Hillslope Erosion Trial
Weetah 2019

This project is supported by NRM North, through funding from the Australian Government's National Landcare Program.

BACKGROUND

This trial has been conducted by NRM North as part of the Hillslope Erosion Project, which aims to build awareness of hillslope erosion and increase the adoption of best practice mitigation techniques to minimize future soil erosion. The project is supported by NRM North, through funding from the Australian Government's Regional Land Partnerships. NRM North chose to trial erosion-control methods on the Weetah site near Deloraine, because the potato and vegetable crops grown on hilly red soil in the area are known as significant erosion sources.

NRM North approached Huett's farm at Weetah in early 2019 to identify a suitable trial location and start the trial process. The aim was to demonstrate and measure erosion in the local area, while learning how different management practices can help on-farm, and how much they cost.

Erosion trial plots on site at Weetah, winter 2019.

TRIAL DETAILS

This demonstration trial had four plots, each approximately 10 metres wide across the slope and running 40 metres downhill. The area was previously in a pasture phase and was described by the owner as having highly erodible soil. An investigation of the soil structure by Julie Finnigan, Technical Agronomist from Serve-Ag, showed the top five centimeters was compacted, with well-structured soil below (see appendix – Field Assessment).

Pasture on the plots was sprayed out on the 22 May, maintaining grass strips in between each plot to maintain trial boundaries.

Preparation of the cultivation treatment plots.

The following plots were cultivated and treatments were applied on 4 June:

- Bare fallow
- Re-sown with grass (as a sacrificial cover crop)
- Deep-ripped with a single tyne across the contour
- Ripper-mulched across the contour*

*An attempt to replicate a ripper-mulcher's effect was made by deep-ripping then pushing straw into the ripline. The ripper-mulcher implement lays straw on top, so this treatment is not an accurate reflection of the implement.

Rip lines in both cultivation treatments were approximately 10 metres apart.

Bamboo pegs to measure the expected erosion were inserted into the soil at approximately 50cm intervals across the slope on each plot. There were eight rows of pegs on the fallow and deep rip plots, ten rows on the ripper-mulch plot and nine rows on the grassed plot. The difference in number of rows was intended to reflect the different treatments.

The pegs were driven into the soil so the tops were flush with the surrounding soil level, however the rows of pegs were not placed near the top of the plots, to enable data capture from areas with higher runoff speed.

In late winter, volunteer regrowth was sprayed off to maintain consistent trial conditions, except in the grassed plot.

Following winter and early spring rainfall, NRM North staff measured soil movement in relation to the pegs on 30 September. This involved finding the pegs and measuring the change in soil depth relative to each peg. A total of 555 pegs were found and measured, giving an average 139 measurements per treatment. The soil surface depth change was averaged per plot, then the average was calculated out to give an expected change on a hectare, to enable comparison of soil loss and financial cost per hectare between treatments.

RESULTS

Fallow
LOSS 65 cubic metres of soil per hectare (average soil depth 6.5mm lower)

Mulched rip lines
LOSS 63 cubic metres of soil per hectare (average soil depth 6.3mm lower)

Deep ripping
LOSS 59 cubic metres of soil per hectare (average soil depth 5.9mm lower)

Grass cover
LOSS 40 cubic metres of soil per hectare (average soil depth 4mm lower)

Do rocks really come up to the surface?

Or does the surface go down to the rocks?

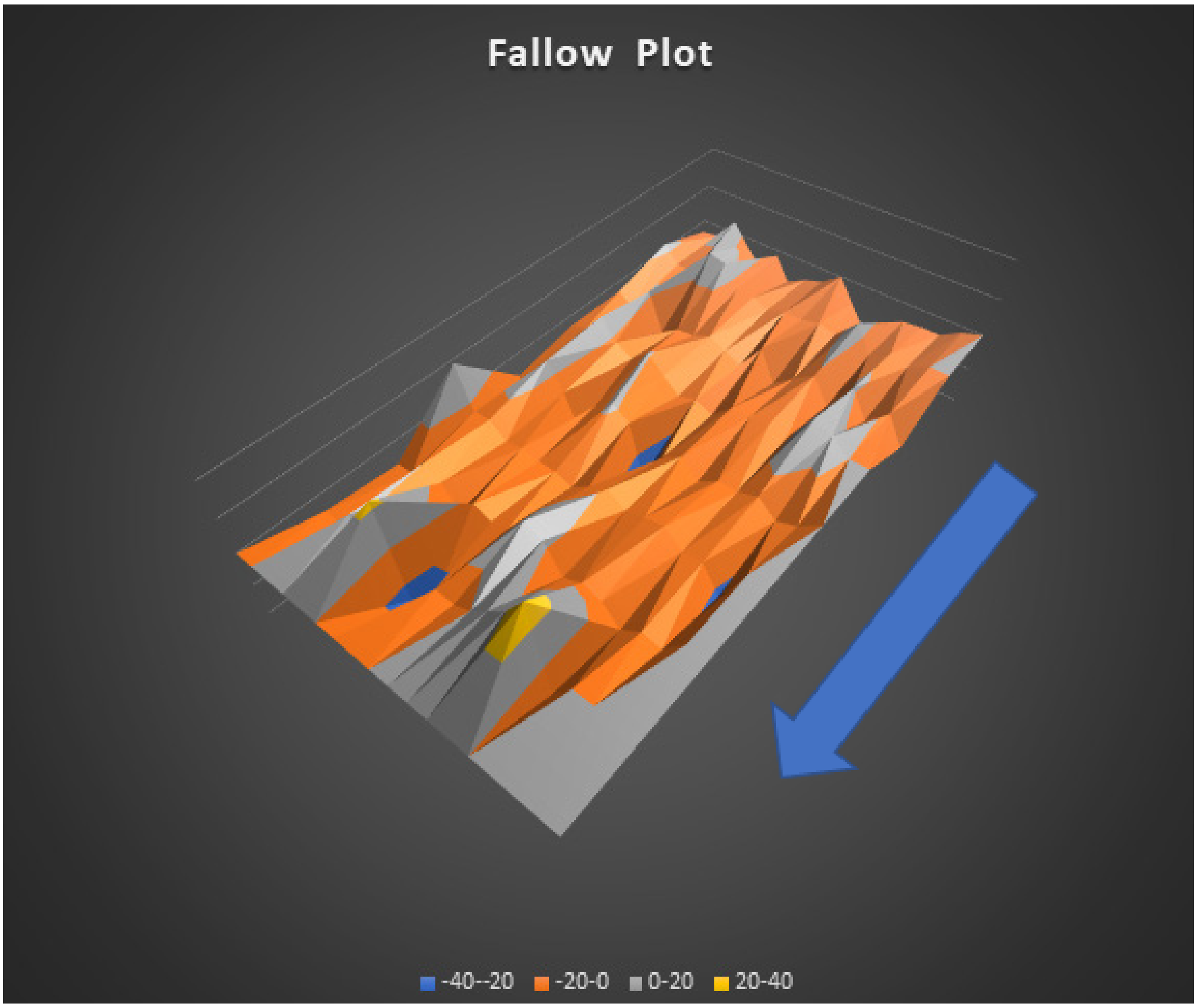
Measuring soil erosion from a trial plot.

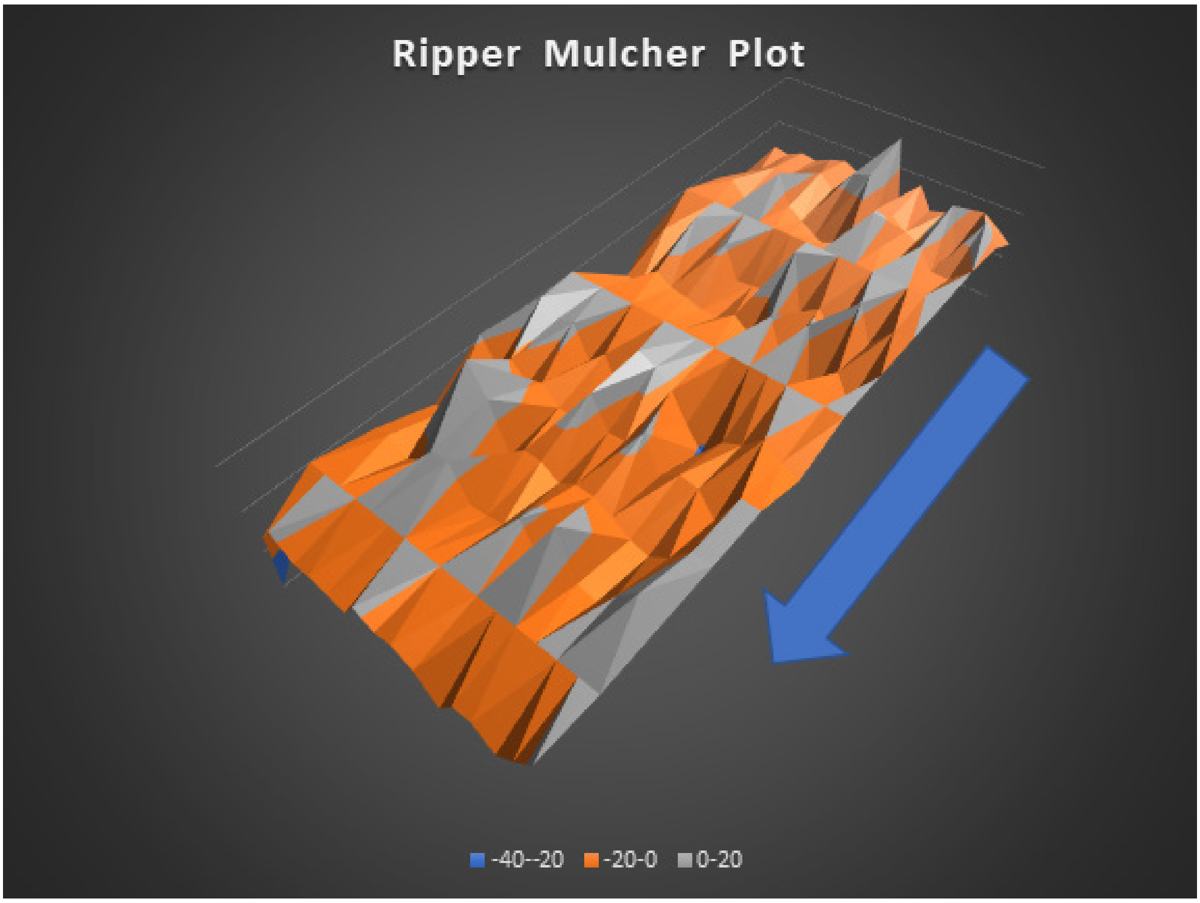
Erosion maps

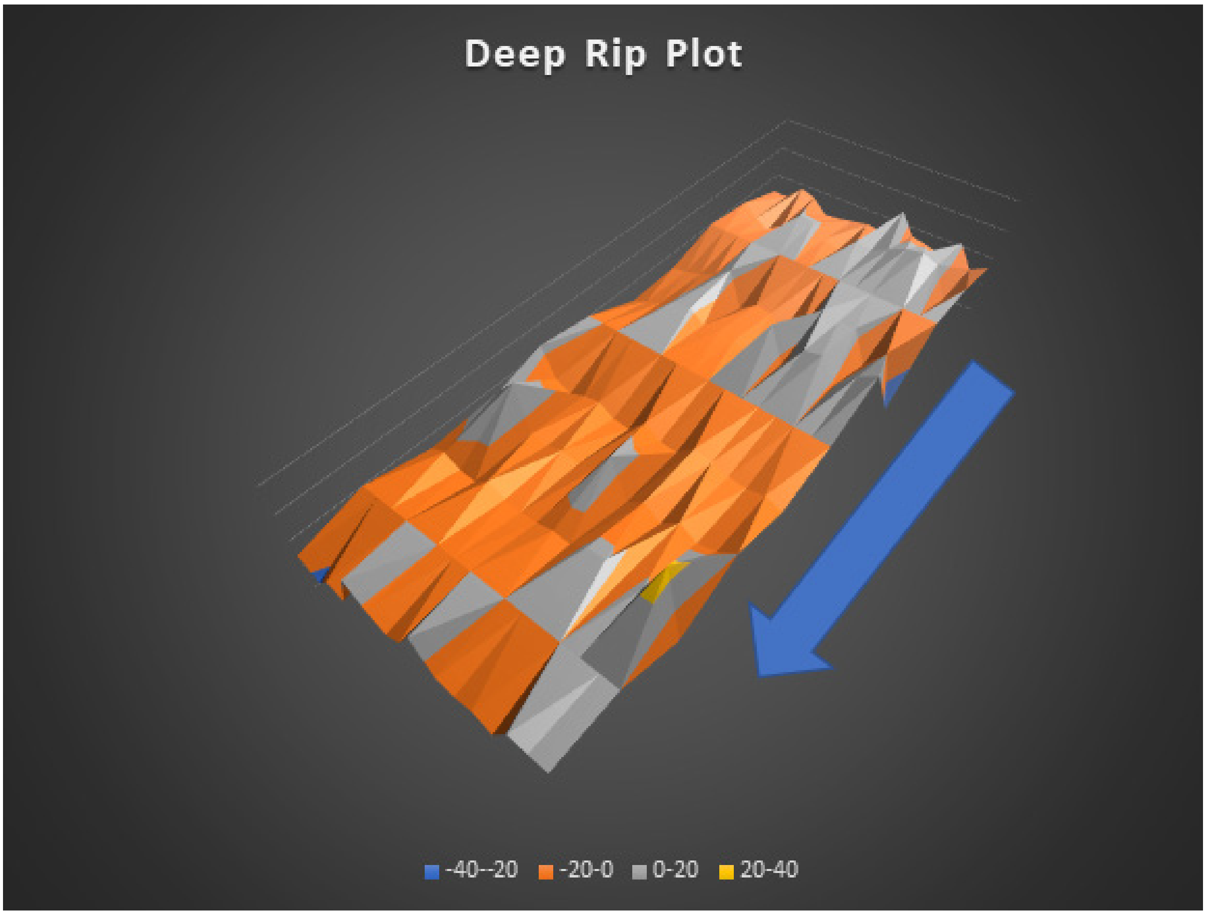
The following erosion maps are 3-D representations of the data points measured. In each map, the top-right side is the highest data line on the plot, leading to the bottom-left as the lowest data line. The blue arrow indicates the slope on each plot for further clarification. This does not represent the entire plot or downslope distances, only the measured pegs.

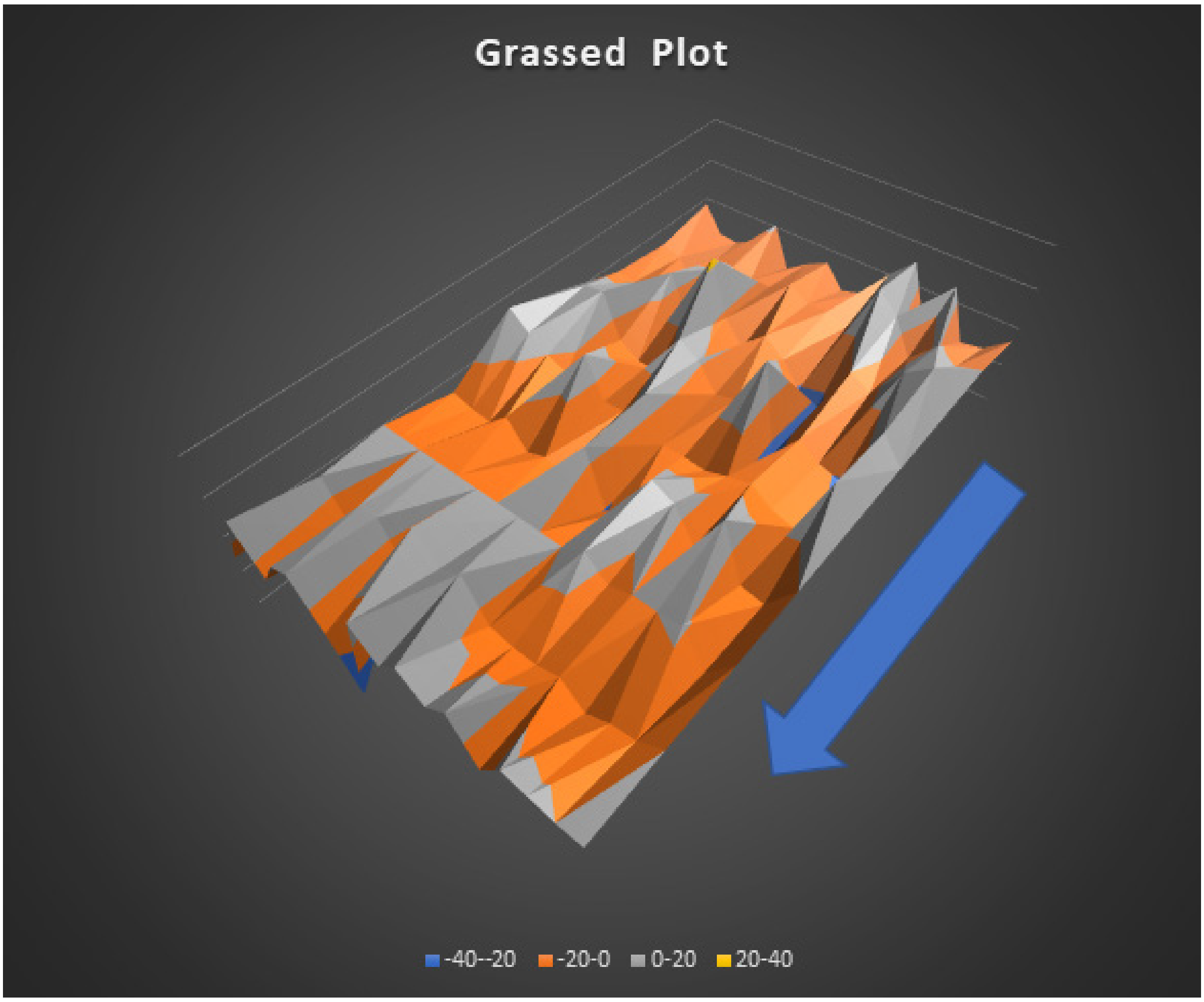
Interpretation:

Flat grey areas	No data (no peg)
Raised grey peaks	Deposition (soil moved on top of the peg) up to 20mm deep
Yellow peaks	Deposition between 20 and 40mm
Orange areas	Soil loss (soil level lower than pegs) by up to 20mm deep
Blue areas	Soil loss between 20 and 40mm


Fallow Plot
-40--20
-20-0
0-20
20-40


Ripper Mulcher Plot
-40--20
-20-0
0-20


Deep Rip Plot
-40--20
-20-0
0-20
20-40


Grassed Plot
-40--20
-20-0
0-20
20-40

ECONOMICS

NRM North asked RMCG to calculate the costs and benefits of the trial treatments in dollar terms. This is difficult, as many effects of erosion on agricultural productivity are complex and long-term, and it's particularly difficult to include environmental costs in monetary figures.

For this analysis, each treatment was assessed in terms of:

- Cost of the treatment – not including the original cultivation for fallow, but including additional labour, machinery costs, hay bales and seed for other treatments;
- Cost of major nutrients lost through erosion, based on the soil test taken prior to the trial (see appendix – soil test), and;
- Cost of soil volume moved, in terms of replacement value through buying topsoil at market rates.

Treatment	Soil loss per hectare (m3)	% of topsoil to 0.3m lost	Estimated loss in nutrient value ($/ha)	Comparative cost of intervention ($/ha)	Intervention plus loss ($/ha)	Intervention plus loss plus soil replacement @ $25/m3 ($/ha)
Fallow	64.7	2.2	847	0	847	$2,464.50
Ripper mulcher (*equivalent)	63.3	2.1	829	218	1047	$2,629.50
Deep ripped	58.7	2	769	180	887	$2,354.50
Grass cover	40.2	1.3	526	300	826	$1,831.00

DISCUSSION

This trial was a simple demonstration, neither randomised nor replicated. Results give only an indication of relative soil loss and movement. Still, with 555 data points measured, you can assume some accuracy in the results from each plot.

The trial operated in a dry winter/spring period. Erosion under typical or wet years is expected to be worse than the 4 - 6.5mm loss measured in this trial. Another consideration is that the soil surface at the beginning was lumpy and uneven – which would slow the water speed and reduce erosive force. Had the site been a fine seed bed, it probably would have eroded more.

It needs to be noted that the 'ripper-mulcher' treatment did not use a ripper-mulcher implement. Rather, rip lines were created, and straw was manually inserted. The effect of this is not expected to be identical to that of a ripper-mulcher.

An important consideration in adapting this information to other farms is that these data are a snapshot – one part of a paddock, particular soil quality, soil surface texture, timeframe of treatments and rainfall totals and intensity. Amounts of soil movement and the economics of soil loss at any other time or place are likely to differ.

Two separate high rainfall events occurred in July, with each fall measuring 44mm on-site. Sacrificial grass cover appeared to have a much greater effect on reducing erosion, compared to the tillage options. If the cover had been sown earlier, this effect could be improved due to greater canopy cover at the time of high rainfall events. Faster-establishing alternatives to ryegrass, such as oats, ryecorn or buckwheat may provide a greater benefit.

A 'sacrificial' cover, like a cover-crop terminated shortly before the cash crop is sown, can also be expected to help maintain soil structure, biology, carbon and nutrients over the winter, compared to a fallow.

Sowing and then terminating a cover was the most expensive treatment to implement. However, given the quantity of erosion reduced and the economic benefits of saving soil and nutrients, during this trial the cover crop option was cheaper than a bare fallow.

Additional costs of soil loss may include de-stoning and ongoing lost productivity due to reduced moisture-holding capacity, reduced rooting depth and increased soil compaction (see appendix – Cost of erosion case study).

Maintaining or growing a soil cover can incur costs, however it may be cheaper than leaving soil bare.

Despite cover crops being the most effective option by far, there are unresolved issues with machinery, seedbed tilth and decomposing plant matter which make subsequent fine-seeded crops challenging. Each production system has its own challenges and options. Where producers understand the scale of their problem and associated costs, they can identify the best solutions for their circumstances.

There are ways and means to reduce erosion in any circumstance. Given the amount of soil moved even in a dry winter/spring, how much soil has been lost in the last 20, 50 or even 100 years?

ACKNOWLEDGEMENTS

This was a complicated trial involving the efforts of many people. The NRM North project team Peter Heading and Adrian James, would like to acknowledge and express their gratitude to:

Simon Eastley and the farm team for support with fencing, spraying, tillage - they were always happy to assist whenever asked;

Michael Huett for agreeing to let us ‘erode the paddock’;

Tom O’Malley - Cradle Coast NRM, for bringing his inclinometer and mapping the plots;

Doris Blaesing - RMCG, for doing the economic assessment of erosion treatments;

Jason Gibson - Roberts Ltd, for doing a great job on the Roberts BBQ every trial event;

Julie Finnigan - Serve-Ag, for pre-trial technical advice, and;

Guest speakers from the earlier field days, including Bill Cotching and Frank Mulcahy - Simplot.

APPENDICES

Trial period rainfall data

Trial paddock soil test

Field Assessment

Cost of erosion case study

This project was supported by NRM North, through funding from the Australian Government’s National Landcare Program.

Trial period rainfall data from Kanangra, Deloraine

Jun	Jul	Aug	Sep	Oct	
0	44.0	0	0	0	
0	20.0	0	3.8	0	
2.2	0	0	1.6	0	
0	0	0	0	0	
0	0	0	0	0	
0	0	0.6	0	6.0	
0	0	4.6	21.0	1.6	
0	4.8	0	0	0	
0.6	1.0	0	1.0	0	
0	1.0	0	0	0	
31.4	44.4	0	0	15.4	
0	7.4	0	4.4	0	
25.0	3.8	0	0	0	
2.2	6.4	0	0	0	
0	0	0	0	0	
0	0	5.0	0	3.8	
1.0	0	0	0	0	
1.0	5.0	9.2	0	4.0	
4.2	5.2	9.2	0	0	
0	0	0	0	0	
0	0	13.0	0	0	
0	12.2	4.0	0	0	
0	16.2	0	6.3	0	
0	9.0	0.8	0	0	
0	1.0	3.0	0	0	
0	2.0	0	0	4.2	
0	0	0	0	3.0	
0	0	0	0	0	
0	1.0	0	0	0	
12.2	0	0	0	0	
	0	0		0	
31.4	44.4	13.0	21.0	15.4	**Highest rainfall that month**
79.8	184.4	49.4	38.1	38.0	**Total rainfall that month**

AGVITA ANALYTICAL

expressSoil®

Client Details

Client:	NRM NORTH	Date received:	01/05/2019
Grower:	S HUETT	Current Paddock:	PADDOCK 29 (Sampled: 01/05/2019)
Order No.:		Date reported:	7/05/19
Sample ID:	19011989	Profile sampled (cm):	30
Lab code:	ES22	Client agronomist:	PETER HEADING
Crop:	SOIL (Pasture)	Soil Type:	Heavy Soil (CEC >12meq)

expressSoil Results

Analyte	Units	Result	Optimal Range	Status
pH (H_2O)*	(pH)	**6.31**	6 - 7	Slightly Acidic
pH ($CaCl_2$)*	(pH)	**5.61**	5.2 - 6.5	Slightly Acidic
EC*	dS/m	**0.108**	0 - 0.15	Satisfactory
Lime requirement	t/ha			
ESI	units	**0.082**	value >0.05	Satisfactory
Total Carbon*	%	**5.067**		
Total Nitrogen*	%	**0.387**		
Carbon:Nitrogen Ratio	(ratio)	**13.087**		
Organic Matter	%	**7.8**	3.25 - 5.2	Very High
M3 PSR	(ratio)	**0.01**	0.06 - 0.23	Very Low
Mehlich Phosphorus*	ppm	**15.9**	40 - 90	Very Low
Potassium*	ppm	**463.6**	245 - 400	High
Sulphur*	ppm	**19.0**	12 - 45	Satisfactory
Calcium*	ppm	**1942**	1950 - 3450	Low
Magnesium*	ppm	**139.0**	220 - 440	Low
Sodium*	ppm	**46.9**	32 - 115	Satisfactory
Chloride*	ppm	**48.05**	0 - 200	Satisfactory
Zinc*	ppm	**1.44**	2.2 - 11	Low
Copper*	ppm	**1.21**	2.5 - 10	Very Low
Boron*	ppm	**1.45**	2.2 - 6	Low
Manganese*	ppm	**21.8**	18 - 70	Satisfactory
Iron*	ppm	**70.0**	40 - 250	Satisfactory
CECe	meq/100g	**15.2**		
Calcium	meq/100g	**9.7 (63.8%CEC)**	9.7 - 17.2	Satisfactory
Potassium	meq/100g	**1.2 (7.9%CEC)**	0.6 - 1.0	High
Magnesium	meq/100g	**1.1 (7.2%CEC)**	1.8 - 3.6	Low
Sodium	meq/100g	**0.2 (1.3%CEC)**	0.1 - 0.5	Satisfactory
Base Saturation	%	**80.2**	80 - 87	Satisfactory
Exchangeable Acidity	meq/100g	**3.1 (19.8%CEC)**	13 - 20 %CEC	Satisfactory
Aluminium Saturation	%	**0.00**		
Ca:Mg Ratio	(ratio)	**8.82**	3 - 5	Very High
K:Mg Ratio	(ratio)	**1.1**	0.3 - 0.5	Very High

ASPAC

This laboratory has been awarded a Certificate of Proficiency for specific soil and plant tissue analyses by the Australasian Soil and Plant Analysis Council (ASPAC). Tests for which proficiency has been demonstrated are highlighted in this report by an * next to the analyte name.

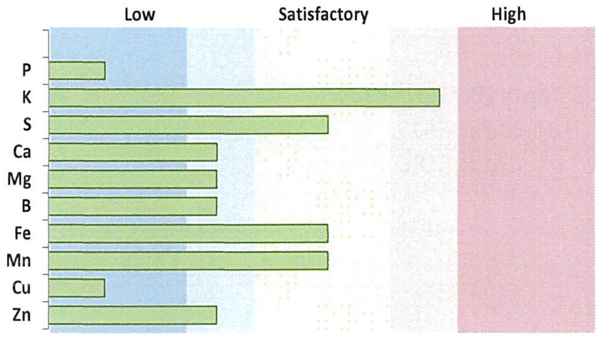
Analysis by AgVita Analytical

BESTPRACTICE CERTIFICATION ISO9001 QUALITY MANAGEMENT SYSTEM

Nutrient Status and Imbalances*

PADDOCK 29 (Sampled: 01/05/2019)

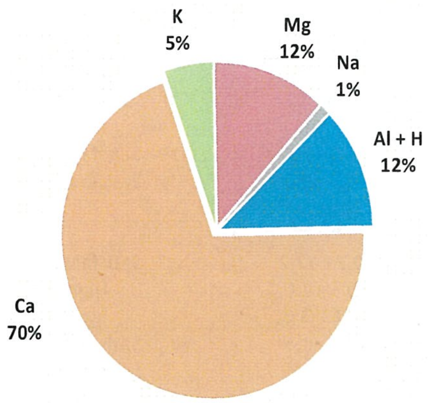
Analyte	Desired Level (kg/ha)	Measured Level (kg/ha)
Phosphorus	49.1	12.0
Potassium	243.8	350.5
Sulphur	21.55	14.33
Calcium	2041.2	1468.3
Magnesium	249.5	105.1
Boron	3.1	1.1
Iron	109.62	52.92
Manganese	33.3	16.5
Copper	4.7	0.9
Zinc	5.0	1.1



* For further explanation, please see our **expressSoil Users Guide** here

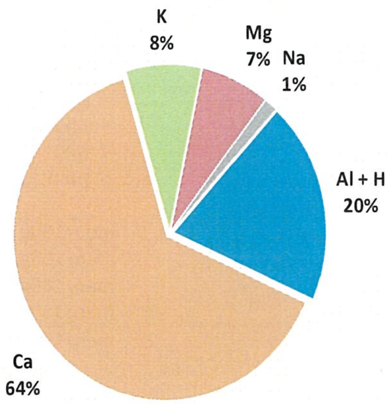
Soil Cation Ratio (as % CECe)

Desirable Levels



*Values are means of optimal ranges.

Measured Levels



RMCG

Cost of erosion case study.

NRM North
28-11-19

1 Introduction

Soil erosion has both on-paddock and off-paddock effects. Loss of soil productivity is the main on-paddock effect. Sedimentation and nutrient enrichment of waterways and dams are common off-paddock effects.

Estimations of soil erosion costs are therefore difficult and complex. Degradation of an affected part of a paddock can go along with improved soil conditions in areas where topsoil is deposited. Also, negative effects of soil loss may be compensated by increased fertilisers inputs that may mask the productivity losses to some degree.

The off-paddock and wider effects (e.g. environmental, social impacts) are usually not accounted for. They can include:

- Sedimentation of waterways
- Flooding
- Nutrient contamination of waterways
- Pesticide contamination of waterways
- Water treatment (for drinking water)
- Electrical power generation
- Repairing affected public property

Estimates of soil erosion costs presented in literature are therefore widely variable and controversial. Good data of all costs is often not available.

2 Overview of erosion costs

The following table provides an overview of general costs associated with erosion. The actual figures will vary from farm to farm.

ISSUE ON UPPER SLOPE	ASSOCIATED PROBLEM	COSTS
Compaction	Soil tillage – slower, needing more horsepower, having more impact on wear and tear of equipment Minimum tillage not an option	Diesel Labour Equipment purchase and maintenance
	Reduced soil life and associated benefits: nutrient cycling disease tolerance weeds more competitive	Fertiliser costs (nutrient replacement) Pesticide costs Yield loss*
	Poor water infiltration Poor water holding capacity – more frequent irrigation required water not converted to biomass	Cost of water, pumping (energy) Labour Yield loss*
	Reduced root growth	Yield loss
Loss of carbon	Reduced soil life and associated benefits: nutrient cycling disease tolerance weeds more competitive	Fertiliser costs Pesticide costs Yield loss*
Loss of nutrients	Nutrients run off with soil	Fertiliser costs Yield loss*

**Yield loss due to combined effect of issues is (0.4-12% per year) depending in severity, according to international literature.*

OVERALL ISSUES	ASSOCIATED PROBLEM	COSTS
Variable soil structure	Uneven crop	Depending on severity
Variable soil fertility	Uneven crop	
Land value	Drop in suitability for high value crops	3% to 7% drop according to literature
Social license	Issues	???

3 Case study paddock

The following case study looks at simple costs aspects of erosion and erosion intervention for the landholder.

Assumptions

Soil volume per hectare	0.3m depth	3000 m^3
Soil weight per hectare		3000 t - at bulk density of 1t/m^3

Estimated costs

Treatment	Soil loss per hectare (m3)	% of topsoil to 0.3m lost	Estimated loss in nutrient value ($/ha)	Comparative cost of intervention ($/ha)	Intervention plus loss ($/ha)	Intervention plus loss plus soil replacement costs*
Fallow	64.7 m^3	2.2	847	0	847	$2,464.5
Ripper mulcher (equivalent)	63.3 m^3	2.1	829	218	1047	$2,629.5
Installing rip lines	58.7 m^3	2	769	118	887	$2,354.5
Grass cover	40.2 m^3	1.3	526	300	826	$1,831.0

***Replacement costs used: $25/m3**

4 Influencing erosion on farms

This section lists aspects to take into account when assessing erosion risks and planning management actions.

SLOPE SREEPNES AND LENGTH

The velocity (and the erosive power) of runoff increases with the length and steepness of the land surface.

Criterium: Row lengths should not be excessive for the slope.

RAINFALL AND IRRIGATION.

The amount of runoff is primarily controlled by the volume and intensity of rainfall or irrigation, although it will be influenced to a degree by soil type, soil moisture levels and soil cover. Criteria are:

- Rainfall erosivity – water runoff and storm intensity-duration (which is relatively uniform across the
- region).
- Irrigation system – irrigation doesn't result in runoff from rows.
- Irrigation scheduling – irrigation applications are based on monitored needs.

GROUNDCOVER

Soil particles are protected from rainfall and runoff by the level and nature of groundcover, and the length of time soil is covered each year. Groundcover also influences the rate of runoff. Good ground cover is often linked to higher organic carbon levels in the soil and to better soil structure. Both help preventing erosion.

Criterium: Soil should be bare for the minimum period each year.

SOIL ERODIBILITY / EROSION POTENTIAL

Soil erodibility is a function of several, often related, variables. Small soil particles (e.g. silts) are more easily eroded than large particles (such as sands), but high levels of organic matter will help bind particles together. Poorly structured soils are more vulnerable to water erosion as there is less infiltration of water and increased runoff for any given event. Soils exposed due to previous erosion are also at more risk than intact soils. Criteria are:

- Soil texture – soil types which are cultivated for production are not easily erodible
- Organic carbon level
- Soil structure
- Areas of active erosion on the paddock.

Soil colour is recognised locally as a key indicator of soil structure and texture and inherent erodibility. The lighter the colour of soil of a certain soil type, the higher is the erosion potential.

SOIL MANAGEMENT

The extent to which soil is exposed to runoff is influenced by tillage practices. Tillage can expose fine soil particles, channel water into long streams or compact soil. Conversely, tillage practices which leave the soil surface rough or increase deep infiltration, or effectively reducing row-length and the velocity of run-off (such as cross-ripping or mulching) will reduce the risk of erosion. Criteria are:

- Cultivation – cultivation minimises compaction and/or erosion.
- Control – in-paddock run-off and erosion is minimised.

Focussing on in-field management, ‘clodiness’ is locally understood as an indicator of poor soil structure affected by cultivation (e.g. the type of equipment used, the speed of cultivation or the use of controlled traffic laneways. Deep ripping, mulching or contoured field-breaks may be used to control the flow of water, and erosion, in-field.

RUNOFF MODIFICATION

Runoff modifiers may be needed to control flows coming onto a property from neighbours or roads higher in the landscape or to control water leaving paddocks. Similarly, in-paddock flows from tracks and natural or constructed drainage lines may need modification by grassed waterways or improved drainage. Criteria are:

- Paddock buffers – excessive run-on or silt laden run-off is managed.
- Gullies – through-field flows are controlled.

Diversion banks or drains, buffer strips or end-of paddock silt traps are examples of actions to manage excessive run-on or run-off. Grassed waterways, contoured drainage lines, table-drains or tracks may carry water through paddocks and help control it.

CROP NUTRITION MANAGEMENT.

Well fertilised soils may support more organic matter via more crop biomass production and hence improve groundcover, but the main reason the factor is included here is because nutrient loss through leaching or dissolved in surface run-off (rather than in sediment) is also important to soil productivity and water quality; two values of primary concern. The amount of nutrient applied, the form in which it is applied and the way it is applied will affect the likelihood of loss. Splitting applications into base-dressings and side-dressings is a key to reducing risks of fertiliser loss. Criteria are:

- Planning (nutrient budgets) and monitoring – nutrient applications match tested needs and plans.
- Application – fertilisers are applied (timing, placement, amount, method, fertiliser type) using low-risk practices.

PROXIMITY TO OFF-SITE ASSETS

The closer an asset (e.g. a waterway, wetland, reserve, public road) is to the source of sediments and nutrients the less 'buffering' there is to protect it. Purpose built buffers and silt traps will help protect roads and downstream waterways from farm runoff. Criteria are:

- Riparian buffers – waterways are separated from cultivation and stock.
- Public assets – public assets e.g. roads do not receive sediment from the farm.

Public assets may be running through the property, adjacent to it or 'downstream'.

NRM North Hill Slope Erosion Project

Field Assessments June 25, 2019

Julie Finnigan

Serve-Ag

Hill Slope Erosion Project NRM North

Corner boundary GPS Locations

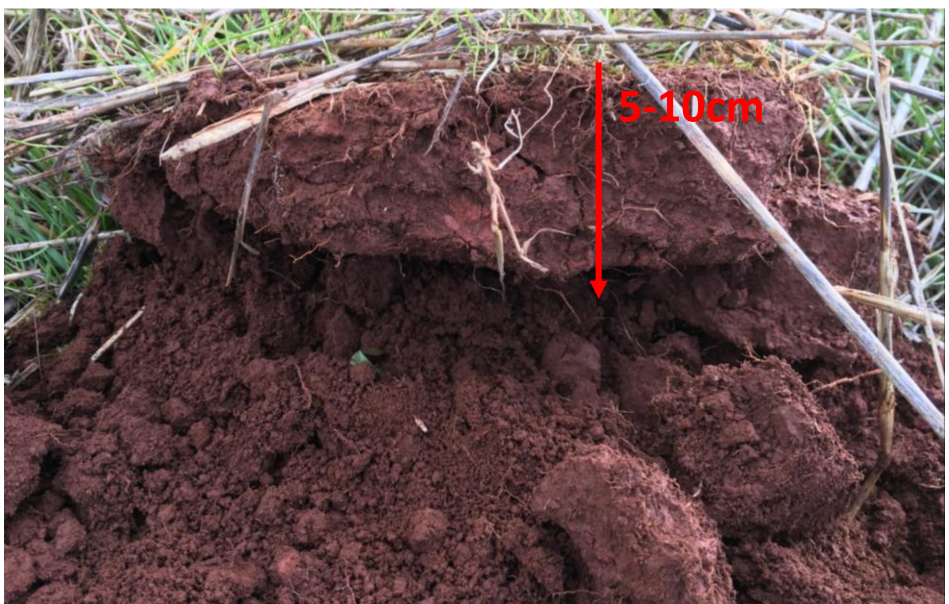
Hill Slope Erosion Project NRM North

Soil Structural Score Assessments

- Six soil pits were dug down to approximately 25 – 30cm, in order to undertake soil structure scores, based on Bill Cotchings' Soil Structure Score Cards for clay-loam textured top soils
- Four pits assessed in the general area of the four boundary corners
- Two pits were assessed within a cultivated treatment plot
- Assessments were taken in cultivated in pasture areas in order to show the structural differences that can temporarily occur through cultivation

Hill Slope Erosion Project NRM North

Soil Structural Score Assessments



Northern Upper Slope

Heavily compacted surface soil

Platey/blocky non-porous clods

Sub-soils more friable with rounded aggregates

Presence of small gravels, 15 – 20mm diameter

Earthworms present

Soil Structural Score

Surface: 2

Sub: 8

Hill Slope Erosion Project NRM North

Soil Structural Score Assessments

Northern Lower Slope

Compacted turfy surface soil

Some blocky/platey clods with minimal porosity (100mm)

Sub-soils very friable with rounded aggregates

Presence of small gravels, 15 – 20mm diameter

Earthworms present

Soil Structural Score

Surface: 4

Sub: 8

Hill Slope Erosion Project NRM North

Soil Structural Score Assessments

Southern Upper Slope

Very compacted turfy surface soil, difficult to dig

Layered compaction with blocky/platey clods with minimal porosity (150mm)

Root system is very shallow

Sub-soils are friable with rounded aggregates

Presence of small gravels and larger rocks up to 150mm diameter

Earthworms present

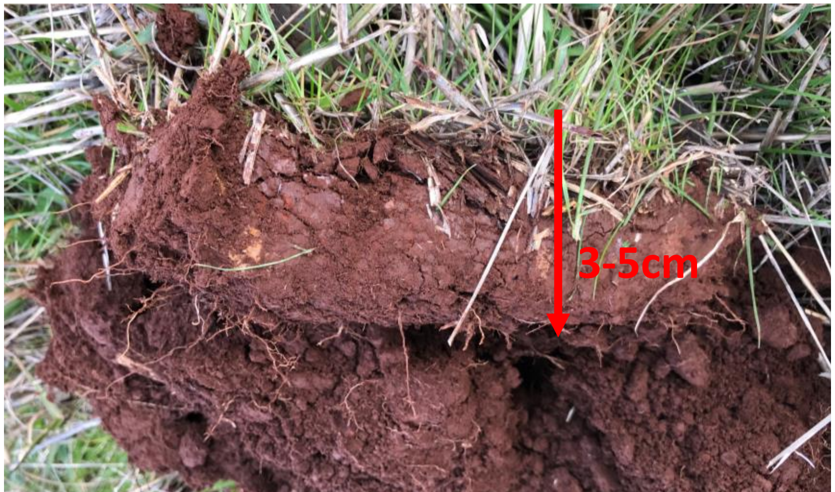
Soil Structural Score

Surface: 3

Sub: 8

Hill Slope Erosion Project NRM North

Soil Structural Score Assessments



Southern Lower Slope

Very shallow upper turfy layer, very easy to lift and peel

Mix of small rounded and angular aggregates

Earthworms present

Black headed cockchafer present

Sub-soils very friable with rounded aggregates

Presence of small gravels and rocks, 15 – 50mm diameter

Soil Structural Score

Surface: 5

Sub: 9

Hill Slope Erosion Project NRM North

Soil Structural Score Assessments

Cultivated Upper Slope

Upper surface soil has a mix of angular and rounded aggregates
All aggregates break readily, and have variable levels of porosity
Sub-soils are more friable with rounded aggregates
Higher presence of red clay (subsoil mixing)
Presence of small gravels, 15 – 30mm diameter
Earthworms present

Soil Structural Score
Surface: 4
Sub: 9

Hill Slope Erosion Project NRM North

Soil Structural Score Assessments

Cultivated Lower Slope

This soil pit is more uniform with depth
Larger aggregates are more rounded and friable, few platey clods present
Sub-soils are very friable with rounded aggregates
Presence of small gravels up to larger rocks, 15 – 150mm diameter
No earthworms found

Soil Structural Score
Surface: 6
Sub: 9

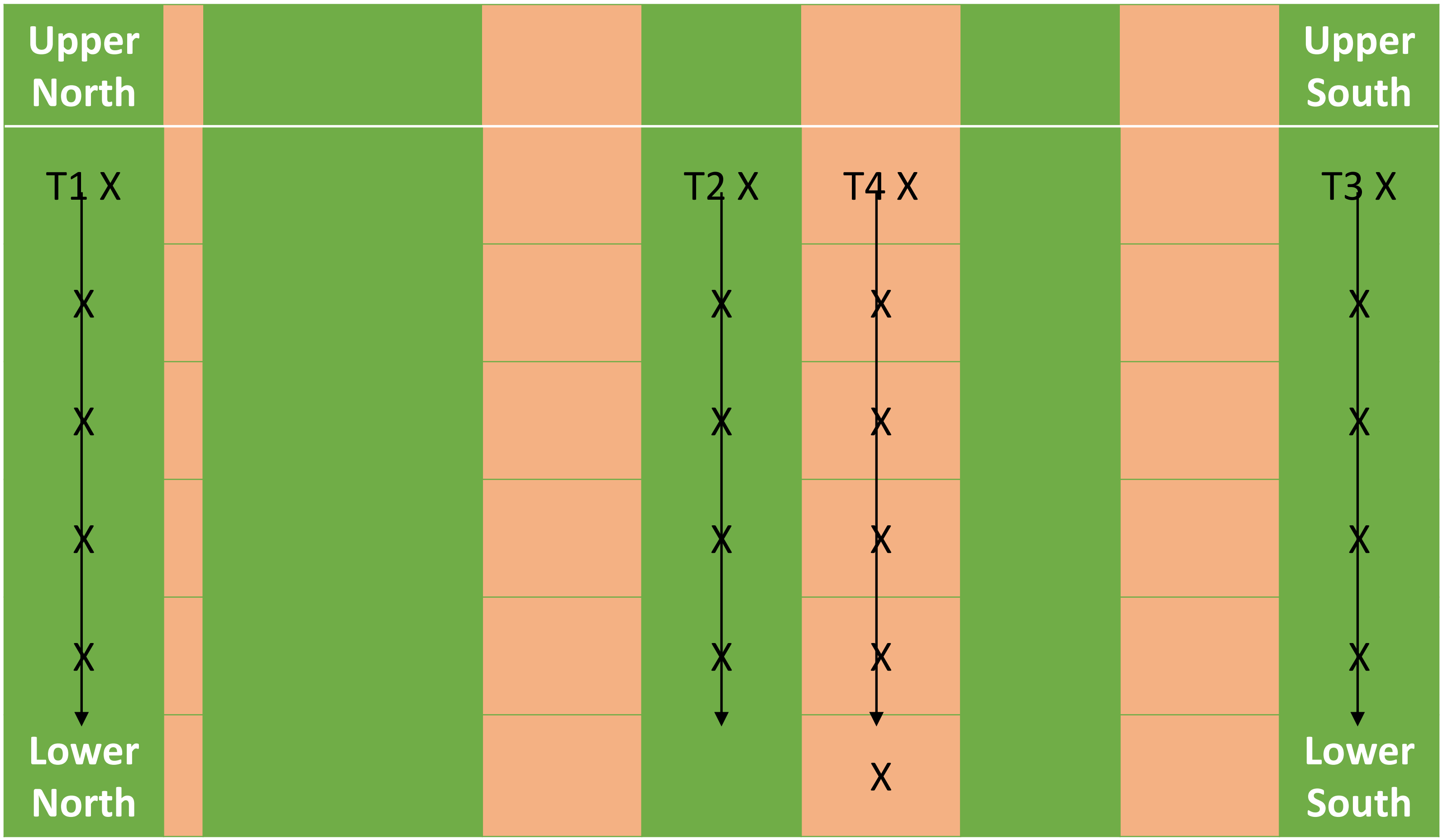
Hill Slope Erosion Project NRM North

Resistance to Penetration - Compaction

- Twenty spot penetration measurements were taken on June 25, 2019.
- Four transects were taken, running from upper to lower slope.
    - Northern edge in pasture
    - Southern edge in pasture
    - Middle area of trial in pasture
    - Third trial plot from the north (Rip only?)
- Several locations failed to insert due to the presence of rock.
- Most of the pasture measurements were very compacted in the upper 10 – 15cm, with less resistance measured below this depth.
- Most measurements could be taken down to 45cm

Hill Slope Erosion Project NRM North

Resistance to Penetration - Compaction



Approximate locations of penetration insertion points for each transect (X)

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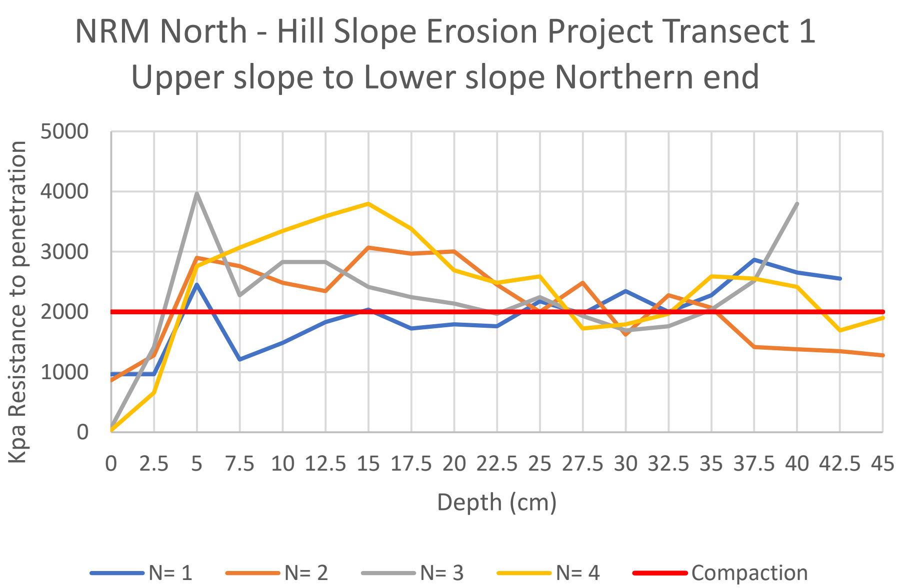
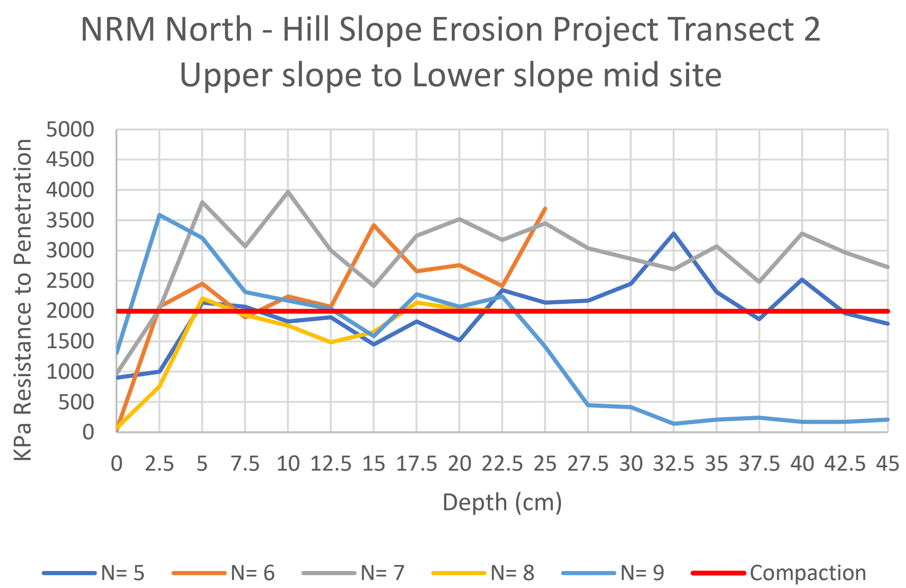
Resistance to Penetration - Compaction





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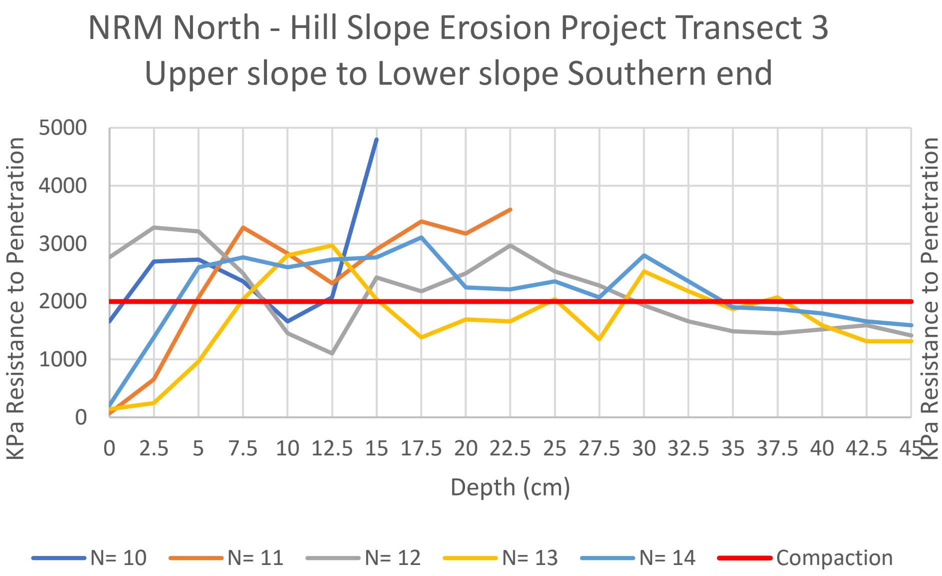
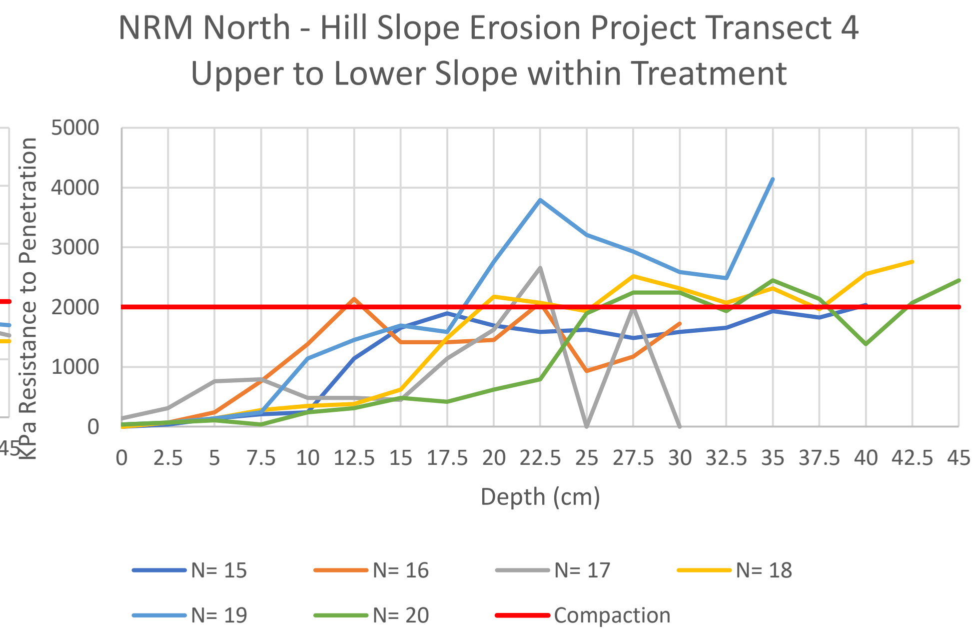
Resistance to Penetration - Compaction





Hill Slope Erosion Project NRM North

Resistance to Penetration - Compaction

Colour coded raw data – blank cells indicate full resistance to penetration

		0.0 cm	2.5 cm	5.0 cm	7.5 cm	10.0 cm	12.5 cm	15.0 cm	17.5 cm	20.0 cm	22.5 cm	25.0 cm	27.5 cm	30.0 cm	32.5 cm	35.0 cm	37.5 cm	40.0 cm	42.5 cm	45.0 cm
		0	2.5	5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35	37.5	40	42.5	45
T1	N= 1	966	966	2450	1208	1484	1828	2036	1725	1794	1760	2174	1966	2346	2001	2277	2864	2656	2553	
	N= 2	862	1276	2898	2760	2484	2346	3070	2967	3002	2450	2001	2484	1622	2277	2070	1414	1380	1346	1276
	N= 3	69	1414	3968	2277	2829	2829	2415	2242	2139	1966	2242	1932	1690	1760	2036	2518	3795		
	N= 4	34	656	2760	3070	3346	3588	3795	3381	2691	2484	2588	1725	1794	1966	2588	2553	2415	1690	1898
	Compaction	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
T2	N= 5	897	1000	2139	2070	1828	1898	1449	1828	1518	2346	2139	2174	2450	3278	2312	1863	2518	1966	1794
	N= 6	34	2070	2450	1898	2242	2070	3416	2656	2760	2415	3692								
	N= 7	966	2036	3795	3070	3968	3002	2415	3243	3519	3174	3450	3036	2864	2691	3070	2484	3278	2967	2726
	N= 8	69	759	2208	1932	1760	1484	1656	2139	2036	2001									
	N= 9	1311	3588	3208	2312	2174	2036	1587	2277	2070	2242	1414	448	414	138	207	242	172	172	207
	Compaction	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
T3	N= 10	1656	2691	2726	2346	1656	2070	4796												
	N= 11	69	656	2070	3278	2829	2312	2898	3381	3174	3588									
	N= 12	2760	3278	3208	2484	1449	1104	2415	2174	2484	2967	2518	2277	1932	1656	1484	1449	1518	1587	1414
	N= 13	138	242	966	2036	2794	2967	2036	1380	1690	1656	2036	1346	2518	2174	1863	2070	1587	1311	1311
	N= 14	207	1380	2588	2760	2588	2726	2760	3105	2242	2208	2346	2070	2794	2346	1898	1863	1794	1656	1587
	Compaction	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
T4	N= 15	0	34	138	207	242	1138	1656	1898	1690	1587	1622	1484	1587	1656	1932	1828	2036		
	N= 16	0	69	242	759	1380	2139	1414	1414	1449	2070	932	1173	1725						
	N= 17	138	310	759	794	483	483	448	1138	1622	2656	0	2001	0						
	N= 18	0	69	138	276	345	380	621	1484	2174	2070	1932	2518	2312	2070	2312	1966	2553	2760	
	N= 19	34	69	138	242	1138	1449	1690	1587	2760	3795	3208	2932	2588	2484	4140				
	N= 20	34	69	104	34	242	310	483	414	621	794	1898	2242	2242	1932	2450	2139	1380	2070	2450
	Compaction	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000

Hill Slope Erosion Project NRM North

Resistance to Penetration - Compaction

- The graphed data shows the measurements captured every 2.5cm down to a maximum of 45cm depth.
- The three transects located either edge of the trial and down the middle of the trial, all show compacted soils with resistance greater than 2000KPa for the majority of the depth of penetration, beginning around 2.5 – 5cm depth. 2000KPa is considered the upper limit for ease of root penetration.
- General trial set-up may have increased the level of compaction around this trial area, however the shallow depth of the pasture roots does suggest that this near surface compaction was occurring prior to trial set-up.
- Transect 4 taken down the slope of Treatment ??, showed far less resistance in comparison, a result of the mechanical working of the soil for the Project, reflecting conventional tillage that would normally occur. Resistance to penetration generally began to increase around 17 – 20cm depth, a common scenario reflecting tillage.
- The establishment of deep rooted crops such as tillage radish and tillage rootmax, a deep rooting rye grass, would help to bust open the compacted soil layer and add soil carbon, root exudates and improve soil biology, all facilitating a healthier and more well structured soil.