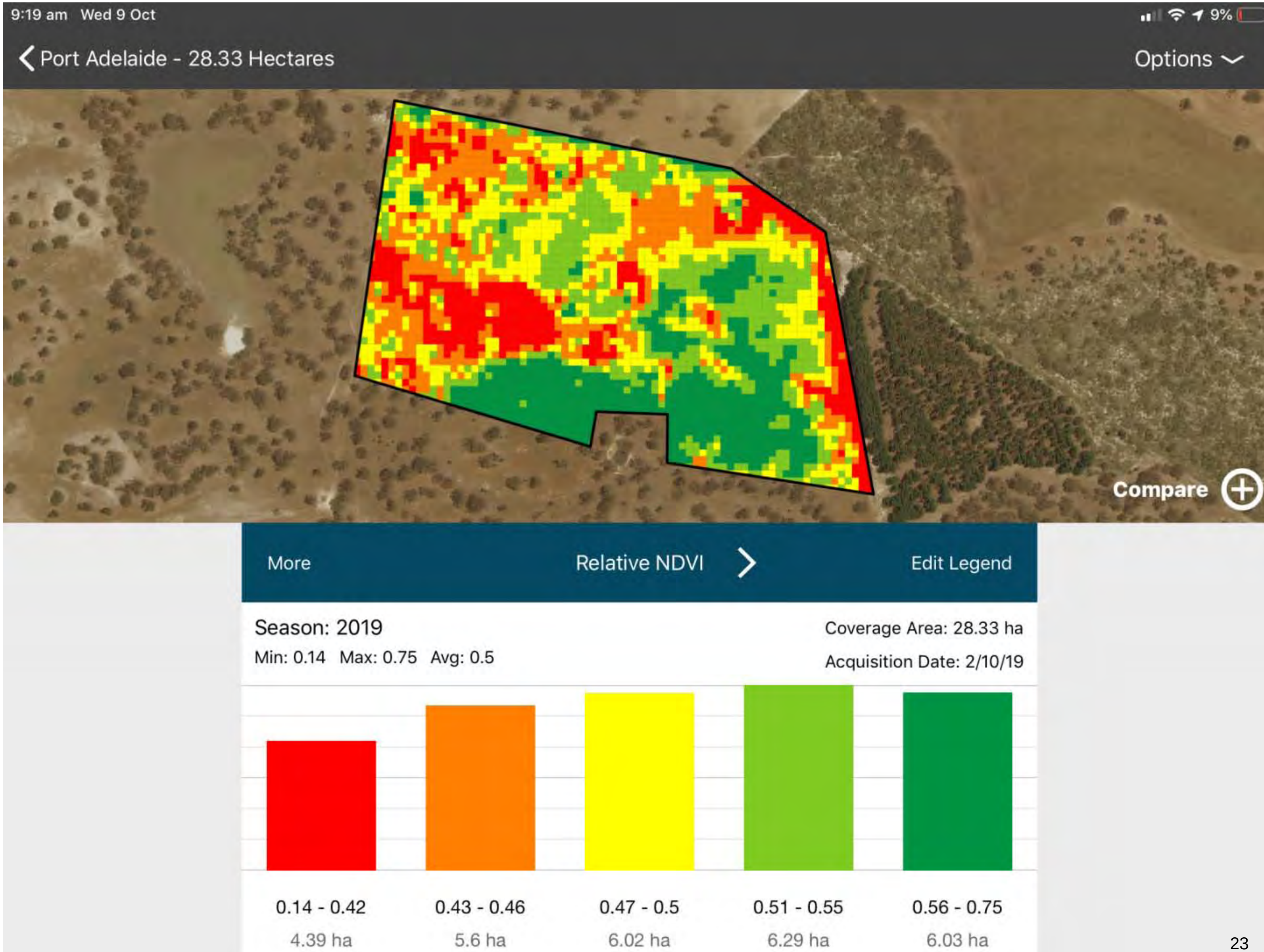
20

Background

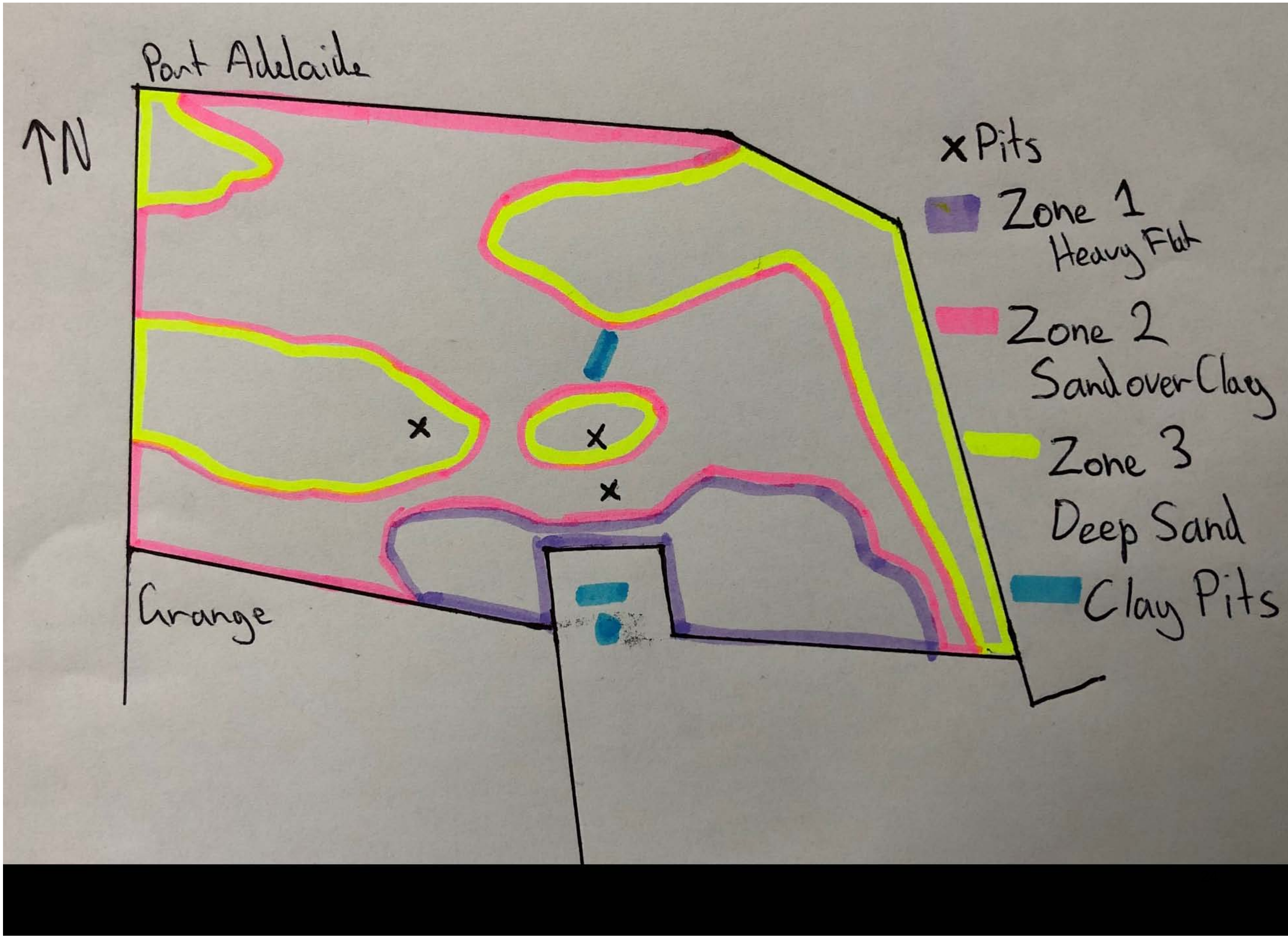
- Undeveloped property, managed with minimal inputs.
- The property was previously run as one paddock, 2 watering points, little/no fertiliser, half the property was pine trees, it was utilised a set and forget winter grazing block.
- From late 2018 onwards we have set about developing back 2 paddocks.
- 3 main soil types; mix of heavy flats, sand over clay and deep sand.

Huge disparity between the nature and productivity of heavy flats and un-clayed, nutrient poor, white sand hills.

NDVI pre-development work, 02/10/19



Rough outline of Soil type Zones 1,2 & 3. Also note the location of Soil Pit sites looked at today and Clay Pits used to spread paddock.



The Zones, there issues and the solutions

Ground truthing pH, repellence and compaction September 2019

	Site A- Top of Sandhill			Site B- Sand over Clay		
Depth (cm)	0-10	20	40	0-10	15	25
Texture	Sand	Sand	Sand	Sand	Sand	Clay
pH (water)	6	7	6.5	6/5.5	6.5	7
BD	1.4	1.36	1.43	1.4	1.45	1.45
Water Repellance	40min+	10s	60s	23min	0	0
	Very Severe	V low/low	Low/modera te	V severe	-	-

Zone 1- Flats

Constraints

- Highly sodic and dispersive subsoil (8-18% ESP)
- Little topsoil, 2-5cm
- Compaction, leading to water logging, poor drainage
- Slightly acidic
- Nutrient deficient (N,P,K,S,Ca,B,Mn,Cu)
- Poor pasture species composition and density. Little biomass production, lack of groundcover

Amelioration

- 2019 Lime spread in 2019 will help increase pH and reduce sodicity
- Gypsum and Lime (lots of it) will increase Ca, improving structure, porosity, drainage and Bulk Density; while decreasing sodicity
- Zn, Mn, Cu from foliar spray, 2 applications 2020
- N- high legume base in 2020 pasture cover crop
- P and S- from fertiliser, SSP, Guano and Gypsum (SSP and Gypsum didn't happen)

Zone 2- Delved sand over clay

Constraints

- Highly water repellent topsoil
- Limited water and nutrient holding capacity
- Nutrient desert (N,P,K,S,Ca,Mg,B,Mn,Cu)
- Acidic topsoil, sodic subsoil
- Compaction layer
- Lack of pasture species diversity (strong veldt but a monoculture), few productive C3 grasses and legumes. Lack of biomass
- Dominance of silvergrass and poa bulbosa

Amelioration

- Delved to overcome water repellent topsoil, increase CEC and WHC (water holding capacity) of topsoil
- Increase pH of topsoil with alkaline clay, break up any compacted layers and sodic 'cap' at the top of clay
- Incorporated Clay by offset disc x2, railway iron x2, offset disc, railway iron, knife point press wheel @ sowing
- P and S from Guano fertiliser
- K, Mg, B, Fe from the clay brought up by delving (possibly other nutrients as well)
- Zn, Mn, Cu from foliar spray, 2 applications 2020
- N- high legume component 2020 pasture cover crop
- Spray topped silvergrass in October 2019

Zone 3- Clay Spread deep sand

Constraints

- Highly water repellent topsoil
- Limited water and nutrient holding capacity
- Nutrient desert (N,P,K,S,Ca,Mg,B,Mn,Cu)
- Acidic topsoil
- Compacted subsoil?
- Lack of pasture species diversity (reasonable veldt but a monoculture), few productive C3 grasses and legumes. Lack of biomass and groundcover
- Dominance of silvergrass and poa bulbosa

Amelioration

- Clay Spreading @250t/Ha with Clay content of ~20-40% to overcome water repellence and increase CEC and WHC
- Increase pH of topsoil with alkaline clay
- Incorporated clay by Tyne cultivator x2 (before and after summer rain), railway iron x2, offset disc, railway iron
- P and S from Guano fertiliser
- K, Mg, B, Fe available from clay from clay spreading (possibly other nutrients as well).
- Zn, Mn, Cu from foliar spray, 2 applications 2020
- N- high legume component 2020 pasture cover crop
- Spray topped silvergrass in October 2019

Earthwork $$$

- Delving =$430/Ha + Offset disc x2 $150Ha
- Delving was done with 2 tynes rather than three, increasing the cost
- Trees also increased cost
- Undeveloped country=stumps=split pins= also increased the cost
- The offset discing could also only be done with narrower disc because of trees; also increased cost.

- Clay spreading =$690/Ha
- I think more Ha than forecast were clay spread because of where delving couldn’t bring up clay so the actual $/Ha cost is likely lower than this.
- Rough paddock (old rabbit warrens, stump holes, soft & gutless sand) reduced travel speed by 2-3 gears, increased cost

Pasture Seed

- Separate mix's were made to suit light and heavy soil. Heavy soil mix was sown over Zone 1 while Light soil mix was sown over Zones 2 and 3.
- Diverse mix to look at what would and wouldn't grow well under new, highly altered, sometimes hostile growing conditions.
- Increased diversity also lowers risk, if one species fails for whatever reason it is easily compensated for by others in the mix.

Heavy Mix			
Species	**kg/Ha**	**$/kg**	**$/Ha**
Vetch	6	0.8	4.8
Balansa	4	3	12
Persian	2	3	6
Rose	0.5	8.8	4.4
Berseem	1	5	5
Ryegrass	7.5	2.75	20.63
Saia Oats	5	0.9	4.5
Triticale	10	0.85	8.5
Grazing Oats	10	1.2	12
Fodder rape	0.5	5.5	2.75
Tillage Radish	2	8.1	16.2
Total	48.5 kg/Ha		$96.78

Light Mix			
Species	**kg/Ha**	**$/kg**	**$/Ha**
Vetch	6	0.8	4.8
Balansa	3	3	9
Arrowleaf	3	2.4	7.2
Rose	0.5	8.8	4.4
Crimson	1	6.4	6.4
Paraggio Medic	2	5.2	10.4
Blast	5	2.75	13.75
Saia	10	0.9	9
Ryecorn	15	0.75	11.25
Triticale	10	0.85	8.5
Fodder Rape	0.5	5.5	2.75
Tillage Radish	1	8.1	8.1
Total	57		95.55

Indicative SMS Guano Analysis

(Test from 6 imports, 3 years)

- **Phosphate (P2O5)** 24 – 25.5 %
- **Total Phosphorus** 11.9 %
- **Organic Carbon** 10 %
- **Potassium** 0.16 %
- **Nitrogen** 0.64 %
- **Sulphur** 0.6 %
- **Calcium** 30.5 %
- **Magnesium** 1.9 %
- **Sodium** 0.08 %
- **Manganese** 22,273 mg/kg
- **Zinc** 2,597 mg/kg
- **Copper** 522 mg/kg
- **Iron** 24,399 mg/kg
- **Aluminium** 28,000 mg/kg
- **Boron** 42.4 mg/kg
- **Cobalt** 13.04 mg/kg
- **Molybdenum** 5.35 mg/kg

Fertiliser

- Sown with 80kg of Guano Sulphate of Ammonia blend
- 6:8:0:7 analysis
- Spreading contractor not getting 200kg/Ha of Single super spread pre seeding has been detrimental, as we will see.

Successes, hurdles & future plans

- Overcame water repellance in the 0-10cm in Zone 3.
- Zone 2 non wetting is still there in patches.
- Weathering, animal impact and future passes when seeding will continue incorporation process
- Increased CEC and Water Holding Capacity of topsoil in zones 1 & 2 to the depth of clay incorporation.
- Increase soil OM to further benefit soil properties.
- Neutralised topsoil acidity with alkaline clay…?
- Lime if required to get pH above 5.5/6 in CaCl2

- Reduced compaction where delved.
- Possibly still a compacted layer where clay spread.
- Deep ripping Zone 3 to break compaction
- Nutrition in clay brought/placed to/on topsoil and incorporated seems to have released nutrition and benefited plant
- Poor nutrition is still an obvious issue, visual symptoms of nutrient deficiencies.
- P, K, S, Ca and Trace Elements will continue to be added annually.
- Good pasture establishment of all species where conditions were right, all have a fit somewhere in the system

- Tinker with Diverse cover mix composition and ratios.
- Re-sow to diverse perennial mix once soil constraints are overcome, nutritionally balanced soil and weed control is adequate
- Good biomass and groundcover Zone 1 & 2
- Average Biomass and groundcover Zone 3
- Reduced weed prevalence Zone 2 & 3
- Sodium dominated Cation ratio, sodicity, poor structure and drainage.
- Gypsum and or Lime to dislodge Na and replace it with Ca.

- Continued weed prevalence in Zone 1
- Considered shallow ripping in Zone 1 with gypsum incorporation, concerned about making it too soft and ‘soupy’
- Wagon Wheel graze with electric fence to increase utilisation and weed consumption.

In Summary; water repellence, sodium, weeds, nutrient desert and poor pasture composition were the major constraints. The answers:

Clay

Gypsum

Herbicides

Fertiliser

Seed

End Goal

- Biologically abundant soil with no physical or chemical constraints or imbalances
- 100% groundcover, 100% of the time
- Living plant roots and green leaves as often as possible
- Above ground diversity to drive below ground diversity and increasing soil OM
- High intensity rotational grazing with naturally intelligent livestock
- Minimise chemical and physical disturbance