Land Capability Assessment for UWA Ridgefield Farm

March 2023

Conducted by ENVT3338 UWA Cohort

Report Author: Warin Chotirosniramit (23207871)

Table of Contents

1. Executive Summary

The UWA ENVT3338 cohort conducted a Land Capability Assessment (LCA) at UWA Farm Ridgefield in 2023 to assess the farm's suitability for different land uses, including dryland cropping, grazing and annual horticulture. We also created a Soil Mapping Unit (SMU) map that groups the soil based on soil forming factors. Then, we used land evaluation standards to derive our soil class map, which categorizes the soil polygons identified by the SMU into soil orders as guided by the Australian Soil Classification System (Isbell, 2016). In addition, we investigated the following features and patterns of soil properties:

- Relationship between organic matter and soil depth,
- Macronutrients in different land uses
- Spatial variation of pH,
- Variation in EC with soil depth and
- Relationship between slope gradients and soil erosion.

To conduct the LCA and investigate the soil properties, we conducted a field trip to the UWA Farm Ridgefield on March 18th, 2023, where we dug auger profiles and a soil pit for each SMU. We collected bulk and composite samples from each pit for laboratory analysis. Soil class map, SMU description and laboratory results can be found in the *Group Folder* at the end of the report. We then used the laboratory results to evaluate each SMU for the three land uses using the land evaluation guideline by Van Gool et al. (2005). Finally, recommendations of land-use were given for each SMU and relevant suggestions on the strategies to improve specific land-use qualities were made.

We found a decreasing trend of total organic matter as depth increases, with A1 horizon having the highest mean total organic matter (8.54%) and A2E horizon having the lowest total organic matter (0.24%), followed by C horizon (0.54%). Because most organic matter is in topsoil, proper topsoil management is crucial for soil fertility. Topsoil erosion should be mitigated where the risks are high by strategies such as using mulch or crop cover.

Different land uses had varying amounts of macronutrients. Cropping soils had the highest phosphorus, whereas grazing soils had the highest calcium and potassium. Remnant and riparian vegetation had the highest magnesium, but the lowest calcium and potassium. These results were partly consistent with other literatures from around the world. Macronutrients are essential for ensuring high crop yields; therefore, cropping soil should have the right macronutrient requirements for specific crops.

Remnant and riparian vegetation soil was the most acidic, with pH between 4 and 5. Cropping and grazing soils were less acidic, with a pH range of 5 to 6. Soil acidity can lead to nutrient deficiency; therefore, lime application using appropriate lime material and practices is recommended to maintain optimal pH in areas that have particularly high acidity.

The EC for Agricultural soils ranged between 20 to 120 µS/cm, which is relatively lower than the EC range of 150 to 1050 µS/cm for remnant vegetation. The EC of topsoil was highest for cropping, grazing and riparian soils, whereas the EC of topsoil was lowest for remnant vegetation. We found that no SMUs were limited by surface salinity, but SMU 2 to 6 had moderate to severe salinity hazards. This could be reduced by salt leaching practices through sprinklings or ponding.

We found a weak negative relationship between the slope and the depth of topsoil, where the gradient of the trendline was -0.0982 and the R^2 value was 0.0577. The results suggest that the relationship is insignificant. This is likely due to the high vegetation cover on steep slopes at SMU 8 and 9 that control the rate of erosion.

In terms of orders of soil on the farm, all grazing and cropping soils were classified as chromosol, except SMU 5, which was classified as sodosol. The riparian vegetation soil (SMU7) was classified as hydrosol. The remnant vegetation soils, SMU 8 and 9, were classified as sodosol and kurosol, respectively. Finally, dolerite dyke, SMU 10, was classified as sodosol.

Figure 1 illustrates each SMU in terms of their suitability for land use, where suitability is defined as the absence of land quality that is severely limited (Land capability class 4 to 5). From our LCA, we found that SMU 1,4.6 and 10 were suitable for all three land uses, and SMU3 and 5 were only suitable for grazing. SMU 2 had at least one land quality with class 4 or 5 for all land uses; therefore, we recommend that SMU 2 land is zoned for conservation instead. This may be in the form of revegetation of deep-rooted native Eucalyptus species, such as *Eucalyptus loxophleba* and *Eucalyptus Accedens*. We also suggest that SMU 7, 8 and 9 are preserved as remnant and riparian vegetation as the costs of losing ecosystem services, such as prevention of dryland salinity, could be greater than the benefits of clearing for agriculture in the long term. Also, the soils of SMU 7, 8 and 9 have severe limitations for agricultural land-uses, especially dryland cropping and horticulture, which supports the reason for the preservation of native vegetation.

Some common limiting land qualities in SMU 1 to 6 and 10 include soil erosion, rooting depth and salinity hazards. Soil erosion can be mitigated through crop cover and mulching. Rooting depth can be enhanced by deep ploughing. Salinity can be reduced by salt leaching and application of gypsum. However, costs of soil remediation and risks of degradation can be minimized if we allocate the land use that is most suitable for specific portions of land. *Figure 1* improves decision-making by identifying the land-use or a range of land uses that is most suitable for different portions of land on the farm.

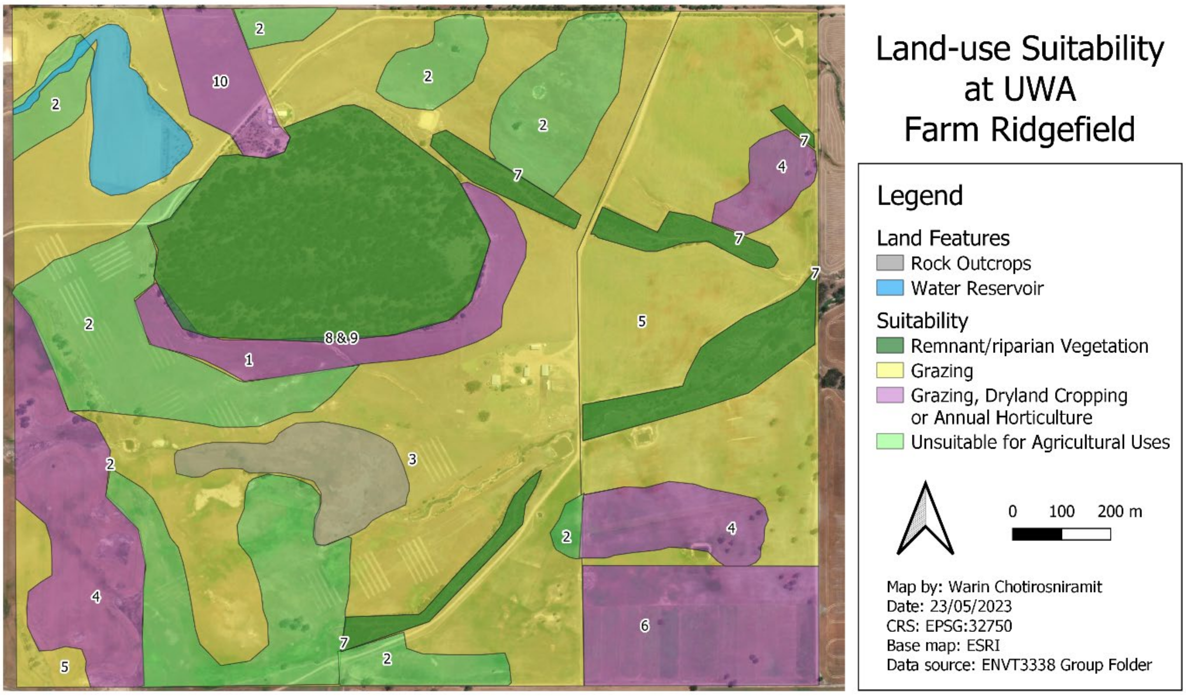


Figure 1: Map of land use suitability at UWA Ridgefield Farm derived from land capability assessment for dryland cropping, grazing and annual horticulture. The numbers represent the number of SMU.

2. Introduction

The UWA School of Agriculture and Environment has been engaged to undertake a land capability assessment (LCA) for the 1600-hectare UWA farm Ridgefield, which supports agricultural experiments and research, such as the Best Practice Farming Systems project, in addition to cropping activities and grazing. This report will present the findings from our soil survey and soil mapping units (SMU), as well as the results of our laboratory analysis of the soil's physical and chemical properties. From our findings, we will identify the constraints to certain land-uses including cropping, horticulture and grazing, and determine ameliorative practices that may overcome the constraints for each SMU.

Our site is situated to the west of Pingelly, a town and shire located in the Wheatbelt region of Western Australia. It is approximately 120 kilometers away from the coastline and lies in the direction of southeast of Perth. The site has been cleared of the original native vegetation for cropping and grazing uses, but there are still areas of remnant vegetation scattered across the farm as shown in *picture 1*, as well as a small strip of remnant native riparian vegetation. Dryland farming systems and sheep production are practiced on the farm as shown in *picture 2.* Furthermore, the farm serves as a role model farm for the wheatbelt community under the "UWA Future Farm 2050" project, which aims to show the ideal farm that can meet the projected increasing demand for foods while avoiding further environmental impact and biodiversity loss.

Picture 1: Control trial crops in the foreground with Remnant vegetation in the background

Picture 2: Dryland cropping field at UWA Farm Ridgefield

The UWA Farm Ridgefield lies on a small Pingelly sub-catchment which flows into the Swan-Avon catchment through the south branch of the Avon River (Ali et al., 2001). Assessment of salinity risk in Narrogin, a town 44 kilometers south of Pingelly, showed that groundwater recharge causing the water tables to rise indicates a high salinity risk, which is a common problem in the wheatbelt (Crossley, 2004). Salinity can be costly for agricultural systems as it limits plant growth or causes plant death by osmotic stress and ionic toxicity (Safdar et al., 2019). In Narrogin, Periodic waterlogging conditions in winter can also occur due to the flat topography and slow lateral drainage, which are landscape characteristics that agricultural fields in Pingelly share (McArthur, 1991). Repeated and prolonged waterlogging can lead to structural deterioration, which has several adverse effects on crops, such as poor root growth and reduced nutrient availability (Crossley, 2004).

In terms of geology, the area lies on a colluvium of partly dolerite that formed due to breaking down of the underneath biotite-rich granite (Ali et al., 2001). The region of Narrogin also contains gneisses, migmatites, meta-sediments, volcanics, and mafic dykes as parts of the underlying geology (McArthur, 1991). The landscape of flat-topped hills is capped by remnant laterites, which commonly form sands, gravels, and duplex soils upon erosion (McArthur, 1991; Sawkins, 2010). Lateritic soils are infertile due to the depletion of essential nutrients such as nitrogen, potassium and phosphorus, low organic matter and clay content in topsoil leading to low Cation Exchange Capacity (CEC), and highly saline pallid zone as a result of long-term accumulation of salt (Brouwer & Fitzpatrick, 2002; Orians & Milewski, 2007; Wong & Wittwer, 2009). Because most agricultural soils in the study region are derived from eroded laterite, they tend to have common limitations that can potentially affect agricultural productivity (O'Brien et al., 2019).

In Western Australia, a region with a Mediterranean climate, precipitation is the main limiting factor for rain-fed agricultural production (Turner & Asseng, 2005). Since the 1970s, a declining trend in rainfall in the Wheatbelt has been observed (Asseng et al., 2010). *Table 1* shows that Pingelly has experienced only a slight decrease in rainfall since 1891. However, projections for rainfall in the Wheatbelt region indicate a strong declining trend, which can lead to severe consequences for agricultural production such as a dramatic reduction in wheat yields (Waha et al., 2022). According to the Bureau of Meteorology, the temperature within the region has increased slightly since 1970 (*Table 2*). The impact of changing temperature on crop yield is complex. Generally, warmer temperatures lead to lower yields due to the shorter growing season; however, the lower temperatures can limit biomass production, especially in the Mediterranean climate; therefore, higher temperatures can also increase yield (Ludwig & Asseng, 2006). The effect of higher temperatures also depended on the soil type where sandy loam soil is more vulnerable than clay soil (Ludwig & Asseng, 2006)

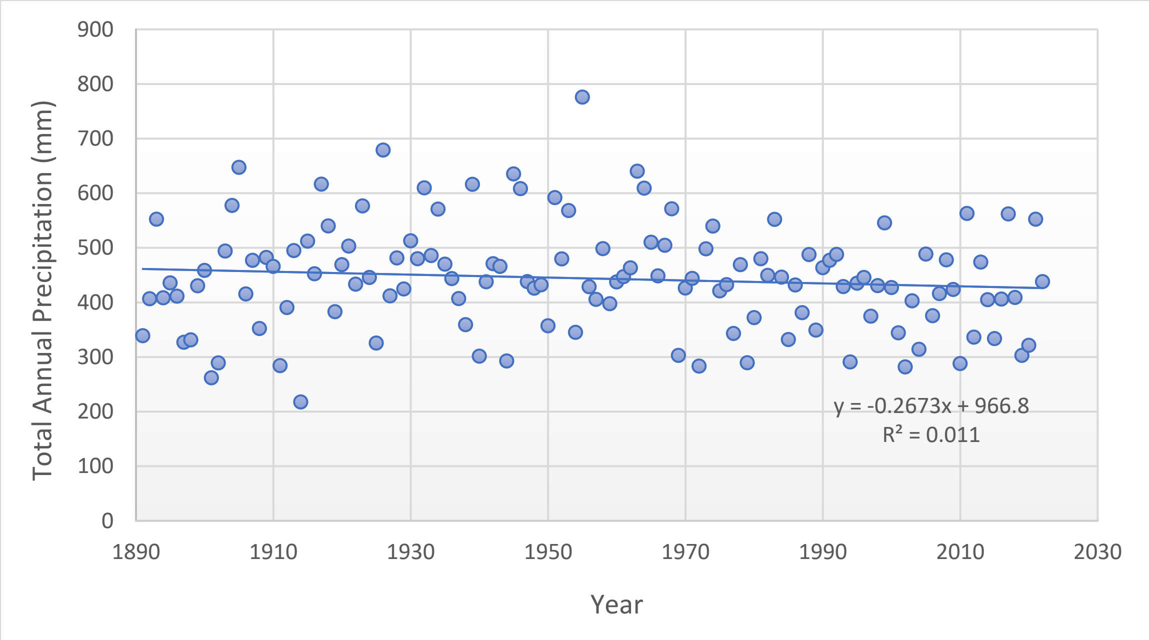


Table 1: Change in total annual rainfall in Pingelly since 1891 measured by Pingelly station 10626 (Source: Bureau of Meteorology)

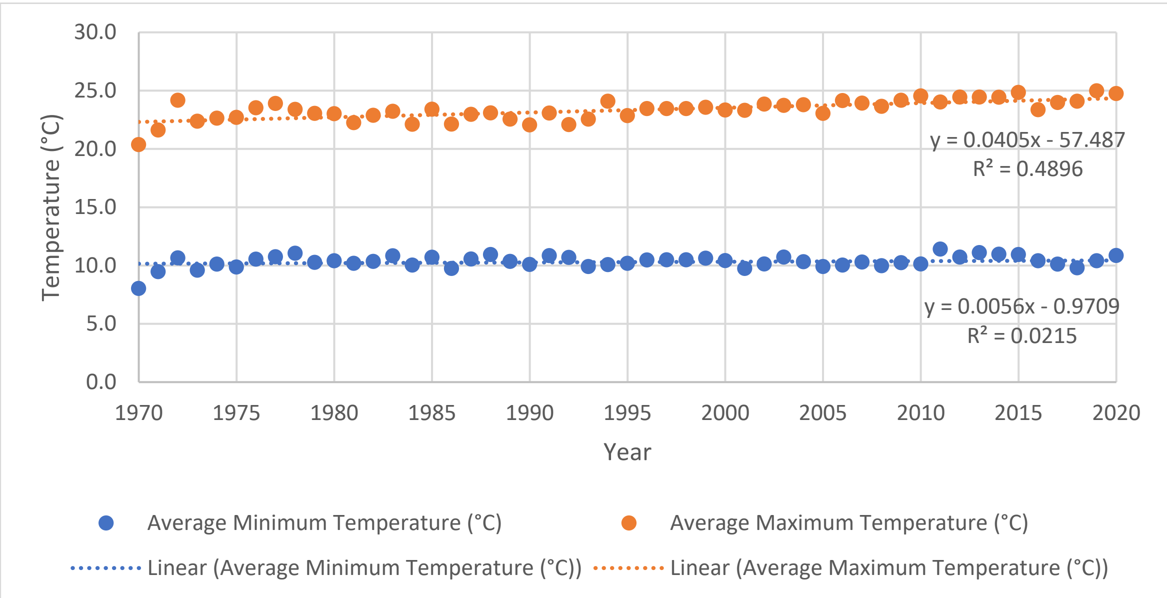


Table 2: Annual mean minimum temperature and maximum temperature measured by Pingelly station from 1970 to 2020 (Source: Bureau of Meteorology)

3. Literature Review

Land capability assessment (LCA) is a method for determining the suitability of a portion of land by identifying the physical, chemical and degradation limitations to the desirable land use (DPIRD, 2019). In Western Australia, a 5-point rating scale is commonly used where Class 1 indicates very few limitations to land use and Class 5 indicates severe limitations with high likelihood of land degradation (DPIRD, 2019). There are distinct differences between the LCA used in Western Australia and in other states of Australia. The land and soil capability assessment in New South Wales has 8 classes with class 1 to 3 describing land capability of a wide variety of uses including cropping, grazing, horticulture, forestry and nature conservation, and class 7 to 8 describing land capability of only forestry and nature conservation (Murphy et al., 2004). The LCA in Victoria uses the same 5-class system as Western Australia; however, the LCA used in Victoria evaluates land capability for agricultural uses, engineering uses, land-based recreation and earth resources, whereas the LCA used in Western Australia focuses mainly on agricultural uses (Rowe et al., 1981). The LCAs used in Western Australia and Queensland both follow the 5-class system and focus on agriculture; nevertheless, there is a slight difference in their details of assessment. Western Australia assesses susceptibility to phosphorus export and rooting depth, which Queensland does not assess; and Queensland assesses nutrients and pests and diseases, which Western Australia does not assess (Branch, 1990; Van Gool et al., 2005).

LCA can also have similarities and differences in different parts of the world, with each country having its own classification systems. For instance, Cambodia uses a 5-class system from very low capability to very high capability based on soil acidity, soil surface condition, rooting depth, nutrient availability, inundation, susceptibility of nutrient and structure decline in topsoil, soil water storage, soil workability, water logging, water erosion risk and phosphate export (Vang, 2013). Another example is the USDA land capability classification system that classifies land into 8 classes, where class I soils have few limitations that restrict agricultural uses and class VIII soils have severe limitations that render agriculture activities impossible(Pease & Coughlin, 1996). Each class is designated into one of the following subclasses based on the nature of their limitation: risk erosion, water, climate and inherent soil properties (Pease & Coughlin, 1996). Despite the differences in methodologies in LCAs worldwide, they tend to be based on how soil properties can limit land uses, in particular agriculture.

Soil surveys aid land capability assessment by grouping soils based on similar characteristics into soil mapping units, which can help land managers develop appropriate homogenous plans for land-use (Dornik et al., 2022; Zeraatpisheh et al., 2022). Traditional soil mapping involves manually mapping the different soils in polygons after field investigations and photo interpretations (Zhu et al., 2001). However, conventional soil mapping has limitations that prevent soil scientists from mapping soils accurately and efficiently. Firstly, the polygon nature of the map causes the level of detail to be limited by the map leading to generalization of soils, where small soil bodies can either be disregarded or merged into the larger soil bodies (Zhu, 1997). Moreover, the polygon-based map also implies that changes in soil types abruptly occur along the boundaries of the polygons, which is an unrealistic representation of spatial variation in soil types (Zhu et al., 2001). Secondly, the manual process tends to be both time-consuming and error-prone, which leads to the poor quality of the soil maps and the inefficient soil map updates (Zhu et al., 2001). As a result of these limitations, modern soil mapping techniques have relied on geographic information systems (GIS) and remote sensing technologies.

Nowadays, soil mapping uses GIS, remote sensing and machine learning methods to create soil mapping units in raster cells from various environmental parameters, such as soil properties, climate and topography (Dornik et al., 2022). An example of soil mapping GIS technology is the Soil Land Inference Model (SOLIM), which utilizes the soil experts' knowledge about the relationship between soils and environmental conditions, environmental databases, and GIS techniques under fuzzy logic to create continuous raster maps of soil properties (Zhu et al., 1997). With the ability of GIS to process several environmental variables simultaneously at high resolution, the quality of maps can be significantly higher than conventional maps as it would be able to map smaller soil bodies and detailed variation (Zhu et al., 2001). Furthermore, the mapping process would be more efficient in both time and cost allowing rapid soil survey updates, and also maintain the knowledge continuity as digitized products and "knowledgebases" of soil-landscape relationships can be passed on to future soil scientists to study more easily (Zhu et al., 2001).

The information on land suitability produced by LCA is typically used by various stakeholders for land-use planning. There are three levels of land-use planning: regional or strategy planning (broad scale), local or municipal planning (intermediate scale) and landholder or farm planning (detailed scale) (Rowe et al., 1981). Urban and regional planners may use the results of LCA at a broad scale to guide land use decisions, such as determining the best locations for residential, industrial development, conservation, or recreation. Environmental managers may use the results of LCA at an intermediate scale to assess the suitability of a particular site for environmental conservation and plan for restoration activities. Farmers may use the results of LCA at a detailed scale to determine which crops can be grown and which farming practices may be appropriated based on the soil properties, drainage features, and other factors. The results of LCA inform a wide range of stakeholders of land-use decisions and guide them on how to use the land in a sustainable and effective manner.

4. Methods

4.1 Soil survey and field work

In preparation for the soil survey fieldwork, we generated an SMU map by grouping areas with similar soil forming factors, including topography, land use and geological parent material. We assumed that climate and physical processes over time were consistent across the farm, so these factors were not considered. We used maps of slopes, vegetation, features from aerial view, and soil groups in the Ridgefield area as inputs to determine the area of each SMU. The slope map categorized soil into steep slope (> 10%), moderate slope (4 – 10%), and flat slope (2 – 4%). The vegetation map indicated areas with remnant vegetation within the farm. Features shown by aerial imagery allowed us to map the land use types (cropping or grazing) and riparian vegetation zone from water course lines. The soil groups map showed the location of dolerite dykes, which we identified as another SMU.

During the fieldwork, we dug a pit at least 80 centimeters deep for each SMU to observe the soil profile and collect bulk and composite samples from each horizon of each SMU to further analyse in the laboratory. We measured the slope of the land at which each pit is situated with a clinometer and determined the aspect with a compass. The depth of each horizon of each pit was measured using a tape measure. The texture of each horizon of each pit was determined by hand using the guide by the National Committee for Soil (2009). The moist soil colour was determined using the Munsell Soil Colour Charts. We recorded our observations of weather, land surface conditions, traces of animal remain, and field data into the soil pit description sheet (*Appendix A*).

4.2 Laboratory analyses

4.2.1 Chemical analyses

For chemical analyses, we measured the pH and EC, the carbon-nitrogen ratio, the phosphorus retention index (PRI), the exchangeable phosphorus (P) and potassium (K), and the cation exchange capacity (CEC). The same laboratory procedures were conducted for each horizon of each SMU using 2 millimeters sieved soil. We measured pH by making up solutions of 1:5 ratio of soil to DI water or 0.01M $CaCl_2$, then measured the pH of the suspension with a calibrated pH meter (Rayment & Lyons, 2011). We then measured electrical conductivity (EC) with a calibrated EC meter using a 1:5 ratio of soil to DI water (Rayment & Lyons, 2011). We used dry, finely ground soil to measure total carbon (TC) and total nitrogen (TN) with the Elementar Vario Macro CNS analyser, which allowed us to calculate the carbon-nitrogen ratio (Muller et al., 2008).

We used a method described by Allen and Jeffery (1990) for PRI. Firstly, we added a known concentration of equilibrating P solution to our samples, filtered the solution, and measured the absorbance values of the extracts with a UV-VIS spectrometer. We used a series of known P standards to create a standard curve for known P concentrations, which we can use to calculate the concentration of P in the extracts based on the absorbance values. The PRI is calculated by dividing the phosphate adsorbed by the sample by concentration of sample after equilibration.

The methods for measuring extractable P and K were developed from Rayment (2010). The samples were prepared by adding 0.5M $NaHCO_3$, then homogenized with a shaker and filtered. For the P analysis, we neutralized the samples with 2.5M sulfuric acid, then added a colouring agent and MilliQ water. We then measured the absorbance values with UV-Vis spectrophotometer. For the K analysis, we added 2.5M sulfuric acid to the samples, then placed them in an ultrasonic bath at 40°C. Then, we measured the raw absorbance values with a flame photometer. We created standard curves with known P and K concentrations to determine the concentration of P and K in the samples.

The CEC was determined using a method based on Blakemore et al (1987). Firstly, we added known concentration of silver thiourea $(AgTu)^+$ to the oven-dried samples, to allow the Ag+ ions to displace the base cations. We then used the Inductively Coupled Plasma Optical Emission Spectrometry to measure the concentrations of Ag and the exchangeable cations, including Na, K, Ca and Mg. The total CEC is equal to the difference between the concentration of $(AgTu)^+$ at the start and the concentration of $(AgTu)^+$ after shaking.

4.2.2 Physical analyses

For physical analyses, we examined the bulk density, the Munsell colour, the water repellence, the stability of the soil aggregate and the percentage of each particle size. We used the bulk samples to calculate the bulk density by dividing their oven-dried mass by the volume of the sampling cylinder (Coughlan et al., 2002). We used the Munsell soil colour chart to describe the colour of both dry and wetted soil (Stuart-Street et al., 2020).

For water repellence, we used the Molarity of Ethanol droplet test, which involved adding a droplet of ethanol solutions from a range of concentrations onto the soil (King, 1981). We started with the lowest concentration and if the droplet was not absorbed within 10 seconds, we proceeded to the next concentration until the droplet was absorbed within 10 seconds. The soil's repellence was rated using *appendix B*, which describes the severity and the range of concentrations.

For aggregate's stability, we used the Emerson aggregate stability test, which entailed placing small soil aggregates from unsieved bulk sample in a petri dish with DI water, then observing the slaking and dispersing behaviour of aggregates (Emerson, 1967). We used *appendix C* to determine the Emerson aggregate class of each sample based on our observation.

Our particle size analysis was guided by McKenzie et al (2002), who based their method on the fact that clay and silt fractions settle at different times. The soil particles were dispersed in water by transforming the clay to a sodium-saturated state and inducing forceful disaggregation. The clay and silt-clay fractions were collected using the pipette method at different times determined by the room temperature. The two components were oven-dried at 105°C and measured as a percentage of the oven-dried sample. The silt fraction can be determined by subtracting the clay from the silt-clay fraction. We assumed that the sand fraction makes up the remaining portion.

4.3 Data analysis

A range of data analysis techniques and software was used to answer research questions. The alpha level was set at 0.05 for all hypothesis testing. All statistical analyses We used Excel to create a boxplot that visualizes the organic matter between horizons from soil across the farm and R to conduct statistical analyses, including Shapiro-wilk test, Kruskal-Wallis test and Pairwise Conover's test. We compared the macronutrient availability in soils of different land uses using Excel to create boxplots and scatterplots and R to conduct Shapiro-wilk test and Kruskal-Wallis test. We used QGIS to perform a spatial analysis of the variation in pH of different SMUs across the farm. We used R to plot how EC varies with depth for different land uses.

5. Results

5.1 SMU map

Figure 2 shows a map of all the 10 SMUs categorized based on slope, land use, vegetation cover and rock parent material. The 10 SMUs are 1) Steep Grazing, 2) Moderate Grazing, 3) Flat Grazing, 4) Moderate Cropping, 5) Flat Cropping, 6) Field Trial Cropping, 7) Flat Riparian, 8) Steep Remnant Vegetation, 9) Moderate Remnant Vegetation and 10) Dolerite Dykes.

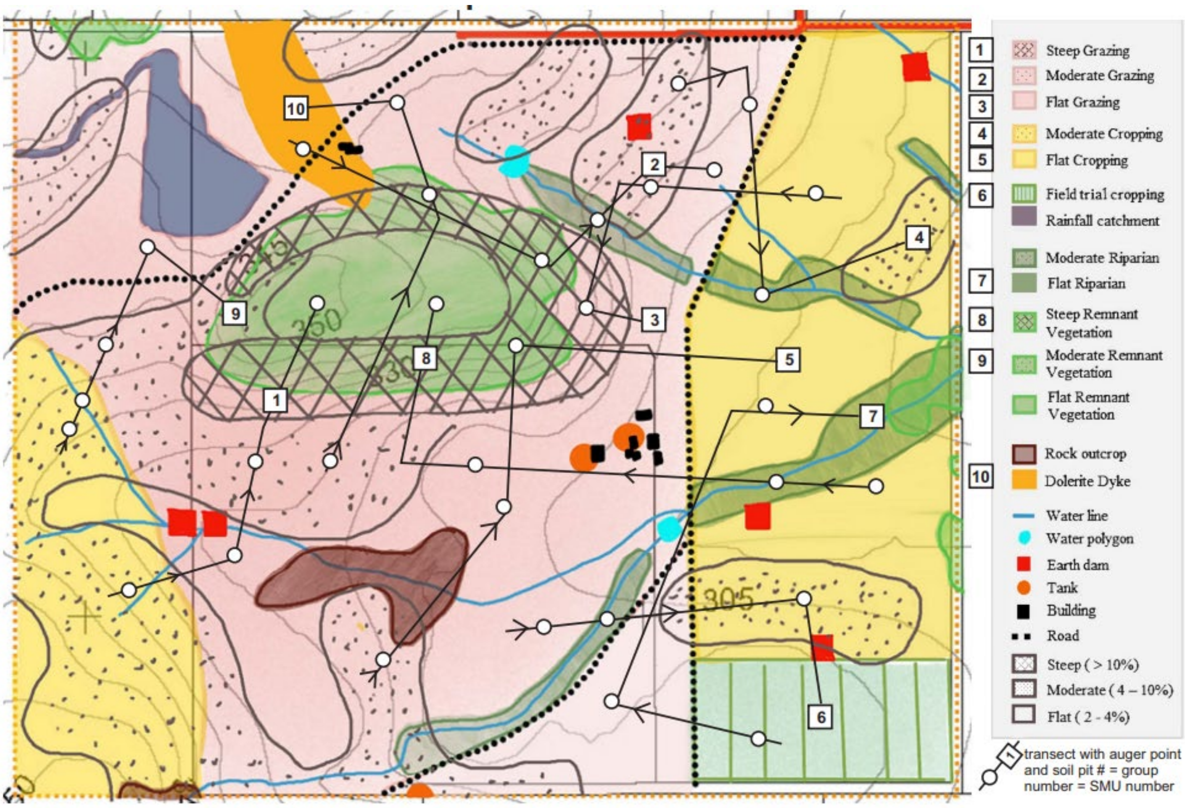


Figure 2: SMU map for the study area indicating the locations of 10 SMUs and relevant auger profiles

5.2 Variation of organic matter with soil depth

Organic matter was calculated by multiplying total organic carbon by 1.72 and 2 for topsoils (A1, A2 and A2E) and subsoils (B1, B2 and C), respectively (Morgan et al., 2020). There was a decreasing trend of total organic matter as depth increases, as shown in *Table 1* and *Figure 3*, except for horizon A2E where the mean total organic matter was the lowest. We also found relatively larger standard deviation in A1 and A2, indicating greater variability in total organic matter in topsoils (*Table 1*).

Table 1: Comparison of mean and standard deviation values of total organic matter between each soil horizon using all SMUs

Horizon	Total Organic Matter (%)		Number of samples
	Mean	SD	
A1	8.53	7.87	10
A2	5.93	5.39	4
A2E	0.24	0.04	2
B1	3.14	2.77	7
B2	1.09	1.02	16
C	0.54	NA*	1

* Unable to compute standard deviation because there was only one sample

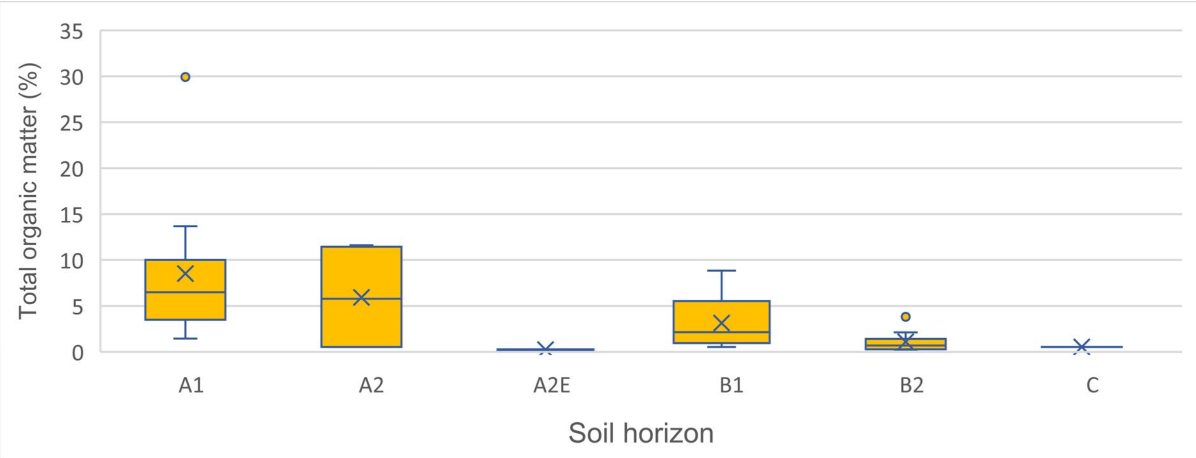


Figure 3: Box plots of total organic matter for each horizon using data from all SMUs. The box indicates the first and the third quartiles, the cross indicates the mean and the line in the middle of the box indicates the median. The whiskers indicate variability outside the upper and lower quartiles, and any point outside those whiskers is considered an outlier. All subsequent box plots follow the same description.

Table 2 shows that the p-value from the Shapiro-Wilk test was smaller than 0.05; therefore, we rejected the null hypothesis that the dataset follows a normal distribution. This led us to proceed with the non-parametric Krushkal-Wallis and pairwise Conover's test. For these tests, we excluded data from horizon C as there was only a single observation, making it impossible to perform any meaningful tests as the tests rely on the ranks of data. The p-value from the Krushkal-Wallis test was also smaller than 0.05; therefore, we rejected the null hypothesis that the population medians of all groups were equal (*Table 2*). The p-values from the pairwise Conover's test indicate that there were no statistically significant differences in the mean values of horizons A1 - A2, A2 - B1, and A2E - B2; the rest of the pairs were significantly different (*Table 3*).

Table 2: Results of Shapiro-wilk test and Kruskal-Wallis test for comparisons of percentage of total organic matter between horizons (except horizon C) of SMU 1 - 9

	Shapiro-Wilk	Krushkal-Wallis
P-value	<0.001*	0.00239*

* indicates p-value lower than 0.05

Table 3: P-values from the Pairwise comparisons Conover's test showing the difference in total organic matter between horizons (except horizon C) of all SMUs

Horizons	A1	A2	A2E	B1
A2	0.0696	-	-	-
A2E	<0.001*	0.0084*	-	-
B1	0.0292*	0.455	0.0064*	-
B2	<0.001*	0.0356*	0.0806	0.0216*

* indicates p-value lower than 0.05

5.3 Availability of macronutrients in soils of different land uses

The extractable macronutrients in soils of all horizons for each land use are shown in *Figures 4* to *7*. From the boxplots, soils from grazing had the highest amount of calcium (Ca) and potassium (K), but the lowest amount of phosphorus (P). Remnant or riparian vegetation zones had the lowest amount of Ca and K, but the highest amount of Magnesium (Mg). Cropping soils had the highest amount of P, but the lowest amount of Mg.

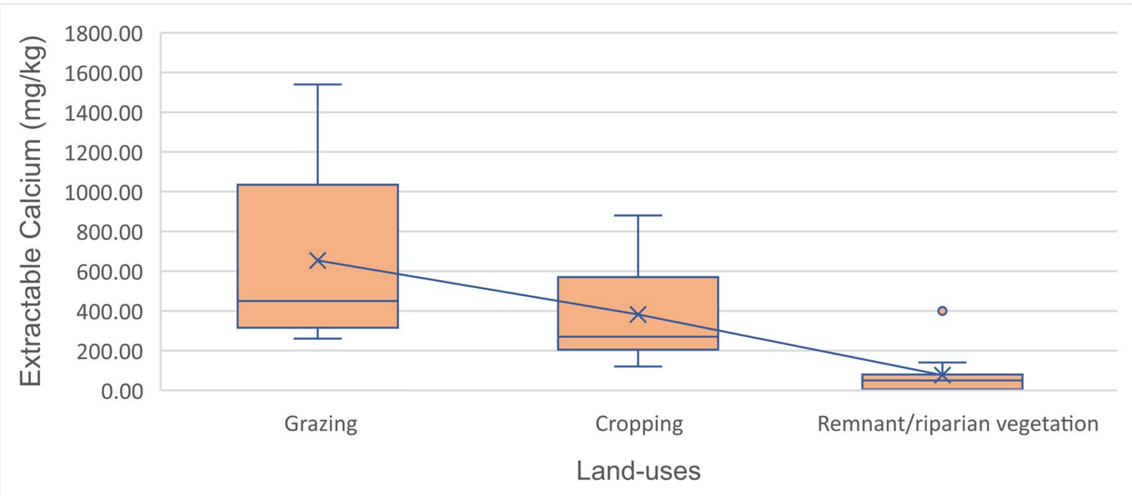


Figure 4: Boxplot comparing extractable calcium values between land uses using data from all horizons of SMU 1 - 9

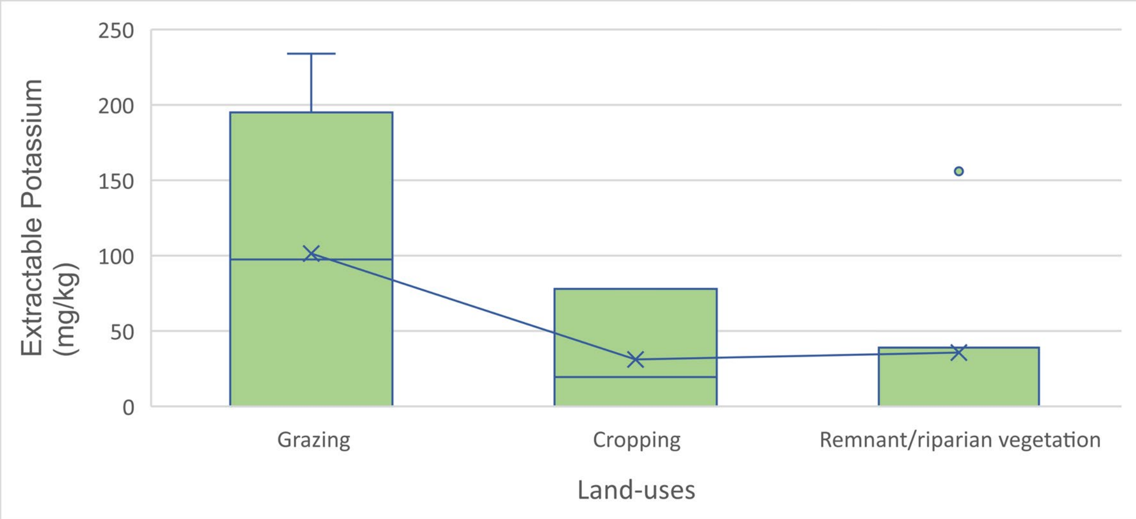


Figure 5: Boxplot comparing extractable potassium values between land uses using data from all horizons of SMU 1 - 9

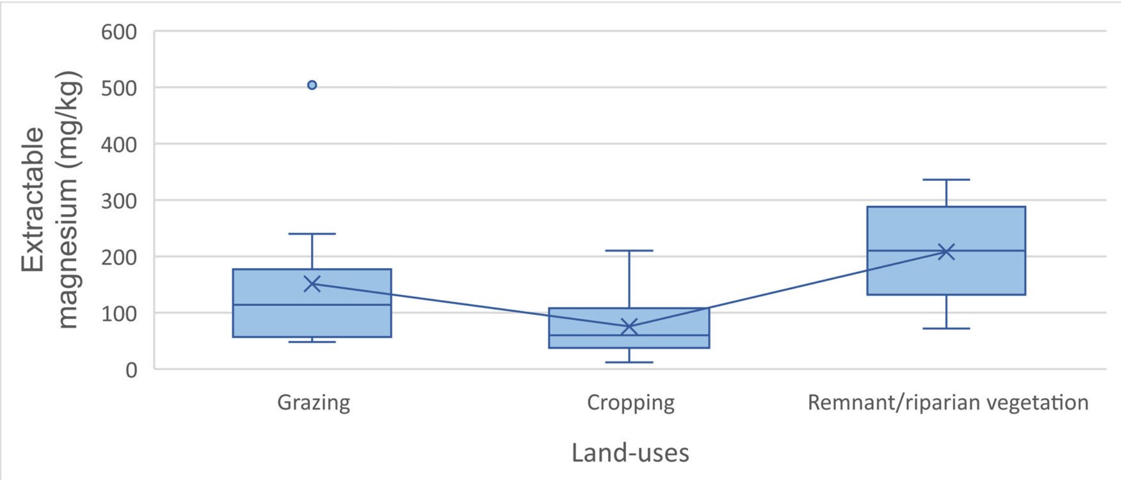


Figure 6: Boxplot comparing extractable magnesium values between land uses using data from all horizons of SMU 1 - 9

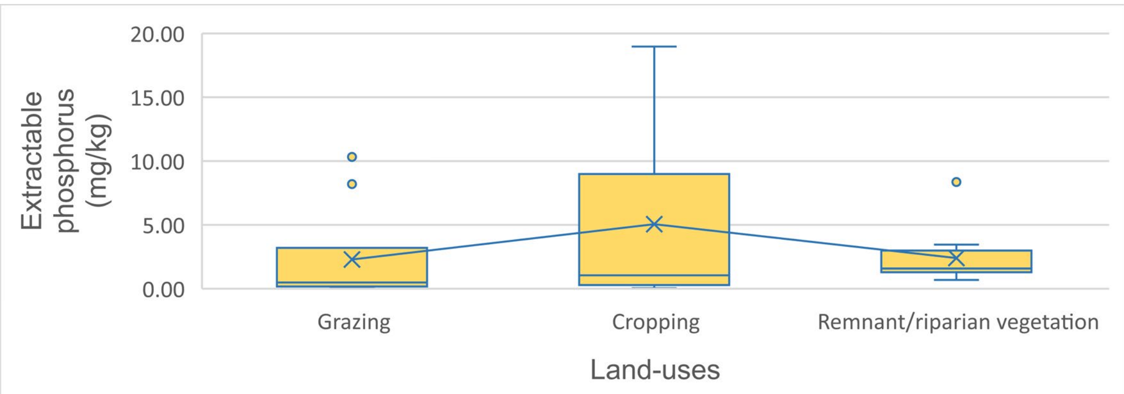


Figure 7: Boxplot comparing extractable phosphorus values between land uses using data from all horizons of SMU 1 – 9

The Shapiro-Wilk tests returned p-values smaller than 0.05, indicating that the datasets of all the macronutrients do not follow a normal distribution; therefore, we proceeded with non-parametric tests (*Table 4*). The Kruskal-Wallis tests resulted in the null hypothesis of equal medians being rejected only for Ca and Mg, whereas the medians between land uses were not significantly different for K and P (*Table 4*). We conducted the pairwise Conover's test for Ca and Mg to compare individual land uses. *Table 5* and *Table 6* show that all the p-values returned by the pairwise test for Ca and Mg, respectively, were all smaller than 0.05; therefore, the null hypothesis of equal means was rejected for all groups of both macronutrients.

Table 4: Results of Shapiro-Wilk test and Kruskal-Wallis test for mean comparisons of CEC and P values for different land uses using data from all horizons of SMU 1 - 9

	Shapiro-Wilk	Kruskal-Wallis
P-value for Ca	<0.001*	<0.001*
P-value for K	<0.001*	0.1583
P-value for Mg	0.00386*	0.00262*
P-value for P	<0.001*	0.219

* indicates p-value lower than 0.05

Table 5: P-values from the Pairwise comparisons Conover's test showing the difference in extractable calcium between land uses

Land use	Cropping	Grazing
Grazing	0.0304	-
Remnant/riparian vegetation	<0.001*	<0.001*

* indicates p-value lower than 0.05

Table 6: P-values from the Pairwise comparisons Conover's test showing the difference in extractable magnesium between land uses

Land use	Cropping	Grazing
Grazing	0.0205*	-
Remnant/riparian vegetation	<0.001*	0.0219*

* indicates p-value lower than 0.05

5.4 Spatial variation of pH in different SMUs

Figure 8 shows a map of pH of soil from A1 horizon measured in $CaCl_2$ solution for each SMU. All of the SMUs were acidic (pH < 7), with the remnant and riparian vegetation being the most acidic ranging from pH 4 to pH 5. The pH of grazing soil ranged from pH 5 to pH 6 falling in the categories of slightly acid to neutral, while the pH of cropping soils ranged from pH 5 to pH 5.5 falling in the slightly acid category. The dolerite dykes SMU had a pH of 5.86; therefore, it falls in the neutral category.

Figure 8: Map of pH ($CaCl_2$) measured in topsoil (A1 horizon) at each SMU across the farm showing spatial variation in pH in different land uses and land covers. Ranges and labels of pH were sourced from Van Gool et al. (2005).

5.5 Variation in EC with depth in different land uses

Figure 9 shows that soils in grazing and cropping lands have a relatively lower mean EC than vegetated areas, ranging from 20 to 120 µS/cm. Riparian vegetation has a higher mean EC, ranging from 100 to 400 µS/cm, whereas remnant vegetation has the highest mean EC, ranging from 150 to 1050 µS/cm. In terms of depth, both cropping and grazing soils had a relatively higher mean EC in the topsoil, then the mean EC dropped in the lower horizon, and increased slightly again in deeper horizons. Soils in riparian vegetation showed a similar pattern where the mean EC in horizon A1 was the highest, suddenly dropped in A2 and A2E, then rose again in horizon B2. In contrast to the previous land uses, soils in remnant vegetation showed the opposite pattern where the mean EC was lowest in the A1 horizon and increased sharply in the A2 horizon, then gradually decreased through B1 and B2 horizons.

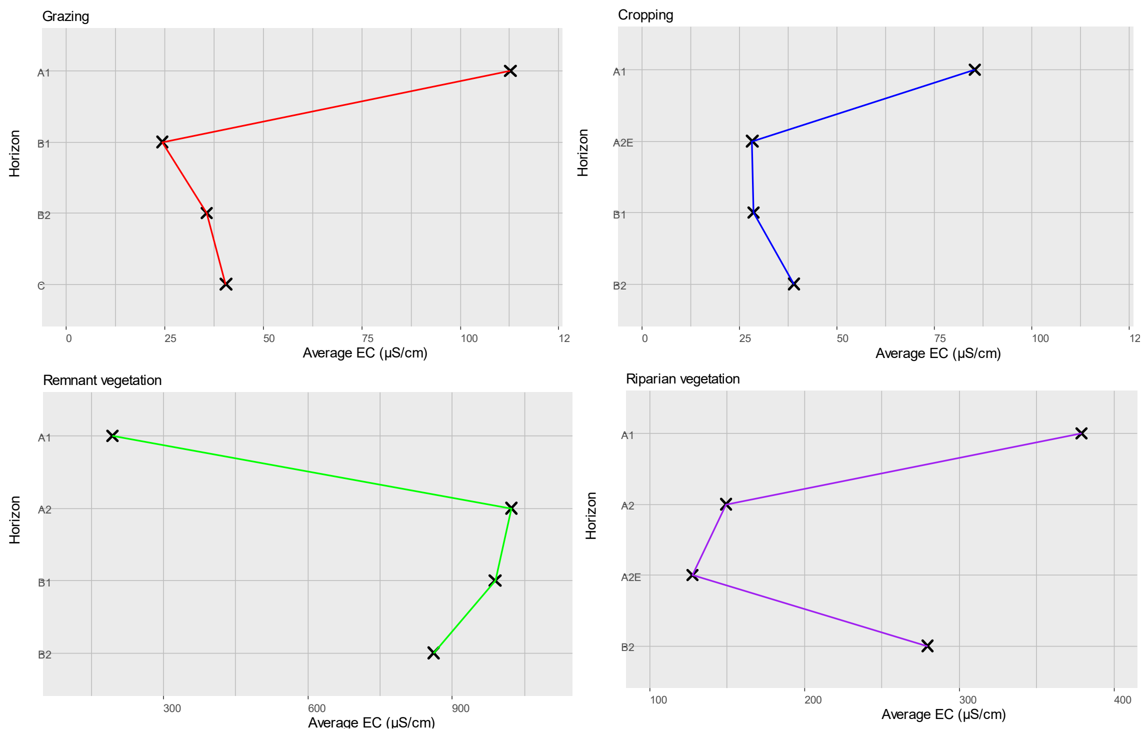


Figure 9: Average EC for each horizon of all SMUs categorized into different land uses and land covers, showing how EC varies with depth

5.6 The impact of slope gradients on soil erosion

Erosion is the process where soil is displaced or lost from the topsoil; therefore, we quantitatively compared the extent of soil erosion in terms of A1 horizon depth at different slope gradients. The slope of the SMUs on riparian vegetation, cropping land, and grazing land was relatively flat, ranging from 1 to 7 %. On the other hand, SMU 8 and 9, which were remnant vegetation, had very steep slopes with a range of 28 to 29%. *Figure 10* shows that there is a decreasing trend in A1 horizon depths as slope increases, as indicated by the negative gradient in the equation of the trendline; however, it was a weak gradient (0.0982). The R^2 value for the linear model was also considerably small (0.0577), suggesting that the slope factor may not be the main explanatory variable or may not be statistically significant in explaining the declining trend in A1 horizon depth (*Figure 10*).

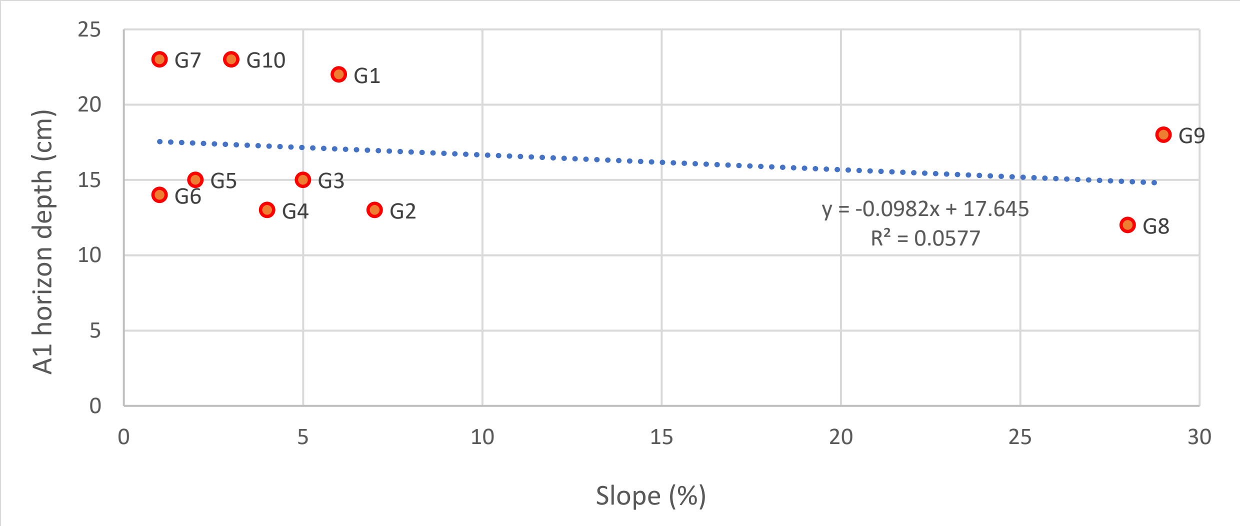


Figure 10: Scatterplot of A1 horizon depths of each SMU group against slope gradients showing the equation and R^2 value of the trendline. Each data point was labelled with its SMU group number to the right of each point.

5.7 Soil conditions in winter

The Wheatbelt region in south-west of Western Australia receives the highest amount of rainfall during the winter months (Pook et al., 2012). Because we sampled our soil in summer, the soil conditions in winter would be different from what we have observed. We can predict the distribution and properties of water in the soil during winter from the data on soil properties that we collected, including soil texture, bulk densities and soil water repellence. Sandy soils allow water to infiltrate and percolate faster than clay, which may hold water and cause water-logging conditions. Soils with high bulk density have fewer pore spaces, leading to less water retention and infiltration and increased potential for run-off (Li et al., 2009). A high MED severity for soil can cause low infiltration, resulting in greater run-off. Information on the landscape position, such as slope and distance from the watercourse lines, also helps predict the behavior of water. Steeper slopes can lead to more run-off as water has less time to infiltrate (Siswanto & Sule, 2019). *Table 7* summarizes these data for each horizon of each SMU.

We can use Table 7 to predict soil-water interactions in a wet winter. SMU 2, 3, 4 and 5 may experience water-logging conditions due to their relatively flatter slope, low or no water repellence and not too high bulk density. SMU 6 is prone to run-off due to high bulk density and moderate water repellence. SMU 7 also has high bulk density soil but no water repellence; therefore, the water would likely infiltrate down to B2 horizon where the bulk density is exceptionally high and form water-logging conditions. Both SMU 8 and 9 may experience run-off due to their steep slopes, but SMU 9 will likely have more run-off due to its clayey texture and greater water repellence. SMU 1 and 10 may see some run-off due to the moderate water repellence, but SMU 10 will likely experience more surface run-off due to a slightly greater slope gradient and loamier topsoil.

Table 7: Summary table of soil properties that affect water behaviour including slope, texture, bulk density and MED severity of each horizon of each SMU

SMU (slope)	Horizon	Texture	Bulk density	MED Severity
Group 1 (6%)	A1	Loamy sand	n/a	Moderate
	B1	Sandy loam	n/a	No repellence
	B2	Loamy sand	n/a	No repellence
	C	Loam	n/a	No repellence
Group 2 (7%)	A1	Loamy sand	1.35	No repellence
	B2	Clayey sand	1.57	No repellence
Group 3 (5%)	A1	Loam	1.21	Low
	B2	clay	1.60	No repellence
Group 4 (4%)	A1	Loamy sand	1.42	Very low
	B1	Clayey sand	1.41	No repellence
	B2	Sandy clay loam	1.65	No repellence
Group 5 (2%)	A1	Loamy sand	1.50	Low
	B1	sandy loam	1.56	No repellence
	B2	Sandy clay loam	1.64	No repellence
Group 6 (1%)	A1	Sand	1.50	Moderate
	A2	Sand	1.80	Low
	A2E	Sand	1.80	Very low
	B2	loam	1.60	No repellence
Group 7 (1%)	A1	Loamy sand	1.47	No repellence
	A2	Sand	1.60	No repellence
	A2E	Sand	1.60	No repellence
	B2	sandy loam	2.01	No repellence
Group 8 (28%)	A1	Loamy sand	1.10	No repellence
	A2	Clay loam	1.00	Moderate
	B1	Loam	1.20	Moderate
	B2	Silty loam	1.46	No repellence
Group 9 (29%)	A1	Clay loam	0.74	Very severe
	A2	Clay loam	0.96	Very severe
	B1	Clay loam	1.24	Very low
	B2	Loam	1.53	No repellence
Group 10 (3%)	A1	Sand	1.50	moderate
	B1	Coarse sand	1.50	No repellence
	B2	Clayey sand	1.50	No repellence

6. Discussion

6.1 Soil-landscape associations and patterns

6.1.1 Trend in organic matter with soil depth

We found a decreasing trend in organic matter as soil depth increases. Despite the lack of significant differences between A1 - A2 and A2 - B1, we could still establish that there were significant differences between all other pairs; hence, we concluded that there was a declining trend. Very small amount of organic matter was found in A2E and C horizons; however, it is important to note that there were insufficient samples to make any meaningful conclusions.

This trend is supported by Brady (2002), who explained that subsoils often lack active stores of organic matter and shallow root systems cannot always penetrate such depth, whereas topsoils have an abundant availability of organic matter and oxygen, causing soil microbes and fungi to be concentrated in the top 10 centimeters of the soil. McArthur (2004) found the same trend in the soils of Narrogin, where the percentage of organic matter in A1 horizon and B2 ranged from 1.1 to 12.6 and 0.2 to 1.38, respectively. Soil organic carbon, a component of soil organic matter, has been documented to decrease sharply with depth from the soil surface by many previous studies around the world (Chandler, 2016; Lawrence et al., 2015; Li et al., 2013). Organic matter benefits the soil in various ways, for instance, release plant-available nutrients upon decomposition and improves soil structure, which enables easy water infiltration and resistance to erosion and crusting (Bot & Benites, 2005). Therefore, proper management of the topsoil is vital for sustaining soil fertility (Tiessen et al., 1994).

6.1.2 Macronutrients availability in different land uses

We conducted comparative analyses for 4 soil macronutrients, including phosphorus, calcium, magnesium and potassium, in different land uses (Broyer & Stout, 1959). We found that there were significant differences between the medians of extractable calcium and magnesium of the land uses, but no statistically significant differences for potassium and phosphorus. Grazing lands had the highest availability of extractable calcium, followed by cropping soils, then remnant and riparian vegetation. Conversely, remnant and riparian vegetation had the highest availability of extractable magnesium, followed by grazing lands, then cropping soils.

McArthur (2004) found availability of extractable macronutrients in in Tutanning Nature Reserve, Narrogin similar to our findings for remnant and riparian vegetation, for instance, they found that the extractable phosphorus in the reserve ranged from less than 2 to 6 mg/kg. However, their range of calcium in the nature reserve was as high as 1400 mg/kg, while we only had an outlier of around 400 mg/kg, meaning that there are some spatial dissimilarities (McArthur, 2004). The findings of a study of soil in India revealed that the availability of phosphorus in cultivated lands for annual crops and pastures are similar, which conforms with our results, but the availability of potassium in pastures is slightly higher than in annual crop lands (Kumar & Paliyal, 2017). A study in Ethiopia by Tiruneh et al. (2021) found that extractable calcium, potassium and phosphorus were the highest in grazing lands compared to forestland and cropland, which matched our results for calcium but not potassium and phosphorus. The findings of a study in Nigeria by Nwite and Alu (2017) showed that the availability of extractable magnesium was highest in forestland, whereas the availability of extractable calcium was highest in grazing land; both patterns of macronutrients aligned with our results.

Despite minor discrepancies, we still found a general pattern of grazing and cropping lands having higher macronutrient availability, with an exception for magnesium, which remnant and riparian vegetation had the highest. High macronutrient availability in agricultural fields could be attributed to fertilization to improve mineral nutrient acquisition (Kalcsits et al., 2020). Grazing lands in Australia are often the results of clearing of native vegetation, which made large amounts of macronutrients available upon decomposition of organic matter from tree felling (Sangha et al., 2005). Because soil-foraging animals recycle macronutrients through grazing and excretion, the macronutrients remain high in the area, which explains the high macronutrient availability (Vendramini et al., 2007). Magnesium is heavily involved in the protein synthesis of chlorophyll pigments in leaves, which could be the reason for the high extractable magnesium in forests due to large amounts of litterfalls, while croplands are declining in magnesium concentration worldwide (Guo et al., 2016; Rosanoff, 2013).

6.1.3 Variation in soil acidity across different land uses

The pH of A1 horizon (topsoil) was used to compare acidity across the farm because the roots of most crops grow in the top 20 centimeters of the soil (Fageria & Moreira, 2011). Through spatial analysis of the pH of A1 horizon across the farm, we found that the soil in remnant and riparian vegetation area was the most acidic, being categorized as moderately acidic to very strongly acidic. Grazing land was in the range of slightly acidic to neutral, whereas cropland was slightly acidic.

In comparison with the findings of McArthur (2004), the pH ($CaCl_2$) of the A1 horizon of soil in Tutanning Nature Reserve, Narrogin ranged from 4.4 to 5.7, which is relatively higher than what we observed for our soil in remnant and riparian vegetation. A study in Bale Mountains, Ethiopia by Yimer et al. (2008) found that native forests had lower pH than croplands and grazing lands, and that after the conversion of a forest to agricultural lands, the soil pH increased significantly. Similarly, Zhou et al. (2019) found that the pH of the soil surface in a forest in northeast Thailand was only 4.2, which is significantly lower than pH of the topsoil of rice fields and sugar cane fields, which had pH of 5.6 and 6.1, respectively. A study of the spatial distribution of pH of European agricultural and grazing soils reported that 36% of their grazing soil samples had pH lower than 5 compared to 26% of their cropland samples (Fabian et al., 2014). This suggests that the single data point of SMU 3 (grazing), which had the highest pH value of 6.04, could be an anomaly as it was higher than all pH values of cropland SMUs.

Many literatures show that pH in forested areas is lower than in agricultural lands. The higher acidity in remnant/riparian vegetation soils could be explained in terms of their abundant organic matter because decomposition of organic matter can produce organic acids, such as humic acids (Fageria & Nascente, 2014). The higher pH values of agricultural lands could be attributed to liming effects. Soil acidity can cause nutrient deficiency by influencing biochemical processes, such as substance translocation, trace element mobility and soil enzyme activities, which adversely affects crop productivity (Neina, 2019; Schroth et al., 2002). Therefore, it is important to maintain optimal pH by implementing effective liming practices that utilize appropriate lime material and application methods (Li et al., 2019).

6.1.4 Pattern of EC with depths for different land uses

Grazing and cropping lands had significantly lower EC values than riparian and remnant vegetation. Although the EC of groundwater under Pingelly town ranges from 1,000 to over 20,000 µS/cm in summer, our average EC measurements for agricultural soils were all less than 200 µS/cm (Crossley, 2001). This suggests that the agricultural soils at our study site may not have been affected severely by dryland salinity, which has severely degraded over 1 million hectares of previously fertile land in Southwest Western Australia (DPIRD, 2022). A study by Mcfarlane and George (1992) found that dryland salinity in a sub-catchment in Wheatbelt was prevented by remnant vegetation, which caused the groundwater level to be 7 meters lower in nearby and downslope areas compared to areas that were cleared of remnant vegetation. This could explain the lower EC values in the agricultural soils as they were near vegetated hilltops characterized by the presence of deep-rooted trees, such as *Eucalyptus loxophleba*, *Eucalyptus exilis* and *Eucalyptus Accedens*.

The EC of agricultural soils also varied with depth, where the topsoil has a higher EC measurement than the subsoils (*Figure 7*). This could be attributed to the excretions of farm animals as they have high sodium content (Chew et al., 2019). Riparian vegetation also shows high EC concentration in the topsoil as the water channels bring salt into the riparian zone as higher rainfall increases the streamflow; then the water evaporates during summer, which concentrates the salt onto the topsoil. Conversely, the topsoil of remnant vegetation had the lowest EC compared to other horizons. The high salinity in subsoil could be due to the accumulation of soluble salts in lateritic soils over time (Watson, 1982). On the other hand, the negative correlation between soil organic matter and salinity could explain the low salinity in topsoil as there is higher total organic matter in the topsoil (Morrissey et al., 2014).

6.1.5 Correlation between slope gradients and soil erosion

We found a weak correlation between slope gradients and the depth of A1 horizons, where increasing slope leads to thinner A1 horizon. Although a negative trend was observed, it was not a significant one as the negative slope gradient of the trendline was only 0.0982. Liu et al. (2001) explained that hillslope runoff erosion is driven by the sheet flow generated during rainfall, which scours the soil surface and transports the soil downstream by overland flow. They found that the sheer scouring capacity and the flow velocity increase with the slope, which causes more erosion to occur (Liu et al., 2001). However, we only found a small correlation between for the slope factor; therefore, other factors like vegetation cover, soil texture and soil moisture could be affecting soil erosion more significantly.

Vahabi and Nikkami (2008) used a rainfall simulator to assess factors impacting soil erosion and found that slope had a positive correlation with sediment yield from run-off, but the effect was minimal; on the other hand, they found that vegetation cover and antecedent soil moisture were significantly negatively correlated with sediment yield. Similar results were noted by Lasanta et al. (2000), who found that vegetation cover was the dominant factor in controlling soil erosion. Gao et al. (2020) also concluded that vegetation cover was the main factor as it explained over 30% of spatial heterogeneity of soil erosion in Beijing; however, they enhanced the spatial distribution of soil erosion to 55% when a combination of vegetation cover and slope was used as explanatory factors.

Studies have shown that slope gradient has an impact on soil erosion but not as significant as vegetation cover. This could explain why SMU 8 and 9, which were covered with remnant vegetation on a steep slope, did not have a significantly shallower A1 horizon compared to their less steep counterparts. The importance of vegetation cover in reducing soil erosion could be utilized in dryland cropping by incorporating crop covers into the crop rotation cycles, for example, planting cover crops like legumes during fallow period. Crop covers have been shown to increase water infiltration by 629% and soil macropores by 33%, and reduce bulk density by 4%; these improvements have been reported to reduce soil loss by 96% (Haruna et al., 2020).

6.2 Soil class map

Our soil class map was derived from the land evaluation standards. In general, our map is more detailed and precise in terms of spatial classification of the soil compared to smaller-scale maps in the literature, which are more spatially generalized. For instance, the soil map of Cape York in Queensland showed uniformly coloured polygons of soil mapping units at a 1:250,000 scale, compared to our large-scale map using a 1:20,000 scale (Biggs & Philip, 1995). Our soil class map used soil orders from the Australian Soil Classification system, which uses factors that influence soil formation, such as soil parent material, climate, vegetation and topography to classify the diverse range of Australian soils (Isbell, 2016). In contrast, Bui et al. (2020) of soils across Fitzroy, Darwin and Mitchell catchments by using Soil Generic Groups classification system, which is more general but able to reflect the geology and landform in terms of land use potential and management of the study area. We mapped our soils using slope and vegetation data at a large scale, which allows us to assess soil quality and the impact of erosion in a way that is useful at a local scale. This gives us more useful information than smaller-scale maps in a local context; however, smaller-scale studies may be more useful in the wider policy context.

6.3 Land capability assessment of each SMU for different land uses

Land capability assessment was performed for each SMU in terms of their suitability for the following land uses: dryland cropping, grazing and annual horticulture. The assessment was guided by Van Gool et al. (2005), who used a 5-point classification system where Class 1 indicates very few physical limitations for the specified land use, while Class 5 indicates severe limitations. Each SMU was evaluated in terms of their land qualities to determine the limiting factors for specific land uses, as shown in *Table 8*. The 5-point classification system for each land-use was based on *Table 8*.

Table 8: Master table for assessing land qualities of each SMU

Land Quality	Soil Mapping Unit									
	1	2	3	4	5	6	7	8	9	10
Ease of Excavation	H	H	M	M	H	H	L	L	M	H
Flood Hazard	N	N	N	L	N	N	M	N	N	N
Land Instability Hazard	N	N	VL	N	N	N	VL	M	M	N
Microbial Purification	VL	L	L	VL	L	L	L	L	M	M
Surface pH	Slac	Mac	Slac	Mac	Slac	Slac	Mac	Vsac	Sac	N
Phosphorus Export Hazard	L	L	M	M	M	low	E	H	VH	L
Physical Crop Rooting Depth	D	VS	S	M	D	D	MS	M	D	M
Salinity Hazard	NR	PR	PR	PR	MR	PR	HR	NR	NR	NR
Salt Spray Exposure	N	N	N	N	N	N	N	N	N	N
Site Drainage Potential	R	W	R	R	W	R	P	R	R	R
Soil Absorption Ability	H	H	L	M	M	H	L	M	H	H
Soil Water Storage	M	VL	ML	L	ML	ML	L	M	M	ML
Soil Workability	G	F	G	G	G	G	P	P	P	G
Subsurface acidification susceptibility	M	H	L	H	H	H	H	P	P	H
Subsurface compaction susceptibility	L	H	M	M	H	M	M	M	L	M
Surface Salinity	N	N	N	N	N	N	M	N	N	N
Surface soil structure decline susceptibility	L	L	L	L	L	L	M	L	M	L
Trafficability	F	F	F	G	G	F	F	P	P	G
Water Erosion Hazard	M	M	M	M	VL	M	H	H	VH	VL
Water repellence susceptibility	M	L	L	L	L	H	L	M	H	L
Waterlogging/inundation risk	N	N	N	N	M	N	H	N	N	N
Wind erosion hazard	L	H	L	L	L	L	L	L	L	L
Trafficability	F	F	F	G	G	F	F	P	P	G

Note: Refer to Van Gool et al. (2005) for the definition of codes

6.3.1 Dryland cropping

Table 9: Land capability class for each SMU in terms of land quality for dryland cropping. Green highlight indicates class 1-2, orange highlight indicates class 3 and red highlight indicates class 4-5

Land Quality	Land Capability Class for Dryland Cropping									
	SMU1	SMU2	SMU3	SMU4	SMU5	SMU6	SMU7	SMU8	SMU9	SMU10
Flood hazard	1	1	1	1	1	1	3	1	1	1
Land instability	1	1	1	1	1	1	1	3	3	1
pH 0-10 cm	1	2	1	2	1	1	2	3	3	1
pH 50-80 cm	1	1	1	2	1	1	2	3	4	1
Phosphorus export	1	1	2	2	2	1	4	3	3	1
Rooting depth	1	5	5	2	1	1	3	2	1	2
Salinity hazard	1	3	3	3	4	3	4	1	1	1
Salt spray exposure	1	1	1	1	1	1	1	1	1	1
Surface salinity	1	1	1	1	1	1	4	1	1	1
Surface soil structure decline	1	1	1	3	1	1	2	1	2	1
Soil water storage	2	4	2	2	2	2	3	1	2	2
Soil workability	1	2	1	1	1	1	4	4	4	1
Subsurface acidification	2	3	1	3	3	3	3	2	3	3
Subsurface compaction	1	2	2	2	2	2	2	1	1	2
Trafficability	2	2	2	1	1	2	2	2	4	1
Water erosion	3	3	3	3	1	3	4	2	5	1
Water repellence	1	1	1	1	1	2	2	1	2	1
Waterlogging	1	1	1	1	3	1	4	1	1	1
Wind erosion	1	3	1	1	1	1	1	1	1	1

According to *Table 9*, SMU 1 and 10 were the most suitable for dryland cropping as they had very few limitations for most of the land qualities, with only one land quality having moderate limitations each. SMU 4 and 6 were less suitable, but they did not have any severe limitations; therefore, they still had the potential for dryland cropping. SMU 2 and 3 were severely limited by rooting depth. However, this limitation can be overcome by deep ploughing, which improves root penetration, allowing access to more nutrients (Alcántara et al., 2016). SMU 2 also had a high degree of physical limitation in terms of soil water storage. This can be improved by implementing reduced tillage or no tillage practices, which have been proven to store significantly more plant-available water than traditional tillage practice (Radford et al., 1995). SMU 5 was limited by salinity hazard, which could be addressed by salt leaching through sprinklings or ponding to leach salts from topsoil to deep below the rooting zones (Qadir et al., 2000). Alternatively, salt-tolerant species can be selected to grow in these areas to cope with salt stress (Sahab et al., 2021). SMU 7, 8 and 9 had several limitations, which would not be cost-effective to overcome. Moreover, these SMUs have ecosystem services, for example, the riparian vegetation in SMU7 helps filter nutrients and toxic particles before they flow into the stream, and the remnant vegetation in SMU 8 and 9 can help prevent dryland salinity; therefore, it is advisable to maintain these SMUs as nature conservation areas (Lambers, 2003; Riis et al., 2020).

6.3.2 Grazing

Table 10: Land capability class for each SMU in terms of land quality for grazing. Green highlight indicates class 1-2, orange highlight indicates class 3 and red highlight indicates class 4-5

Land quality	**Land Capability Class for Grazing**									
	SMU1	**SMU2**	**SMU3**	**SMU4**	**SMU5**	**SMU6**	**SMU7**	**SMU8**	**SMU9**	**SMU10**
Flood hazard	1	1	1	1	1	1	2	1	1	1
Land instability	1	1	1	1	1	1	1	3	3	1
pH 0-10cm	1	2	1	2	1	1	2	3	2	1
pH 50-80cm	1	1	1	2	1	1	2	4	4	1
Phosphorus export	1	1	1	1	1	1	4	2	3	1
Rooting depth	1	4	3	1	1	1	2	1	1	1
salinity hazard	1	2	2	2	3	2	4	1	1	1
salt spray exposure	1	1	1	1	1	1	1	1	1	1
surface salinity	1	1	1	1	1	1	3	1	1	1
surface soil structure decline	1	1	1	2	1	1	1	1	1	1
soil water storage	1	4	1	3	2	2	3	1	1	2
soil workability	1	1	1	1	1	1	1	1	1	1
subsurface acidification	1	2	1	2	2	2	2	2	2	2
subsurface compaction	1	2	1	1	2	1	1	1	1	1
trafficability	1	1	1	1	1	1	1	2	2	1
water erosion	1	1	1	1	1	1	2	2	3	1
water repellence	2	1	1	1	1	3	1	2	3	1
waterlogging	1	2	1	1	2	1	3	1	1	1
wind erosion	1	3	1	1	1	1	1	1	1	1

According to *Table 10*, SMU 1 and 10 were the most suitable for grazing because they had very few physical limitations present for all land qualities listed. SMU 3,4,5 and 6 all had potential for grazing as they also had very few limitations, with only one land quality having moderate physical limitations each. Although no crops being grown in this land use, soil physical qualities are still essential for the health of grazing grasses. SMU2 was compromised by serious limitations for rooting depth and soil water storage. In addition, the soil in SMU2 experienced moderate risks of wind erosion. Trampling of hoofed grazing animals directly causes soil compaction by collapsing larger soil pores, which exacerbates risks of erosion and reduces penetration of rooting crops (Batey, 2009; Schack-Kirchner et al., 2007). Compaction also leads to reduced water storage as it decreases the hydraulic conductivity of the soil (Radford et al., 2000). SMU2 is already grazing land; therefore, it could possibly be creating their own limitations through compaction. Grazing strategies, such as avoiding grazing when the soil is moist and rotational grazing, which minimizes livestock traffic, can help reduce compaction and potentially improve the limitations faced by SMU2 (Hamza & Anderson, 2005; Lemus, 2011). SMU 7 was severely restricted in terms of land quality; thereby, the most viable option might be to set it aside for nature conservation and ecosystem services. SMU 8 and 9 were also quite physically limited for grazing. Moreover, clearing remnant vegetation may lead to dryland salinity, which could have adverse effects on surrounding SMUs that have higher potential for grazing (Lambers, 2003). Therefore, it is more practical to conserve these lands as remnant vegetation.

6.3.3 Annual horticulture

Table 11: Land capability class for each SMU in terms of land quality for annual horticulture. Green highlight indicates class 1-2, orange highlight indicates class 3 and red highlight indicates class 4-5

Land quality	Land Classification Class for Annual Horticulture									
	SMU1	SMU2	SMU3	SMU4	SMU5	SMU6	SMU7	SMU8	SMU9	SMU10
Flood hazard	1	1	1	2	1	3	3	1	1	1
Land instability	1	1	1	1	1	3	1	3	3	1
pH 0-10 cm	1	2	1	2	1	1	2	3	3	1
pH 50-80 cm	1	1	1	2	1	1	2	3	3	1
Phosphorus export	1	1	2	2	2	1	5	3	4	1
Rooting depth	1	5	4	2	1	1	3	2	1	2
Salinity hazard	1	3	3	3	4	3	4	1	1	1
Salt spray exposure	1	1	1	1	1	1	1	1	1	1
Surface salinity	1	1	1	1	1	1	4	1	1	1
Site drainage potential	1	1	1	2	2	1	3	1	1	2
Soil water storage	1	3	1	2	1	1	2	1	1	1
Soil workability	1	2	1	1	1	1	4	4	4	1
Trafficability	2	2	2	1	1	2	2	3	3	1
Water erosion	3	3	3	3	1	3	4	4	4	1
Water repellence	1	1	1	1	1	3	1	1	2	1
Waterlogging	1	1	1	1	3	1	4	1	1	1
Wind erosion	1	3	1	1	1	1	1	1	1	1

According to *Table 11*, SMU 10 was the most suitable for annual horticulture as it had very few physical limitations present, then SMU 1 and 4, which had only a few land qualities with moderate limitations. SMU6 was less suitable and would require conservation measures as it had 5 land qualities in Class 3 category. We found moderate to severe limitations for multiple land qualities in SMU2, 3 and 5, which may make them not advisable for annual horticulture due to excessive rehabilitation costs and considerable degradation risks; nevertheless, there are ameliorative measures for these issues. Rooting depth was severely limited for SMU 2 and 3. This can be improved by deep ploughing, which increases rooting depth and water storage capacity, making crop yields more stable under climate change conditions (Alcántara et al., 2016). Salinity hazard moderately limited the potential for annual horticulture of SMU 2, 3, 4 and 6, and was severely limiting for SMU5. Salinity can adversely affect nutrient uptake and disrupt nutrient partitioning within plants, causing nutritional disorders that may reduce yield or quality of horticultural crops (Grattan & Grieve, 1998). A salinity management strategy could involve a combination of excess irrigation that accounts for leaching fractions and annual application of gypsum (Phogat et al., 2020). Water erosion was a medium risk for SMU1, 2, 3, 4 and 6. It is recommended that tillage and herbicide application are avoided as they lead to high a water erosion rate; on the other hand, the use of vegetation cover and mulching should be implemented because they can reduce runoff and soil loss (Keesstra et al., 2016). SMU 6 was moderately limited by soil water repellency. This soil can be remediated by using surfactants or wetting agents, which reduce the surface tension of water to allow easier absorption of water by hydrophobic soils; however, this can be costly as continuous applications are required to maintain the benefits (Müller & Deurer, 2011). A cheaper alternative could be to select crops that are prone to drought (Blackwell, 2000). Water logging conditions, the moderate limiter of SMU 5, could be managed by strategic deep tillage, which improves drainage in the subsoil (Manik et al., 2019). Similarly with assessment for dryland cropping and grazing, we suggest the preservation of native vegetation at SMU 7,8 and 9 due to severe limitations which would be veery costly to remediate the soil for annual horticulture.

7. References:

Alcántara, V., Don, A., Well, R., & Nieder, R. (2016). Deep ploughing increases agricultural soil organic matter stocks. *Global Change Biology*, *22*(8), 2939-2956. https://doi.org/https://doi.org/10.1111/gcb.13289

Ali, M., E, C., & Siddique, J. (2001). *Groundwater Study of the Pingelly Town site, Western Australia*.

Allen, D., & Jeffery, R. (1990). *Methods for analysis of phosphorus in Western Australian soils*. Chemistry Centre of WA.

Asseng, S., Dray, A., Perez, P., & Su, X. (2010). Rainfall–human–spatial interactions in a salinity-prone agricultural region of the Western Australian wheat-belt. *Ecological Modelling*, *221*(5), 812-824. https://doi.org/https://doi.org/10.1016/j.ecolmodel.2009.12.001

Batey, T. (2009). Soil compaction and soil management – a review. *Soil Use and Management*, *25*(4), 335-345. https://doi.org/https://doi.org/10.1111/j.1475-2743.2009.00236.x

Biggs, A., & Philip, S. (1995). *Soils of Cape York Peninsula*. Queensland Department of Primary Industries.

Blackwell, P. (2000). Management of water repellency in Australia, and risks associated with preferential flow, pesticide concentration and leaching. *Journal of Hydrology*, *231*, 384-395.

Bot, A., & Benites, J. (2005). *The importance of soil organic matter: Key to drought-resistant soil and sustained food production*. Food & Agriculture Org.

Brady, N. C., Weil, R.R. (2002). *The nature and properties of soils* (No. Ed. 13 ed.). PrenticeHall I.

Branch, Q. L. R. (1990). *Guidelines for Agricultural land evaluation in Queensland*. Queensland Department of Primary Industries.

Brouwer, J., & Fitzpatrick, R. W. (2002). Interpretation of morphological features in a salt-affected duplex soil toposequence with an altered soil water regime in western Victoria. *Soil Research*, *40*(6), 903-906.

Broyer, T., & Stout, P. (1959). The macronutrient elements. *Annual Review of Plant Physiology*, *10*(1), 277-300.

Bui, E. N., Searle, R. D., Wilson, P. R., Philip, S. R., Thomas, M., Brough, D., Harms, B., Hill, J. V., Holmes, K., & Smolinski, H. J. (2020). Soil surveyor knowledge in digital soil mapping and assessment in Australia. *Geoderma Regional*, *22*, e00299.

Chandler, R. D. (2016). *Soil organic carbon distribution with depth: Implications for ecosystem services* Clemson University].

Chew, K. W., Chia, S. R., Yen, H.-W., Nomanbhay, S., Ho, Y.-C., & Show, P. L. (2019). Transformation of Biomass Waste into Sustainable Organic Fertilizers. *Sustainability*, *11*(8), 2266. https://www.mdpi.com/2071-1050/11/8/2266

Coughlan, K., Cresswell, H., & McKenzie, N. (2002). *Soil Physical Measurement and Interpretation for Land Evaluation*. CSIRO Publishing.

Crossley, E. K. (2001). Groundwater study of the Pingelly townsite.

Crossley, E. K. (2004). Groundwater study of the Narrogin townsite.

Dornik, A., Cheţan, M. A., Drăguţ, L., Iliuţă, A., & Dicu, D. D. (2022). Importance of the mapping unit on the land suitability assessment for agriculture. *Computers and Electronics in Agriculture*, *201*, 107305. https://doi.org/https://doi.org/10.1016/j.compag.2022.107305

DPIRD. (2022). Dryland salinity in Western Australia. https://www.agric.wa.gov.au/soil-salinity/dryland-salinity-western-australia-0

Emerson, W. (1967). A classification of soil aggregates based on their coherence in water. *Soil Research*, *5*(1), 47-57.

Fabian, C., Reimann, C., Fabian, K., Birke, M., Baritz, R., & Haslinger, E. (2014). GEMAS: Spatial distribution of the pH of European agricultural and grazing land soil. *Applied Geochemistry*, *48*, 207-216. https://doi.org/https://doi.org/10.1016/j.apgeochem.2014.07.017

Fageria, N. K., & Moreira, A. (2011). Chapter Four - The Role of Mineral Nutrition on Root Growth of Crop Plants. In D. L. Sparks (Ed.), *Advances in Agronomy* (Vol. 110, pp. 251-331). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-385531-2.00004-9

Fageria, N. K., & Nascente, A. S. (2014). Chapter Six - Management of Soil Acidity of South American Soils for Sustainable Crop Production. In D. L. Sparks (Ed.), *Advances in Agronomy* (Vol. 128, pp. 221-275). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-802139-2.00006-8
Gao, J., Jiang, Y., Wang, H., & Zuo, L. (2020). Identification of Dominant Factors Affecting Soil Erosion and Water Yield within Ecological Red Line Areas. *Remote Sensing*, *12*(3), 399. https://www.mdpi.com/2072-4292/12/3/399
Grattan, S. R., & Grieve, C. M. (1998). Salinity–mineral nutrient relations in horticultural crops. *Scientia Horticulturae*, *78*(1), 127-157. https://doi.org/https://doi.org/10.1016/S0304-4238(98)00192-7
Guo, W., Nazim, H., Liang, Z., & Yang, D. (2016). Magnesium deficiency in plants: An urgent problem. *The Crop Journal*, *4*(2), 83-91. https://doi.org/https://doi.org/10.1016/j.cj.2015.11.003
Hamza, M. A., & Anderson, W. K. (2005). Soil compaction in cropping systems: A review of the nature, causes and possible solutions. *Soil and Tillage Research*, *82*(2), 121-145. https://doi.org/https://doi.org/10.1016/j.still.2004.08.009
Haruna, S. I., Anderson, S. H., Udawatta, R. P., Gantzer, C. J., Phillips, N. C., Cui, S., & Gao, Y. (2020). Improving soil physical properties through the use of cover crops: A review. *Agrosystems, Geosciences & Environment*, *3*(1), e20105. https://doi.org/https://doi.org/10.1002/agg2.20105
Isbell, R. (2016). *The Australian soil classification*. CSIRO publishing.
Kalcsits, L., Lotze, E., Tagliavini, M., Hannam, K. D., Mimmo, T., Neilsen, D., Neilsen, G., Atkinson, D., Casagrande Biasuz, E., Borruso, L., Cesco, S., Fallahi, E., Pii, Y., & Valverdi, N. A. (2020). Recent Achievements and New Research Opportunities for Optimizing Macronutrient Availability, Acquisition, and Distribution for Perennial Fruit Crops. *Agronomy*, *10*(11), 1738. https://www.mdpi.com/2073-4395/10/11/1738
Keesstra, S., Pereira, P., Novara, A., Brevik, E. C., Azorin-Molina, C., Parras-Alcántara, L., Jordán, A., & Cerdà, A. (2016). Effects of soil management techniques on soil water erosion in apricot orchards. *Science of The Total Environment*, *551-552*, 357-366. https://doi.org/https://doi.org/10.1016/j.scitotenv.2016.01.182
King, P. (1981). Comparison of methods for measuring severity of water repellence of sandy soils and assessment of some factors that affect its measurement. *Soil Research*, *19*(3), 275-285.
Kumar, R., & Paliyal, S. (2017). MACRONUTRIENT STATUS OF DIFFERENT LAND USES IN SOILS OF NORTH WESTERN HIMALAYAS, H.P-INDIA. *International Journal of Advanced Research*, *5*, 1582-1586. https://doi.org/10.21474/IJAR01/4575
Lambers, H. (2003). Introduction: Dryland salinity: A key environmental issue in southern Australia. *Plant and soil*, v-vii.
Lasanta, T., García-Ruiz, J. M., Pérez-Rontomé, C., & Sancho-Marcén, C. (2000). Runoff and sediment yield in a semi-arid environment: the effect of land management after farmland abandonment. *CATENA*, *38*(4), 265-278. https://doi.org/https://doi.org/10.1016/S0341-8162(99)00079-X
Lawrence, C. R., Harden, J. W., Xu, X., Schulz, M. S., & Trumbore, S. E. (2015). Long-term controls on soil organic carbon with depth and time: A case study from the Cowlitz River Chronosequence, WA USA. *Geoderma*, *247*, 73-87.
Lemus, R. (2011). Breaking soil compaction: Does it increase forage production. *Missisippi State University Extension Service*, *4*(1).
Li, M., Zhang, X., Pang, G., & Han, F. (2013). The estimation of soil organic carbon distribution and storage in a small catchment area of the Loess Plateau. *CATENA*, *101*, 11-16.
Li, Y., Cui, S., Chang, S. X., & Zhang, Q. (2019). Liming effects on soil pH and crop yield depend on lime material type, application method and rate, and crop species: a global meta-analysis. *Journal of Soils and Sediments*, *19*(3), 1393-1406. https://doi.org/10.1007/s11368-018-2120-2
Li, Z., Wu, P., Feng, H., Zhao, X., Huang, J., & Zhuang, W. (2009). Simulated experiment on effect of soil bulk density on soil infiltration capacity. *Transactions of the Chinese Society of Agricultural Engineering*, *25*(6), 40-45.

Liu, Q.-q., Chen, L., & Li, J.-c. (2001). Influences of Slope Gradient on Soil Erosion. *Applied Mathematics and Mechanics*, *22*(5), 510-519. https://doi.org/10.1023/A:1016303213326

Ludwig, F., & Asseng, S. (2006). Climate change impacts on wheat production in a Mediterranean environment in Western Australia. *Agricultural Systems*, *90*(1), 159-179. https://doi.org/https://doi.org/10.1016/j.agsy.2005.12.002

Manik, S. N., Pengilley, G., Dean, G., Field, B., Shabala, S., & Zhou, M. (2019). Soil and crop management practices to minimize the impact of waterlogging on crop productivity. *Frontiers in plant science*, *10*, 140.

McArthur, W. M. (1991). Reference soils of south-western Australia. *ASSSI, WA, Perth, Australia, 1991*.

McArthur, W. M. (2004). Reference soils of south-western Australia. *Australian Society of Soil Science W.A. Branch., and Department of Agriculture and Food.*(Department of Primary Industries and Regional Development, Western Australia, Perth).

Mcfarlane, D. J., & George, R. J. (1992). Factors affecting dryland salinity in two wheat belt catchments in Western Australia. *Australian journal of soil research*, *30*(1), 85-100. https://doi.org/10.1071/SR9920085

Morgan, C., Cappellazzi, S., & Liptzin, D. (2020). Assessing Soil Health: Soil Carbon Cycling and Storage. *Crops & Soils*, *53*(6), 43-47. https://doi.org/https://doi.org/10.1002/crso.20076

Morrissey, E. M., Gillespie, J. L., Morina, J. C., & Franklin, R. B. (2014). Salinity affects microbial activity and soil organic matter content in tidal wetlands. *Glob Chang Biol*, *20*(4), 1351-1362. https://doi.org/10.1111/gcb.12431

Muller, J., Kylander, M., Martinez-Cortizas, A., Wüst, R. A., Weiss, D., Blake, K., Coles, B., & Garcia-Sanchez, R. (2008). The use of principle component analyses in characterising trace and major elemental distribution in a 55 kyr peat deposit in tropical Australia: implications to paleoclimate. *Geochimica et Cosmochimica Acta*, *72*(2), 449-463.

Müller, K., & Deurer, M. (2011). Review of the remediation strategies for soil water repellency. *Agriculture, Ecosystems & Environment*, *144*(1), 208-221. https://doi.org/https://doi.org/10.1016/j.agee.2011.08.008

Murphy, B., Murphy, C., Wilson, B., Emery, K., Lawrie, J., Bowman, G., Lawrie, R., & Erskine, W. (2004). A revised land and soil capability classification for New South Wales. 13th International Soil Conservation Organisation Conference-Brisbane,

National Committee for Soil. (2009). *Australian soil and land survey field handbook*. CSIRO PUBLISHING.

Neina, D. (2019). The Role of Soil pH in Plant Nutrition and Soil Remediation. *Applied and Environmental Soil Science*, *2019*, 5794869. https://doi.org/10.1155/2019/5794869

Nwite, J., & Alu, M. (2017). Carbon sequestration and assessment of fertility status of soil under different land uses for agronomic potentials in Abakaliki South Eastern Nigeria. *African Journal of Agricultural Research*, *12*(11), 871-880.

O'Brien, F. J., Almaraz, M., Foster, M. A., Hill, A. F., Huber, D. P., King, E. K., Langford, H., Lowe, M.-A., Mickan, B. S., & Miller, V. S. (2019). Soil salinity and pH drive soil bacterial community composition and diversity along a lateritic slope in the Avon River critical zone observatory, Western Australia. *Frontiers in Microbiology*, *10*, 1486.

Orians, G. H., & Milewski, A. V. (2007). Ecology of Australia: the effects of nutrient-poor soils and intense fires. *Biological Reviews*, *82*(3), 393-423. https://doi.org/https://doi.org/10.1111/j.1469-185X.2007.00017.x

Pease, J. R., & Coughlin, R. E. (1996). *Land evaluation and site assessment: A guidebook for rating agricultural lands*. Soil and Water Conservation Society Ankeny, Iowa.

Phogat, V., Mallants, D., Cox, J. W., Šimůnek, J., Oliver, D. P., & Awad, J. (2020). Management of soil salinity associated with irrigation of protected crops. *Agricultural Water Management*, *227*, 105845. https://doi.org/https://doi.org/10.1016/j.agwat.2019.105845

Pook, M. J., Risbey, J. S., & McIntosh, P. C. (2012). The Synoptic Climatology of Cool-Season Rainfall in the Central Wheatbelt of Western Australia. *Monthly Weather Review*, *140*(1), 28-43. https://doi.org/https://doi.org/10.1175/MWR-D-11-00048.1

Qadir, M., Ghafoor, A., & Murtaza, G. (2000). Amelioration strategies for saline soils: a review. *Land Degradation & Development*, *11*(6), 501-521.

Radford, B., Bridge, B., Davis, R., McGarry, D., Pillai, U., Rickman, J., Walsh, P., & Yule, D. (2000). Changes in the properties of a Vertisol and responses of wheat after compaction with harvester traffic. *Soil and Tillage Research*, *54*(3-4), 155-170.

Radford, B. J., Key, A. J., Robertson, L. N., & Thomas, G. A. (1995). Conservation tillage increases soil water storage, soil animal populations, grain yield, and response to fertiliser in the semi-arid subtropics. *Australian journal of experimental agriculture*, *35*(2), 223-232. https://doi.org/10.1071/EA9950223

Rayment, G. E., & Lyons, D. J. (2011). *Soil chemical methods Australasia*. CSIRO Pub.

Rayment, G. E., Lyons, D.J. (2010). Method 9C-9C1,18A1: Bicarbonate extractable P,K(Olsen P,K), pp. 166-168, pp385-388

in Soil Chemical Methods - Australasia. Australian Soil and Land Survey Handbooks Series. CSIRO Publishing Clayton,

Victoria, Australia.

Riis, T., Kelly-Quinn, M., Aguiar, F. C., Manolaki, P., Bruno, D., Bejarano, M. D., Clerici, N., Fernandes, M. R., Franco, J. C., Pettit, N., Portela, A. P., Tammeorg, O., Tammeorg, P., Rodríguez-González, P. M., & Dufour, S. (2020). Global Overview of Ecosystem Services Provided by Riparian Vegetation. *BioScience*, *70*(6), 501-514. https://doi.org/10.1093/biosci/biaa041

Rosanoff, A. (2013). Changing crop magnesium concentrations: impact on human health. *Plant and soil*, *368*, 139-153.

Rowe, R., Howe, D. F., Alley, N., & AUTHORITY, S. C. (1981). *Guidelines for land capability assessment in Victoria*. Soil Conservation Authority.

Safdar, H., Amin, A., Shafiq, Y., Ali, A., Yasin, R., Shoukat, A., Hussan, M. U., & Sarwar, M. I. (2019). A review: Impact of salinity on plant growth. *Nat. Sci*, *17*(1), 34-40.

Sahab, S., Suhani, I., Srivastava, V., Chauhan, P. S., Singh, R. P., & Prasad, V. (2021). Potential risk assessment of soil salinity to agroecosystem sustainability: Current status and management strategies. *Science of The Total Environment*, *764*, 144164. https://doi.org/https://doi.org/10.1016/j.scitotenv.2020.144164

Sangha, K. K., Jalota, R. K., & Midmore, D. J. (2005). Impact of tree clearing on soil pH and nutrient availability in grazing systems of central Queensland, Australia. *Soil Research*, *43*(1), 51-60. https://doi.org/https://doi.org/10.1071/SR03152

Sawkins, D. (2010). Landscapes and soils of the Narrogin district.

Schack-Kirchner, H., Fenner, P. T., & Hildebrand, E. (2007). Different responses in bulk density and saturated hydraulic conductivity to soil deformation by logging machinery on a Ferralsol under native forest. *Soil Use and Management*, *23*(3), 286-293.

Schroth, G., Lehmann, J., & Barrios, E. (2002). Soil nutrient availability and acidity. In (pp. 93-130). CABI Publishing. https://doi.org/10.1079/9780851995939.0093

Siswanto, S., & Sule, M. (2019). The Impact of slope steepness and land use type on soil properties in Cirandu Sub-Sub Catchment, Citarum Watershed. IOP Conference Series: Earth and Environmental Science,

Stuart-Street, A., Short Dr, N., Galloway, P., & Schoknecht, N. R. (2020). A simple guide for describing soils.

Tiessen, H., Cuevas, E., & Chacon, P. (1994). The role of soil organic matter in sustaining soil fertility. *Nature*, *371*, 783-785.

Tiruneh, G. A., Alemayehu, T. Y., Meshesha, D. T., Vogelmann, E. S., Reichert, J. M., & Haregeweyn, N. (2021). Spatial variability of soil chemical properties under different land-uses in Northwest Ethiopia. *Plos one*, *16*(6), e0253156.

Turner, N. C., & Asseng, S. (2005). Productivity, sustainability, and rainfall-use efficiency in Australian rainfed Mediterranean agricultural systems. *Australian Journal of Agricultural Research*, *56*(11), 1123-1136.

Vahabi, J., & Nikkami, D. (2008). Assessing dominant factors affecting soil erosion using a portable rainfall simulator. *International Journal of Sediment Research*, *23*(4), 376-386. https://doi.org/https://doi.org/10.1016/S1001-6279(09)60008-1

Van Gool, D., Tille, P. J., & Moore, G. A. (2005). Land evaluation standards for land resource mapping: assessing land qualities and determining land capability in south-western Australia.

Vang, S. (2013). Cambodia's Agricultural Land Resources: Status and Challenges. *Cambodian Agricultural Research and Development Institute*.

Vendramini, J., Silveira, M., Dubeux Jr, J., & Sollenberger, L. (2007). Environmental impacts and nutrient recycling on pastures grazed by cattle. *Revista Brasileira de Zootecnia*, *36*, 139-149.

Waha, K., Clarke, J., Dayal, K., Freund, M., Heady, C., Parisi, I., & Vogel, E. (2022). Past and future rainfall changes in the Australian midlatitudes and implications for agriculture. *Climatic Change*, *170*(3), 29. https://doi.org/10.1007/s10584-021-03301-y

Watson, J. (1982). Analysis of salinity profiles in lateritic soils of south-western Australia. *Soil Research*, *20*(1), 37-49. https://doi.org/https://doi.org/10.1071/SR9820037

Wong, M., & Wittwer, K. (2009). Positive charge discovered across Western Australian wheatbelt soils challenges key soil and nitrogen management assumptions. *Soil Research*, *47*(1), 127-135.

Yimer, F., Ledin, S., & Abdelkadir, A. (2008). Concentrations of exchangeable bases and cation exchange capacity in soils of cropland, grazing and forest in the Bale Mountains, Ethiopia. *Forest Ecology and Management*, *256*(6), 1298-1302. https://doi.org/https://doi.org/10.1016/j.foreco.2008.06.047

Zeraatpisheh, M., Bottega, E. L., Bakhshandeh, E., Owliaie, H. R., Taghizadeh-Mehrjardi, R., Kerry, R., Scholten, T., & Xu, M. (2022). Spatial variability of soil quality within management zones: Homogeneity and purity of delineated zones. *CATENA*, *209*, 105835. https://doi.org/https://doi.org/10.1016/j.catena.2021.105835

Zhou, W., Han, G., Liu, M., & Li, X. (2019). Effects of soil pH and texture on soil carbon and nitrogen in soil profiles under different land uses in Mun River Basin, Northeast Thailand. *PeerJ*, *7*, e7880.

Zhu, A.-X., Band, L., Vertessy, R., & Dutton, B. (1997). Derivation of Soil Properties Using a Soil Land Inference Model (SoLIM). *Soil Science Society of America Journal*, *61*(2), 523-533. https://doi.org/https://doi.org/10.2136/sssaj1997.03615995006100020022x

Zhu, A. X. (1997). A similarity model for representing soil spatial information. *Geoderma*, *77*(2), 217-242. https://doi.org/https://doi.org/10.1016/S0016-7061(97)00023-2

Zhu, A. X., Hudson, B., Burt, J., Lubich, K., & Simonson, D. (2001). Soil Mapping Using GIS, Expert Knowledge, and Fuzzy Logic. *Soil Science Society of America Journal*, *65*(5), 1463-1472. https://doi.org/https://doi.org/10.2136/sssaj2001.6551463x

8. Appendices

Profile/Pit No.	Group morning: afternoon: A: B:	Date:	Project/unit
SURVEY:			Animal remains on surface?
LOCATION:			Slope: % ° Type / Aspect:
GPS Coordinate range:			Land surface condition: (e.g. degradation presence & type, soil surface looseness, *etc.*)
Landform:	Land use and remarks:		
Surface stones (size, lithology, & percentage)	Drainage: Perched water table?		Landscape / Profile sketch:
Parent material / geology:	Vegetation: (current, likely past)		
Weather conditions:	Depth to clay: Depth to gravel:		
Other observations (*e.g.*, root abundance & size, rooting depth, soil biology, bioturbation, profile mottles, *etc.*)			Please refer to *Field Handbook* for description classes, *etc.*

Sample Number	Horizon Symbol	Upper Depth (cm)	Lower Depth (cm)	Boun-dary form	Texture (hand)	Pan? Y / N	Water Repel? Y /N	Field pH	Field EC (µS/cm)	Moist soil colour	Structure (type, size)	Coarse Fragments (Gravel) Type	Size	%	Segregations Type	%

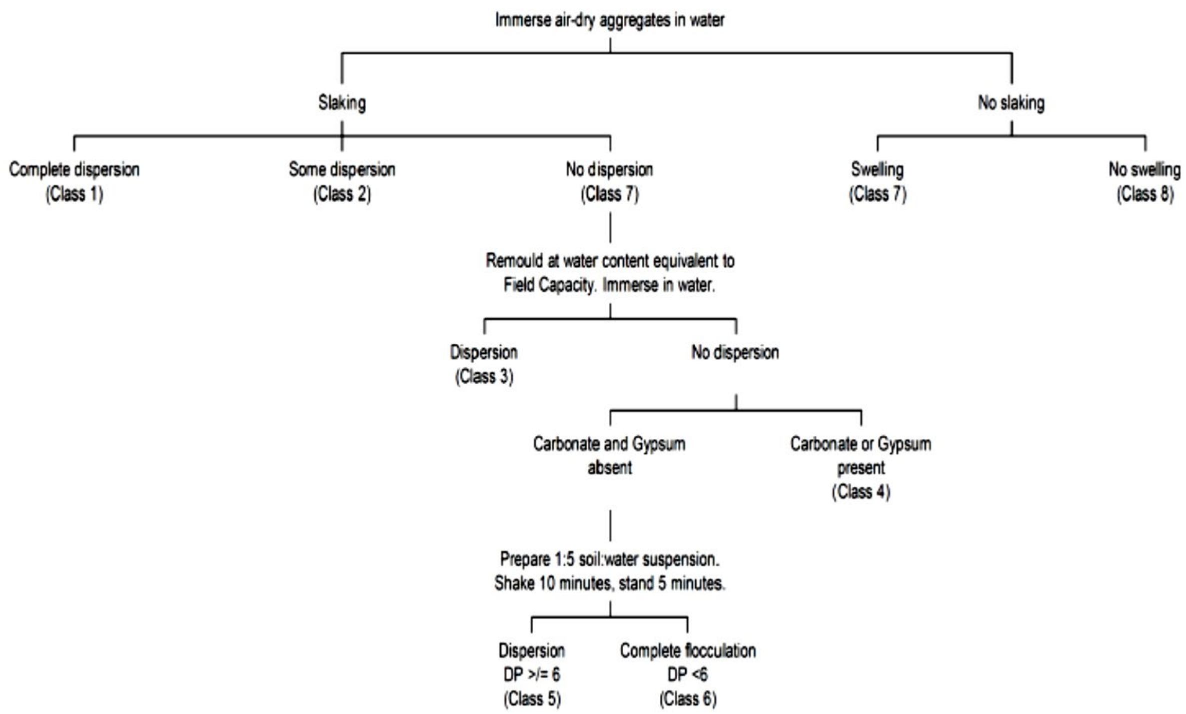
make sure you read µS/cm not mS/cm

Appendix A: Soil pit description sheet

CRITERIA FOR WATER REPELLENCE

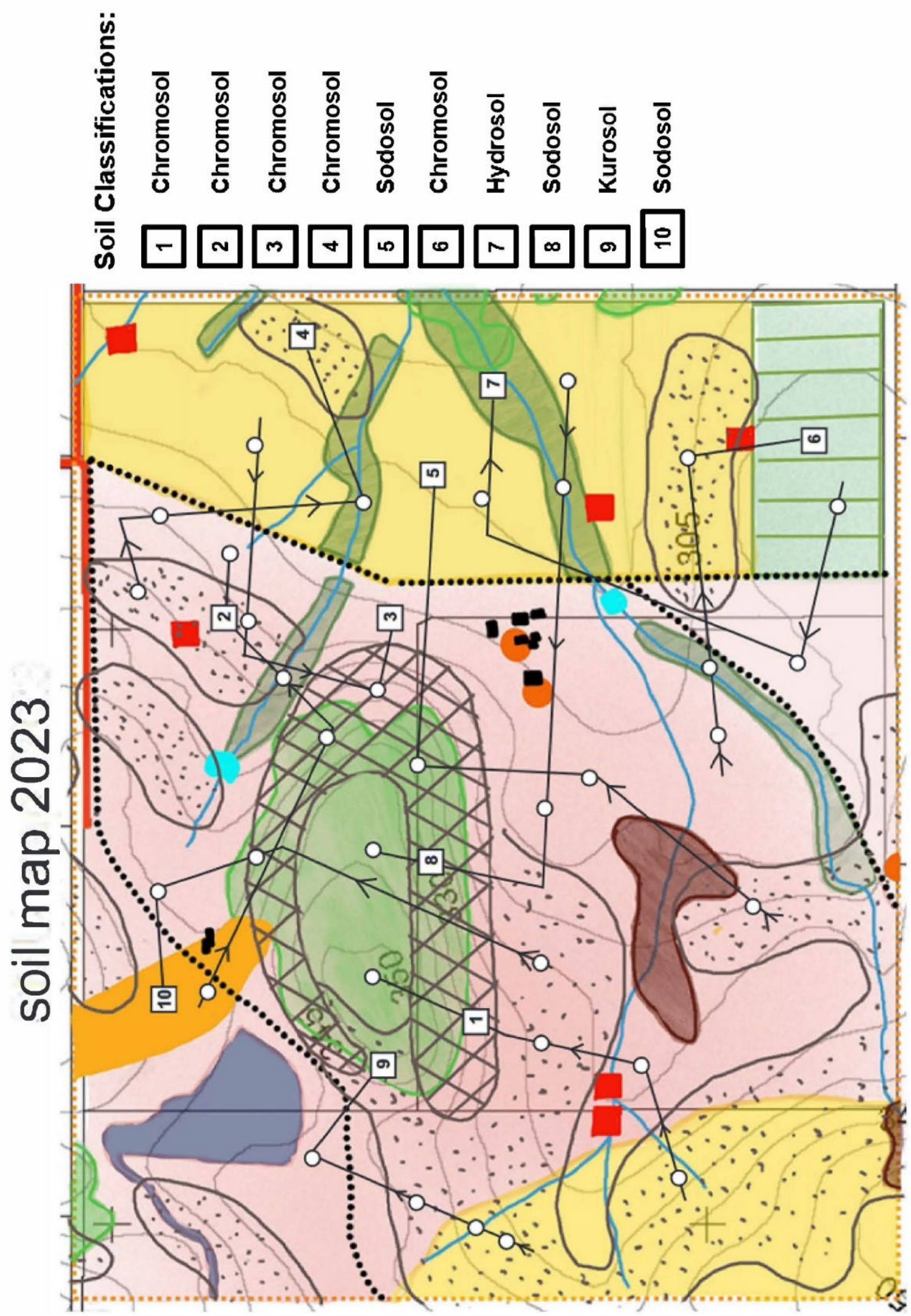
RATING	SEVERITY	ALCOHOL mol/L
1	no repellence	0
2	very low	0
3	low	0
4		0.4
5		0.8
6	moderate	1.2
7		1.6
8		2.0
9		2.4
10		2.8
11	very severe	3.2
12		3.8

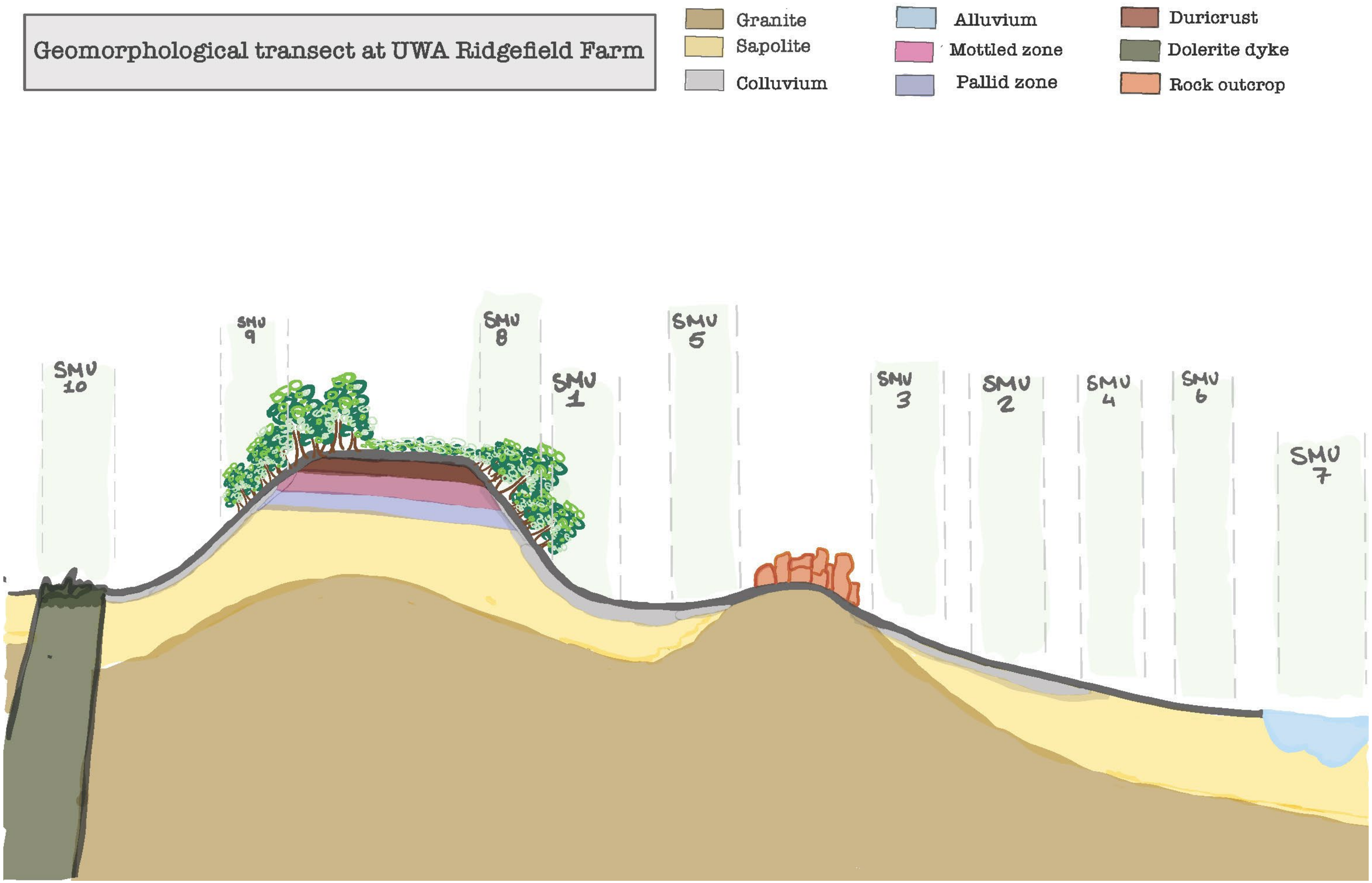
Appendix B: Soil water repellence rating Table ((King, 1981)



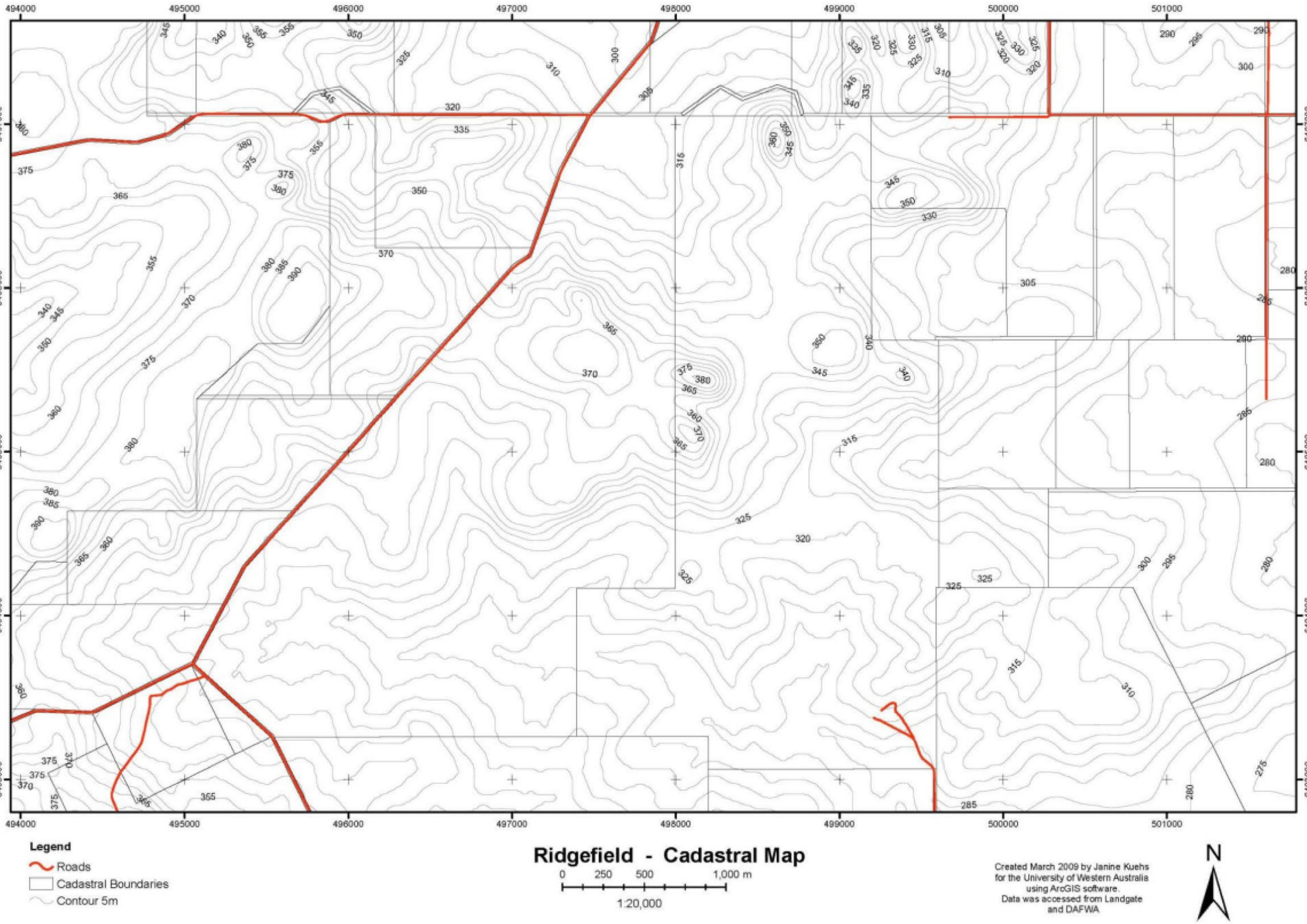
Appendix C: Guide for determining the Emerson aggregate class (Emerson, 1967)

9. Group Folder





Geomorphological transect at UWA Ridgefield Farm



Ridgefield - Cadastral Map
0 250 500 1,000 m
1:20,000
Legend
Roads
Cadastral Boundaries
Contour 5m
Created March 2009 by Janine Kuehs
for the University of Western Australia
using ArcGIS software.
Data was accessed from Landgate
and DAFWA
N

Group 1 Folder

Briana Marino, Cooper Anspach, Emily Kelly, Jessie Ellis, Sarah Zou, Sean Rimmer

Profile Group 1:

Australian Soil Classification:

Chromosol

Location:

GPS UTM coordinates 50H 499310E 6406370N

UWA Ridgefield Farm

Approximately 10 km north of Pingelly, WA

Landform/Topography:

Description: Grazing area adjacent to Avery's Hill, with limited vegetation (Dry grasses). The elevation is ~320 m above sea level with a simple slope, moderate (gently inclined) ~ 6%.

Parent Material:

Dolerite dykes that lie within granite gneiss

Drainage:

Pingelly is a part of the Avon River catchment area with the Dale River being the closest river that feeds directly into the Avon River. This is a perennial river fed from the Dale reserve as the main subcatchment. The region has a moderate risk of flooding from 50 year storm events and low risk of flooding from 20 year rainfall events.

Weather and Climate:

West Pingelly has a Mediterranean climate with cool wet winters and hot dry summers. The mean minimum temperature in March for the region is 13.6 degrees with the mean maximum temperature being 29.1 degrees. On the day this soil profile was created, the minimum temperature was 10.4 degrees with the maximum temperature reaching 28 degrees. Winds were easterly at 9km/h. Within March 2023, total rainfall was 33.5mm with a maximum rainfall being 32mm in one day. The average rainfall over the years however for march is 17.8 mm for the month.

Natural vegetation and land use: York gum **(***Eucalyptus loxophleba),* Drummonds Mallee *(Eucalyptus drummondii),* Boyagin Mallee *(Eucalyptus exilis),* Powder Bark Wandoo (*Eucalyptus Accedens*), Brown Mallet (Eucalyptus Astringens). Land use includes livestock grazing, cropping and agricultural research.

Table 1: Description of the G1 soil profile

Sample no.	Horizon	Depth (cm)	Description
1	A1/P	0-22	Fine clump ½ ribbon texture
2	B1	22-38	Fine and gritty (1cm) particles, with clay
3	B2	38-49	Sparse, coarse rocks
4	C	49-80	Clayey texture, with gritty, small particles

Table 2: Chemical analyses

	pH							Exchangeable (mg/kg)	
Sample no.	H_2O	$CaCl_2$	EC (µS/cm)	Organic C (%)	Total N (%)	CN Ratio	PRI	P	K
1	5.92	5.12	104.8	5.11	0.411	12.43	22	8.19	270.91
2	6.55	5.11	24.4	0.79	0.059	13.39	13	0.33	407.41
3	6.51	5.15	24.85	0.34	0.027	12.59	14	0.64	246.14
4	6.70	5.17	23.1	0.27	0.022	12.27	12	0.17	174.13

Table 3: CEC analysis (<2mm fraction) exchangeable cations cmol/100g

Sample no.	CEC	ex-Ca	ex-Mg	ex-K	ex-Na	ex-Al
1	8.9	7.7	0.8	0.5	0.2	0
2	3.3	1.9	0.4	0.6	0.1	0
3	2.8	1.5	0.4	0.5	0.1	0
4	2.5	1.3	0.5	0.3	0.1	0

Table 4: Physical analyses

Sample no.	Particle size (%)			Bulk density (g/cm^3)	Munsell colour		Water repellency (MED)
	Clay	Silt	Sand		Wet	Dry	
1	9.32	8.8	81.9	n/a	10YR 2/2	10YR 3/3	6
2	10.51	10	79.5	n/a	10YR 4/6	10YR 4/4	1
3	5.8	13.3	80.9	n/a	7.5YR 5/8	10YR 5/8	1
4	16.5	20.3	63.2	n/a	10YR 6/8	10YR 6/4	1

SMU1 Description.

SMU1, used as grazing land, is located on moderately sloped (6%) land at the base of Avery's Hill. The 80cm deep soil profile pit consisted of loamy sand in the A1/P (A1) horizon (0-22cm), sandy loam in the B1 horizon (22-38cm), loamy sand in the B2 (38-49cm) again, and loam in the C(49-80cm) horizon. Gravel content (>2mm fraction) was highest in the B2 horizon at 40.8%, and lowest in the A1 horizon at 16.3%. The B2 and C horizons had similar percentages, at 26.7% and 24.7% respectively. The A1 horizon was classed as moderately water repellent (class 6). All other horizons had no water repellence. The A1 horizon had an Emmerson aggregate stability class of 8 (No swelling, no slaking). All other horizons were class 2 (slaking, no dispersion). Total nitrogen and total carbon % decreased with depth. The ratio of C to N remained consistent throughout the horizons, with the A1 and C horizons having a ratio of 12, and the two B horizons having a ratio of 13. EC decreased with depth, although there was evidence of slight leaching from the B1 (24.4 µS) to B2 (24.85 µS) horizons. EC was highest in the A1 horizon, at 104.8 µS. EC was lowest in the C horizon, at 23.1 µS. pH readings were consistent, ranging from 5.12 (A1) to 5.17 (C). Extractable potassium values were high, peaking in the B1 horizon at 407.41. The A1 and B2 horizons had similar values, at 270.91 and 246.14 respectively. Extractable potassium was lowest in the C horizon at 174.13. Extractable-P spiked in the A1 horizon at 8.19, before decreasing into the 0.17-0.64 range for the subsequent horizons. Extractable-Al was non-existent, and the other cations showed a similar trend of decreasing with depth. Phosphorous retention was highest in the A1 horizon, rated at strongly adsorbing. All other horizons were moderately adsorbing. Exchangeable sodium increased with depth, increasing from 2.2% in the A1 horizon, to 4.5% in the C horizon. The auger profiles followed similar trends but did not experience a decrease in the gravel contents of the C horizons; they increased instead. EC and pH levels were similar, but horizon O of auger 1 had a markedly increased EC value of 291.7 µS.

GROUP 1

Auger: General Description

Auger Number	Location	Topography/ Landform	Current Land Use	Stage of Erosion	Native Vegetation	Geology/ geomorphology	Weather Condition
1	50H 0499304 UTM 6406289	South-east facing slope, rolls from south to east, ~7 degrees slope	Moderate slope grazing	Very limited erosion, high amounts of vegetative land covering	Sopradic surrounding vegetation, 100m closest cluster, brown mallet	Clostest outcrop 20 m away, palm sized rocks sporadically dispersed adjacent to auger	Slightly cloudy with a moderate wind, ~20°C
2	50H 0499275 UTM 6406134	Valley landscape, flat ground, ~4 degrees North-east facing slope	Flat grazing	Potential water erosion, but no immediate signs, less weathered than Auger 1, finely decomposed organic matter	Closest cluster 90m away, brown mallet, nearby river bushes	Granite outcrop ~70m distance and South-east direction from auger	Slightly cloudy, warm temperature, very little wind, ~23°C
3	50H 0499321 UTM 6406512	No slope, pleatau, top of vegetated Avery's hill, 350masl	Native, remiant vegetation.	Highly eroded, dry soil easily transported by wind, high water repellance, sides of hill heavily eroded	Close proximity to surrounding vegetation, predominantly eucalyptus species	Iron stone, duricrust, lichen covered rocks	Now sunny / much hotter / very little wind, ~28°C

Auger: Pictures

Auger #1	GPS coordinates: 50H 0499304 UTM 6406289 Left image: Soil auger profile Right image: surrounding landscape, vegetation and landuse (as described above)			
Auger #2	GPS coordinates: 50H 0499275 UTM 6406134 Left image: Soil auger profile Central image: nearby river vegetation (as described above) Right image: nearby rocky outcrop (as described above)			
Auger #3	GPS coordinates: 50H 0499321 UTM 6406512 Note: low image quality as the profile wasnt complete due to the soil not being able to be augered Left image: Soil auger profile Right image: eucalypt trees, surrounding vegetation on the plateau (as described above)			

Auger/Horizon: Specific Parameters

Auger Number	Horizon O,A,E,B,C	Depth (cm)	Texture	pH Value	Gravel Content (%)	Root Availablity	EC	Wet Colour (Munsell)
1	O	0-1	Clumpy OM / roots	6.63	0	Not Assessed	291.7	NA
1	A	1-16	Gritty / red chunks	5.75	5	-	87.7	10 YR 2/2
1	E	16-32	More gritty than above / sandy texture	6.22	10	-	19.25	5 YR 3/4
1	B	32-65	more smaller rocks tho	6.4	12	-	25.88	7.5 YR 3/4
1	C	65-80	red and yellow very small rocks / the	6.59	22	-	20.09	10 YR 4/6
2	O	0-7	Sandy / very gritty	5.09	0.5	-	76.26	10 YR 3/6
2	A	7-16	than above / more rocks	5.64	2	-	52.5	10 YR 4/6
2	E	16-29	Clumping (less than above) / gritty	5.72	7	-	50.2	2.5 Y 5/6
2	B	29-54	Smoother / clay like	6.01	15	-	41.3	2.5 Y 5/6
2	C	54-67	Clay clumps / gooey	6.57	40	-	65.2	10 YR 4/6
2	R	67-80	Clay clumps / gooey	6.27	80	-	38.99	-
3	O	0-20	Sandy / High OM	5.99	0	-	36.63	-

Group Folder

Soil Profile Group 2:

Australian Soil Classification:

Chromosol

Location:

GPS UTM coordinates 499820E, 6406671N

UWA Ridgefield Farm, via Page Road

Approximately 10 km north of Pingelly, WA

Landform/Topography:

Description: Sample taken from a gently sloping grazing paddock with some remnant wheat stalks but little other vegetation. Sample taken within 20 metres of a dolerite dyke.

Elevation: ~300 m above sea level

Slope: Gently inclined ~5-10%

Parent Material:

Granite-Gneiss with Dolerite dykes

Drainage:

This area is a part of the ancient hydrologic region, Avon River catchment area. No observable drainage on the day due to lack of rainfall over summer

Weather and Climate:

Pingelly has a Mediterranean climate as it experiences dry summers and cool winters. On the day the profile was dug, Pingelly experienced 27°C maximum temperature, with no rainfall throughout the day. Pingelly's annual mean rainfall is 445mm, with a January mean of 11mm and 81mm in July.

Natural vegetation and land use: Native vegetation has been cleared, but it was likely to have been Eucalyptus based on the pockets of uncleared land on the farm. Land use is currently a grazing paddock, with intermittent use for wheat crops.

Table 1: Description of the G2 soil profile

Sample no.	Horizon	Depth (cm)	Description
1	A1	0-13cm	Topsoil – rich in organic matter, dark in colour.
2	B2.a	13-30cm	Sub soil.
2	B2.b	30-45cm	Accumulation zone.
4	B2.2	>45cm	Some weathered rock fragments, small particles, soft texture.

Table 2: Chemical analyses

	pH							Exchangeable (mg/kg)	
Sample no.	H_2O	$CaCl_2$	EC (µS/cm)	Organic C (%)	Total N (%)	CN Ratio	PRI	P	K
1	4.81	4.93	116.1	4.26	0.318	13	7	1.18	266.4
2	5.88	4.76	33.1	1.02	0.066	15	10	0.24	85.1
3	6.03	4.55	28.3	0.7	0.045	16	8	0.16	85.3
4	5.23	5.37	62.9	0.19	0.027	7	95	0.07	392.1

Table 3: CEC analysis (<2mm fraction) exchangeable cations cmol/100g

Sample no.	CEC	ex-Ca	ex-Mg	ex-K	ex-Na	ex-Al
1	8.2	6.6	1.3	0.4	0.3	0
2	4.2	3	0.8	0	0.2	0
3	4.3	2.9	1	0	0.2	0
4	7.2	1.6	4.2	0	1.1	0.1

Table 4: Physical analyses

Sample no.	Particle size (%)			Bulk density (g/cm^3)	Munsell colour		Water repellence (MED)
	Clay	Silt	Sand		Wet	Dry	
1	4.4	19.2	76.4	1.3	5YR 5/8	7.5YR 4/4	1
2	4.7	8,4	86.9	1.6	5YR 5/8	7.5YR 4/6	1
3	16.8	4.8	78.5	1.6	5YR 5/8	7.5YR 4/6	1
4	33	47	20	1.8	10YR 5/8	7.5YR 6/8	1

GROUP 3

Auger: General Descirption

Auger Number	Location	Topography/ Landform	Current Land Use	Stage of Erosion	Native Vegetation	Geology/ geomorphology	Weather Condition
1	ill on the east	12% (slope)	Grazing	None?	n a cleared pad	boulders, laterite	nny, 25 degree
2	vegetation hi	4%	Grazing	None?	n a cleared pad	Dolerite dyke	nny, 25 degree
3	ation by appr	11%	Cropping	None?	n a cleared pad	e from dolerite dy	nny, 25 degree

Auger: Pictures

Auger #1	GPS	499904	6406571
			
Auger #2	GPS	500025	6406787
			
Auger #3	GPS	500322	6406778
	ing a picture (		

Auger/Horizon: Specific Parameters

Auger Number	Horizon O,A,E,B,C	Depth (cm)	Texture	pH Value	Gravel Content (%)	Root Availablity	EC	Wet Colour (Munsell)
1	A1	0-18	No ribbon, bolus formed	5.7	5%		25.41	7.5YR 2.5/2
1	B1	18-42	bbons of 1cm, bolus form	6.1	10-15%		18.87	5YR 3/3
1	B2	42-65	bbons of 3cm, bolus form	6.65	15-20%		26.68	7.5YR 3/4
2	A1	0-24	5-1cm ribbons, bolus form	5.34	20%		58.8	7.5YR 2.5/3
2	A2	24-41	bbons, bolus crumbled sli	5.65	35%		25.6	5YR 4/6
2	B1	41-51	2cm ribbons, bolus formed	5.95	10%		52.1	5YR 3/4
3	A1	0-14	no ribbon, no bolus	6.03	30%		53.3	5YR 2.5/2
3	B1	14-34	no ribbon, bolus formed	6.31	20%		20.41	10YR 4/6
3	B2	34-49	ibbon, slightly crumbling b	6.75	35%		16.19	10YR 6/6

Group Folder

Profile 3:

Australian Soil Classification:

Chromosol

Location:

GPS UTM coordinates 4999898E, 6406489N

UWA Ridgefield Farm, via Page Road

Approximately 10 km north of Pingelly, WA

Landform/Topography:

Description: Gentle slope from hilltop with native vegetation (*Eucalyptus loxophleba*), with the presence of laterite and granite.

Elevation: ~310m above sea level

Slope: Very gentle slope ~5%

Parent Material:

Laterite and Granite-Gneiss.

Drainage:

This area is a part of the ancient hydrologic region, Avon River catchment area.

Weather and Climate:

Ridgefield Farm experiences a Mediterranean climate, with hot summers and mild winters. Pingelly receives an average rainfall of 425mm annually. The average maximum temperature during Summer in the Wheatbelt is 34°C, whilst the maximum temperature during Winter is 17°C. The key climate drivers in the Wheatbelt include the Sub-Tropical Ridge, Indian Ocean Dipole, Southern Annular Mode, and El Nino/Southern Oscillation.

Natural vegetation and land use: *Eucalyptus loxophleba*

Table 1: Description of the G7 soil profile

Sample no.	Horizon	Depth (cm)	Description
1	A1	0-15	Loam
2	B2(1)	15-29	Loam
3	B2(2)	29-60	Clay

Table 2: Chemical analyses

	pH							Exchangeable (mg/kg)	
Sample no.	H_2O	$CaCl_2$	EC (µS/cm)	Organic C (%)	Total N (%)	CN Ratio	PRI	P	K
1	6.07	6.04	117.2	4.46	0.280	15.92	24	10.33	127.67
2	6.44	6.34	44.8	0.68	0.040	16.93	13	1.99	56.96
3	6.49	6.52	36.3	0.38	0.027	14.11	28	1.08	64.07

Table 3: CEC analysis (<2mm fraction) exchangeable cations cmol/100g

Sample no.	CEC	ex-Ca	ex-Mg	ex-K	ex-Na	ex-Al
1	5.6	4.7	0.9	0.2	0.2	0.1
2	2.7	1.9	0.7	0.1	0.1	0.1
3	3.8	2.1	1.5	0.1	0.1	0.1

Table 4: Physical analyses

Sample no.	Particle size (%)			Bulk density (g/cm3)	Munsell colour		Water repellence (MED)
	Clay	Silt	Sand		Wet	Dry	
1	13.8	14.6	71.6	1.21	10YR 2/2	10YR 4/3	4
2	16.0	12.8	71.2	1.65	7.5YR 5/8	7.5YR 5/6	1
3	40.8	13.4	45.7	1.60	5YR 5/8	5YR 6/6	1

SMU Horizon Summary

A brief summary for each SMU with relationships with landscape, the relative proportion of different SPC. All analyses should be tabulated:

SMU 3:

SMU 3 sits in an area used for 'Moderate Grazing' and is located on a 'Flat-Moderate' incline approximately 124 meters downhill East of native vegetation. The gradient of the landscape transitions swiftly from 'Moderate' to 'Steep' grazing at around 50 meters West of the soil pit towards the native vegetation. The closest alternate land use starts approximately 50 meters East of the SMU 3 Soil pit and is defined as 'Flat Cropping' with a low 2% slope where it continues for approximately 500m before reaching the seasonal creek at around 300m elevation above sea level.

The profile itself consists of two loam horizons described as A1 and B2(1) above a horizon of clay which was later identified as B2(2) Horizon. From the surface down to the lowest horizon we observed a trend of increasing proportions of gravel sized particles above the 2mm fine earth fraction. Starting at A1 the gravel content began at 8.8%, increasing to 10.6% in the next horizon (B2[1]) before reaching its maximum of 11.8% in the B2(2) horizon between the depths of 29 cm - 60 cm. Water repellency was highest within the top layer with a MED Score of 4 whilst the remaining horizons were described as 'non-water repellent'. In a similar pattern, the top horizon showed signs of swelling with no dispersion (Class 8) whilst the lower two horizons were classified as Class 2 with signs of minimal dispersion after a 24 hour period.

Common across many soil types, both nitrogen and carbon within SMU 3 showed a declining trend that increased with depth. Interestingly, the ratio of these two also decreased with the C:N ratio starting at 16 in the top horizon and finishing at 14 on the bottom horizon, a trend that suggests rising percentages of nitrogen in proportion to the amount of carbon within the soil. The pH of the horizons across each testing medium (H20, CaCL) show a similar trend, increasing in alkalinity as depth increases starting from 6.04 in A1 to 6.34 in B2(1) and 6.49 in B2(2) . Electrical conductivity (EC) returned a figure of 117.2 (us/cm) in the top layer, which represented a 61.8% decrease from our A1 layer to our sub-surface B2(1) layer.

In terms of exchangeable and extractable elements, each of the exchangeable cations returned a similar reduction in values with the decrease in depth with the exception of Magnesium which showed a minimal increase within the lowest B2 (2) Horizon. Extractable phosphorus and extractable potassium both showed their highest values within the top horizon at 10.33mg/kg and 127.67mg/kg, reducing sharply into our second horizon (B2(1)) with a continuing trend in the results of extractable phosphorus. Extractable Potassium whilst showing a similar trend in the first two horizons began to rise again in the lowest horizon (B2(2)), rising from 56.96mg/kg to 65.07mg/kg

GROUP #

Auger: General Descirption

Auger Number	Location	Topography/ Landform	Current Land Use	Stage of Erosion	Native Vegetation	Geology/ geomorphology	Weather Condition
1	Cunninhams paddock	Mid slope along a dry	Remnant vegetation	Slight erosion	Yes, Shrubs	Fist sized rocks, reddish colour	Partly Cloudy,dry
2	North avery paddock	Mid elevation on slight hill	Grazing	N/A loose top soil	N/A, Open field	N/A	Partly Cloudy,dry

Auger: Pictures

Auger #1	GPS: 50H 0500227 6406601 
Auger #2	GPS: 50H 0500193 6406938 

Auger/Horizon: Specific Parameters

Auger Number	Horizon O,A,E,B,C	Depth (cm)	Texture	pH Value	Gravel Content (%)	Root Availablity	EC	Wet Colour (Munsell)
1	A1	0-10	loam	6.26	10	many roots, seeds, fibres	56.75us	N/A
1	A2	10-30	clay, sand	8.79	10-15	N/A	19.22us	N/A
1	B	30-35	Sandy	9.51	5	N/A	33.38us	N/A
2	0	0-10	sandy	5.33	10	organic material	38.7us	5YR 2.5/1
2	A1	10-15	silt and sand	5.62	5	some water repellency	39.15us	N/A
2	A2	15-22	clay and gravel	6.15	20	N/A	16.36us	10Yr 3/6
2	B1	22-40	clay	6.2	5	N/A	8.16us	7.5YR 5/6
2	B2	40-45	clay	6.66	5	N/A	11.86us	10YR 4/6

Group Folder

Profile SMU4:

Australian Soil Classification:

Chromosol

Location:

GPS UTM coordinates 500501E, 6406698N

UWA Ridgefield Farm, via Page Road

Approximately 10 km north of Pingelly, WA

Landform/Topography:

Description: Moderately sloped cropping area, adjacent to riparian zone. Area located in Cunningham Paddock. Cleared of majority of native vegetation and land is generally quite flat and uniform.

Elevation: ~300m above sea level

Slope: Moderate slope ~4-10%

Parent Material:

Parent material is granite-gneiss.

Drainage:

Waterways in this area flow into the Dale River, which is part of the Avon River catchment area. Land clearing in the area has resulted in increased flood risk and a rising water table.

Weather and Climate:

Pingelly has a Mediterranean climate with dry summers and cool winters. On the day the profile was dug, the maximum temperature was 19°C and no rainfall was recorded. Minimal rainfall was recorded in the weeks prior to visit, meaning soil was quite dry. The annual mean rainfall in Pingelly is 445mm, with a January mean of 11.3mm and 81.2mm in July. Pingelly's average temperature is 32°C in January and 15.4°C in July.

Natural vegetation and land use:

Land is mainly cleared with some remnant vegetation *Eucalyptus loxophleba*. Current land use is cropping.

Table 1: Description of the G7 soil profile

Sample no.	Horizon	Depth (cm)	Description

1	A1	0-13	Loamy sand
2	B1 (top)	13-35	Loamy sand
3	B1 (bottom)	13-35	Clayey sand
4	B2	35-70	Sandy clay loam

Table 2: Chemical analyses

Sample no.	pH		EC (µS/cm)	Organic C (%)	Total N (%)	CN Ratio	PRI	Exchangeable (mg/kg)	
	H_2O	$CaCl_2$						P	K
1	6.19	5.4	83.3	2.52	0.176	0.14	10	19.0	121.3
2	5.82	4.68	21.5	0.59	0.047	0.13	8	5	36
3	5.77	4.77	23.7	0.48	0.034	0.14	6	4	32
4	5.84	5.03	27.3	0.38	0.036	0.11	10	1.5	14.6

Table 3: CEC analysis (<2mm fraction) exchangeable cations cmol/100g

Sample no.	CEC	ex-Ca	ex-Mg	ex-K	ex-Na	ex-Al
1	5.0	4.4	0.7	0.2	0.1	0.0
2	2.2	1.1	0.3	0.0	0.0	0.1
3	2.0	1.1	0.4	0.0	0.0	0.1
4	2.7	1.2	0.9	0.0	0.1	0.0

Table 4: Physical analyses

Sample no.	Particle size (%)			Bulk density (g/cm^3)	Munsell colour		Water repellence (MED)
	Clay	Silt	Sand		Wet	Dry	

1	7.8	5.8	86.5	1.4	10YR 2/2	10YR 3/4	2
2	7.8	6.8	85.4	1.4	10YR 4/6	7.5YR 6/4	1
3	10.1	8.3	81.6	1.7	10YR 4/6	10YR 5/6	1
4	17.5	7.6	74.9	1.7	7.5YR 5/8	10YR 6/6	1

SMU4:

SMU4, used as a paddock for cropping, and is located on a gentle slope approximately 50 metres away from a seasonal creek. The pit profile consisted of loamy sand in the A1 and top of the B1 horizon, followed by clayey sand in the bottom of the B1 horizon, sitting above sandy clay loam in the B2 horizon. In the A1 horizon, the gravel content consisted of approximately 85% large, rounded pebbles of laterite between 20mm and 60mm in size, around 15% fine gravelly angular quartz between 2mm and 6mm. In the top of the B1 horizon, the gravel content consisted of approximately 80% large subrounded pebbles of laterite between 20mm and 60mm in size, around 20% fine gravelly angular quartz between 2mm and 6mm. In the bottom of the B1 horizon, the gravel content consisted of approximately 60% medium subrounded pebbles of laterite between 20mm and 60mm in size, around 40% fine gravelly angular quartz between 2mm and 6mm. In the B2 horizon, the gravel content consisted of approximately 50% medium subrounded pebbles of laterite between 20mm and 60mm in size, around 50% fine gravelly angular quartz between 2mm and 6mm. The A1 horizon had very low water repellence, and the rest of the horizons all had no water repellence. The Emerson aggregate stability was high for the A1 horizon and top of the B1 horizon, and low for all other horizons. For the A1 horizon and top of the B1 horizon, the Emerson aggregate stability class was Class 7, and Class 2 in all other horizons. The percentage of N and organic C decreased with depth, and the ratio of C to N was similar. EC decreased from the A1 horizon to the top of the B1 horizon, and increased from the top of the B1 horizon to the B2 horizon. The highest EC reading was from the A1 horizon, at 83.3 µS/cm. pH readings were slightly acidic, and were within the range of between 5 and 7. Extractable-P decreased with depth, while extractable-K decreased markedly below 13cm. Exchangeable-Al, K and Na were virtually non-existent, while all other cations decreased from the A1 horizon to the bottom of the B1 horizon, before slightly increasing in the B2 horizon. Phosphorus retention was moderately adsorbing for all horizons. Extractable sodium percentage showed a slight decrease with depth, from 1.9% to 0.0% from the A1 horizon to the bottom of the B1 horizon, before increasing to 4.5% in the B2 horizon.

GROUP 5

Auger: General Description

Auger Number	Location	Topography/ Landform	Current Land Use	Stage of Erosion	Native Vegetation	Geology/ geomorphology	Weather Condition
1	Field	Moderate eastward slope (7°)	Grazing field	No water erosion, limited wind erosion	no native vegetation	granite outcrop nearby	Dry, sunny, relatively hot, partially cloudy
2	Field	Low, south south east slope (3°)	Grazing field	No evident erosion	no native vegetation	no rock formations nearby	Dry, sunny, relatively hot, partially cloudy

Auger: Pictures

Auger #1	GPS	50H 0499542E 6405932N UTM 
Auger #2	GPS	50H 0499761E 6406211N UTM 

Auger/Horizons Specific Parameters

Auger Number	Horizon O,A,E,B,C	Depth (cm)	Texture	pH Value	Gravel Content (%)	Root Availability	EC (us)	Wet Colour (Munsell)
1	A1	0-10	Loamy sand	5.45	5%	no roots	165.5	10Yr2/2
1	B1	10-22	Sandy loam	6.14	10%	no roots	30.2	7.5Yr2.5/2
1	B21	22-40	Sandy clay loam	6.06	15-20%	no roots	21.13	7.5Yr3/4
1	B22	40-45	Clay loam sand	6.01	25%	no roots	24.21	10Yr3/2
2	A1	0-14	Sandy loam	6.04	3%	no roots	233.1	10Yr2/2
2	A2/E	14-38	Sandy clay loam	6.44	5%	no roots	29.5	10Yr3/4
2	B1	38-56	Light medium clay	6.4	3%	no roots	61.8	10Yr4/6

Group Folder

Profile 5:

Australian Soil Classification:

Sodosol

Location:

GPS UTM coordinates:
50H 0500261E 6406474N

UWA Ridgefield Farm, via Page Road

Approximately 10 km north of Pingelly, WA

Landform/Topography:

Description: Flat terrain in the middle of wheat cropping area, surrounded by grazing area to the west and riparian area to the north and south. No surface stones were found.

Elevation: ~300 m above sea level

Slope: Low slope ~ 2%

Parent Material:

Lateritic duricrust

Drainage:

This area is a part of the ancient hydrologic region, Avon River catchment area.

Weather and Climate:

Pingelly has a Mediterranean climate as it experiences dry summers and cool winters. On the day the profile was dug, Pingelly experienced around 16 °C temperature in the morning, with hot, dry and sunny weather in the afternoon. Pingelly's annual mean rainfall is 445mm, with a January mean of 11.3mm and 81.2mm in July. The highest rainfall recorded in those months was 116.9mm and 222.6mm, respectively.

Natural vegetation and land use: The land use is dryland cropping. No native vegetation was found near the soil profile.

Table 1: Description of the G5 soil profile

Sample no.	Horizon	Depth (cm)	Description
1	A1	0 – 15	Loamy sand texture (tested by hand). No coarse fragments. Structure is pedal and weak, around 2- 5 mm size. Water repellent.
2	B1	15 – 40	Sandy loam texture (tested by hands). No coarse fragments. Structure is pedal and moderate, around 5 – 10 mm. Slightly water repellent
3	B2H	40 – 80	Sandy clay loam texture (tested by hands). No coarse fragments. Structure size ranges from 10 to 50 mm. Not water repellent. Has greyish areas that show preferential flow paths.
4	B2L	40 - 80	Sandy clay loam texture (tested by hands). No coarse fragments. Structure size ranges from 10 to 50 mm. Not water repellent. Has greyish areas that show preferential flow paths.

Table 2: Chemical analyses

	pH							Exchangeable (mg/kg)	
Sample no.	H_2O	$CaCl_2$	EC (µS/cm)	Organic C (%)	Total N (%)	CN Ratio	PRI	P (mg/L)	K (mg/kg)
1	5.91	5.01	95.23	2.18	0.149	0.146	5	17.76	32.26
2	6.59	5.16	34.64	1.2	0.043	0.279	5	6.06	23.70
3	6.39	5.7	56.37	0.17	0.016	0.106	26	0.59	16.84
4	6.47	6.7	74.3	0.18	0.023	0.078	59	0.59	15.12

Table 3: CEC analysis (<2mm fraction) exchangeable cations cmol/100g

Sample no.	CEC	ex-Ca	ex-Mg	ex-K	ex-Na	ex-Al
1	3.1	2.5	0.6	0	0.2	0.1
2	3.4	2	0.9	0	0.2	0.1
3	3.1	0.8	1.5	0	0.3	0
4	3.6	0.8	2	0	0.5	0

Table 4: Physical analyses

Sample no.	Particle size (%)			Bulk density (g/cm^3)	Munsell colour		Water repellence (MED)
	Clay	Silt	Sand		Wet	Dry	
1	9.6	9.4	81.0	1.5	10YR 3/3	10YR 4/3	Low
2	7.9	8.7	83.4	1.6	7.5 YR 4/3	10YR 5/4	No repellence
3	16.8	13.4	69.8	1.8	10YR 5/8	5YR 4/6	No repellence
4	20.8	15.2	64.0	1.6	10YR 5/8	10YR 6/8	No repellence

SMU 5 – Area is mainly used for flatland cropping and is located on a gradually sloping area (2%) adjacent to a creek line. The soil profile consists of A1 being loamy soil, B1 being sandy loam and B2 (high and low) consisting of sandy clay loam. The gravel shape went from angular in the first three horizons to subangular in B2 low. The gravel content gradually increases down the profile from 10.8% to 16.4% with a slight decrease to 15.9% in B2 low. Down the soil profile, the horizons had an increase in clay and slit content while a decrease in sand content. % of total carbon and nitrogen decreased with depth which was reflected in the decreasing C:N ratio but there was a large spike in B1 horizon but stayed in the range from 8 - 28. There was an overall decline in EC from 95.23 uS/cm to 74. 30uS/cm, but a larger decline in B1 and a rise in B2 high. The pH (water) down the profile increased with depth with the range of 5.91 to 6.47. This pattern was mirrored in the pH ($CaCl_2$) measurements as well. The CEC ranged from 3.1 to 3.6 in the soil profile. Exchangeable Al and K were low (> 0.1 mequiv/100g). Exchangeable Ca decreased with depth (2.5 - 0.8 mequiv/100g). Sodium increased with depth (0.6 - 2 mequiv/100g). The ESP increased with depth and doubled once it reached the B2 low horizon. The phosphorus retention index (PRI) went from moderate to strongly absorbing with depth. Extractable P and K decreased down the profile, Ex – P had a sharp decrease at B2 high while Ex – K has a gradual decline. The Emerson aggregate stability class in A1 was Class 7 and then dropped to Class 2 and 1 in B1 and B2. The MED repellence test revealed low repellence (0.2) in the A1 horizon, whilst lower horizons had zero repellence.

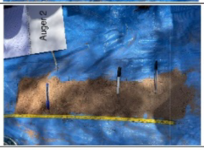
Lastly, the exchangeable sodium percentage (ESP) remained relatively constant within horizons A1 and B2(1) averaging 3.65% before falling to 2.6% in the lower B2(2) horizon.

GROUP # 2

Auger: General Description

Auger Number	Location	Topography/ Landform	Current Land Use	Stage of Erosion	Native Vegetation	Geology/ geomorphology	Weather Condition
1	UTM 50H E: 4040400 N: 6402386	Gently sloping in SW direction Low slope (~2%)	Grazing (sheep manure)	Not affected by erosion	Nothing within 10m	Dolerite outcrops nearby	Dry, sunny, light breeze, low cloud cover
2	UTM 50H E: 0439821 N: 6400671	Moderate slope/low 7-8 degrees slope	Native vegetation woodland	Not assessed	Eucalyptus woodland: Eucalyptus wandoo, brown mallet, eucalyptus astringens	Rocky outcrop > 30m away	Dry, sunny, light breeze, low cloud cover

Auger: Pictures

Auger #1	GPS E: [illegible] N: [illegible]	
Auger #2	GPS E: [illegible] N: 6401671	

Auger/Horizon Specific Parameters

Auger Number	Horizon O,A,E,B,C	Depth (cm)	Texture	pH Value	Gravel Content (%)	Root Availability	EC (uS/cm)	Wet Colour (Munsell)
1	A1	0-12cm	LS	[illegible]	10-15%	Not Assessed	68	10YR/2/2
	B1	12-47cm	SL	5.52	3-5%	Not Assessed	15.6	10YR/5/4
	B1	47-62cm	SCL	5.36	<2%	Not Assessed	46.5	10YR/7/8
	B2	62-70cm	CL	5.86	<1%	Not Assessed	61	10YR/6/8
2	A1	0-10cm	LS	5.5	10-15%	Not Assessed	2.77	7.5YR/2.5/2
	B1	10-30cm	LS	5.89	10-15%	Not Assessed	79.9	7.5YR/5/4
	B1	30-62cm	CS	5.68	5-10%	Not Assessed	874	7.5YR/5/4
	B2	62-82cm	SCL	5.65	5%	Not Assessed	1.75	7.5YR/5/4

Group 6 Folder

Profile Group 6:

Australian Soil Classification:
Chromosols

Location:
GPS UTM coordinates 0500315 6405829
UWA Ridgefield Farm, via Page Road
Approximately 10km north of Pingelly, WA

Landform/Topography:
Description: Hilly slope with native vegetation (*Eucalyptus loxophleba*) on the hilltop, adjacent to grazing area, with presence of dolerite dykes intruded upward.
Mild slope used for grazing area.
Elevation: ~348 m above sea level
Slope: Gently inclined ~9%

Parent Material:
Granite-Gneiss with Dolerite dykes

Drainage:
This area of Pingelly is a part of the ancient hydrologic region, Avon River catchment area. The soil profile was taken at the top of the hill therefore surface runoff flows in a westerly direction. The topography and surface features of the soil profile are subjected to different flow paths. Although at the top of the slope, may face flood risk from the cleared profile, and the evident perched water table (Horizon A2e).

Weather and Climate:
Pingelly has a Mediterranean climate as it experienced mild winters and dry summers. On the day the profile was dug, Pingelly experienced 16 °C with a minimum temperature of 10.4°C. Pingelly's annual mean rainfall is 444.3mm, with January being the driest and July having the wettest.

Natural vegetation and land use: Eucalyptus loxophleba and Grazing

Table 1: Description of the G7 soil profile

Sample no.	Horizon	Depth (cm)	Description
1	A1	0-14	Sand
2	A2	14-40	Sand
3	A2e	40-57	Bleached horizon (Sand)
4	B2	57-87	Loam

There is no agricultural land use in this area, and it has not been cleared. The area is just conserved native vegetation. This vegetation includes flooded gum, eucalyptus exilis, reeds and rushes (baumea riparia).

Table 1: Description of the G7 soil profile

Horizon	Depth (cm)	Description
A1	0-23	Sandy loam horizon
A2	23-34	Sand horizon
A2E	34-58	Sand horizon
B2	50+	Loamy sand horizon with mottled appearance

Table 2: Chemical analyses

	pH							Exchangeable (mg/kg)	
Horizon	H_2O	$CaCl_2$	EC (µS/cm)	Organic C (%)	Total N (%)	CN Ratio	PRI Value	P	K
A1	5.40	4.77	379	0.84	0.05	0.18	10	1.64	34.62
A2	6.42	4.76	149.5	0.32	0.03	0.11	6	1.32	15.75
A2E	6.19	5.2	127.6	0.14	0.02	0.08	6	1.01	0.05
B2	5.78	4.9	279.5	0.12	0.10	0.06	17	0.69	7.90

Table 3: CEC analysis (<2mm fraction) exchangeable cations cmol/100g

Horizon	CEC	ex-Ca	ex-Mg	ex-K	ex-Na	ex-Al
A1	1.2	0.7	1.5	0.1	0.9	0.1
A2	2.2	0.4	1.5	0	0.8	0
A2E	1.3	0.1	0.8	0	0.5	0
B2	4.1	0.2	2.8	0	1.3	0.1

Table 4: Physical analyses

Horizon	Particle size (%)			Bulk density (g/cm^3)	Munsell colour		Water repellence (MED)
	Clay	Silt	Sand		Wet	Dry	
A1	5	6.8	88.2	1.5	7.5YR 2.5/2	10YR 4/3	1
A2	3.8	4.8	91.4	1.6	7.5YR 2.5/3	10YR 5/4	1
A2E	4.5	6	89.5	1.6	2.5Y 5/4	10YR 6/3	1
B2	9.3	19.7	71	2.0	10YR 6/6	10YR 7/4	1

GROUP 8

Auger: General Description

Auger Number	Location	Topography/ Landform	Current Land Use	Stage of Erosion	Native Vegetation	Geology/ geomorpholo	Weather Condition
1	(0)500429 6406247	Wild oats	Cropped	none	stubble/grass	Flat	Hot 25
2	(0)412951 6421781	Down hill from water channel (10m).	Grazing	none	grass	flat, slight slope ~8%	Hot-25

Auger: Pictures

Auger #1	GPS: (0)500429 6406247
	
Auger #2	GPS: (0)412951 6421781
	
Auger #3	

Auger/Horizon: Specific Parameters

Auger Number	Horizon O,A,E,B,C	Depth (cm)	Texture	pH Value	Gravel Content (%)	Root Availability	EC	Wet Colour	Wet Colour (Munsell)
2	A1	0-8cm	sandy, can't form ball	6.18	5	Minimal root availability (wild oat roots	119.4	dark grey	10YR 4/1
2	A2	8-17cm	forms a slight ball but can not press	5.82	40-50	Minimal root availability	97.7	light grey rocky	10YR 6/2
2	B1	17-30cm	forms a ball and can press around 2 cm	5.93	60 contains larger pebbles	Minimal root availability	66.8	cream/light	10YR 8/2
2	B2	30-36cm	forms a ball, can press easily, very clay lik	6.51	20	Minimal root availability	74.3	cream/yellow	10YR 8/6
1	A1	0-10cm	dry and rocky	5.55	20	Minimal root availability	77.7	dark brown	10YR 4/3
1	A2	10-21cm	slightly wet, clay like texture	5.73		Minimal root availability	26.7	brown/orange	10YR 5/6
1	B1	17-30cm	slightly wet, clay like texture	5.1	30	Minimal root availability	18.4	lighter orange yellow	10YR 6/8
3	Bed rock	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Group 7 Soil Profile

Profile: Soil Profile 7, Riparian Zone/Creek Line

Australian Soil Classification:

Hydrosol

Location:

GPS UTM coordinates: 50H 0500419E, 6406374N

UWA Ridgefield Farm

Approximately 10km North of Pingelly, Western Australia

Landform/Topography:

Description: low lying, riparian zone with native vegetation. The area is lined with reeds and small gum trees.

Elevation:

Slope: 2%, low slope

Parent Material:

Granite, Quartz and Feldspar.

Drainage:

Water collects in this area during periods of high rainfall. During these times the soil can become quite waterlogged. Due to hydrosol soil type, this area has poor drainage.

Weather and Climate:

The UWA farm experiences Mediterranean climate conditions of hot summers with little to no rainfall and mild winters with higher rainfall (Gleeson et al, 2016). The farm receives approximately 445 mm of annual rainfall (Gleeson et al, 2016). The average annual minimum temperature is 10.4°C (Gleeson et al, 2016). The average annual maximum temperature is 23.4°C (Gleeson et al, 2016). Between the years 1891 and 2023 the highest average monthly rainfall occurs in July and lowest rainfall occurs in January (Bureau of Meteorology). On the day of sample collection, it was around 27 degrees (at midday) and sunny with no rain or cloud cover.

Natural vegetation and land use

Table 2: Chemical analyses

Sample no.	pH H$_2$O	pH CaCl$_2$	EC (µS/cm)	Organic C (%)	Total N (%)	CN Ratio	PRI	Exchangeable (mg/kg) P	Exchangeable (mg/kg) K
1	5.98	5.5	77.5	1.6	0.112	0.143	22	0.639059	25.49
2	6.30	5.04	23.5	0.31	0.018	0.172	21	0.363275	14.97
3	6.39	5.36	28.3	0.1	0.01	0.100	20	0.055045	18.47
4	6.56	5.62	24.6	0.15	0.016	0.094	26	0.038823	32.56

Table 3: CEC analysis (<2mm fraction) exchangeable cations cmol/100g

Sample no.	CEC	ex-Ca	ex-Mg	ex-K	ex-Na	ex-Al
1	4.4	3.9	0.4	0.2	0	0
2	1.4	1.1	0.2	0.1	0	0
3	0.8	0.6	0.1	0.1	0	0
4	2.1	1.5	0.4	0.2	0.1	0

Table 4: Physical analyses

Sample no.	Particle size (%)			Bulk density (g/cm^3)	Munsell colour		Water repellence (MED)
	Clay	Silt	Sand		Wet	Dry	
1	0.75	4.51	94.74	1.5	7.5YR 5/2	7.5YR 4/2	5
2	5.5	3.5	91	1.8	7.5YR 4/4	7.5YR 6/4	3
3	3.75	5.01	91.24	1.8	10YR 6/4	10YR 8/3	2
4	12.62	11.98	75.4	1.6	10YR 6/6	10YR 7/6	1

Results

SMU 6 is used as a trial cropping field located on a gently inclined simple slope area. The pit profile consisted of coarse sand for A1, A2 and A2e horizons with, loam in B2 horizon. The gravel content increased gradually through the horizons from 8.8% in A1 to 53.1% in B2. Water repellence decreased from A1 to B2 with, A1 having moderate repellence and B2 having none. Emerson aggregate stability varied across the profile. A1 and A2e were classified as Class 2, B2 was allocated to Class 1 and A2 was Class 7. Percentage of N and organic C decreased from A1 to A2e with a slight increase in B2. The highest ratios were in A1 and A2 horizons. EC decreased with depth however experienced a slight increase in A2e before decreasing again. The highest reading of 77.5 uS/cm was found in A1. pH readings ranged around 5 highlighting an acidic soil profile. B2 has the greatest reading of 5.62 and A2 had the lowest at 5.04. Extractable P decreased significantly below 40cm. Extractable K decreased from A1 to A2 before increasing slightly to A2e and significantly to B2. Extractable Al was non-existent which was similar for

Na except for the B2 horizon. The other cations demonstrated a similar pattern of steadily decreasing with depth before showing an increase in the B2 horizon. Phosphorus retention was rated as strongly absorbing for A1, A2 and B2 and moderate for A2e. Exchangeable sodium percentage was non-existent for all horizons except for B2 having 5%.

SMU 7 Summary

SMU 7 is located in areas of uncleared riparian vegetation and recent revegetation along ephemeral creek lines located predominantly in the south-east of the study area in a flat low-lying area. There are two areas of riparian vegetation which join at the eastern border of the study area which during rainfall events would continue to flow east. Due to the low-lying nature of this area, the creek is seasonally waterlogged for >3 months of the year. All areas of riparian vegetation are relatively narrow ranging from approximately 50 to 150 meters in width with most surrounding areas being cleared for agricultural use.

The soil profile pit is located in the main branch of riparian vegetation located in the south east corner of the study area between two cropping fields. The soil profile itself consisted of 4 horizons in the top 80 cm. None of the horizons were water repellent. All horizons had an Emerson aggregate stability class of 7 (except the B2 horizon that was class 2). All horizons measure exchangeable sodium percentages (ESP) between 27 - 36%, which are considered *strongly sodic;* this is related to clay dispersion and aggregate breakdown.

The first horizon was an A1 horizon of sandy loam texture and had a gravel content of 11.8%. This horizon had the highest electrical conductivity (EC) (379 µs/cm), total nitrogen (0.048%), organic carbon (OC) (0.84%) and carbon to nitrogen ratio (18). The A1 horizon also has the highest phosphorus (P) (1.64 mg/kg), potassium (K) (34.62 mg/kg) and calcium (Ca) (0.7 cmol/100g) concentration and a relatively acidic pH of (4.77 measured in CaCl). This horizon also had the lowest cation exchange capacity (CEC) (1.2 cmol/100g)

The second horizon was an A2 horizon of a sand texture and had a gravel content of 16.0%. This horizon had a very similar pH (4.76 measured in CaCl) to A1 horizon and lowest percentage of clay sized particles (3.8%). CEC was higher in the second horizon (2.2 cmol/100g) and relatively similar levels of macronutrients to the A1 horizon. Extractable phosphorus and potassium decreased from the A1 horizon to 1.32mg/kg and 15.75 mg/kg respectively. EC dropped noticeably from 379 uS/cm in A1 down to 149.5 uS/cm in A2

The third horizon was an A2E horizon, also of sand texture and had a gravel content of 26.1%. This horizon had the lowest percentage of nitrogen (N), phosphorus retention index value (PRI) and the lowest CEC at 1.3 cmol/100g. Overall A2E has the lowest amounts of macronutrients and extractable potassium was noticeably lower at 0.049 mg/kg. A2E has the highest pH out of all four layers (5.2 measured in $CaCl_2$) and EC was lower than A2E at 127.6 uS/cm.

The fourth horizon identified still has a relatively high proportion of sand sized particles at 71% however there was an increase in silt sized particles to 19.7% which classified the soil to have sandy loam texture. Gravel content was determined to be 18.0%. B2 recorded a pH of 4.9 (measured in $CaCl_2$) and EC increased to 279.5 uS/cm. CEC was highest in B2 at 4.1cmol/100g, and lowest extractable phosphorous (0.690 mg/kg), and the highest PRI.

GROUP 7

Auger: General Descirption

Auger Number	Location	Topography/ Landform	Current Land Use	Stage of Erosion	Native Vegetation	Geology/ geomorphology	Weather Condition
1	50J 0402274 6469675	aspect: north 350°, slope 5°	intense pasture grazing	very dry, no evidence of erosion	land is cleared, so there is no sign of vegetation	No outcrop	Partly cloudy
2	50J 0499938 6405863	aspect: northwest 299°, slope 5°	cropping	very dry, no evidence of erosion	land is cleared, so there is no sign of vegetation	No outcrop	Partly cloudy
3	06406385	slope 2°	cropping	erosion	there is no sign of	No outcrop	Partly cloudy

Auger: Pictures

Auger #1	
Auger #2	
Auger #3	

Auger/Horizon: Specific Parameters

Auger Number	Horizon O,A,E,B,C	Depth (cm)	Texture	pH Value	Gravel Content (%)	Root Availablity	EC	Wet Colour (Munsell)
1	A1	0-15	sand	6.76	20-25	no root	2.88µS	not accessed
1	B1	15-50	loamy sand	6.69	15	no root	35.5µS	not accessed
1	B2	50++	clayey sand	6.83	10	no root	66.1µS	not accessed
2	A1	0-10	sand	5.03	20-25	not accessed	101.8µS	not accessed
2	B1	10-34	loamy sand	5.61	15	not accessed	33.5µS	not accessed
2	B2	34++	sandy clam loam	5.79	<10	not accessed	70µS	not accessed
3	A1	0-15	sand	6.36	10	not accessed	62µS	not accessed
3	B1	15-42	loamy sand	6.59	15	not accessed	44.4µS	not accessed
3	B2	42++	sandy clay loam	6.27	15	not accessed	99.6µS	not accessed

Group Folder

Profile: Group 8

Australian Soil Classification: Sodosol

Location:
GPS UTM coordinates 0499557E, 6406577N
UWA Ridgefield Farm, via Page Road
Approximately 10 km north of Pingelly, WA

Landform/Topography:
Description: Hilly slope with native vegetation (*Eucalyptus loxophleba*) on the hilltop, adjacent to grazing area, with presence of dolerite dykes intruded upward. Around 2-10 million years ago sea levels dropped exposing lateritic mantel creating laterite profiles found throughout the landscape (Safstrom, 1997).
Elevation: ~348 m above sea level
Slope: Steep slope ~28%

Parent Material: Granite-Gneiss with Dolerite dykes and Migmatite rocks. This has been a relatively stable landscape for 2400 million years. Gneisses is a hard crystalline rock which are formed under high temperatures and pressures with minerals like quartz and feldspar present, it is a banded rock and metamorphic. Granite is a hard crystalline rock, it is not banded, formed from magma that intrudes into the crust. Dykes form from molten rock that is fractured within the base rock, it is often dolerite and commonly found in the Pingelly region (Safstrom, 1997).

Drainage: This area is a part of an ancient hydrologic region, the Avon River catchment area. The river system runs south of the Pingelly shire, forming the southern boundary. The Avon consists of four main rivers; the Avon, the north Mortlock, east Mortlock and the Dale (Safstrom, 1997).

Weather and Climate: Pingelly is considered a Mediterranean climate, consisting of dry summers and cool winters. On the day the profile was dug, maximum temperature was 22°C, with no rainfall throughout the day. Pingelly on average will receive 445mm of rainfall annually. Maximum temperatures on average are 31.7°C in January and 15.2°C in July. Average minimum temperatures are 16.0°C in February and 5.6°C in August (Safstrom, 1997).

Natural vegetation and land use: Native vegetation: Eucalyptus loxophleba, Jarrah, Marri, Powderbark, Wandoo, Banksia. Some current land uses grazing, cropping, farming and agriculture. Significant portions of native vegetation have been removed in the region for agricultural purposes (Safstrom, 1997).
Table 1: Description of the G8 soil profile

Sample no.	Horizon	Depth (cm)	Description
1	A1	0-12	Loamy sand
2	A2	12-30	Clay loam
3	B1	30-44	Loam
4	B2	44-59+	Silty loam

Table 2: Chemical analyses

	pH							Exchangeable (mg/kg)	
Sample no.	H_2O	$CaCl_2$	EC (µS/cm)	Organic C (%)	Total N (%)	CN Ratio	PRI	P	K
1 - A1	4.39	4.07	200.1	7.95	0.225	35	67	2.294	73.67
2 – A2	4.48	4.18	792.5	6.40	0.200	32	111	1.524	55.43
3- B1	4.88	4.32	206	4.42	0.160	28	117	1.465	37.35
4- B2	3.71	3.53	629.5	0.70	0.028	25	137	1.27	0

Table 3: CEC analysis (<2mm fraction) exchangeable cations cmol/100g

Sample no.	CEC	ex-Ca	ex-Mg	ex-K	ex-Na	ex-Al
1	1.5	0.4	0.6	0.1	1.2	0.4
2	3.2	0.4	2.1	0.1	3.9	0.5
3	2.5	0.1	2	0.1	3.5	0.3
4	2.3	0	1	0	2.3	2.1

Table 4: Physical analyses

Sample no.	Particle size (%)			Bulk density (g/cm^3)	Munsell colour		Water repellence (MED)
	Clay	Silt	Sand		Wet	Dry	
1	11.5	22.2	66.2	1.1	5YR 2.5/2	2.5YR 4/2	1
2	22.3	14.1	63.6	1.0	5YR 3/2	10YR 4/4	7
3	17.8	11.6	70.7	1.2	2.5YR 4/4	10YR 5/4	7
4	17.1	42.4	40.6	1.5	10YR 5/8	10YR 7/6	1

References:

Safstrom, R. (1997). Native Vegetation Handbook for the Shire of Pingelly . [online] Department of Primary Industries and Regional Development. Available at: https://library.dpird.wa.gov.au/cgi/viewcontent.cgi?article=1017&context=nat_veg [Accessed 23 May 2023].

SMU 8 Soil Profile Description

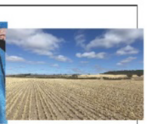
SMU 8 is located on a steep slope (28%) with native vegetation present away from any agricultural use. The area is fenced off from stock. The pit profile consisted of loamy sand in the A1 horizon, followed by clay loam on the A2 horizon, the B1 horizon had loam and the B2 horizon had silty loam present. In the A1 and A2 horizons the gravel content consists of rounded/subrounded gravel that are less than 3-4 mm in size. In the B1 horizon the gravel content consists of angular/subangular with a majority being less than 10 mm in size. In the B2 horizon gravel content consists of rounded tabular with a majority less than 3mm in size. Duricrust and laterite gravel is present in the soil horizons. The A1 and B2 horizons had no water repellency with a rating of 1, the A2 and B1 horizons had moderate water repellency with a rating of 7 and was able to repel up to 1.6 mol/L during the water repellency test. For the Emerson aggregate stability the A1 horizon has a stability class of 8, A2 and B1 horizons have Emerson aggregate stability class of 7 and B2 has an Emerson aggregate stability class of 2. The organic carbon content is high in the top layers (as excited for a native vegetation area) and then decreases with depth to almost zero in the B2 silty loam layer. Total nitrogen follows a similar trend for likely the same reason. pH was fairly consistent being strongly acidic for all horizons. The pH went up slightly with depth (4.39 to 4.88 from A1 to B1), except for B2 where the pH dropped with depth and was the most acidic (lower pH). DI and $CaCl_2$ gave similar trends with $CaCl_2$ being slightly lower pH values as expected. The EC was lower for A1 (around 200) and higher for A2 (neary 800), and the same trend for B1 being around 200 and B2 being over 600 µS/cm. Extractable-P, A1 horizon had a value of 2.294, A2 was 1.524, B1 was 1.465 and B2 was 1.270. This means as you go further down the soil profile the lower phosphorus can be extracted. Extractable-K, the A1 horizon had a value of 73.67 which is the highest of all the horizons. A2 had a value of 55.43, B1 had a value of 37.35 and B2 was 0.00. This means as you go further down the soil profile the less K is extractable. For phosphorus retention index (PRI) the A1 horizon had a value of 67 making it strongly absorbing. For the A2 horizon was very strongly absorbing with a value of 111. The B1 horizon was very strongly absorbing as well with a value of 117 along with the B2 horizon which was very strongly absorbing with a value of 137. Exchangeable-Al, K and Na. For exchangeable Al the values are; A1 is 0.4, A2 is 0.5, B1 is 0.3 and B2 is 2.1. So for our top three profiles they had a relatively similar exchangeable Al level but our highest profile was B2. The values for exchangeable K are the following 0.1 for A1, A2 and B1 and 0 for B2. The values for exchangeable Na are: A1 was 1.2, A2 was 3.9, B1 was 3.5 and B2 was 2.3. For extractable phosphorus the A1 horizon had a value of 2.29 of phosphorus (mg kg) -1. The A2 horizon had a value of 1.52 (mg kg) -1, B1 had a value of 1.47 (mg kg) -1 and B2 had a value of 1.27 (mg kg) -1. For extractable potassium A1 had a value of 73.67 (mg kg) -1, A2 had a value of 55.43 (mg kg) -1, B1 had a value 37.35 (mg kg) -1 and B2 had no extractable potassium.

Overall trends down through the profile saw a decreasing trend in total carbon (%) from 0.84 in the A1 horizon down to 0.12 in the A2E horizon. Bulk density was relatively high in the A1 horizon (1.5g/cm3) and continued to increase 1.6g/cm3 in A2 and A2E and up to 2g/cm3 in the B2 layer.

Auger: General Description

Auger Number	Location	Topography/ Landform	Current Land Use	Stage of Erosion	Native Vegetation	Geology/ geomorphology	Weather Condition
1	Down slope Cropping	Highly inclined slope - westerly slope	Currently used for cropping	Larger A2 because on a slope - affected by erosion.	Eucalyptus and shrub	Orange particulates (iron oxides), young not crystallized as contains water. Whiter rocks due to pores of saprite and isovolumetric mass loss.	Sunny dry and conditions
2	Riparian Zone	Gentle hills from previous water currents	Creek for waterway management	Due to dry period, accumulation of sediment and moderate slopes (minimal erosion)	Planted Riparian Eucalyptus, shrub	Heavily influenced by creeks. Erosive power of flowing water led to removal of some sediments. Fine-grained silt clay.	Sunny dry and conditions
3							
4							
5							

Auger: Pictures

Auger #1	GPS Left Image: Soil Auger profile. right image: surrounding auger landscape, (Cropping)	50H 0499952 UTM 6406032	  
Auger #2	GPS Left Image: Soil Auger profile Right image: riparian zone	50H UTM 0499952 6406004	 

Auger/Horizon Specific Parameters

Auger Number	Horizon O,A,E,B,C	Depth (cm)	Texture	pH Value	Gravel Content (%)	Root Availability	EC	Wet Colour (Munsell)
1	A1	0-23cm	No ribbons, Sand	6.53	Not assessed	Some roots present	96	5 YR 2.5/1
	A2	24-40cm	No ribbons, Sand	6.5	-	-	33.7	7.5YR 4/2
	B1	41-51cm	Sandy Texture, small gravel	6.78	-	-	66.4	5 YR 5/1
	B2	52-60	Few ribbons, loamy sand	6.38	-	-	25.2	5 YR 4/4
2	O	0-4cm	Sandy/gravy layer	5.55	-	-	818	7.5YR 3/1
	A1	5-9cm	clayey and more clumping	5.57	-	-	437	10YR 6/6
	A2	10-21cm	Silty white sand	5.69	-	-	219	10YR 7/1
	B1	22-28cm	more coarser gravel content	5.19	-	-	310	10YR 5/4
	B2	29-37cm	Clumping and more ribbons	5.28	-	-	492	10YR 4/4

Group Folder

Profile SMU9

Australian Soil Classification:

Red Kurosol

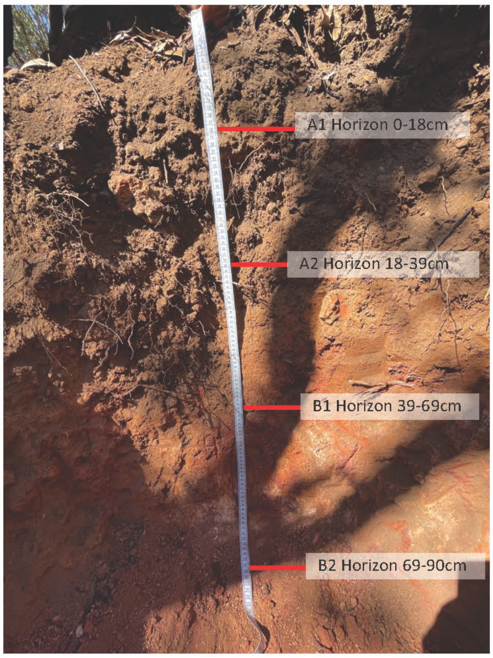
Location:

GPS UTM coordinates 50H 0499272E 6406571N

UWA Ridgefield Farm, via Page Road

Approximately 10 km West of Pingelly, WA

Landform/Topography:



Description of the area surrounding the soil profile is it is located on Avery Hill, a large, medium sloped area of remnant native vegetation, predominantly of the species *Euecalyptus loxophleba.* The hill is adjacent to several rotating cropping and grazing paddocks on gentle slopes.

Elevation from the top of Avery Hill is 350m above sea level.

Slope of the West side of Avery hill is a waning rocky steep slope (29%).

Parent Material:

A region of granite and gneiss with dolerite dyke intrusions

Drainage:

The UWA farm lies within the Avon Basin catchment. The farm lies to the West of the Basin in the zone of rejuvenated drainage and in the Avon River sub catchment. Several small water courses cross the farm which drain to the east into the Avon River South which subsequently flows into the Avon River.

Weather and Climate:

Pingelly experiences traits of a Mediterranean climate with hot, drier summer and then a wet and cool winter. The average annual rainfall within Pingelly is 444mm (BOM), 50% of which falls during the winter months. The average maximum temperature experienced in January is 32 degrees Celsius, then dropping to 15.4 degrees Celsius in July. There had been little rain in the days leading up to when the soil profile was dug, resulting in hard, dry soils.

Natural vegetation and land use: *Eucalyptus loxophleba*

Table 1: Description of the G7 soil profile

Sample no.	Horizon	Depth (cm)	Description
N/A	O	+4-0	Leaves, from newly fallen to weathered and branches
1	A1	0-18	Dusky red (10YR 3/2 wet) clay loam; moderate polyhedral (5-20mm); 16% rounded to subangular ironstone gravel (2-70mm), majority less than (10mm) and course fragments from cobbles up to stones; abrupt smooth boundary to
2	A2	19-39	Dark Reddish brown (5YR 3/2 wet) clay loam; moderate polyhedral (2-10mm); 16% rounded ironstone gravel (2-30mm), most under 10mm and cobbles; diffuse irregular boundary to
3	B1	39-69	Reddish brown (2.5YR 5/4 wet) clay loam; massive; 15.5% angular ironstone gravel (2-60mm), majority under 20mm; gradual wavey boundary to
4	B2	69+	Dark red (10R 3/6 wet) loam; massive; 19.5% rounded to subangular ironstone gravel (2-70mm), majority under 10mm

Table 2: Chemical analyses

Sample no.	pH		EC (µS/cm)	Organic C (%)	Total N (%)	CN Ratio	PRI	Exchangeable (mg/kg)	
	H_2O	$CaCl_2$						P	K
1	5.49	4.46	187	17.4	0.52	33.333	2	8.35	236.5
2	4.28	4.15	1253	6.75	0.21	31.991	14	3.45	52.1
3	4.09	4.05	1772	2.76	0.10	27.327	22	3.10	47.6
4	4.07	3.75	1092	0.62	0.03	21.379	3	2.65	51.9

Table 3: CEC analysis (<2mm fraction) exchangeable cations cmol/100g

Sample no.	CEC	ex-Ca	ex-Mg	ex-K	ex-Na	ex-Al
1	6.5	2	2.5	0.4	2.1	0.4
2	2.7	1.8	0.3	0.1	2.6	5.5
3	2.1	0	2	0.1	5.8	2.2
4	2	0.8	0	0.1	1.4	4.7

Table 4: Physical analyses

Sample no.	Particle size (%)			Bulk density (g/cm^3)	Munsell colour		Water repellence (MED)
	Clay	Silt	Sand		Wet	Dry	
1	23.5	12.3	64.2	0.7	10YR 2/2	10YR 3/2	Very severe
2	23.8	17.3	58.9	1.0	5YR 3/2	5YR4/4	Very severe
3	30.5	19.4	50.1	1.2	2.5YR 3/6	2.5YR 5/4	Very low
4	21.1	15.9	63.0	1.5	10R 3/6	10R4/4	No repellence

SMU 9 brief summary:
SMU9 is used as remnant native vegetation, located on the West side of a waning steep sloped hill, surrounded by a mixture of cropping and grazing paddocks. The pit's profile consisted of four horizons, the A1, A2, B1 and B2, and additionally the O horizon. Both A horizons and the B1 horizon were clay loams, with the B2 being loam. Water repellence decreases with depth, being very severe in A1 and A2 horizons but then having no repellence in the B2 horizon. The A horizons also have a greater Emerson's aggregate stability, both being class 8, whereas the B horizons are class 2. Soil pH of the pit overall becomes more acidic with depth, decreasing from 5.49 to 4.07. EC is very small in the A1 horizon, only 187 µS/cm, until it increases with the greatest value found in the B1 horizon of 1772 µS/cm, before decreasing slightly at the base of the profile. Percentage of nitrogen and organic carbon both decrease with depth, with the ratio of C to N decreasing from 33.33 to 21.38 as well. Exchangeable P and K are greatest in the A1 horizon, but then decreases, although exchangeable K remains steady around 50 mg/kg for the latter three horizons. Phosphorus retention was very low in the A1 and B2 horizons, being rated as weakly absorbing, but then rated as moderately absorbing and strongly absorbing for the A2 and B1 horizons respectively. The cation exchange capacity of the soil profile is greatest in the A1 horizon, being 6.5, before decreasing with depth, with the lower three horizons having a value of less than 3.

GROUP 9

Auger: General Description

Auger Number	Location	Topography/ Landform	Current Land Use	Stage of Erosion	Native Vegetation	Geology/ geomorphology	Weather Condition
1	50 H 0464105 UTM 6494758	slope, +4°	cropping	some	none	granite surface stones	dry, sunny
2	50 H 0498091 UTM 6406107	slope, +2°, water way	cropping	some water erosion	none	granite surface stones	dry, sunny
3	50 H 0499062 UTM 6406545	Slope, +9°	pasture	some wind erosion	none but some nearby	none	hot, dry, sunny
4							
5							

Auger: Pictures

Auger #1	GPS	
Auger #2		
Auger #3	GPS	
Auger #4	GPS	
Auger #5	GPS	

Auger/Horizon: Specific Parameters

Auger Number	Horizon O,A,E,B,C	Depth (cm)	Texture	pH Value	Gravel Content (%)	Root Availability	EC	Wet Colour (Munsell)
1	A	0-11cm	*	5.71	3	Very few roots	40.7µs/cm	
1	B	11-30cm		6.33	5	Very few roots	26 µs/cm	
2	A	0-10cm		5.95	4	Very few roots	145.5 µs/cm	
2	B	10-21cm		6.44	2	Very few roots	51.7 µs/cm	
3	A	0-14cm		5.57	3	Very few roots	109 µs/cm	
3	B	14-30cm		5.94	1	Very few roots	26.9 µs/cm	

*Too water repelient to successfully test

*Louise confirmed that our auger wasn't the right style for sandy soils, thus auger profiles are not

Group Folder

Profile 10:

Australian Soil Classification:

Sodosol

Location:

UTM 50H 499337.5 E, 6406913.99 N

UWA Ridgefield Farm, via Page Road

Approximately 10 km north of Pingelly, WA

Landform/Topography:

Description: Top of a gentle slope, slope 3%, aspect 270 west

Parent Material:

Granite-Gneiss with Dolerite dykes,

Drainage:

This area is a part of the ancient hydrologic region, Avon River catchment area. No obvious erosion or perched water table.

Weather and Climate:

Pingelly has a Mediterranean climate as it experiences dry summers and cool winters. On the day the profile was dug, Pingelly experienced 25 degree celsius maximum temperature, partly cloudy and dry conditions. Pingelly's annual mean rainfall is 445mm, with a January mean of 11.3mm and 81.2mm in July. The highest rainfall recorded in those months was 116.9mm and 222.6mm respectively.

Natural vegetation and land use: *intense grazing, no vegetation cover, no ground cover, likely that pre-clearing vegetation was open Eucalypt woodland. Animal remains on surface, surface stones and coarse quartz sand. No roots visible.*

Table 1: Description of the G7 soil profile

Sample no.	Horizon	Depth (cm)	Description
1	A1	0-23cm	Coarse sand, with accumulation of OM giving it a colour of 10YR 2/1

2	B1	23-30cm	Coarse sand, colour lighter than A1, Colour = 10YR4/4
3	B2(1)	30-45cm	Coarse sand with slightly higher clay content and small amount of gravel, colour = 10YR 6/8
4	B2(2)	45-60cm	Coarse sand with slight clay content, and small gravel content, 10YR 7/8
5	B2(3)	60-70cm	Clayey sand, with higher aggregate stability, some gravel and reddish mottling, colour = 7.5YR 6/8

Table 2: Chemical analyses

	pH							Exchangeable (mg/kg)	
Sample no.	H_2O	$CaCl_2$	EC (µS/cm)	Organic C (%)	Total N (%)	CN Ratio	PRI	P	K
1 A1	6.6	5.86	166.4	3.27	0.234	14	4	12.93	0.2
2 – B1	6.51	5.05	34.22	0.27	0.051	5	6	6.38	0
3- B2(1)	6.25	5.14	25.8	0.28	0.027	10	4	3.67	0
4B2(2)	6.23	5.27	18.18	0.14	0.02	7	3	2.99	0
5 – B2(3)	6.43	5.53	29.74	0.12	0.025	5	13	2.98	0

Table 3: CEC analysis (<2mm fraction) exchangeable cations cmol/100g

Sample no.	CEC	ex-Ca	ex-Mg	ex-K	ex-Na	ex-Al
1 A1	8.5	7.4	1.1	0.2	0.3	0
2 B1	1.4	1.3	0.2	0	0.1	0.1
3 B2(1)	0.7	0.8	0.2	0	0.1	0
4 B2(2)	0.9	0.5	0.2	0	0	0
5 B2(3)	1.3	0.6	0.8	0	0.1	0

Table 4: Physical analyses

Sample no.	Particle size (%)			Bulk density (g/cm^3)	Munsell colour		Water repellence (MED)
	Clay	Silt	Sand		Wet	Dry	
1 A1	0.746	5.721	93.533	1.5	10YR 2/1	10 YR 4/3	7
2 B1	2.984	5.969	91.047	1.5	10YR 4/4	10YR 5/4	1
3 B2(1)	7.376	6.988	85.774	1.5	10YR 6/8	10YR 6/4	1
4 B2(2)	3.233	8.207	88.560	1.5	10YR 7/8	10YR 7/6	1
5 B2(3)	9.504	9.253	81.243	1.6	7.5YR 6/8	10YR 7/6	1

GROUP #10

Auger: General Descirption

Auger Number	Location	Topography/ Landform	Current Land Use	Stage of Erosion	Native Vegetation	Geology/ geomorphology	Weather Condition
1	499530.17 m E 6406912.15 m S	5% Slope gentle, Aspect- East 100 degrees, Elevation 347 m above sea level	Grazing	Minimal	None present	Granite outcrop nearby, potentially on a dyke	Cloudy, sunny, dry
2	499686.79 m E 6406727.41 m S	Slope, Aspect NNE 4 degr	Remnant vegetation	very eroded, lateritic colluvium	Open Eucalypt woodland with sparse understory	On lateritic slope, iron duricrust colluvium	Dry clouded, 25 degrees
3							
4							
5							

Auger/Horizon: Specific Parameters

Auger Number	Horizon O,A,E,B,C	Depth (cm)	Texture	pH Value	Gravel Content (%)	Root Availablity	EC	Wet Colour (Munsell)
1	O	+ 1 cm	Coarse sand + small gravel					
	A2	0-12cm	Sand	5.86	5%	None	80.6us / cm	10YR 2/2
	B1	12-16cm	Loamy sand + coarse sand	6.02	10%	None	33.3us/cm	10 YR 3/4
	B2(1)	16-30cm	Loamy sand + coarse sand	5.79	10%	None	26.7us/cm	10YR 4/6
	B2(2)	30-50cm	Sandy loam + coarse sand	6.33	10%	none	39.5us/cm	10YR 6/6
2	O	+2cm						
	A1	0-11cm	Coarse sand	4.9	10%	None	495us/cm	10YR 3/2
	A2	11-16cm	Loamy sand	4.79	10%	Minimal	465us/cm	7.5YR 3/3
	B1	16-21cm	Clayey sand	4.69	15%	Minimal	866us/cm	7.5YR 2.5/3

Auger: Pictures

Auger #1	GPS 
Auger #2	GPS 
Auger #3	GPS
Auger #4	GPS
Auger #5	GPS