



## Soil testing to support decision making in the rangelands

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### Abstract

Soil testing is not typically conducted in extensive and low input rangelands systems. To assess the usefulness of quantifying soil properties, we benchmarked selected soil physicochemical properties with producers from 33 properties in the semi-arid rangelands of NSW, Australia. Producers selected sampling locations of different soil types and landscape positions to compare attributes of the upper rootzone (10 cm increments to 30 cm) for pH, salinity, exchangeable cations, sulphur (S), phosphorus (P), and soil organic carbon (SOC).

Laboratory analyses typically showed an increasing soil pH with depth to alkaline levels on alluvial soils. The pH of non-alluvial soils (aeolian and bedrock-derived soils) was evenly distributed from moderately acidic to moderately alkaline, though some areas were identified with acidity constraints. Soil salinity was generally low, but some targeted sites had soil salinity levels comparable to sea water. Sodic soils were found in many areas. Low SOC was associated with high salinity and sodicity. Soil P was high in some areas, particularly the alkaline alluvial soils, though on some non-alluvial soils P was low enough to limit livestock productivity.

Benchmarking soil properties proved a strategic tool for rangeland producers to identify constraints not previously quantified and assess management options. Some targeted ameliorants or supplements may lead to improved productivity and returns on investment. The results provide a basis for further investigation to address any constraints and variable productivity.

### Introduction

Chemical, physical and biological properties influence the inherent productivity of soils, though soil testing is not typically conducted in extensive and low input rangeland systems. Management in rangelands is complicated by a typically variable climate, often compounded by historic degradation which sees producers managing landscapes in various stages of soil stabilisation and recovery. This management requires attention to soil health, identified by farmers in NSW semi-arid rangelands as a priority for their production systems.

The objective of this paper was to identify potential constraints to production in NSW rangelands from targeted soil sampling on 33 properties in the semi-arid rangelands of NSW, Australia.

## Methods

Producers were trained in soil sampling for laboratory testing in 2023. Samples were collected from up to four sites each, enabling comparison between sites. Training in the use of the soil kits was undertaken through regional workshops and discussion with the project team. At each site, samples were composited at depths 0-10, 10-20 and 20-30 cm for laboratory testing. Laboratory testing of samples to characterise the upper rootzone increments included pH in water (pHw) and CaCl<sub>2</sub> (pHCa), electrical conductivity (EC), exchangeable cations, soil organic carbon (SOC) by dry combustion, P by Colwell and BSES, and S (KCl40). Chloride (Cl) was measured on selected samples for salinity (Shaw 1999) and effective EC was estimated according to Shaw (1999) for samples with EC>0.3 dS/m or by Slavich and Peterson (1993). Exchangeable cations were measured according to pH and EC (15C1 for samples with pHw>7.3 and EC>0.3, or 15E1; all procedures as per Rayment and Lyons 2011). Results were grouped into samples taken from alluvial or non-alluvial sites.

## Results

### Acidity, salinity, sodicity and organic carbon

Across all sites, the pH of the 0-10 cm samples ranged from slightly acidic to slightly alkaline (Figure 1), generally increasing with depth. The difference between pHw and pHCa varied with EC, from zero (highest EC) to two units (lowest EC). Approximately 5% of samples had pHCa less than 4.8 (minimum 4.1).

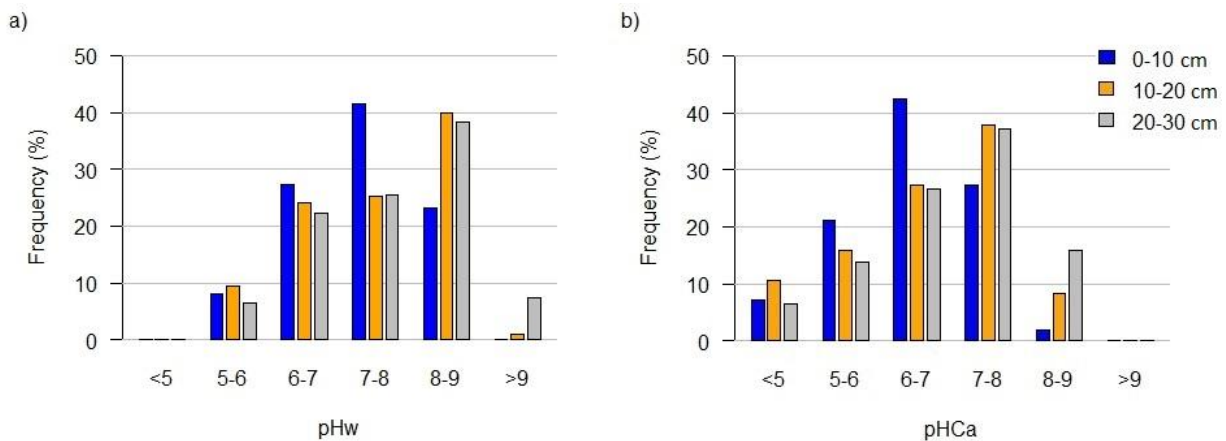


Figure 1. Frequency distribution of soil a) pHw and b) pHCa by depth for all samples.

Salinity was generally low in the samples collected from the upper 30 cm at each site (Figure 2). High salinity was more common in alluvial areas than the non-alluvial areas. 14% of sites sampled were areas of low productivity areas or scalds where the salinity was above 8 dS/m, and as high as the mid-fifties dS/m.

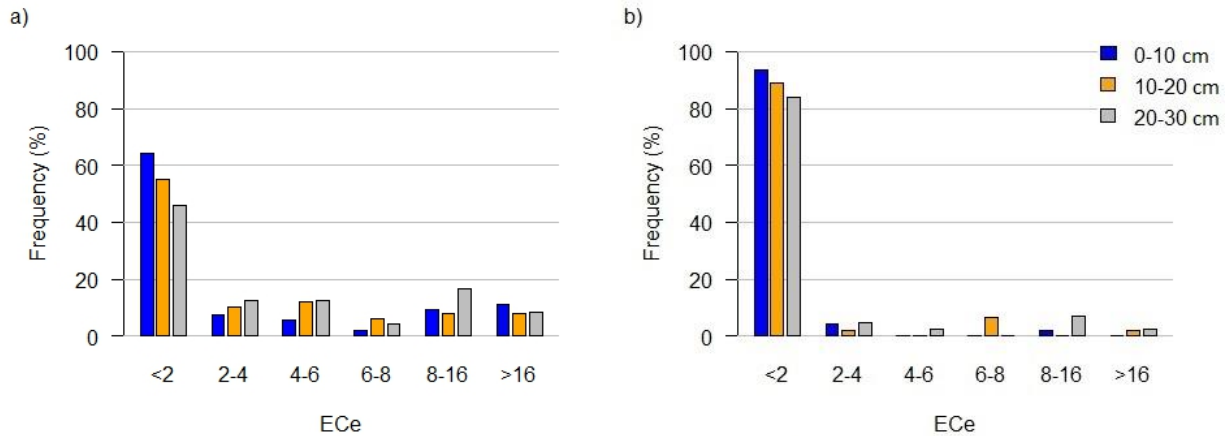


Figure 2. Salinity (electrical conductivity, ECe (dS/m) by depth in a) alluvial and b) non-alluvial areas.

Sodicity (ESP > 6%) was more common on the alluvial soils than the non-alluvial soils. There was a pattern of lower SOC in samples of increasing salinity and sodicity (Figure 3).

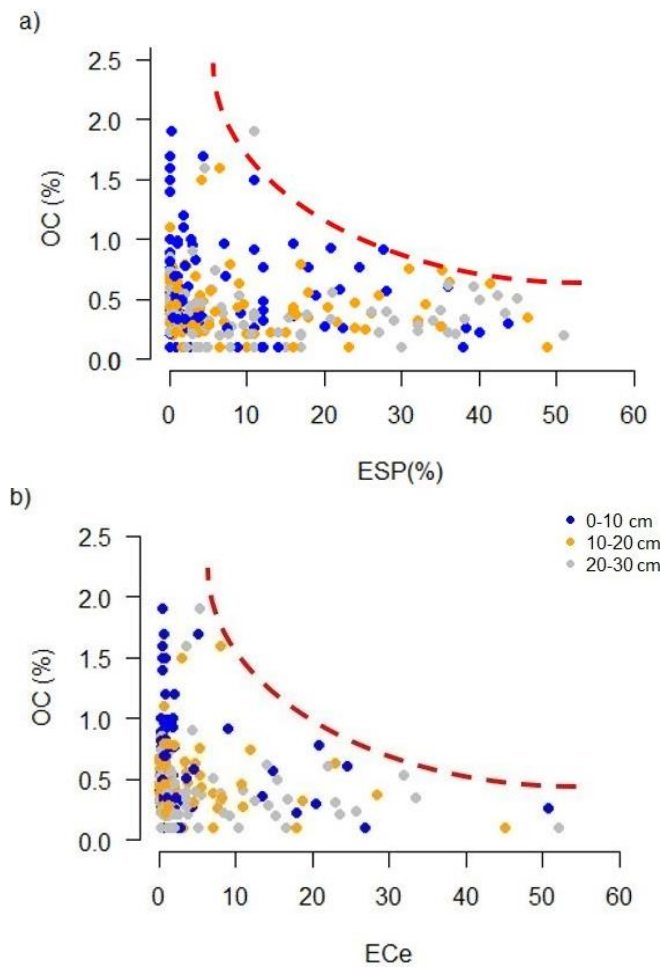


Figure 3. Relationship between soil organic carbon and a) ESP and b) salinity, by depth for all samples.

**Fertility**

The Colwell-P results ranged from below the laboratory’s limit of reporting (LOR; <2 mg/kg) to 160 mg/kg (Figure 4). Colwell-P was higher in the surface than the deeper increments, and the non-alluvial soils had lower Colwell-P than the alluvial sites. In the non-alluvial areas 33% of 0-10 cm samples had Colwell-P <5 mg/kg, and a further 15% <8 mg/kg. At acidic to neutral pH levels the ratio of BSES-P:Colwell-P was between 1:1 and 4:1 (Figure 5), but at pHw >7.5 the ratio increased over 5:1 and up to 24:1 in 34% of 82 samples.

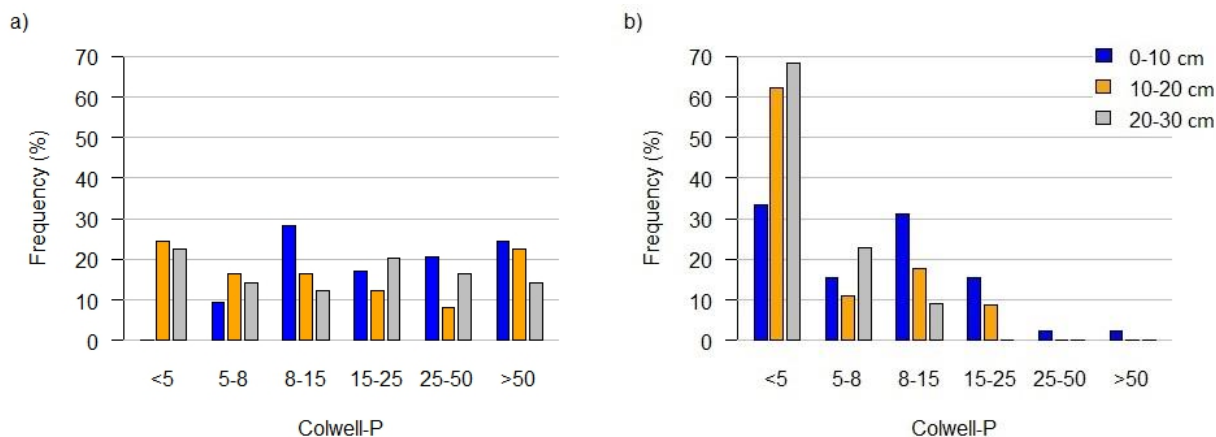


Figure 4. Frequency distribution of Colwell-P (mg/kg) by depth from a) alluvial and b) non-alluvial sites.

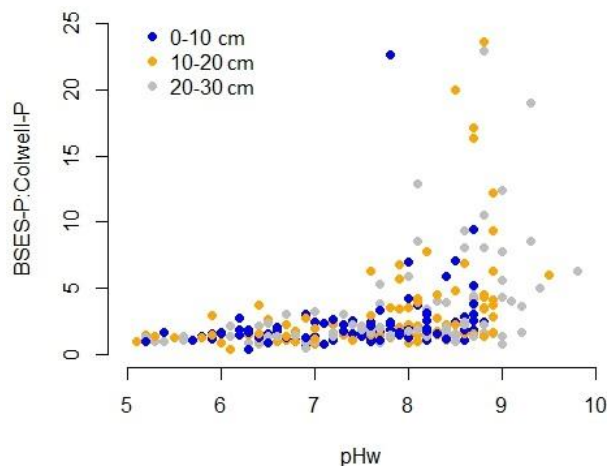


Figure 5. The ratio of BSES-P:Colwell-P v pHw by depth for all samples.

Sulphur levels were low (<5 mg/kg) at 42% of alluvial sites and 82% of non-alluvial sites (Figure 6). At the non-alluvial sites there was generally no substantial store at depth (92% had <10 mg/kg and 72% <5 mg/kg). By comparison, half the alluvial sites with low surface S had >20 mg/kg in the lower depth increments.

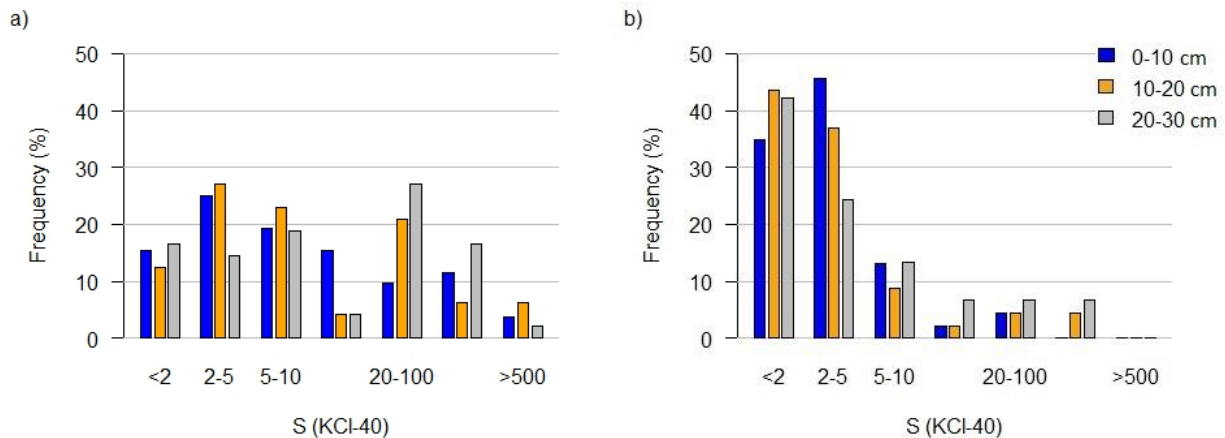


Figure 6. Frequency distribution of sulphur (mg/kg) by depth from a) alluvial and b) non-alluvial sites.

## Discussion

Soil testing is rarely undertaken in the low input, extensive nature of livestock production in the semi-arid rangelands of southern Australia despite soil erosion, sodicity, surface sealing and salinity commonly causing constraints to production. Due to low rainfall, the soils are generally less leached and therefore can have higher pH, salinity, and fertility than high rainfall regions. Conversely, organic matter levels are generally low, which accentuates a range of soil structural and nutrient cycling problems.

This survey highlights the influence that attributes such as geomorphology have on soil properties. For example, soil alkalinity can induce nutrient deficiencies, while acidity found in some non-alluvial soils can restrict root growth and seedling establishment through nutrient imbalances and aluminium toxicity. The difference between pH<sub>w</sub> and pH<sub>Ca</sub> fundamentally reflects the ions in solution (Slattery et al. 1999), and the most saline soils had the closest values. Salinity was a consistent feature of scalded areas, and in marginal areas was observed to vary within metres from high levels on bare ground and low levels under plant cover. Salinity >10 dS/m was common at such sites, and some cases approached double the concentration of seawater.

Low sodicity of the non-alluvial sites was expected as the region (Cobar pediplain, NSW Australia) has little sodicity, while sodium accumulation is common in western alluvial systems (Isbell et al 1997). Sodic soils limit infiltration and root growth, and salinity limits moisture availability to plants. The low SOC with high sodicity and salinity may reflect a restriction to plant growth and accumulation of organic matter. Understanding these patterns highlights the importance of maintaining or building soil organic matter to buffer the impacts of salinity and improve soil structure, and can inform producers of appropriate management options.

Phosphorus was low on many non-alluvial areas characterised by mulga (*Acacia aneura*) and ironbark (*Eucalyptus crebra*) (Jackson et al. 2012). If forage on areas of higher P is not accessible to livestock their nutrition may be deficient (Schatz et al. 2023), even if at sub-clinical levels. Conversely, the 'reserve' of acid-soluble P at high pH represents a bank of fertility for plants that can acidify their rhizosphere (Dinkelaker et al. 1989).

Collecting soil samples from areas of interest allowed participants to link soil properties with production – high or low. This project encouraged producers to monitor soil data to support their decision making. Our

recommendation was to pick key areas that are meaningful for monitoring of soil properties every 3 to 5 years to better understand major climate drivers and longer-term land management improvements and impacts.

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