Soil Statement

Dr Katharine Brown

"The Winona soils are naturally fragile, low fertility soils that are resilient, protected, and productive under a no-till pasture-cropping regime." (Katharine Brown pers. comm. Soils For Life, 2020).

Introduction

This report presents a desktop review of existing soil information and a field and laboratory assessment of a Winona soil to complement the '*Winona The Ecological Journey*' (Soils For Life 2020). The purpose of undertaking the soil assessment was to collect and interpret soil data and information to increase our knowledge and understanding of the soil in relation to land management.

The Winona soils have formed *in situ* (in place) from the weathering of igneous or sedimentary parent materials, or from the alluvium and/or colluvium derived from these parent materials. Soil development in general is a result of at least five (major) soil-forming factors: climate, organisms, relief, parent material and time. These soil-forming factors interact to give the soils their unique, inherent characteristics that determine soil function.

Soil function refers to the many and varied roles of soil, including as a storer, supplier and cycler of nutrients, carbon and water, and as a habitat. An understanding of soil function is fundamental to maximising soil productivity while ensuring sustainable (avoiding all forms of degradation) soil and land use. At Winona, soil productivity may be defined as the capacity of the soils to produce a certain crop and pasture yield under regenerative land management practices.

Methods

Site selection was based on "The Site Concept" of Speight and McDonald (NCST 2009). That is, the SFL field team pre-selected a small area of land considered representative of the landform, vegetation, land surface and other land features at Winona following a review of existing information including soil mapping (Figure 1).

The site, and the location of the soil observation within the site, was then confirmed in the field in consultation with the land manager, Colin Seis. The location of the soil observation was recorded using a GPS, effectively creating a 'benchmark location' or reference site for the future assessment and/or monitoring of improvements in soil condition at the property (Figure 2).

Above-ground observations and measurements such as ground cover and yield are considered useful indicators of productivity. However, below-ground soil observations and measurements better reflect soil capability[1] and soil condition[2], two of the four factors that determine the productive potential of land (the remaining two being seasonal temperatures and water availability). In addition, soil observations and measurements allow for the naming of the soil. Describing and naming the soil (both local and formal classifications are recommended) enables the simple communication of soil information in a standard way (Stuart-Street et al. 2020).

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[1]Soil (or land) capability is the inherent physical capacity of the soil (or land) to sustain a range of land uses and management practices in the long term without degradation to soil, land, air and water resources (OEH 2012).

[2]Key soil attributes in relation to known or perceived target or threshold values measured by long-term monitoring. Soil condition is often considered a measure of soil health or quality (Bennett et al. 2019)

Figure 1 Lees Pinch (background) and Turill (foreground) soil landscapes (Murphy and Lawrie (1998).

Figure 2 The site selected as representative of the typical landform, vegetation and land features at Winona.

The Winona soil was excavated using a general purpose hand auger fitted with a 100 mm diameter Jarrett auger head. The soil profile (Figure 3) was described in the field according to the nationally endorsed standards described in the Australian Soil and Land Survey Field Handbook (NCST 2009). Some soil characteristics such as drainage were inferred from other soil features, including rooting depth and soil colour and mottling.

Figure 3 The Winona soil (SFL 2020).

One individual soil sample was collected from 0-10 cm, 20-30 cm, 30-40 cm and 70-80 cm depths in the excavated soil profile (4 individual samples in total) for soil chemical analyses. These depths represented the soil horizons (layers of soil with different properties) deduced from the profile description data.

A composite sample (a subsample of 20 individual samples randomly collected from 0-10 cm depth across the site) was collected for soil 'fertility' analyses (representing the typical soil testing that is performed on farming properties to determine the nutrient status of the topsoil). A sixth and final individual sample was collected from 0-10 cm depth for soil microbial analyses.

Soil laboratory analyses were undertaken to determine the chemical and biological status of the Winona soil. The resulting dataset also provided an insight into current soil condition, potential productivity and allowed the soil to be classified according to the Australian Soil Classification (Isbell and NCST 2016) for the purposes of communication and land use management.

Four individual samples and one composite sample were submitted to Environmental Analysis Laboratories (EAL), a National Association of Testing Authorities (NATA) and Australian Soil and Plant Analysis Council (ASPAC) accredited laboratory. The sixth individual sample was submitted to Microbiology Laboratories Australia for analysis of soil microbial functional groups.

Results and Interpretation

A desktop review of the Australian Soil Classification Soil Type map of NSW (OEH 2012) suggested the Winona soil belonged to the Turill soil landscape (Murphy and Lawrie 1998) and is likely to be either a Rudosol or Tenosol (known locally as light, granitic soils). Based on existing soil landscape mapping, the third dominant soil type at Winona is Sodosols (OEH 2012).

One objective of assessing soils in the field and the laboratory is to confirm existing soil mapping. Based on the description of the soil observation in the field and the chemical analyses by the laboratory, the Winona soil was classified as a Brown Chromosol according to the Australian Soil Classification (Isbell and NCST 2016). The existing mapping of the Winona soil orders (OEH 2012) and the concept of the soil orders according to Isbell et al. (1997) are summarised in Table 1.

Table 1 Mapped Winona soil orders and concept (Isbell & NCST 2016).

Soil Order	Concept
Chromosols[1]	Soils with an abrupt increase in texture between the topsoil and subsoil which are not strongly acid or sodic
Rudosols[2]	Soils with negligible (**rud**imentary) pedologic organisation (soil development)
Sodosols[2]	Soils with an abrupt increase in texture between the topsoil and subsoil which are **sod**ic (high in exchangeable **sod**ium) but not strongly acid
Tenosols[2]	Soils with weak (**ten**uous) pedological organisation (soil development) in the subsoil

[1] Winona soil assessment (Soils For Life 2020).
[2] Australian Soil Classification Soil Type map of NSW (OEH 2012).

The interpretation and description of the Winona site and the Winona soil observation according to the Australian Soil and Land Survey Field Handbook (NCST 2009) is summarised in Figure 4 and Figure 5.

The laboratory results (soil chemical properties) are summarised in Table 2 and were interpreted following research into the existing literature to determine the desirable ranges for soil chemical properties and by applying expert knowledge.

The desirable ranges serve as a general indication for the grazing of pastures in NSW (Peverill et al. 1999; Horneck et al. 2011; Hazelton and Murphy 2016). A “traffic light” approach representing **good**, **moderate** or **poor** allows the status of each of the soil properties to be assessed at a glance.

The soil biological properties assessed for the Winona soil serve as an indicator of the general health and resilience of the soil system. The results of the analyses conducted by Microbiology Laboratories Australia (2020) are presented in Figure 6 and Figure 7.

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Site Information

Project Winona	**Date** 02/07/2020	**Scribe** BROK	**Location** 30 Acres Paddock	**Observation**	Manual auger		**Latitude** 32° 10' 36" S	**Zone** N/A	**ASC Mapped**	Tenosol
Dominant Vegetation Form	Non-woody	**Ground Cover %**	Dense (>70%)	**Aspect**	North		**Longitude** 149° 33' 38" E	**Scale** N/A	**ASC Ground Truth**	Chromosol
Secondary Vegetation Form	Non-woody	**Ground Cover %**	Dense (>70%)	**Slope %**	10		**Rock Outcrop**	No rock outcrop	**Erosion Type**	None evident
Vegetation (species)	Native C4 perennials (dormant) including Red grass (Bothriochloa macra), Subterranean clover (Trifolium subterraneum), Perennial ryegrass (Lolium perenne)						**Drainage (site)**	Moderately well-drained	**Erosion Extent**	None evident
Landform	Lower slope		**Soil Surface Condition**		Soft		**Land Use**	Pastures	**Erosion State**	None evident

Landscape Photo (North)

Landscape Photo (East)

Soil Surface Condition Photo

Landscape Photo (South)

Landscape Photo (West)

Other Photo (Pasture Cropping)

Dominant Vegetation Photo 1

Dominant Vegetation Photo 2

Other Photo

Site Type	
Detailed + Sampled for Lab	
Microrelief	
Type	None evident
Vertical (m)	
Horizontal (m)	
Sampled	
Other Information	

Figure 4 Winona site information.

Soil Description

Horizon	Depth (mm)	Profile Photo	Boundary	Texture	Moist Colour	Mottle (colour, abundance)	Segregations (abundance, nature)	Coarse fragments (abundance, size)	Structure (type)	Structure (grade)	Consistence (soil water status)	Roots (abundance, size)	Field pH	EC (dS/m)	Depth of Sample for Lab (mm)
A1	0-25		Clear	Sandy Loam	7.5YR 3/3	nil	Not recorded	10-20 % 2-6 mm	Polyhedral	Weak	Weak (moderately moist)	Many (25-200) Medium (2-5 mm)	5.5	0.04	0-10
A2	25-60		Clear	Sandy Clay Loam	7.5YR 4/3	nil	Not recorded	10-20 % 2-6 mm	Apedal	Massive	Weak (moderately moist)	Many (25-200) Fine (1-2 mm)	6.5	0.02	30-40
B2	60+			Medium Clay (sandy)	10YR 5/4	7.5YR 5/8	Not recorded	2-10 % 20-60 mm	Polyhedral	Weak	Firm (moderately moist)	Common (10-25) Very fine (<1 mm)	7.5	0.03	70-80
Other information Field aggregate stability: 0-25 cm stable, 25-60 cm slakes slowly, 60+ cm slakes slowly with minor dispersion. Australian Soil Classification: Mottled (DQ), Mesotrophic (AG), Brown (AB) Chromosol (CH).															

Figure 5 Winona soil description.

Case Study

Table 2 Winona soil chemistry.

Soil Depth (cm)	pH_{CaCl} (pH units) Desirable Range 5.0-6.5	pH_{Water} (pH units) Desirable Range 6.0-7.5	$EC_{1:5}$ (dS/m) Desirable Range <0.24	ECe (dS/m) Desirable Range <2.8	ESP (%) Desirable Range <3.0
0-10 (Fertility)	4.8	5.8	0.04	0.46	0.50
0-10	5.4	6.3	0.04	0.43	0.99
20-30	5.6	6.6	0.02	0.18	0.62
30-40	6.2	7.2	0.02	0.15	0.75
70-80	6.9	8.0	0.03	0.21	1.26

Soil Depth (cm)	Exch. Ca (meq/100g) Desirable Range 2-30	Exch. Mg (meq/100g) Desirable Range 1-15	Exch. Na (meq/100g) Desirable Range 0.05-5.0	Exch. K (meq/100g) Desirable Range 0.2-2.0	CEC (meq/100g) Desirable Range 0-100
0-10 (Fertility)	4.60	1.00	0.07	0.74	6.5
0-10	4.52	1.13	0.07	0.69	6.4
20-30	3.67	0.89	0.07	0.40	5.0
30-40	3.59	1.26	0.07	0.29	5.2
70-80	3.92	2.56	0.09	0.27	6.8

Soil Depth (cm)	Ca:Mg Desirable Range 4-6	Total N (%) Desirable Range 0.15-0.25	Total C (%) Desirable Range 1-3	Labile Carbon Desirable Range 0.5-1.5	C:N Desirable Range 15:1-25:1
0-10 (Fertility)	4.4	0.16	2.20	-	-
0-10	4.0	0.13	1.97	0.29	14
20-30	4.1	0.04	0.63	0.08	15
30-40	2.9	0.03	0.33	0.05	16
70-80	1.5	0.02	0.27	0.05	12

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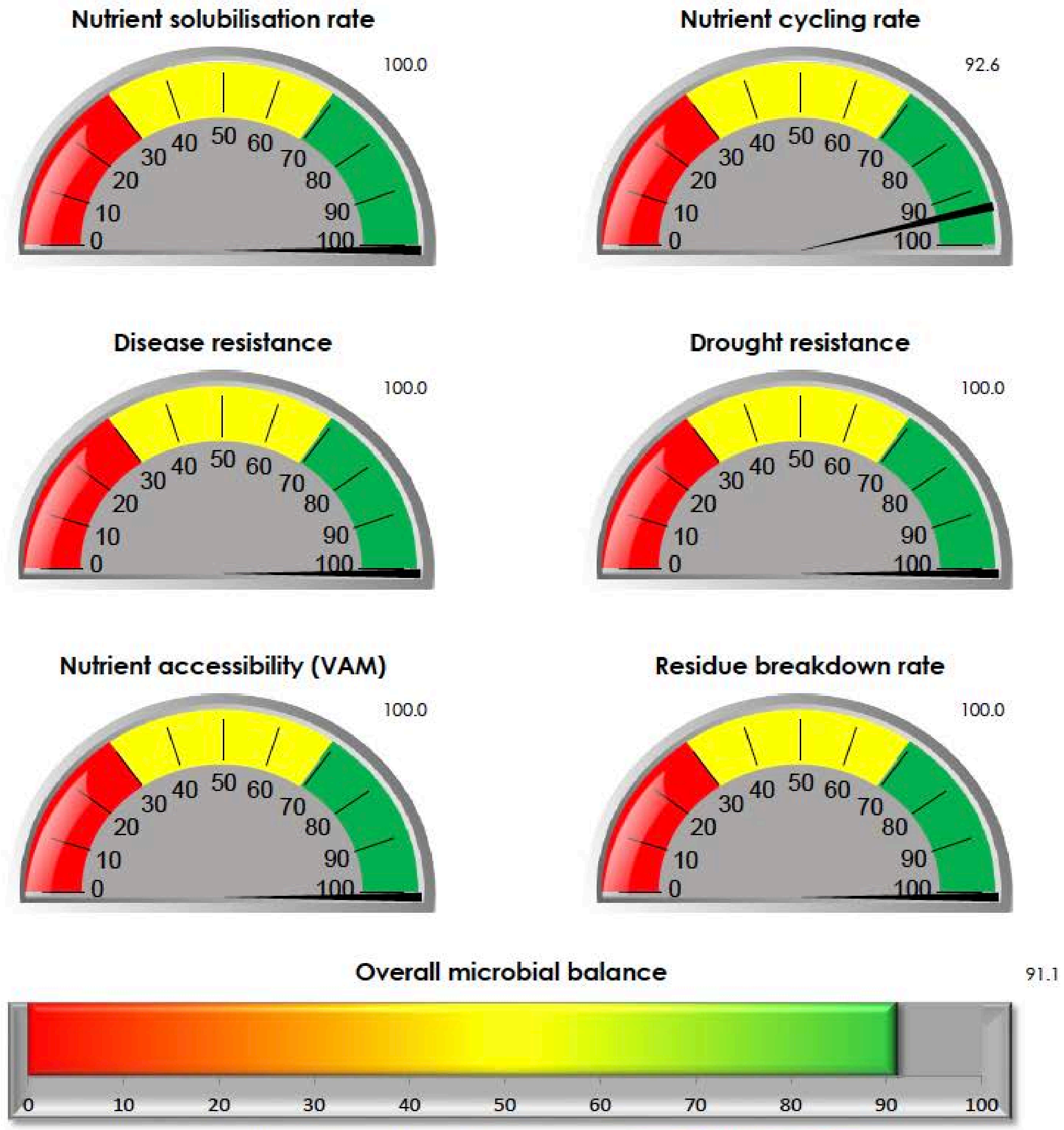
MICROBE WISE FOR SOIL

Name: EAL | Sample: J5754/1 | Analysis no.: 2576-1-MWSS | Date: 16/07/2020

Customer name	EAL	**Date received**	16/07/2020
Client name	Graham Lancaster	**Agent**	Environmental Analysis Labo
Sample name	J5754/1	**Advisor**	
Crop	Not specified	**Authorised by**	Dr Maria Manjarrez
Date sampled	1/01/2000	**Analysis no.**	2576-1-MWSS

Microbial Soil Indicators



For more information about these indicators visit us at www.microbelabs.com.au

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Figure 6 Microbial indicators of an individual topsoil (0-10 cm) sample from the Winona soil.

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MICROBE WISE FOR SOIL

Name: EAL Sample: J5754/1 Analysis no.: 2576-1-MWSS Date: 16/07/2020

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Biomass (mg/kg) Guide
Total microorganisms	82.1	50.0
Total bacteria	16.3	15.0
Total fungi	62.9	33.8

Microbial indicators	Yours	Guide
Microbial diversity	39.7	80.0
Fungi : Bacteria	3.8	2.3
Bacterial stress	0.4	< 0.5

Group	Biomass (mg/kg) Yours	Biomass (mg/kg) Guide
Bacteria		
Pseudomonas	1.725	1.000
Actinomycetes	2.542	1.000
Gram positive	8.612	4.000
Gram negative	7.733	11.000
Methane oxidisers	0.000	0.500
Sulphur reducers	0.000	< 0.005
True anaerobes	0.440	< 0.005
Eukaryotes		
Protozoa	2.862	1.300
Mycorrhizal fungi (including VAM)	16.893	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor Fair Good

Comments

The soil indicators were all good. The total mass of microbes in your sample was very good. Biomasses of other key desirable microbe groups were also good. However, with these microbial levels Nitrogen needs to be monitored as high amounts of this nutrient may be kept by the microbes, thus competing with the plant. Protozoa, which were good here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was elevated and needs to be balanced. These results suggest that management practices should initially focus on building microbial diversity and bacteria biomass. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit www.microbelabs.com.au for more information.

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Figure 8 Pasture cropping and sheep grazing, the two dominant land uses supported by the Winona soils.

Conclusions

- The Winona soils are inherently low in fertility and susceptible to degradation due (primarily) to the parent material from which they have formed.
- The **moderate** C:N and labile carbon levels as a result of three years of drought suggest the Winona soil may benefit from the addition of organic matter to increase the capacity to retain and supply nutrients to plants.
- Although total soil biomass is **good**, microbial diversity is considered **moderate** and the balance of fungi and bacteria could be improved by building the bacterial biomass.
- Maintaining the nutrient status and neutral pH in soils with a low capacity to retain nutrients indicates land use and management is appropriate to the soil and landscape.
- Regenerative land management practices have greatly decreased the reliance on fertilisers, herbicides and pesticides.
- Abundant ground cover across the majority of Winona has increased soil resilience and minimised the risk of soil loss and land degradation.

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