Saline Bush Foods Project - Developing a Paddock to Plate Supply Chain to Restore Degraded Land, Badgebup WA

Environmental Reporting for Saline Bush Foods Production - Soil, Water and Habitat -

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1. SUMMARY:

1.1. Overview

This Katanning Landcare Saline Bush Foods Project aimed to assess the impact of salt tolerant native plants as a rehabilitative management technique on soil health, soil salinity, and saline ground-waters within an expanding established production farming context. The project has been developed east of Katanning with the aim to utilise degraded saline land for low input food production. The project examined indigenous food plants in the context of production for market within salinity affected degraded farmland within a paddock to plate supply chain. This study considers the production strategies of the Plantation Site, the Wild Harvest Site (with scarification plant management activities), and the greenhouse cultivated plants.

The expectation was that with additional plant growth (in the Plantation Site and Wild Harvest Site scarification was utilised to stimulate growth), the ground water table will be lowered over the period of the study, allowing soil salts to be washed out of the upper soil profile. Such additional plant growth was also expected to contribute organic carbon and nutrient availability within the soil profile, leading in turn to increased soil microbial content, diversity and metabolic function capacity both over time and spatially (under compared to between plants and to non-treatment areas). With the measurement of increased plant material present, an increased variety of habitat and food supplies can be inferred to promote a more diverse associated flora, micro-fauna and macro-fauna above ground with the associated ecosystem benefits and resilience.

The project has been developed by Katanning Landcare (KL) in conjunction with the "Moojepin" broad acre farming enterprise (DW and SE Thompson) (LH). The project has input from the following critical service providers Anthony Mercieca (AM) & Associates, Chatfields Engineering and WAGOGA food marketers, and was funded through the Australian Government National Landcare Program Smart Farming Partnerships (Department of Agriculture, Water and the Environment).

The data within this report provides an ideal basis for tracking the below and above ground ecological benefits of introducing and cultivating saline bush foods. With the limited timeframe of the project and significant disturbance of each site in the early phase of the project, the soil, plant and water monitoring has served to map the recovery process of each system from this disturbance. Such disturbance was required to implement the commercial enterprises, but may be optimised in alternate projects where rehabilitation is more the focus. An additional significant influence on the two field production systems was the delivery of a higher and later rainfall than typical for the region in the winter/spring of 2021. This highlighted the importance of the comparison of the Plantation Site results across the three years of sampling in the absence of a control area (i.e. no representative area excluded from tilling and planting) or post-tilling step change (i.e. sampling immediately post tilling) and of the retention of a designated control (non-scarified) area within the Wild Harvest Site.

1.2. Soil - General Analysis

1.2.1. Plantation Site

The 2019 Plantation Site results defined a baseline for this Site from which future change as a result of the activities associated with both the creating of the Plantation Site and the subsequent plant growth impact itself on the soil and broader ecosystem may be measured. The analysis identified high salinity soil and poor nutrient availability compared to a standard agricultural expectation. Such a finding was replicated in 2020 and 2021 within the Plantation Site data and the Wild Harvest Site data. This highlights the appropriateness of the location for alternate production options from which value can be obtained – i.e. being tailored to these conditions and without exorbitant expense for production ensures the agricultural practice is financially sustainable. 2019 Plantation Site results also highlighted the difference in soil properties across the Plantation Site surveyed and the need within future analysis to not only consider the Plantation Site average, but the temporal variation across each individually sampled plot to establish an accurate representation of change. Limited statistically significant results were observed between 2019 and 2020 results within the Plantation Site.

Within the 2020 Plantation Site data, the electrical conductivity, the exchangeable sodium and the exchangeable sodium as a percentage (ESP) of the effective cation exchange capacity (ECEC), being indicators of salinity, are all higher under the plants rather than between. The dominant cause was considered most likely to be the tilling of the soil brings up the more saline subsoils combined with the plant coverage partially protecting the area from rainfall and hence reducing the soil washing effect. It was not anticipated that for short duration of the trial the impact of salt removal from the soil by the plants would be detectable. Whilst the under plant samples are higher than the between plant samples, these values from the 2020 sampling were well in excess of the 2019 levels. The 2021 data set determined these salinity indicators to have dropped back to towards the 2019 level, suggesting the system is recovering from the initial impact of soil inversion and is establishing a new trajectory. If it assumed that the 2020 to 2021 trajectory best represents the recovery of the Plantation Site system, then this snapshot indicates:

- Increasing **2020 to 2021**, total data set – total nitrogen %, exchangeable calcium, exchangeable aluminium, calcium %, aluminium %, hydrogen %, Manganese and Copper
- Decreasing **2020 to 2021**, total data set – Electrical Conductivity, sulfur, exchangeable sodium, and sodium %.
- The Total Nitrogen, aluminium (exchangeable and total %), and calcium % increasing results were replicated both under and between plants.

Absent from this list was the total carbon behaviour within the Plantation Site. By the conclusion of the project, the total carbon within the Plantation Site had been generally re-established following the degradation incurred in the preparation for planting process. Future carbon behaviour is anticipated to continue this increasing trajectory, should the impact of the water logging on plant survival rates within 2021 not be too severe. Salt bush harvesting, excluding the incident of compaction as a risk of increased traffic within the area, should serve to promote soil carbon through regular shedding of root systems as the plant foliage is reduced and the promotion of new root systems during regrowth. Soil coverage within the Plantation Site bodes well for the preservation and growth of the soil flora and fauna community, further increasing both the carbon and the system's resilience to extreme events impacting plant and soil health. The 2021 total nitrogen within the Plantation Site demonstrated a similar trend to the carbon, with the 2021 data sets all higher than those from 2020 and approaching the 2019 original levels. Such information highlights the importance of minimum tillage and keeping soil coverage in place to minimize the impact of the topsoil's (and its ecosystems) exposure to diurnal and seasonal weather extremes and the potential for erosion.

1.2.2. Wild Harvest Site

The Wild Harvest Site had typically a lower available and total soil nutrient content than the Plantation Site. Throughout the analysis of the Wild Harvest Site data there was the consistent presentation of higher exchangeable sodium and effective cation exchange capacity within the scarified compared to non-scarified areas. Within the 0-10cm sample depth total data set, the exchangeable sodium and sodium - ESP %, key salinity indicators, were higher between the plants in the 2021 results. For the under plant subset, the 0-10cm depth the electrical conductivity, exchangeable magnesium, exchangeable sodium, and the effective cation exchange capacity were all higher within the scarified area. The higher exchangeable sodium and the effective cation exchange capacity in the scarified compared to non-scarified area was replicated in the 10-30cm depth. Within the 2021 sampling regime there was also a statistically significant difference identified (a) between the electrical conductivity of the scarified and non-scarified soil samples taken from the shallow depth soil under plants; and (b) both in the 0-10cm depth and the 10-30cm depth, there was a significantly higher conductivity identified between the plants as opposed to under them.

The rise in electrical conductivity, effective cation exchange capacity and exchangeable sodium of the soil sampled occurring between 2020 and 2021 was steeper within the scarified area as compared to the non-scarified. Whilst the electrical conductivity, exchangeable sodium and cation exchange capacity was higher in soil sampled from between the plants to under them, the change in these values from 2020 to 2021 was a consistent significant rise for both locations. All results, irrespective of depth, plant proximity or scarification indicated elevated salinity compared to the laboratory recommended guideline.

Within the Wild Harvest Site, the under plant total carbon was higher than the between plant for the shallow soil depth in the non-scarified area in 2020, highlighting the benefit of root systems in promoting and protecting soil flora and fauna (represented by carbon measurement). This indicates that the plant coverage was developing and protecting carbon stores pre-scarification. For the 2021 samples, where no significant statistical difference was determined between the scarified and non-scarified samples, it suggests that with coverage the system is recovering. However it is noted that for the non-scarified area, a higher carbon content was identified under the plants compared to between in 2021 suggesting that the more plants that are available in the long term, the higher the system's total carbon. However, the scarified area had minimal plants compared to the non-scarified area due to the scarification process suggesting a far lower average mass of soil carbon per unit area. The bush layer as opposed to the current, fine leaved ground cover / individual small plants is anticipated to take many years to return to pre-scarification levels.

1.3.Soil - DNA Analysis

1.3.1. Plantation Site

Analysis of the soil bacteria diversity was assessed at the Plantation Site, with samples grouped across all plots in two factors 1) under or between the saltbush (i.e. sample location), 2) at two soil depths (i.e. 0-10cm, 10 to 30cm - soil depth). Alpha diversity (the mean diversity of species in different sites or habitats within a local scale) was calculated using common indices such as OTU richness (the number of species detected), Fisher (which takes into account of richness and number of individuals), inverse Simpson (weighted proportional abundance), and evenness (how close in numbers each species in an environment is). Alpha diversity was not impacted by sample location, though the soil displayed a slight increase with increased depth for species richness (e.g. the total number of species) and Fisher (which includes Richness and distribution of species) for 2020. This phenomena is common for duplex soils where clay is in higher content at depth. Interestingly, the results were opposite for 2021, with soil depth having no impact to alpha diversity indices, though there were increases in diversity for samples extracted directly underneath relative to between the saltbush plants. This can be attributed to either increased diversity of plant species (e.g. saltbush, encroaching adjacent field species and other plants), and/or the secondary succession (albeit human induced, Cline & Zak, 2015) of the Plantation Site.

Beta diversity (a measure of similarity or dissimilarity of two communities) showed differences of community composition within sample location (under Vs between) and soil depth (0 to 10 Vs 10 to 30cm) at both years 2020 and 2021, though no difference over the sampling period. Phylum level (broad scale) relative abundance for 2020 showed no changes, though 2021 displayed increases in Actinobacteria, Firmicutes and Proteobacteria in the 0 to 10cm soil profile, which is common in managed agroecosystems (Dai et al., 2018). An opposite trend for Acidobacteria occurred, though this phyla was observed at relatively low amounts or abundance.

For 2020, detection of carbon cycling genes via an in-silico approach (PICRUSt) displayed no changes under or between saltbush. However there was a single change with increases in Catalase within the 0 to 10cm soil profile, which represents a potential for these bacteria to mineralise harder carbon compounds (e.g. lignin). This trend (increasing lignin degrading potential) was again observed for 2021, with some additional trends. For example in 2021 there were increases in beta-galactosidase (easily available carbon) in the 0 to 10 cm soil profile irrespective of sample location (under or between plants), however the trend for beta-glucosidase degrading capacity (e.g. ability degrade plant or microbe derived cellulose) was increased under the plants, for both soil profiles which is likely to be in relation to increased Nitrogen availability. Plantation Site (2020) nitrogen cycling was greater at soil depth 10 to 30cm for N fixation, and both nitrification (amoB, HaO), though this was not impacted by sample location (under or between plants). Minor changes to N cycling potential were observed in 2021, with increases in N fixation (nifD) at the deeper soil depth 10 to 30cm, and a decrease in denitrification (nirK) from the shallow to deeper soil profile. Nitrogen cycling potential was not impacted by sample location (under or between plants).

In summary, all of these changes to the soil microbiology as impacted by the saltbush plants indicate minor positive improvements to the new Plantation Site between 2020 and 2021, likely driven by the increased plant biomass above ground impacting both soil depths, with greater enhancement directly under individual saltbush plants as a function of time. However, due to the sampling time of 2021 being a water soaked environment it is possible some of these results may be driven by excess quantities of water, which can change the diversity of soil bacteria and may skew the 2021 microbial data set.

1.3.2. Wild Harvest Site

From the soil bacteria diversity profiling via DNA sequencing, with subsequent analysis of functional genes relating to carbon and nitrogen cycling processes, indicate little or minor differences to these soil biological processes when examined under and between the plants in the 2020 sampling regime. Wild Harvest Site also displayed only minor changes in 2020 caused by farm management practices (i.e. scarification) or sampling location (under, between plants), with even less change in soil carbon and nitrogen cycling processes. During 2021 alpha diversity calculators showed no major alterations for the impact of soil scarification in the 0 to 10 cm soil profile, though the deeper soil profile (10 to 30 cm) saw a reduction in alpha diversity indices (Fisher, Richness, Inverse Simpson) for the soil bacteria between plants, indicating plant species above ground impacting the deeper soils have a positive impact on soil bacteria diversity. Additionally, there was no impact of scarification or not on soil alpha diversity indices at the deeper soil profile (10 to 30cm), this indicates no negative impact of soil disturbance (scarification management practice) at greater depths to alpha diversity.

Phylum level relative abundance in the samples extracted in 2020 within the top soil profile (0 to 10cm) displayed some influences related to the soil disturbance (i.e. scarification or not) with dynamic impacts of scarification on Actinobacteria for both sample locations (under or between plants), and also sampling time (2020 - increasing with scarification, and 2021 - decreasing with scarification). This increase in Actinobacteria is likely to be driven by greater exposure of organic matter for the first sampling time (2020) as this key phyla plays fundamental roles in organic matter decomposition, and also water availability. Subsequent decreases for Actinobacteria 2021 may be due to the system stabilising. Sample location for 2020 also had an influence for less prominent major groups (Chloroflexi, Bacteroidetes), though these bacteria were less dominant and influential.

Within the deeper soil profile (10 to 30cm) during 2020 there were also observed increases in Actinobacteria with soil disturbance (i.e. scarification). During the 2021 sampling time for the deeper soil profile (10 to 30cm) there was no significant impact of sampling location, or scarification at the phylum level relative abundance, this could be due to large variation in the sequencing data, which could have been driven by enhance water availability of the site conditions. Using broad scale community changes at species level (e.g. analysis via a NMDS), there were distinct clustering of soil bacteria species level communities within the 0 to 10 cm soil profile for the sampling location of between and under the saltbush plants, though scarification had no impact of community structure, however at the deeper soil profile (10 to 30cm) the species level communities were similar for both scarification, and between and under the salt bush plants.

Analysis of the species level community assemblage during 2020 (within the 0 to 10cm profile) shared similarities to the sampling time of 2021. With the following exception that during the 2021 period the scarification and an interaction between scarification and sampling location occurred (Figure 4.5.4). However, at the deeper soil profile (10 to 30cm) there were no detected changes to sampling location (between or under plants), though scarification as a treatment showed a distinct community composition compared to the unscarified area.

The predicted (2020) carbon cycling capacity of soil bacteria for the shallow soil profile (0 to 10cm) was not impacted by soil disturbance (i.e. scarification) though did increase most carbon cycling genes for sample location under the plant. Within the deeper soil (10 to 30cm) there were also no major changes to predicted carbon cycling capacity for either sample location or scarification treatment. However, there were more carbon cycling alterations during the 2021 sampling period, though this was only observed for some C cycling genes comparing under and between plants, with no impact for soil scarification at both depths. For the shallow soil profile (0 to 10cm) there was a net reduction in easily digestible carbon cycling capacity starch through minor increases in glucoamylase for the sampling location under the plant. A similar trend of reduction of hemicellulose (endoglucanase) for the same treatment (0 to 10cm, under plant). There was an increase observed for predicted carbon cycling in the bacteria able to degrade cellulose through increasing betaglucosidase. Whilst there was increasing potential carbon cycling capacity in the soil, these alterations were not impacted by scarification and were only minor fluctuations, and therefore should be viewed as having little overall impact to soil biological processes. A minor impact for soil carbon cycling process occurred at the deeper soil profile (10 to 30cm) within the sample location in relation the plants. Indeed, only one significant result was observed at this depth and it was an increase in the ability to degrade more recalcitrant carbon (e.g. lignin). There was no impact at to any other carbon cycling potential, and the impact of the land management practice of scarification showed little effect.

Predicted nitrogen cycling capacity was marginally impacted for both 2020 and 2021 for sample location with inconclusive results with denitrification (narG, nirK) showing both increases and decreases for sample location for both under and between plant location. Overall, there appears to be no adverse impact over the sampling time period to soil scarification. The full suite of nitrogen cycling capacity was observed, and is indicative of a perfectly functional soil able to perform all levels of nitrogen cycling.

1.4. Plant - Comparative Growth / Habitat Parameters

The mean plant coverage for the Plantation Site increased from 70% coverage/non-bare soil in 2020 to 87% in 2021. It was noted that the plant coverage was estimated at 0% at the completion of the Plantation Site preparation and 10-20% at the completion of the initial planting. No analysis was performed prior to the preparation and so the overall impact on the ecosystem cannot be determined. In 2020, the Non-Scarified plots in the Wild Harvest Site had greater coverage than the scarified (76% and 64% for Non-Scar Plot 1 and 2 respectively compared to 24% for the Scarified). After a further year’s growth, the soil coverage within the scarified versus individual non-scarified plots were no longer significantly different, however the combined non-scarified areas combined did demonstrate a higher coverage (78% versus 64%). In the comparison of the 2021 data, the Plantation Site had a higher plant coverage than that identified in the Wild Harvest Site (87% compared to 74% respectively). It was noted that the examination of coverage does not take into account the quality/longevity/height of coverage which must also be considered in the defining of environmental benefit and habitat/micro-climate creation. The mean tree height for the Plantation Site increased from 76cm in 2020 to 124cm in 2021. Whilst this was not surprising over that period, it indicated that even with harvesting occurring at various times in between the two sampling regimes, a generally larger vertical habitat was evident in 2021 than in previous years. With both a greater soil coverage and tree height, the increase in the habitat available which was visually evident has been reinforced through an objective analysis.

Not surprisingly, in the 2020 analysis (4 months post scarification), the plant heights recorded for the Non-Scarified areas were approximately double that identified within the limited number of plants in the Scarified area (51cm and 25cm height respectively). A similar relative presentation was recorded for 2021 (63cm Non-Scarified and 28cm for the Scarified areas). Plant height considered in conjunction with soil coverage demonstrates the significance of the increase in habitat compared to immediately post Plantation Site preparation or Wild Harvest Site scarification.

1.5. Specific Salinity Parameters

The outcome of this study has highlighted the conflicting interest within the short term of a saltbush regenerative program coupled with a saltbush harvesting program on ecological systems. It was apparent that the detrimental impact on the soil itself as a result of the preparation of the Plantation Site (broad area tilling and full landscape exposure rather than rehabilitation style individual plant holes) had not been fully recovered by the conclusion of the trial, where soil health is measured in terms of soil carbon. When considering the salinity indicators, the electrical conductivity and sodium content of the 2021 analysed soils both under and between the plants was approximately equivalent to the 2019. In the longer term however it is anticipated that salinity indicators will reduce and, should light harvesting is continued, the soil carbon and available mineral content as well as the above ground coverage and vertical habitat creation will increase. In turn, this increase will provide ecological and environmental benefits potentially in excess of what was present prior to the project (note: pre-project measurements were not taken within the Plantation Site). However it is noted that in the Plantation Site where water logging, due to unusually consistent winter rains, hampered the growth of the bushes in 2021 and where heavy pruning was subsequently implemented, this benefit was likely significantly set back.

Within the Wild Harvest Site, the trial of scarification to enhance bush food plant growth demonstrated that, again in the short term and under the weather conditions of the project period, the ecological cost was significant with exposed soil subject to weathering and micro climate / habitat removal. This impact was marked by an overall increase in the 2020 to the 2021 samples for electrical conductivity (1:5 water) for the total data set which was dominated by the change in the scarified data set (0.79dS/m to 1.03dS/m and 0.78dS/m to 1.4dS/m respectively). The effective cation exchange capacity (reflected in the exchangeable sodium content) as a salinity indicator also demonstrated a rise from 2020 to 2021 within both the under and between locations of the scarified area, whilst the non-scarified remained relatively consistent. The sodium content as a percentage (ESP) of the effective cation exchange capacity (ECEC) was lowest under plants, in the non-scarified soils and within the 0-10cm depth. With the larger area scarified and with the majority of plants within this area removed, the average salinity within the Wild Harvest Site has been significantly increased and the habitat markedly depleted within the short to medium term.

Contents

2. INTRODUCTION

This document provides a summary of the research findings for the environmental monitoring scope within the Project titled "Saline Bush Foods – Developing a Paddock to Plate Supply Chain to Restore Degraded Land, Badgebup WA" (the Project). The document captures the research methodology and results from the late winter/spring 2019, 2020 and 2021 Plantation and Wild Harvest Site soil base-line and progressive soil sample analysis.

2.1. Project Description

The Project brought together Katanning Landcare, and the 'Moojepin' broadacre farming enterprise (DW & SE Thompson) in a unique partnership, with skilled key delivery partners – AM & Associates horticulturalist, Chatfields Engineering and WAGOGA food marketers - to create a cultivated supply chain of saline bush foods for the fine food market.

By creating a complete paddock to plate agricultural supply chain based on native saline bush foods, this Project created opportunities to simultaneously improve degraded soils, restore native vegetation and increase agricultural productivity.

The Project encompassed production within an in-paddock growing (Wild Harvest and Plantation) and irrigated shade-house techniques for bush food species including saltbush (A. nummilaria), ice-plant (Mesembryanthemum spp.), pig-face (Carpobrotus spp) and samphire (Tecticornia indica, T. lepidoptera, Sarcornia quinqueflora).

Harvesting equipment was designed and built, a packing facility created to improve product handling and quality, and people were formally trained in horticultural production. Market awareness and customer bases were expanded, and a training package developed and delivered to support broadacre and other organisations/enterprises to enter into the supply chain.

The project was funded through the Australian Government's National Landcare Program "Smart Farming Partnerships". The project commenced in spring 2018, and was completed in autumn 2022.

(Adapted from Request for Research Services – Katanning LCDC, 2019)

2.2. Scope Specific Project Objectives

1. To monitor the influence of a saltbush regenerative and harvesting program. A naturally vegetated (mixed species) scarification program within a degraded landscape on soil health, plant productivity, ground water quality, and the carbon and nitrogen cycling processes.
2. To comment on the observed soil, plant and groundwater characteristics over the life of the project in relation to improvements in productivity, profitability and natural resource condition opportunities for Australian farmers through such programs as the development of a bush food paddock to plate supply chain.

2.3. Environmental Impact Specific Project Outcome

1. Scientific monitoring of the impact of constructing suitable growing systems on the natural resources within saline affected areas. The expectation was that growing bush foods on degraded saline land and using salinized groundwater will influence soil carbon and alter soil microbial processes, reduce erosion, lower water tables and improve habitat availability compared to 'doing nothing'. If beneficial, a bush food industry could be expanded to degraded land right across the agricultural landscape and create wide-spread improvement in environmental condition within an economically viable and productive context.

2.4. Project Impact Questions

2.4.1. Relevant Environmental Impact Questions

Primary Question 1: What are the impacts of the three different in-soil growth systems (Plantation, old Wild Harvest, refreshed Wild Harvest) on soil health, erosion, compaction, and root biomass & growth?

- To be measured within soil laboratory analysis and through site photography.

Primary Question 2: Can the bush food production system help to slow or stop the spread of salinity? Are the salinity levels in the water and soil consistent over time, are they fluctuating seasonally and/or are they reducing to a measurable extent as expected (either in total or within the seasonal fluctuation)?

- To be measured with hand held field EC analysis (observation well ground water), in greenhouse water exchange monitoring (reported within the Greenhouse Scope), and in soil laboratory analysis.

Other Questions:

Are the activities having an impact on the water table? Can this be quantified within the timeframe of the project due to the size of the re-vegetation area, the immaturity of the plants within this timeframe, the potential for annual rainfall differences, and the impact two years post-scarification on the Wild Harvest's productivity to influence the water table? *(Note: A related question of "What scale would be required to make an impact on the water table?" was considered beyond the reasonable scope of the research project and so has been appropriately omitted.)*

- To be measured within observation wells.

Does extraction of groundwater increase after harvest and with the growth of new shoots? Can this be quantified within the greenhouse aspect of the project through a direct water uptake assessment?

- To be measured within observation wells within greenhouse experiment (monitored flow rate requirements and inlet water quality within greenhouse - reported within the Greenhouse Scope). Acknowledged inferred results for Plantation Site only due to short project monitoring timeframe.

Does the in-ground production and harvest encourage the regeneration of other desirable (environmentally or productively) plants?

- To be measured through site photography of soil coverage.

Note: whilst the greenhouse experiment is not within the scope of the environmental monitoring scope, valuable insights were anticipated to be somewhat indicative of field based plant characteristics and hence the inclusion a selection of this data within this scope for comparison.

2.4.2. Relevant Production Impact Questions

What are the available nutrients in the groundwater, and which of these are being taken up by the plants?

- Not within environmental science scope, but interesting input to field understanding.
- To be measured within greenhouse experiment.

3. SAMPLING AND ANALYSIS METHOD

3.1. Method Overview

The project tested three different growth strategies located as per Figure 3.1.1:

1. Mass planting (Plantation Site) at site:
   The mass planting site comprised part of the upper portion of a saline drainage between two broadacre cropping fields on the farming property. The planting site is “salt scalded” bare area that is lens shaped and approximately 200m long x 80m wide straddling a small indistinct drainage and which was planted with the selected test species of edible native crops in 2019. This crop was a pseudo-monoculture of saltbush planted in rows with a variety of other species planted less systematically or allowed to self-propagate opportunistically.
2. Wild harvest from existent plants in a similar drainage:
   A lower lying saline drainage area with existing native halophytes that have been previously used for Wild Harvests (ice-plant, samphire, pigface), was scarified using a tractor mounted wide spaced scarifying rake to promote new growth. This scarification was conducted with a shallow plough which acted to mix the topsoil and “prune” (break) the plants. This was undertaken in mid-2020 and effectively removed the majority of the above ground and shallow plant based carbon from the location. Limited plants remained. Areas were left non-scarified to serve as control locations to enable season specific comparable samples to be taken. Samples were taken within the same seasonal window as the Plantation Site sampling (Note: a 2 month delay occurred in 2021 due to site accessibility).
3. Greenhouse planting irrigated by saline ground water:
   A greenhouse was constructed and fitted out. This was utilised to grow potted and irrigated crops. The irrigation water was sourced from saline groundwater via a production bore located adjacent to the Plantation Site.
   Note: whilst the greenhouse experiment was not within the scope of the environmental monitoring scope, insights were recorded as somewhat indicative of field based plant characteristics and hence the inclusion of some data within this report.

This assessment focused most particularly on the observable impacts on: (Supply Contract – Katanning LCDC)

- Soil health – i.e. microbial activity, biomass, salinity, nutrient availability.
- Groundwater – i.e. salinity variation, potential plant salinity extraction, depth.
- Plant behaviour – i.e. soil coverage, plant profile, defining habitat creation.

Figure 3.1.1: Project Experimental Area Map
("Moojepin" broad acre farming enterprise, Badgebup, WA)

The potential for a discernible change within the timeframe of the project was monitored across the Plantation Site both under (Plantation Site tree impacted / rhizosphere) and between (control / traffic zone / not within Plantation Site tree rhizosphere) the plants for the 2020 and 2021 growing seasons. The results were examined in comparison to (a) a control sample set taken in 2019 at the time the Plantation Site was established and (b) the samples taken from between the planting rows for the purpose of evaluating the transformative effects of plant roots on the soil. It was noted that the process of the Plantation Site preparation will have caused significant impact on the soil through tilling and traffic changes across the site. No representative control / non-disturbance area was retained within the Plantation Site itself for comparative purposes. The trajectory of change in soil parameters was considered within the analysis to investigate the relative influence of this site preparation impact versus that of the Plantation Site flora itself. Soil parameter change over time was examined throughout the Wild Harvest Site by examining both under and between soils for the plants both the scarified (where plants remained) and non-scarified (control) soil areas for the 2020 and 2021 growing seasons.

Soil health was assessed broadly through the examination of soil C, N and other nutrient availability. The finer definition of soil health was demonstrated through the use of DNA molecular techniques, and evaluation of microbial community structure and composition, biomass, and metabolic function with respect to C and N cycling using predictive metagenomics software from 16s rRNA sequencing.

<u>Key Indicators:</u>

A. Soil health, by measuring any changes for each growth system over project time frame:
    - Soil total C and N, organic carbon content and other basic nutrients.
    - Microbial abundance, diversity, community composition and function.
    - Visual evidence of soil health (coverage with plants, erosion, water repellence.
B. Salinity changes over time (if measureable within project time frame):
    - Soil salinity changes (single season per year).
    - Soil water/water table salinity and quality changes (observation well, monthly).
    - Water tables level (observation well, monthly).
C. Plant survival and productivity (yield)
    - Plant production - shoot (height of plants), and root mass (inferred from soil coverage) - of each of 2 different growth systems Plantation and Wild Harvest.
D. Habitat availability : (inferred from other information gathered)
    - Height of planted plants in transect and soil coverage.
    - Soil microbial abundance and diversity.

3.2. Soil Sampling and Analysis Strategy

3.2.1. Plantation Site

Within the Plantation Site, the area was sampled immediately prior to planting in 2019, and at the 12 (2020) and 24 (2021) month time steps post planting. For this sampling, 4 regularly placed 12.5x12.5m plots were used with 6 samples taken using set volume cores at randomly selected locations within the plots (in line with standard soil carbon sampling procedures in Australia). This sampling provided a temporal control/base line for the future planting (Figure 3.2.1.1).

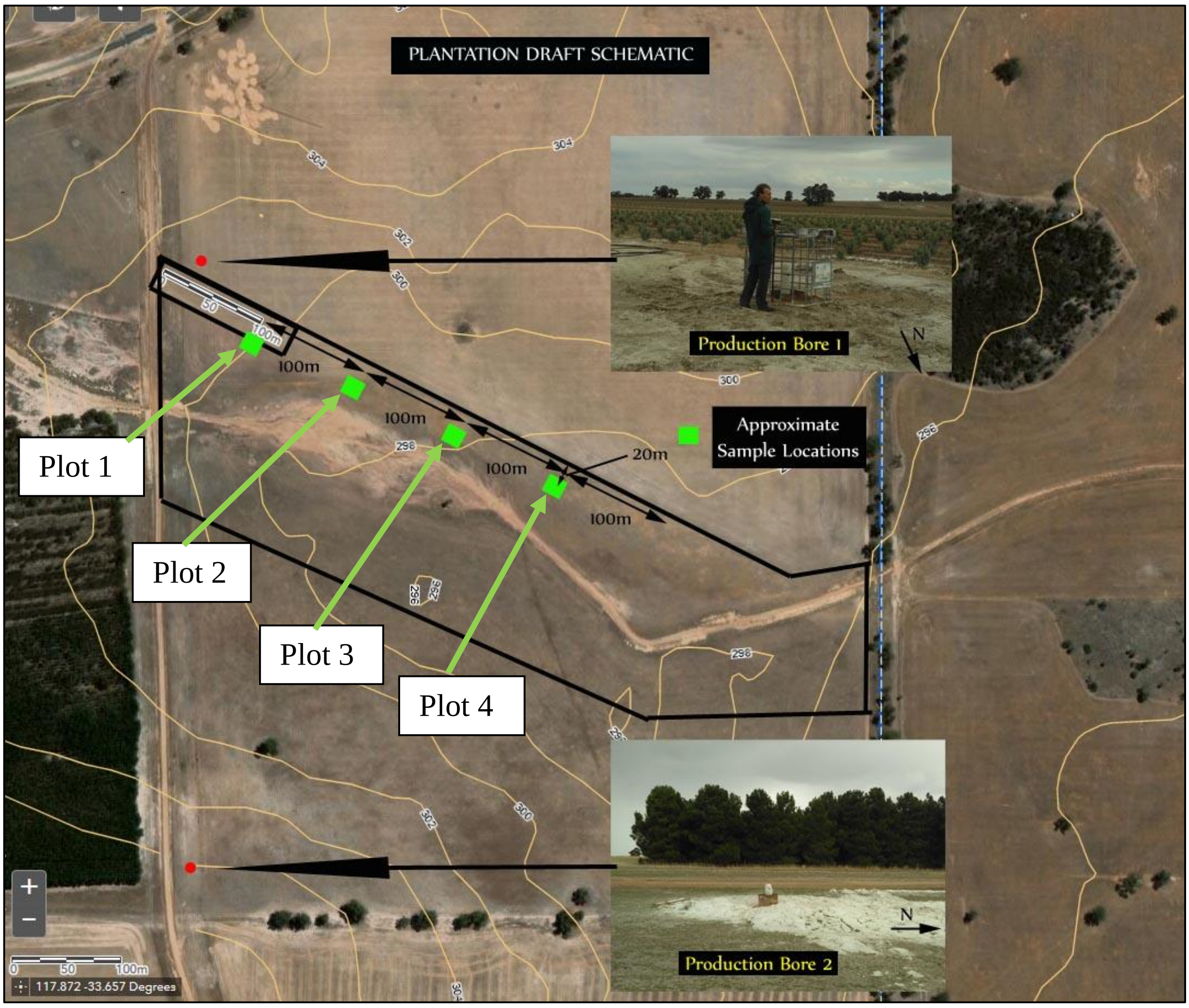


Figure 3.2.1.1: Plantation Site: Area Map with Production Wells and Sample Plots

Two tiers of analysis were conducted (soil chemical and physical analysis):

- Detailed analysis – (2 of 5 samples per plot, 0-10cm and 10-30cm samples, 16 samples total)
    - pH and EC (1:5 water);
    - Available Calcium, Magnesium, Potassium, Ammonium, Nitrate, Phosphate, Sulfur;
    - Exchangeable Sodium, Potassium, Calcium, Magnesium, Hydrogen, Aluminium;
    - Effective Cation Exchange Capacity;
    - Plant Available and Exchangeable Phosphorus;
    - Available Micronutrients Zinc, Manganese, Iron, Copper, Boron, Silicon;
    - Total Carbon (TC), Total Nitrogen (TN), Organic Matter, TC/TN Ratio;

- Limited analysis – (3 of 5 samples per plot, 0-10cm samples, 12 samples total)

  As per the above with the exclusion of:
    - Available Calcium, Magnesium, Potassium, Ammonium, Nitrate, Phosphate, Sulfur;
    - Plant Exchangeable Phosphorus;
    - Available Micronutrients Zinc, Manganese, Iron, Copper, Boron, Silicon.

A tabular summary of the soil sampling strategy and analysis is presented in Section 7, Appendix 1.

For information on the importance and function of the Macro and Micro nutrients see Section 8.4, Appendix 1.

For the 2020 and 2021 growing season, the selection of sample locations within the Plantation Site was conducted as per 2019. This consistency was essential due to the soil variations identified within the 2019 soil analysis. I.e. For this sampling, the 4 plots were used with 3 paired sets of samples taken from each using set volume cores. i.e. 3 samples taken from randomly selected locations across each grid in positions under the plants (“under-plant” soil) and a further 3 samples taken from between the plants (“between-plant” soil). The latter sample set provided an ongoing spatial control to quantify the seasonal impacts on soil characteristics albeit with some additional impact incurred due to the inter-row traffic. Samples were taken at 0-10cm and 10-30cm depth intervals from the same penetration.

Whilst the same location of plots were sampled for the 2019, 2020 and 2021 sampling to maintain similar comparable composite soil types, the under and between bush locations were varied between 2020 and 2021 to avoid prior sampling influencing future results.

Again two tiers of analysis were conducted (soil chemical, physical and biological analysis):

- Detailed analysis – (1 of 3 samples per plot under plant and 1 of 3 samples per plot between plants, 0-10cm and 10-30cm samples, 16 samples total)
  - As per the 2019 analysis (soil chemical and physical analysis).
  - Plus the use of DNA molecular techniques to evaluate community structure and composition, biomass, and metabolic function with respect to C and N cycling:
    - Bacterial and archaeal molecular sampling comprised of DNA extraction and amplification of 16S rRNA using barcoded primers 341/ 806 (Mori et al., 2013) with standard amplification conditions (as Whitely et al., 2012).
    - DNA Sequencing was by Illumina MiSeq for a 300 bp amplicon read length.
- Focused analysis – (2 of 3 samples per plot under plant and 2 of 3 samples per plot between plants, 0-10cm samples, 16 samples total):
  - As per the 2019 analysis (soil chemical and physical analysis).
  - Plus the above DNA molecular analysis for reduced sample set.

The potential for limited change to be observed from 2019 to 2020 within the Plantation Site both over that time and relatively between and under the plants led to a subset of sample analyses to be completed in 2020. However a full set of analysis was completed in 2021. Owing to no 2019 data being available for the DNA analysis comparison, a full set of Plantation Site samples were extracted and analysed to ensure the establishment a base line for change was possible from 2020 to 2021 and to enable a comparison for the Wild Harvest Site data where appropriate.

Thus the soils sampled in 2019 as well as the ongoing sampling from between the plants acted as the control comparison for the under plant / treatment locations. This enabled the identification of the direction and early rate of change of characteristics within the soils specific to the Plantation Site preparation activity and the impact of plants in situ through the exclusion of seasonal influences. However it is noted that the influence of traffic could not be excluded.

Additional opportunistic soil sample analysis have been completed adjacent to the Plantation Site with analysis of the Production Bore 2 excavation interim depth soil samples. 10 samples were assessed for pH and electrical conductivity (1:5 water), with a subset of 4 samples also analysed for exchangeable calcium, magnesium, potassium and sodium (with the resultant calculation effective cation exchange capacity (ECEC) provided); and a soil texture analysis. The excavated soil samples from Production Bore 1 were significantly impacted (displaced) by drilling fluids and therefore were considered contaminated.

3.2.2. Wild Harvest Site

No samples were extracted from within the Wild Harvest Site in 2019. In autumn 2020 ground scarification of the area was completed with pre-determined areas omitted to act as controls. For the 2020 and 2021 growing season, the selection of sample locations within the Wild Harvest Site was conducted using randomly placed transects across the total area. For this sampling, 10 randomly placed transects were used for both the treatment (ground scarification) and the control (non-scarified) areas, and samples were taken from positions along these transects (i) under the plants ("under plant" soil) in each of the scarified and non-scarified / control locations), and (ii) further samples taken between the plants ("between plant" soil) in each of the scarified and non-scarified / control locations. Photographs were also taken of the transects for the purpose of deferred plant coverage assessments. See Figure 3.2.2.1 for layout.

Note: The scarification process in mid-2020 effectively removed the majority of the above ground and shallow soil plant based material, as such limited discernible under and between plant samples were available. Whilst under and between samples were extracted to the best of the sampling team's ability, the risk was acknowledged that this sampling regimen mismatched these samples for the between plant samples due to the recent removal of the majority of the plants.

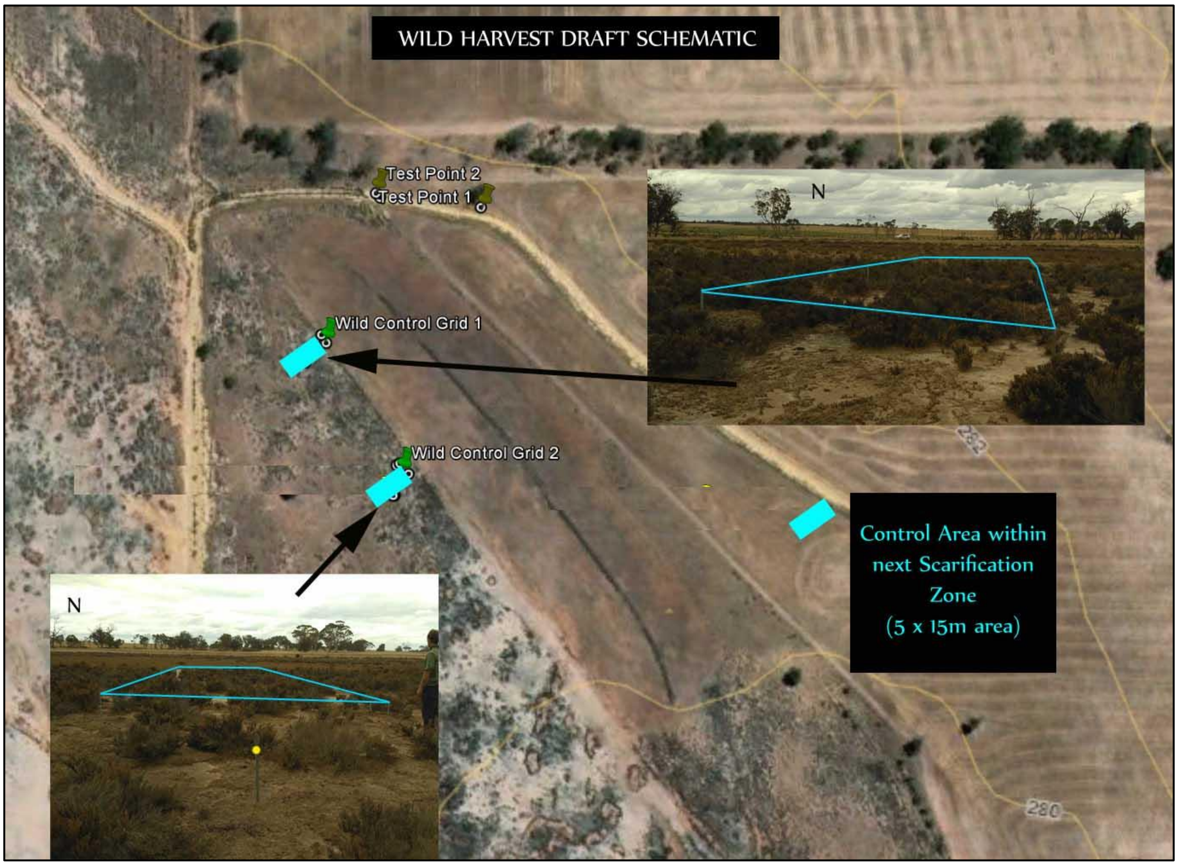


Figure 3.2.2.1: Wild Harvest Site: Area Map with Scarification Control Areas Indicated.

The 2020 and 2021 sample set combination provided (a) long term / steady state / control under plant soil characteristics (non-scarified under plant), (b) long term / steady state / control proximal plant soil characteristics (non-scarified between plant), (c) short term impact of scarification on under plant soil and (d) short term impact of scarification on between plant soil. Samples were taken for 0-10cm and 10-30cm depths.

Again two tiers of analysis were conducted*:

- Detailed analysis – (0-10cm and 10-30cm samples, 5 samples combined to produce single composite per transect, for 4 plots/transects, for under and between plants and for scarified and non-scarified, 32 samples total):
    - As per the 2019 Plantation Site analysis (soil chemical and physical analysis), plus the use of DNA molecular techniques to evaluate community structure and composition, biomass, and metabolic function with respect to C and N cycling.
- Focused analysis – (0-10cm samples, 5 samples combined to produce single composite per plot/transect, for 6 plots/transects, for under and between plants and for scarified and non-scarified, 24 samples total):
    - As per the 2019 Plantation Site analysis (soil chemical and physical analysis), plus the use of DNA molecular techniques to evaluate community structure and composition, biomass, and metabolic function with respect to C and N cycling.

The analysis of these soil's characteristics enables the comparison of the between plant samples from the Wild Harvest Site control with those of the Plantation Site to consider the long term effect of plant proximity. Additional comparisons regarding the under plant direction of soil characteristic change are possible within the Plantation Site when compared to that within the Wild Harvest Site.

3.3. Plant Sampling and Analysis Strategy

3.3.1. Plantation Site

Plant health was assessed in 2021 through plant productivity in the form of:

- Example plant size (height and width),
- Sample plot area coverage, and
- Plant profile within plots for habitat consideration.
- Plant material composition

Note: Weight/quality of Plantation Site harvest was not recorded in a manner to enable a comparative assessment with soil sampling. Lower product demand resulting from COVID-19 resulted in no harvesting from the Wild Harvest Site. Thus this aspect of the project has been omitted within the analysis.

Randomly selected plant heights were measured in 2021. These measurements were completed through photographs taken with a perspective tool in situ. It was noted that the impact of harvest and potential for non-uniform harvesting occurring for the different productivity plants may have impacted the validity of these measurements. Where this was suspected, those plants were omitted. However replication of the photographs with the plants provided an indication of progressive plant maturity, productivity and recovery from harvest across the different plots and over time.

Additionally the presentation of all plant species coverage has been recorded in 2021 as the development of increased habitat availability both above and below ground through a soil coverage analysis. From the total plot sequential photographic data of 2020 and 2021, an average soil cover provision has been recorded. Photographs were taken in 2021 at approximately the same time of year as the 2020 recordings and, as paired information, have been assessed in conjunction with soil sampling. Example photographs are contained within the results section.

Limited harvest information was supplied by the land manager. Recordings were taken throughout the project, however only bulk property harvest information was available. The decision has been taken not to include this information as its use would be to reflect more the seasonal and market drivers from production in relation to the sampling period, rather than a differential between soil sampling locations.

Plant material was sampled and analysed during the project to provide insight into the potential salt removal of saltbush harvest and sales off property.

It must be noted that during the winter of 2021 (see Results), significant waterlogging of the Plantation Site resulted from significant rainfall, not typical in recent years for the area. Broad plant death attributed to this water logging occurred following the visit to site and therefore the subsequent treatment of the plants (heavy pruning) did not impact the results beyond the impact of the water logging itself. This information will be included as a commentary, but does mean that the habitat and plant specific comments were only of relevance at the time samples were taken. Such information identifies the potential of the Plantation Site, but will not necessary reflect what is there currently.

3.3.2. Wild Harvest Site

Plant health was assessed in 2021 through plant productivity in the form of:

- Relative plant number with respect to scarification impact,
- Example plant size (height),
- Plant soil coverage.

Random plant sizes were measured in 2021. These measurements were completed through photographs taken with a perspective tool in situ. Note: due to the soil scarification, at the time of soil sampling in 2020, limited plants were evident within the scarified area of the Wild Harvest Site. The control areas were omitted from the scarification process and therefore reflect the impact of the scarification. From this data and from additional total transect sequential photographic data, an average soil cover provision was recorded. From the total plot sequential photographic data of 2020 and 2021, an average soil cover provision was defined.

Note that during the winter of 2021 (see Results, Section 4.1) significant rainfall delayed access to the Wild Harvest Site resulting in a delay in sampling and photography from that site. Therefore whilst the Plantation Site was sampled in August (under water logged conditions, but prior to plant death and harsh pruning effecting the analysis results), the Wild Harvest Site was not sampled until October. However, it could be said, based on the ongoing rainfall frequency, the comparison of the Wild Harvest Site in August 2020 is more appropriate with the October 2021 with access becoming possible at the end of the “winter” indicating potentially comparable soil water content at the Wild Harvest Site.

No Wild Harvest Site plant material was harvested during the project.

3.4. Groundwater Sampling and Analysis Strategy

3.4.1. Plantation Site and Wild Harvest Site

The salinity specific rehabilitation of the degraded land was assessed through the measurement of soil salinity (annually), and shallow ground water salinity (monthly, in 2021 only). Background information on catchment geology of the area, together with topographic and soil landscape maps, and satellite images place the site as mid slope drainage feeding into to a wide flat alluvial filled saline drainage of the Coblinine system (unnamed leading to Lake Coyrecup). This suggests that groundwater at the site is present in an unconfined perched aquifer with minimal alluvial cover. (Timmins, A., 2019)

Two water production bores were installed in February 2020 and commenced extracting water from a depth of ~55m. Soil extracts were deposited every two meters, and, of these, samples were extracted at points of visually discernible soil profile change or at intervals through the greater depths of uniform visual presentation. These samples were analysed to define a log of soil to depth for general parent rock and subsurface soil characteristic information (i.e. pH, EC, Exchangeable Calcium/Magnesium/Potassium/Sodium, Effective Cation Exchange Capacity (ECEC) and Soil Texture) rather than for trial data input. The production bore water composition was analysed early in 2021 as part of the Greenhouse Scope.

Two ground water observation wells were drilled in July 2020 for the Plantation Site and a single observation well was drilled for the Wild Harvest Site to enable local water quality analysis. The Plantation Site had one observation well located in the middle of the treatment area and a second reference "control" bore in a location of comparable topography outside of the treatment area as per the diagrams over the page. The Wild Harvest Site had only the observation well located within the treatment area drilled. The second planned "control" well for the Wild Harvest Site was not completed. These were installed as per the DPIRD recommended approach (www.agric.wa.gov.au, https://www.agric.wa.gov.au/soil-salinity/monitoring-groundwater, July 2019). The wells were lined with a 60mm OD PVC pipe, slotted at the lower end and solid above the water table. The pipe has been capped 350mm above the ground level. The installed production and observation wells enabled the monitoring of the deep and shallow water-table layers respectively, throughout the project and the year 2021 respectively.

The observation of water table salinity was completed monthly throughout 2021 using a field EC meter with the shallow ground water EC as the main focus observed in comparison to that of the production bore water, the soil at interval depths down the production bore and the surface soil at different trial plots. The observation well water depth and pH was also recorded. The water table height was measured from the ground level using a tape measure and plopper (See DPRID, July

2019). The observation well EC analysis was conducted on a monthly basis to enable the relationship of rainfall to groundwater (recharge rate) to be defined.

See Figures 3.4.1.1 and Figure 3.4.1.2 (over the page) for production bore and observation well layout for the Plantation and Wild Harvest Sites respectively

Figure 3.4.1.1: Plantation Site Map with Observation and Production Wells Indicated.

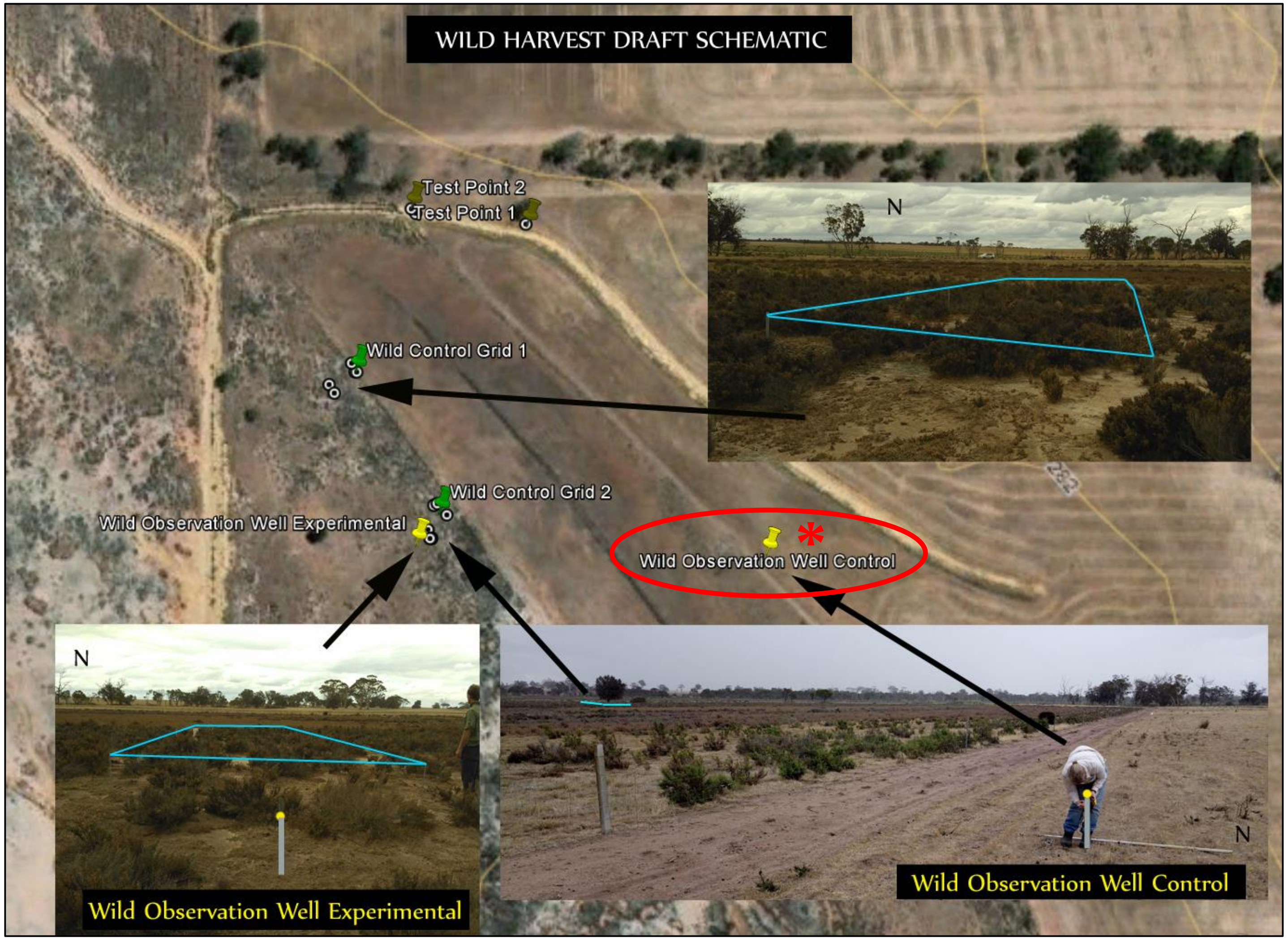


Figure 3.4.1.2: Wild Harvest Site: Area Map with Observation Wells and Control Areas Indicated.

**NOTE: Wild Harvest Site Observation Well Control was omitted from drilling regime.*

3.5. Greenhouse Experiment

Whilst the greenhouse experiment was not within the environmental monitoring scope, valuable insights were made available from this aspect of the project. Results associated with plant water uptake, water salinity monitoring and plant growth / harvest information have been provided as an indicative reflection of field based plant characteristics/behaviour and ground water change over the life of the project. Hence the inclusion of this data collection within this scope for comparison and reporting, with thanks to Anthony Mercieca (AM) & Associates.

3.6. Soil Bacteria Assessment Through DNA Analysis

A common method to assess soil health is to quantify the bacteria in the soil. These bacteria play fundamental roles in nutrient cycling, decomposing crop residue, and mineralizing organic nutrients into plant available nutrients, as well as other co-benefits including soil physical structure, and chemical fertility. Soil bacteria are ubiquitous in agricultural soils and quantification has moved from microscopy into DNA sequencing. For DNA sequencing, the soil is collected and taken to a clean laboratory, where a 21 step process is used to separate the soil from the genomic DNA. Once the DNA has been isolated, primers are used to amplify bacteria only DNA (there is lots of other DNA in soil, e.g. fungi, insect, animal etc.). The amplified DNA is then sent to a sequencing lab, where each sample is sequenced and then aligned against an international bacteria DNA reference library for consensus of DNA sequence to a taxonomic bacteria species identification (which is also called an operational taxonomic unit). From here we can calculate a range of alpha diversity, and beta diversity values, to help identify if experimental treatments (I.e. soil depth, sampling location, scarification) are impacting these diversity indices. Recently, an additional analysis has been used to identify the functional capacity of soil by using the taxonomic DNA data set to predict functional genes. In this report, there is the inclusion of an in-silico (PICRUSt) analysis of carbon and nitrogen functional genes - I.e. the genes responsible for carbon cycling (ranging from easily degradable to very recalcitrant carbon), and nitrogen (all parts of the nitrogen cycle, N fixation, nitrification, and denitrification). Soil DNA analysis and subsequent DNA processing was performed exactly the same for both Plantation and Wild Harvest Sites in both 2020 and 2021.

3.6.1. DNA Extraction

Soil was collected from the field, and immediately kept in cool dark conditions until the sample was frozen (-20°C) for DNA extraction. DNA was extracted from 0.4 g of soil using a Power Soil® DNA Isolation Kit (Mo Bio, Carlsbad, CA, USA) and following the protocol of the manufacturer. Extracted DNA was quantified (Qubit, Life Technologies, Australia) and adjusted to 1 ng/µL using moleculargrade water and stored at − 20 °C until further analysis. The DNA preparation and sequencing library preparation were performed following the recommendations described by Scholer et al. (2017). Amplification of the target 16S rRNA genes was carried out following the protocol of Mickan et al. (2018) using 27F/519R bacterial primers.

3.6.2. DNA Sequencing

DNA sequencing was performed on the Illumina Mi-seq platform. Paired-end reads were assembled by aligning the forward and reverse reads using PEAR (version 0.9.5). The primers were identified, and using Quantitative Insights into Microbial Ecology (QIIME 1.8), USEARCH (version 8.0.1623, and UPARSE software, the trimmed sequences were processed. Using the USEARCH, sequences were denoized, quality filtered, and chimera checked according to abundance. The reads were mapped back to the operational taxonomic units (OTUs) based on 97% identity to obtain the number of reads in each OTU. Using the Greengenes database5 to assign the QIIME taxonomy (version 13_8, Aug 2013), a Phylogenetic Investigation of Communities by Reconstruction of Unobserved States (PICRUSt) (https:// picrust.github.com) was performed (Langille et al., 2013). The genes characterized were those identified in C and N cycling (Mickan et al., 2018).

3.6.3. DNA Statistical Analysis

Two-way analysis of variance (ANOVA) was used to evaluate the effect of soil depth (0 to 10cm, 10 to 30cm), and sample location (between or under plant) for the Plantation Site, and a two way ANOVA for soil disturbance (scarified or unscarified), and sample location (between or under plants) was nested within each soil profile (0 to 10cm, 10 to 30cm) for the Wild Harvest Site plots. Bacterial community composition, through alpha diversity, and relative abundance was performed. Bray–Curtis dissimilarity was used to analyse bacterial community compositional changes at OTU 97% similarity level. The significance of different treatments driving bacteria community composition was assessed with permutational multivariate analysis of variance (PERMANOVA) using distance matrices (adonis function) and square root-transformed OTU relative abundance data. All data analyses were conducted in the R statistical environment.

4. RESULTS

Prior to the commencement of the results presentation a summary of the climate conditions for the duration of the trial is critical in the light of the transition from El Niño to La Niña within the Pacific Region between 2020 and 2021 bringing greater rainfall for Australia in the second year of the trial. Such a transition is inferred to have significantly influenced the results of the project. Hence the criticality of the retention of control plots within the Wild Harvest Site and the limitations imposed by the absence of a control plot within the Plantation Site. However it is noted that as this is a commercial enterprise, the setting aside of potentially productive areas was unlikely feasible within such a broad project scope. Similarly, note must also be taken of the event of the COVID19 pandemic which influenced the product markets and hence the harvesting of plant material. Fortunately the impact of the pandemic did not inhibit soil sampling or analysis.

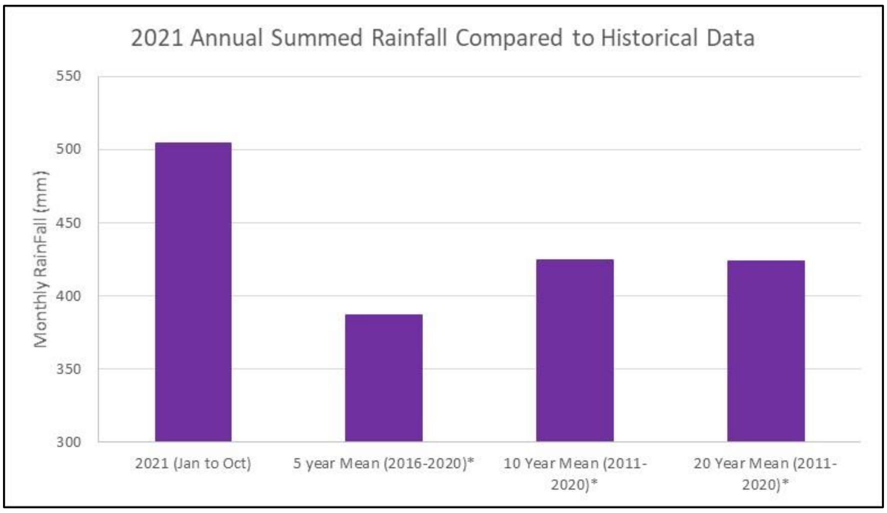


Figure 4.1(a): Comparison of Total Annual Rainfall for Katanning – 2021 compared to 5, 10, and 20 year historical averages. *Note results are averaged from available data points within Bureau of Meteorology data sets (*http://www.bom.gov.au/jsp/ncc/cdio/weatherData - Station 010916*)

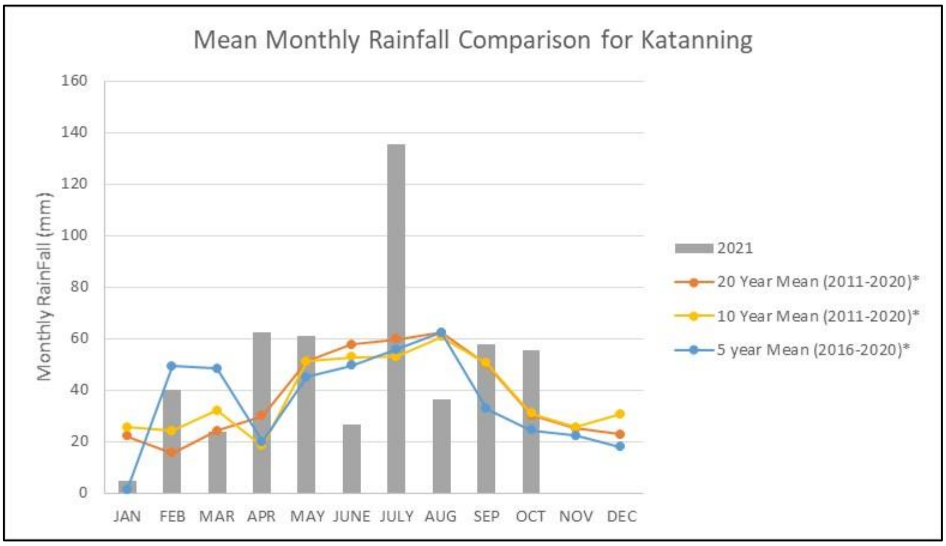


Figure 4.1(b): Comparison of Monthly Rainfall for Katanning –5, 10, and 20 year historical averages.
*Note results are averaged from available data points within Bureau of Meteorology data sets
(*http://www.bom.gov.au/jsp/ncc/cdio/weatherData - Station 010916*)

4.1. Plantation Site Plot Comparison Results – Annual Results

4.1.1. Plantation Site Plot Base Line Results – 2019

It is important to note that at the time of the 2019 sampling, there had been a number of activities associated with the preparation and planting of the Plantation Site which would likely have a significant impact on the soil properties in parallel to the impact of the plants themselves. These included significant disturbance / tilling within the plant rows and the commencement of increased traffic within the between plant sections. However, no other activities have been reported which would impact chemical properties (e.g. fertiliser, pesticide etc.). The below provides a high level summary of the soil across the Plantation Site at the start of the project with general comments of the area as a whole and with consideration of variation between the individual plot results for reference within the sampling results from later in the project.

High level summary of trial commencement soil:

- Moderately low pH.
- Moderately high Electrical Conductivity (EC).
- Moderately low carbon (C).
- Low nitrogen (N) content relative to carbon content, lower nitrate relative contribution compared to ammonium (and relative to Laboratory Indicative Guidelines – See Appendix 2).
- High C/N ratios suggest a depletion of organic nitrogen.
- Generally low calcium (Ca), potassium (K), phosphorus (P), aluminium (Al), hydrogen (H), and the micro nutrients zinc (Zn), manganese (Mn), copper (Cu), Boron (B), and Silicon (Si).
- Generally high magnesium (Mg), Sodium (Na), Sulfur (S), and the micronutrient iron (Fe). Very high sulfur ~3 times indicative guidelines.
- Low Ca and high Mg has led to low Ca/Mg ratio results.

Plot Specific Notes:

- Plot 1 – Lowest Mg across the board.
- Plot 2 - Was often different other plots:
  - Plot 2 has high nitrogen outliers.
  - Plot 2 – higher Exchangeable Calcium compared to all other plots (multiple samples within plot had this higher value).
  - Phosphorus lower in Plot 2.
- Plot 3 -
  - Phosphorus higher in Plot 3.
- Plot 4 –
  - Lower Base Saturation calcium compared to all other plots.

    - Nitrate Nitrogen – extreme high outlier within plot 4.
- All others presented with no significant plot difference.
- Differences have been identified between the individual plot soil properties leading to the conclusion that the use of plots should be retained for the Plantation Site.

Depth Specific Notes:

- pH, Exchangeable Sodium Potential was higher with depth (i.e. results > for 10-30cm than 0-10cm).
- Total C, Total N, Ammonium Nitrogen, Sulfur, Manganese, Iron and silicon – shallow sample had higher content (i.e. results > for 0-10cm than 10-30cm).
- Low Ca and high Mg relative relationship has led to higher ratio in 0-10cm than 10-30cm.
- All others presented with no significant depth difference.

Overall, on average the nutrient content of the Plantation Site soil was poor, highlighting the value in finding an alternate, low fertility, hardy production option for this location. This soil was appropriate for this type of trial and the findings therefore will be valuable to other land managers with similarly saline degraded soils within the region. A detailed examination of this nutrient content will be included in subsequent sections, (i) with consideration of each individual year's average change and differences established both across the plots and (ii) with the comparison of the soil samples taken from under with those taken between the plants within the 2020 and 2021 Plantation Site soil comparison.

Plot locations are as per those identified in Figure 3.2.1.1 with consecutive numbering starting from the North West plot. See Appendix 2, Section 8 for summary of soil property data. Full graphical and tabular differential analysis outcomes available on request.

4.2. Plantation Site Results (2019/2020/2021)

Data provided within this report was collected with just 24 months of plant development following significant disturbance and is provided as an indication of a potential direction of future change (I.e. ~ 24 months post tilling, planting and inspection/harvest traffic alteration on the site). It was not anticipated that significant change would be noted within the 2020 results, however these data with the additional data from the 2021 sampling regime provides validity for the conclusions presented here.

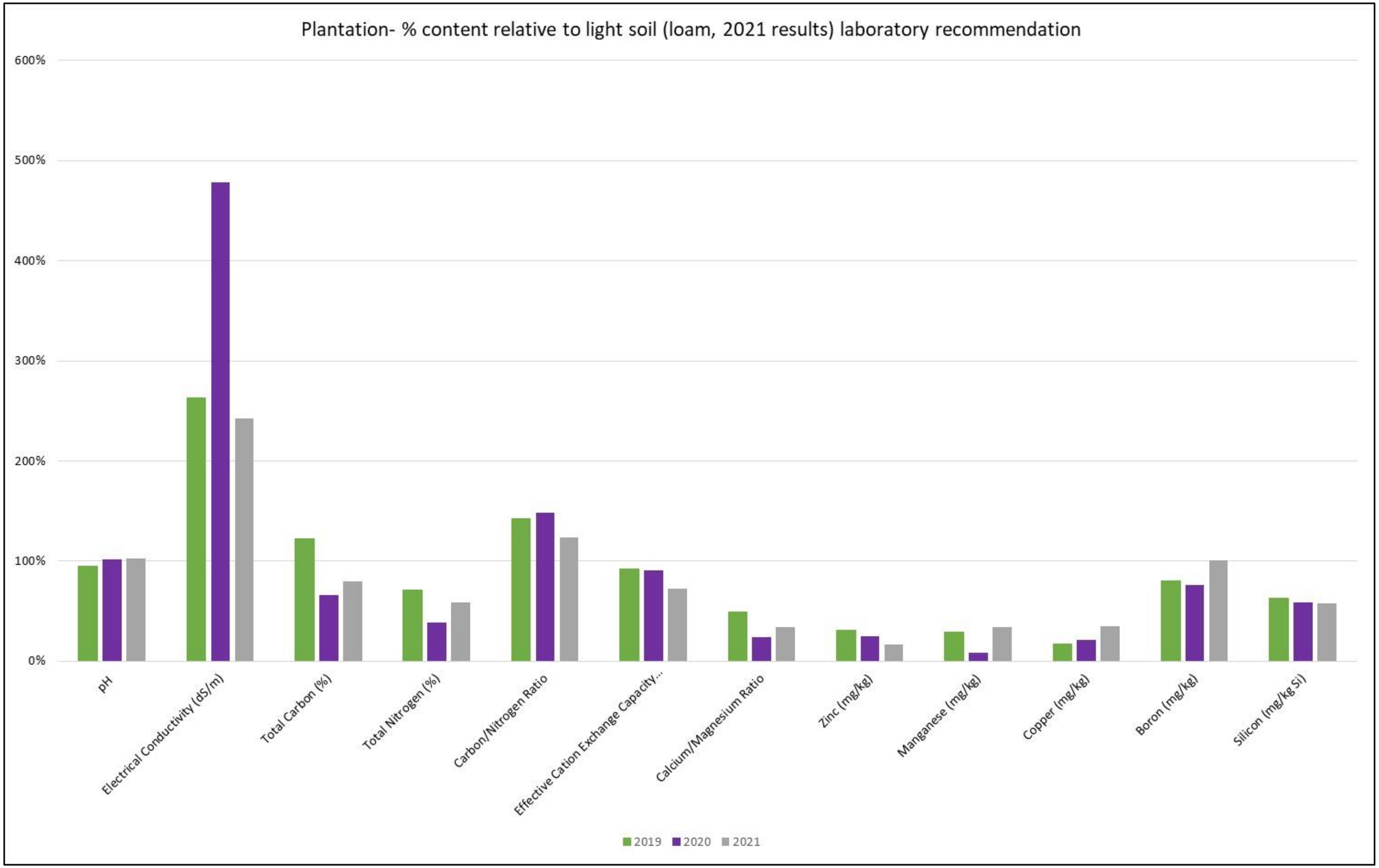
However, differences when assessing under versus between plant, 2019 versus 2020 and 2021, and between the plots themselves, delivered a 3-point temporal trend for the duration of the project. This allows a comparative understanding of the impact of the plants and the more general site treatment impacts (i.e. tilling) with examination of variations in these trends.

Note: Where greater than half the samples have been identified at "less than the detectable levels" these have been excluded from the analysis. Where these "<" values are present in less than half the samples, then 0.85% of the "<" value has been assumed to acknowledge the presence of these low range values and enable the statistical analysis to be completed.

4.2.1. Plantation Site Overall Nutrient Content

The general comparison of the Plantation Site soils to the laboratory recommended values for light/loam soil type indicates: (See Graphs 4.2.1 (a) – (d), stated as per 2021 data)

- High – pH, electrical conductivity (EC), Carbon/nitrogen ratio, boron, magnesium (soluble, exchangeable and percent ECEC), sulfur and sodium (exchangeable and percent ECEC).
- 75-100% - total carbon %, and calcium (soluble).
- 50-75% - total nitrogen %, effective cation exchange capacity (ECEC), phosphorus, silicon, and ammonium nitrogen.
- 25-50% - calcium/magnesium ratio, calcium (percent ECEC), potassium (soluble, and exchangeable), manganese and copper.
- Remainder less than 25%.



(a)

Figure 4.2.1 (a), (b), (c) and (d): Plantation Site - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines- Part 1. Note Lab Guidelines can be found in Section 9.3, Appendix 2

(b)

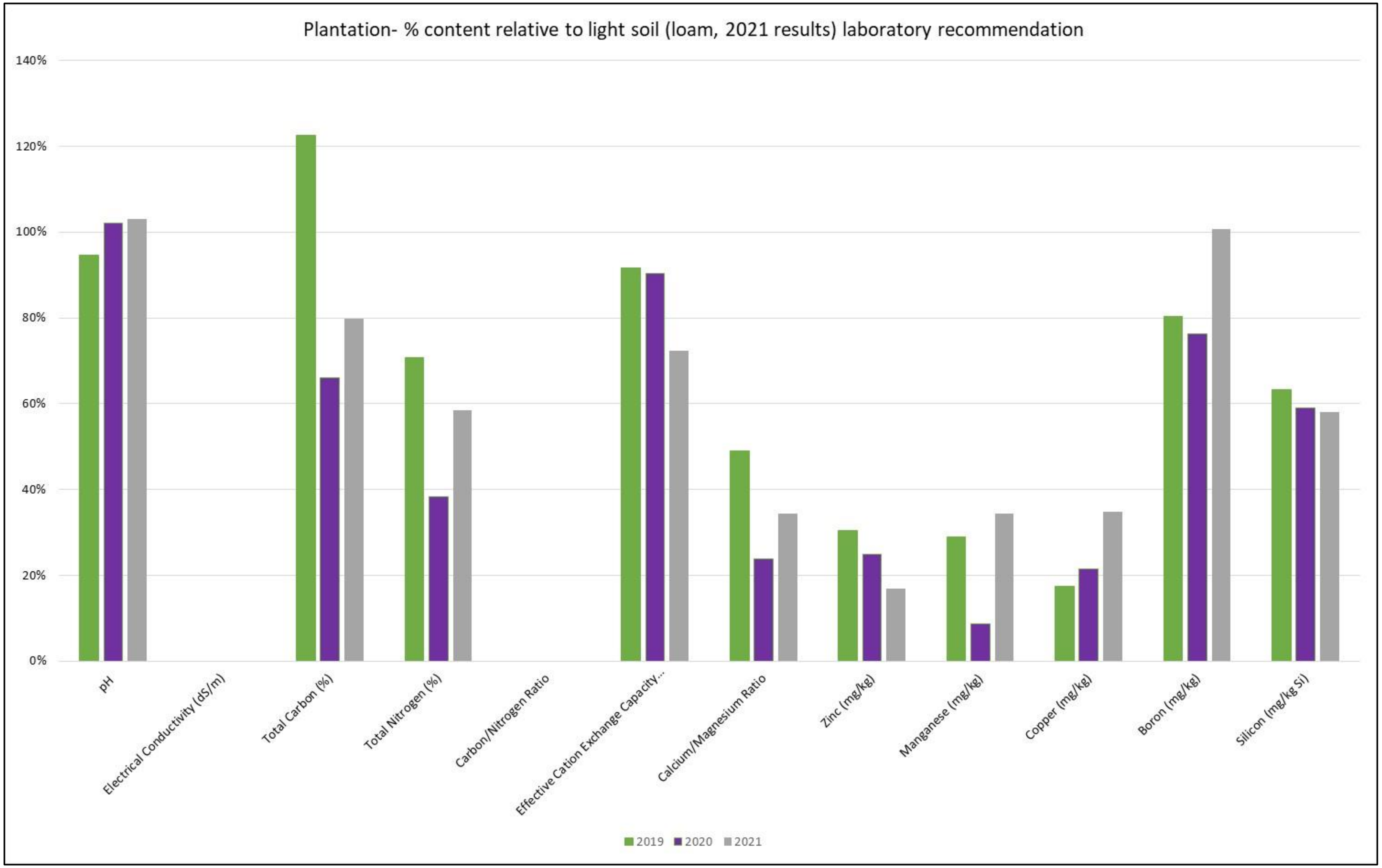


Figure 4.2.1 (a), (b), (c) and (d): Plantation Site - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines- Part 1 with Electrical Conductivity (EC) and Carbon Nitrogen ratio extreme values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2

(c)

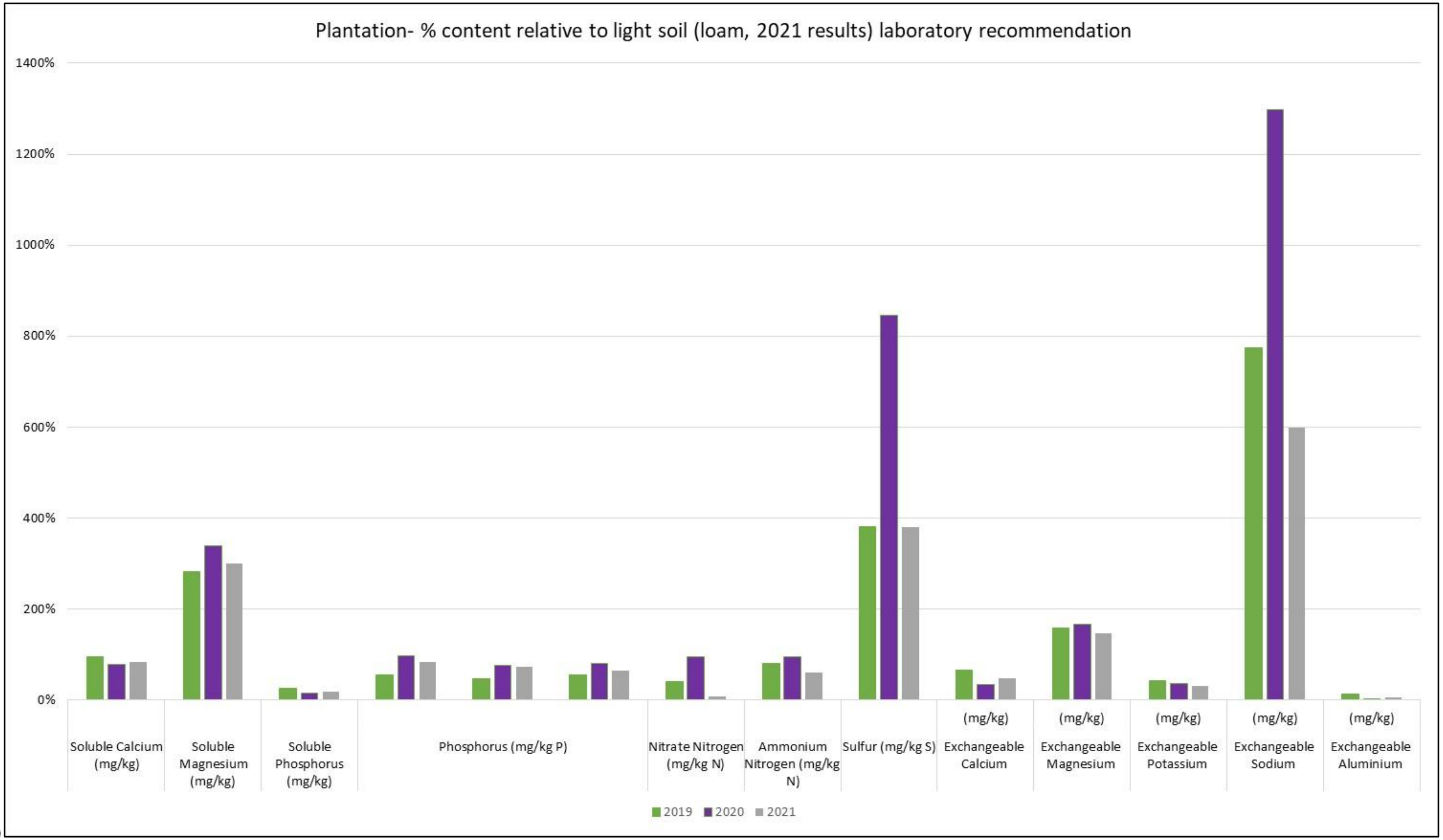


Figure 4.2.1 (a), (b), (c) and (d): Plantation Site - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines-Part 2. Note Lab Guidelines can be found in Section 9.3, Appendix 2

(d)

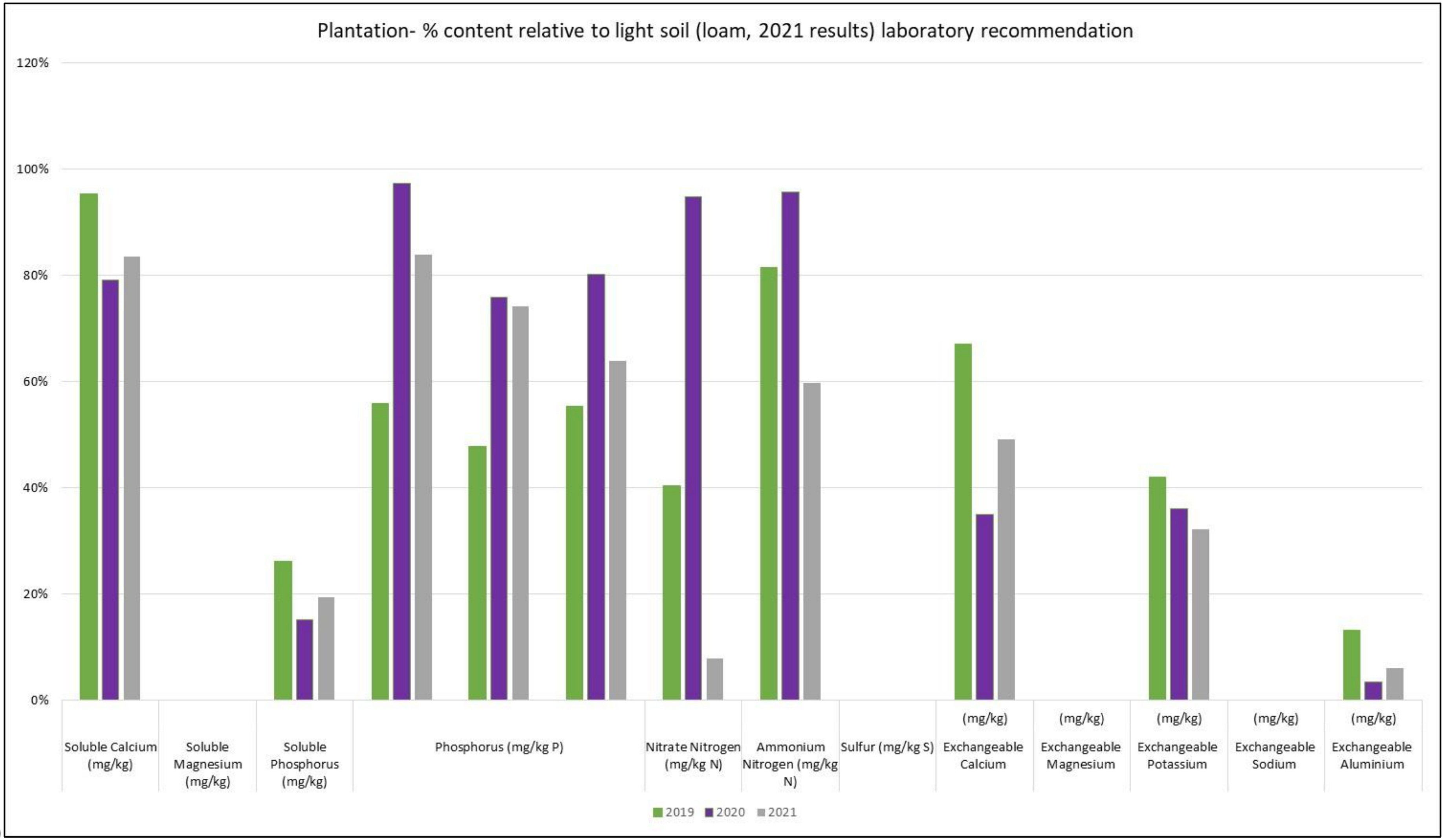


Figure 4.2.1 (a), (b), (c) and (d): Plantation Site - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines- Part 2 with Soluble Magnesium, Sulfur, Exchangeable Magnesium and Exchangeable Sodium high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2

- On average the soil nutrient content was poor, which highlights the value in finding an alternate, low fertility, hardy production option for this location.
- The difference in 2019, 2020 and 2021 data sets are discussed in Section 4.2.3 where outliers, under versus between and statistically significant differences are outlined. Without this analysis, it was apparent that the initial impact of the Plantation Site may have only been partially reversed over the final year of the project for many soil properties.
    - Only ECEC, zinc, silicon and exchangeable potassium have a consistent decline over the three sample times, and only copper has a consistent increasing trend in mean values for the 0-10cm depth samples across the project.
    - EC, Carbon/Nitrogen Ratio, Magnesium (soluble and exchangeable), Phosphorus (Bray1, 2 and Colwell), Nitrogen (nitrate and ammonium), sulfur and sodium (exchangeable) increased from 2019-2020 and then fell from 2020 to 2021.
    - Total Carbon, Total Nitrogen, Calcium/Magnesium Ratio, Manganese, Boron, Calcium (soluble and exchangeable) and Aluminium (exchangeable) firstly declined from 2019 to 2020 and then recovered into 2021.
    - For the underneath plant samples the differences from the above trends were – EC (increased 2019 to 2020 then declined for the 2021 samples, but was still above the 2019 level), ECEC (increased 2019 to 2020 then declined to below 2019 level), manganese (decreased 2019 to 2020 then increased to higher than 2021), boron (increased 2019 to 2020 then consistent), silicon (consistent increase 2019 to 2020 then drop to 2021), and phosphorus (consistent increase over 3 samples).
    - For the between plant samples the differences from the above trends were – silicon (decreased 2019 to 2020 then increased), and exchangeable magnesium (decreased 2019 to 2020 then increased to 2021).

4.2.2. Plantation Site 2020/2021 Under Vs Between Detailed Analysis:

No statistical difference was identified by the direct comparison of the between and under plant samples from the Plantation Site plots for the soil compositional components in the 2020 data. This was not unreasonable given the variation between the plots identified within the 2019 detailed differential analysis. Minimal differences within the total data set were identified for some soil properties within the 2021 data. The pH (6.7 to 6.3 for the under versus between analysis respectively) and the electrical conductivity (EC, 0.34 to 0.24 for the under versus between analysis respectively) of the samples taken in 2021 identified higher values under the plants compared to between them across the combined data of the four plots. Thus rather than a direct, averaged statistical comparison being completed across the Plantation Site, the plots were considered independently.

With selection criteria of three of the four plots displaying a similar relative average relationship a total of 20 parameters were found to meet the criteria within the 2020 under versus between-plot comparison for the total data set. Soil Results from the 2020 sampling indicated the under plant Vs between plant differences to be:

- Under plants higher than between – pH; EC; carbon nitrogen ratio; exchangeable magnesium, potassium, and sodium; effective cation exchange capacity (ECEC); potassium %; boron and silicon.
- Between plants higher than under – total carbon %, plant available phosphorus, ammonium nitrogen, exchangeable aluminium, total magnesium, aluminium %, calcium / magnesium ratio, zinc, iron, and copper.
- See Appendix 3 for detailed Under versus Between analysis

Within the 2021 data set selection criteria of three of the four plots displaying a similar relative average relationship a total of 24 parameters were found to meet the criteria within the 2021 under versus between-plot comparison for the total data set. Soil Results from the 2021 sampling indicated under plant Vs between plant differences to be:

- Under plants higher than between – pH, EC, nitrate nitrogen*, ammonium nitrogen**, calcium (soluble, exchangeable) *, magnesium (exchangeable, %ECEC), potassium (soluble, exchangeable), phosphorus (soluble, Colwell, Bray 2)**, sulfur*, ECEC, sodium (exchangeable and ESP), and silicon.
    - *additional to 2020 results.
    - **different relationship compared to 2020 results.
- Between plants higher than under – exchangeable aluminium, total magnesium, aluminium %, the calcium / magnesium ratio, zinc, iron, and copper.
- Note: total carbon % failure to meet the 3 out of 4 criteria and thus the omission of total carbon % from this above. See discussion over page.
- See Appendix 3, Section 9 for detailed Under versus Between analysis and Figure 4.2.2.1 for an example.

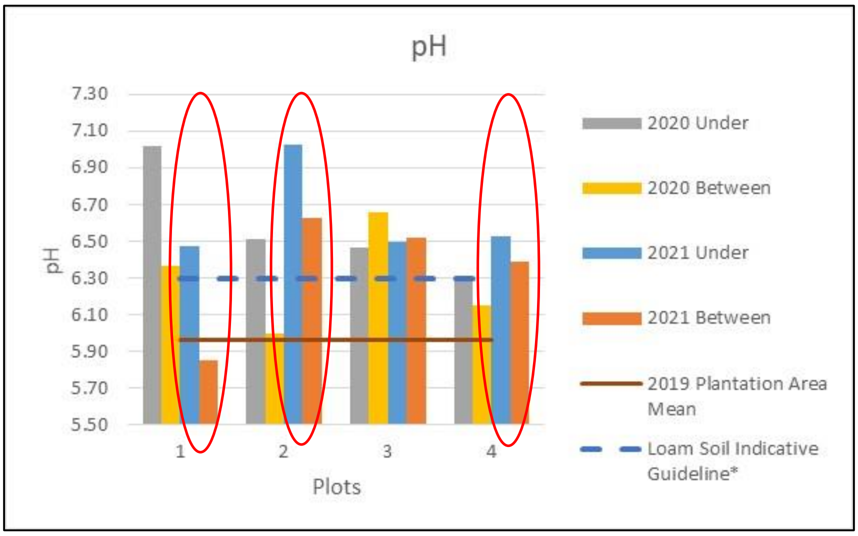
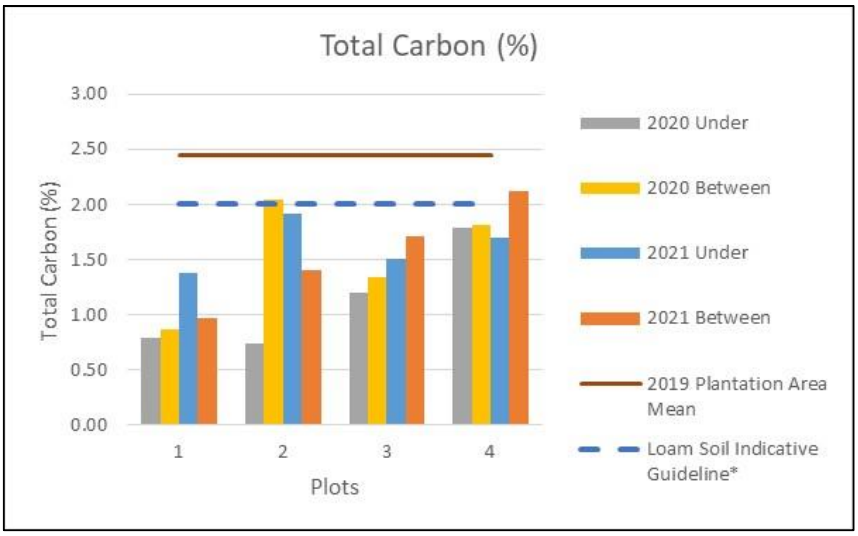


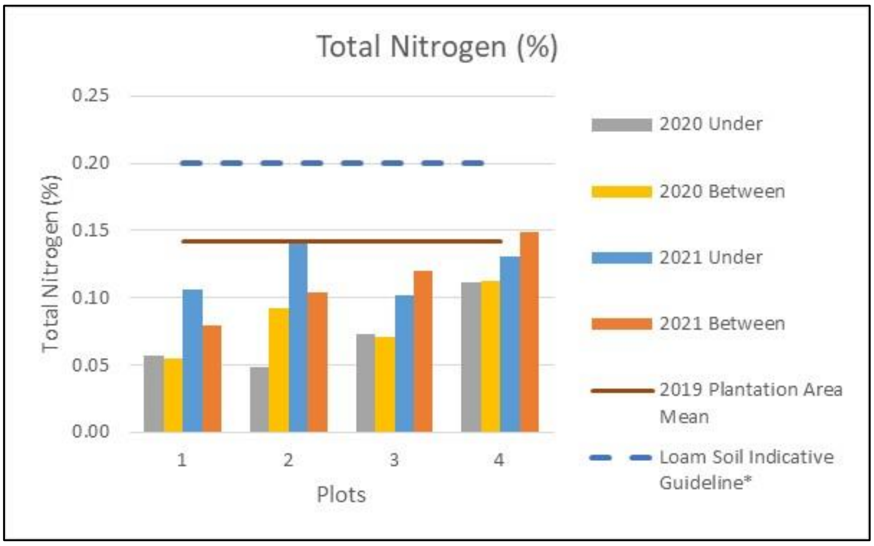
Figure 4.2.2.1: pH as example of 3 out of 4 plots meeting similar trend Under>Between for the 2021 data and compared to the 2019 Plantation Site mean. 2020 & 2021 (Reflected in pH statistical analysis also). Red Oval.

It was noted that total carbon was higher between the plants rather than under for the 2020 data which was counterintuitive. It suggested that the tilling prior to planting may have induced a decline in carbon rather than the anticipated increase with plant growth. There was no longer a consistent total carbon % trend within the 2021 data with the 2 more western plots having a lower content between compared to under the plants and the 2 eastern plots having the opposite. It is noted however that the total carbon percentage was still significantly below that seen in the 2019 samples. Given this trend was no longer consistent in 2021 data this tilling induced decline in carbon would appear to be the case. This potential alternate impact, beyond the analysis of the role the plant presence has on soil carbon, highlights the caution required in drawing conclusions within a short term project timeframe. On average carbon levels had declined from 2019 to 2020 sampling timestamps. The total nitrogen % demonstrated a similar trend. See Figure 4.2.2.2(a) and (b).



(a)

Figure 4.2.2.2(a): Total Carbon % with inconsistent presentation within the 4 plots and compared to the 2019 Plantation Site mean. 2020 & 2021



(b)

Figure 4.2.2.2(b): Total Nitrogen % with inconsistent presentation within the 4 plots and compared to the 2019 Plantation Site mean. 2020 & 2021

Note also that there was a repeat of the 2020 finding that the EC was higher under the plants compared to between. The higher EC under the plants may be due to the drawing up of ground water by the plant root system with a lesser soil washing effect from precipitation as occurring between the plants. The continuation of the trend into 2021 sampling suggests that this may be true however there was a moderating impact on the EC being enacted with the 2020 to 2021 data showing a decline. It was noted that the under plant soil was elevated compared to the between plant soil likely due to the Plantation Site preparation, which may also have been impacted by both the rainfall due to plant cover washing the salts through the soil, but also the impact of the water logging of the shallow soils in the 2021 sampling regime. Note that the plant rows have raised edges on either side, limiting the water ingress and pooling. See Figure 4.2.2.3. See Section 9.2 in Appendix 3 for tabulated means and P-values for significance justification.

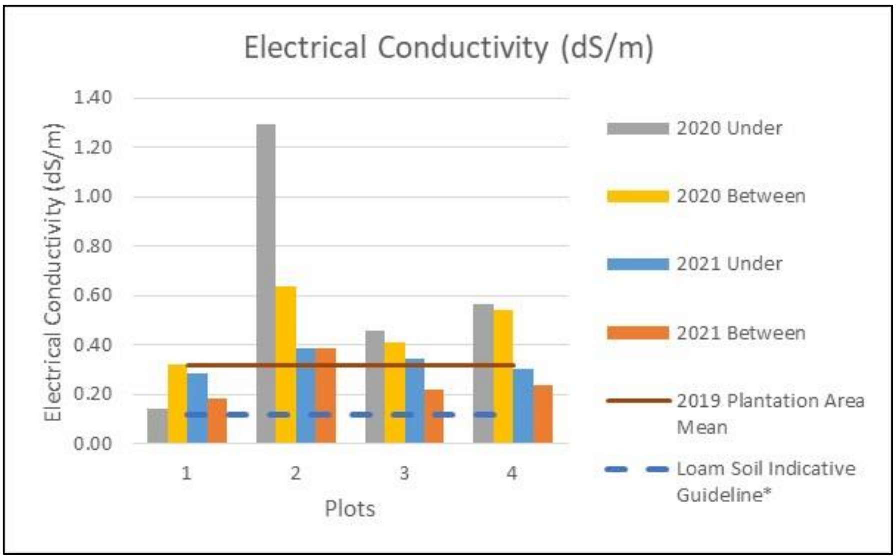


Figure 4.2.2.3: Electrical Conductivity higher under plants than between them consistently presenting within all 4 plots and compared to the 2019 Plantation Site mean.

4.2.3. Plantation Site Overall Soil Results 2019 to 2021 Detailed Analysis:

Differentials across the two sampling timeframes represent the seasonal, Plantation Site preparation and Plantation Site growth impact. The statistically significant differences were:

- Increase across **2019 to 2020**, total data set – pH (5.96 to 6.43), electrical conductivity (EC, 0.316 to 0.575dS/m), sulfur (30.5 to 67.7mg/kg), and sodium % (22.9 to 34.6%).
- Decrease across **2019 to 2020**, total data set – total carbon % (2.45 to 1.32%); total nitrogen % (0.14 to 0.08%); calcium (exchangeable and %, 670 to 349mg/kg, 48.3 to 30.3%), aluminium (exchangeable and %, 4.29 to 1.13mg/kg, 0.654 to 0.146%); hydrogen % (0.608 to 0.084%) and Manganese (5.23 to 1.55mg/kg).
- The pH, Total Carbon, Exchangeable Calcium, and Exchangeable Aluminium results were replicated both under and between plants.

- Increase across **2019 to 2021**, total data set – pH (5.96 to 6.49), phosphorus (Bray1, 13.4 to 20.1mg/kg), Magnesium % (25.2 to 29.9%) and Copper (0.28 to 0.56mg/kg).
- Decrease across **2019 to 2021**, total data set – total carbon % (2.45 to 1.60%), total nitrogen % (0.142 to 0.117%), calcium (exchangeable, 670 to 491mg/kg), aluminium, (exchangeable and total %, 4.29 to 2.01mg/kg, 0.654 to 0.411%), potassium (exchangeable, 63.1 to 48.3mg/kg), cation exchange capacity (ECEC, 7.15 to 5.65cmol/kg) and zinc (1.22 to 0.678mg/kg).

- Increase across **2020 to 2021**, total data set – total nitrogen % (0.077 to 0.117%), calcium (exchangeable, 349 to 491mg/kg), aluminium (exchangeable 1.13 to 2.01mg/kg), calcium % (30.3 to 42.5%), aluminium % (0.146 to 0.411%), hydrogen % (0.084 to 1.645%), Manganese (1.55 to 6.18mg/kg) and Copper (0.345 to 0.557mg/kg).
- Decrease across **2020 to 2021**, total data set – EC (0.575 to 0.291dS/m), sulfur (67.7 to 31.4mg/kg), sodium (exchangeable, 656 to 303mg/kg), and sodium % (34.6 to 23.3%).
- The Total Nitrogen, Aluminium (exchangeable and total %), and Calcium % results were replicated both under and between plants.

Only Exchangeable Aluminium presented a consistent decrease for both under and between plants for the duration of the project data. See Table 4.2.3.1 for tabulated means and P-values for significance justification.

It is noted that when a comparison was made between the 2019 and 2021 data, the Total Carbon %, never regained the 2019 content highlighting the importance on soil coverage and minimal tilling to protect soil carbon and soil ecology for the development of saline impacted soils as well as highlighting the rate at which these systems recover when considering a timeframe for analysis.

Table 4.2.3.1: Plantation Site – Annual Sample Comparison

Location	Significant Data	Analysis - 2021									
		pH	Electrical Conductivity	Total Carbon (%)	Total Nitrogen (%)	Phosphorus (mg/kg P,	Sulfur (mg/kg S)	Exchangeable Calcium	Exchangeable Potassium	Exchangeable Sodium	Exchangeable Aluminium
	Average 2019	5.96	0.316	2.45	0.142		30.5	670			4.29
Total Data	Average 2020	6.43	0.575	1.32	0.077		67.7	349			1.13
	P(T<=t) two-tail	3.06E-03	4.23E-02	2.81E-05	9.61E-06		7.70E-04	2.05E-06			1.90E-07
	Average 2019	5.96		2.45	0.142	13.4		670	63.1		4.29
Total Data	Average 2021	6.49		1.60	0.117	20.1		491	48.3		2.01
	P(T<=t) two-tail	5.50E-06		8.40E-05	1.47E-02	2.54E-02		1.51E-03	1.41E-02		2.06E-05
	Average 2020		0.575		0.077		67.7	349		656	1.13
Total Data	Average 2021		0.291		0.117		30.4	491		303	2.01
	P(T<=t) two-tail		2.06E-02		6.17E-04		8.60E-04	2.87E-03		3.59E-02	2.12E-04
	Average 2019	5.96		2.45				670			4.29
Under	Average 2020 (under)	6.59		1.64				510			1.62
	P(T<=t) two-tail	1.12E-05		1.73E-04				2.18E-02			2.35E-06
	Average 2020 (under)			1.13	0.073			336			1.09
Under	Average 2021 (under)			1.64	0.121			510			1.62
	P(T<=t) two-tail			2.76E-02	2.20E-03			1.15E-02			3.68E-02
	Average 2019	5.96		2.45	0.142			670	63.1		4.29
Between	Average 2020 (between)	6.39		1.55	0.113			472	45.1		2.36
	P(T<=t) two-tail	1.26E-03		8.71E-04	3.21E-02			6.70E-03	3.44E-03		5.00E-04
	Average 2020 (under)				0.081		65.3			467	1.18
Between	Average 2021 (under)				0.113		24.0			290	2.36
	P(T<=t) two-tail				4.54E-02		1.02E-02			4.96E-02	2.31E-03

Location	Significant Data	Analysis - 2021								
		Cation Exchange	Calcium (%)	Magnesium (%)	Sodium - ESP (%)	Aluminium (%)	Hydrogen (%)	Zinc (mg/kg)	Manganese (mg/kg)	Copper (mg/kg)
	Average 2019		48.3		22.9	0.654	0.608		5.23	
Total Data	Average 2020		30.3		34.6	0.146	0.084		1.55	
	P(T<=t) two-tail		4.13E-05		4.91E-04	3.43E-06	1.20E-04		5.68E-03	
	Average 2019	7.15		25.23		0.654		1.217		0.280
Total Data	Average 2021	5.65		29.86		0.411		0.678		0.557
	P(T<=t) two-tail	1.43E-02		9.69E-03		9.88E-03		1.61E-02		1.42E-02
	Average 2020		30.3		34.6	0.146	0.084		1.55	0.345
Total Data	Average 2021		42.5		23.3	0.411	1.645		6.18	0.557
	P(T<=t) two-tail		6.62E-07		8.59E-05	3.73E-05	5.08E-03		2.11E-03	3.55E-02
	Average 2019	7.15	48.3	25.23		0.654		1.217		
Under	Average 2020 (under)	5.81	41.6	30.53		0.349		0.592		
	P(T<=t) two-tail	3.21E-02	2.99E-02	2.44E-02		3.00E-03		6.05E-03		
	Average 2020 (under)		27.1			0.128	0.078			
Under	Average 2021 (under)		41.6			0.349	1.196			
	P(T<=t) two-tail		5.71E-04			4.89E-03	3.28E-02			
	Average 2019	7.15								0.280
Between	Average 2020 (between)	5.51								0.711
	P(T<=t) two-tail	3.36E-02								3.15E-03
	Average 2020 (under)		32.7		35.6	0.166			1.63	0.362
Between	Average 2021 (under)		43.5		22.7	0.479			7.82	0.711
	P(T<=t) two-tail		1.18E-04		7.84E-04	4.94E-03			7.88E-03	2.70E-02

4.2.4. Plantation Site Soil Results Plot by Plot Comparison 2019 to 2021:

As a result of the 2019 analysis outcomes displaying significant differentials in soil parameters between the Plantation Site analysis plots, a comparison of the individual plot soil parameter changes over time has been completed. The statistically significant differences to 2020 were:

- Plots 1, 2, and 3 each displayed a drop in total carbon %, total nitrogen %, exchangeable calcium and aluminium %.
- Plots 1 and 2 had a drop in the calcium % and hence the calcium magnesium ratio – the continuation of this trend would suggest (in addition to the calcium drop identified as between plants) that there was a calcium deficiency, however it is noted that both the exchangeable calcium and magnesium was low.
- Plot 3 was the only plot to identify an increase in pH suggesting that the average pH increase identified may well be resultant from samples within Plot 3 increasing average across the Plantation Site and not reflecting a change over time.

Of the significant Total Data sets identified between 2019 and 2021 with consistent trends, the comparison of significance across the individual plots was also examined:

- pH – All comparisons for the under plant assessments were significant and Plot 2 and 3 displayed a significant increase between the plants.
- Electrical Conductivity (EC) – No significant difference within any plot.
- Total Carbon – Plots 2 and 3 under plants as well as Plots 1 and 2 between plants had significant decrease since the commencement of the project.
- Total Nitrogen – Plot 3 under plants as well as Plot 1 between plants had significant decrease since the commencement of the project.
- Exchangeable Calcium - Plot 1 under plants as well as Plots 1 and 2 between plants had significant decrease since the commencement of the project.
- Exchangeable Aluminum - Plots 1and 2 under plants as well as Plot 2 between plants had significant decrease since the commencement of the project.
- Effective Cation Exchange Capacity (ECEC) - Plot 2 under plants as well as Plots 1 and 2 between plants had significant decrease since the commencement of the project.

The consistency of Plots 1 and 2 in featuring as significant difference suggests that the more western area of the Plantation Site has soil properties with a greater propensity to respond to change within a disturbed environment. However as harvest data is not available for the specific plots it may also be the case that the changes in soil properties over the duration of the project were related to productivity / harvest impacts. See Table 4.2.4.1 for tabulated means and P-values for significance justification.

Table 4.2.3.1: Plantation Site – Plot Specific Soil Property Sample Comparison

Location	Significant Data	Analysis 2019-2021						
		pH	**Electrical Conductivity (dS/m)**	**Total Carbon (%)**	**Total Nitrogen (%)**	**Exchangeable Calcium (mg/kg)**	**Exchangeable Aluminium (mg/kg)**	**Cation Exchange Capacity (cmol+/kg)**
Plot 1	Average 2019	5.65				639	5.29	
Plot 1 Under	Average 2021	6.48				406	1.16	
	P(T<=t) two-tail	2.97E-02				2.81E-02	7.07E-03	
Plot 2	Average 2019	5.99		2.93			3.89	8.82
Plot 2 Under	Average 2021	7.03		1.91			1.89	7.16
	P(T<=t) two-tail	1.22E-02		3.54E-02			1.87E-02	5.71E-03
Plot 3	Average 2019	6.20		2.762	0.149			
Plot 3 Under	Average 2021	6.49		1.503	0.101			
	P(T<=t) two-tail	5.83E-03		3.67E-02	1.60E-02			
Plot 4	Average 2019	5.93						
Plot 4 Under	Average 2021	6.52						
	P(T<=t) two-tail	2.12E-02						
Plot 1	Average 2019			1.89	0.120	639		5.43
Plot 1 Between	Average 2021			0.97	0.079	314		3.61
	P(T<=t) two-tail			1.46E-03	1.95E-02	2.90E-05		1.86E-02
Plot 2	Average 2019	5.99		2.93		932	3.89	8.82
Plot 2 Between	Average 2021	6.63		1.40		548	1.94	7.07
	P(T<=t) two-tail	2.77E-02		9.31E-03		3.62E-02	3.04E-03	3.32E-02
Plot 3	Average 2019	6.20						
Plot 3 Between	Average 2021	6.52						
	P(T<=t) two-tail	7.85E-03						
Plot 4	Average 2019							
Plot 4 Between	Average 2021							
	P(T<=t) two-tail							

4.2.5. Plantation Site Soil Salinity

No statistical difference was identified between plots for the 2019 and 2021 for electrical conductivity (EC). Plots 2, 3, and 4 displayed a lower EC between compared to under the plants for both the 2020 and 2021 sampling regimes, however the plot averages indicate both under- and between-plant sample results highlight elevated salinity compared to the laboratory recommended guideline of 0.120 dS/m for loam. With the exception of the Plot 1 Under plant samples, all results saw a reduction in EC from 2020 to 2021. See Figure 4.2.5.1.

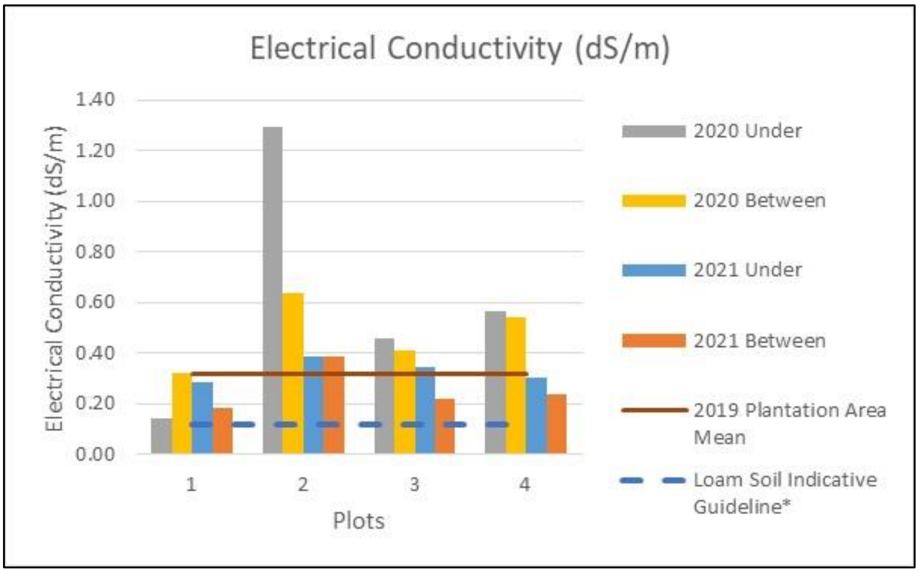


Figure 4.2.5.1: Electrical Conductivity Comparison across Plots.

An exchangeable sodium % in excess of 5% indicates a potential salt issue. All plots exhibited average values that were in excess of 30%. See Figure 4.2.5.2.

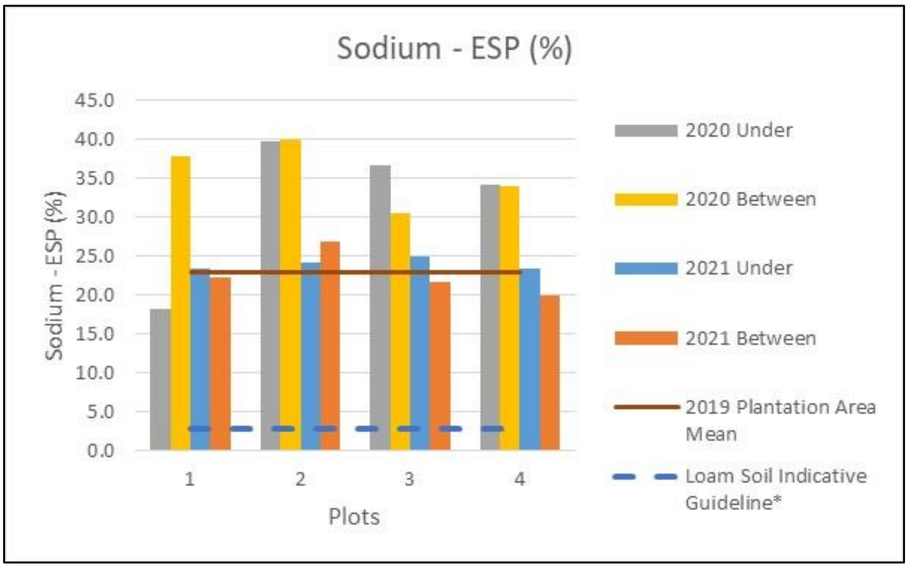


Figure 4.2.5.2: Exchangeable Sodium Potential Comparison across Plots.

4.2.6. Production Well Data

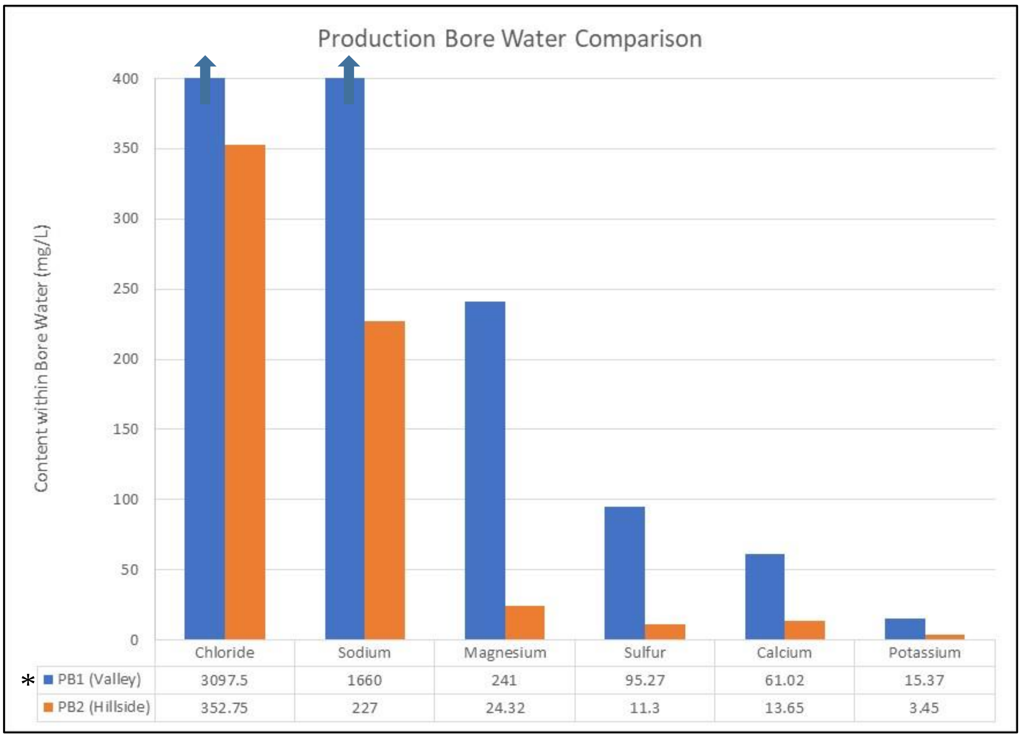
The two water production wells (Production Bore (Valley) 1 (PB1), Production Bore (Hill) 2 (PB2)) were installed adjacent to the Plantation Site in February 2020. The wells extract ground-water from a depth of ~55m and have been analysed for water quality and composition. The water extracted from PB1 has been analysed with respect to electrical conductivity (EC) in conjunction with the unused growing medium (coir substrate) and the growing media of the actively growing plants (i.e. measuring the active removal of salt from the media by the halophytes) within the shade houses. The EC data is presented in Table 4.2.6 and identifies that the Production Bore 1 EC was ~14% that of sea water and classified as within the drinking tolerance for sheep (7.5-14.9 dS/m, livestock can adapt without loss of production), but at the cusp of salinity for salt tolerant crops (8.1 dS/m) (Ref: Measuring salinity - Science notes Land series L137, Queensland Government publications (publications.qld.gov.au)). It was apparent from the data that the Heart-leafed Ice-plant 1 and the Slender Ice-plant have the lowest EC results within the water present and hence potentially the highest salt extraction from the production bore water supplied. It is noted that the comparative samples between Production Bore 1 and Production Bore 2 shows Bore 2 to have ~14% that of Production Bore 1 and more of a brackish water EC. No further sampling data was available.

Table 4.2.6: Greenhouse Water Electrical Conductivity Analysis of Plant Growing Medium Post Irrigation and Plant Growth to Date. (Sampling Date: 04/03/2021)

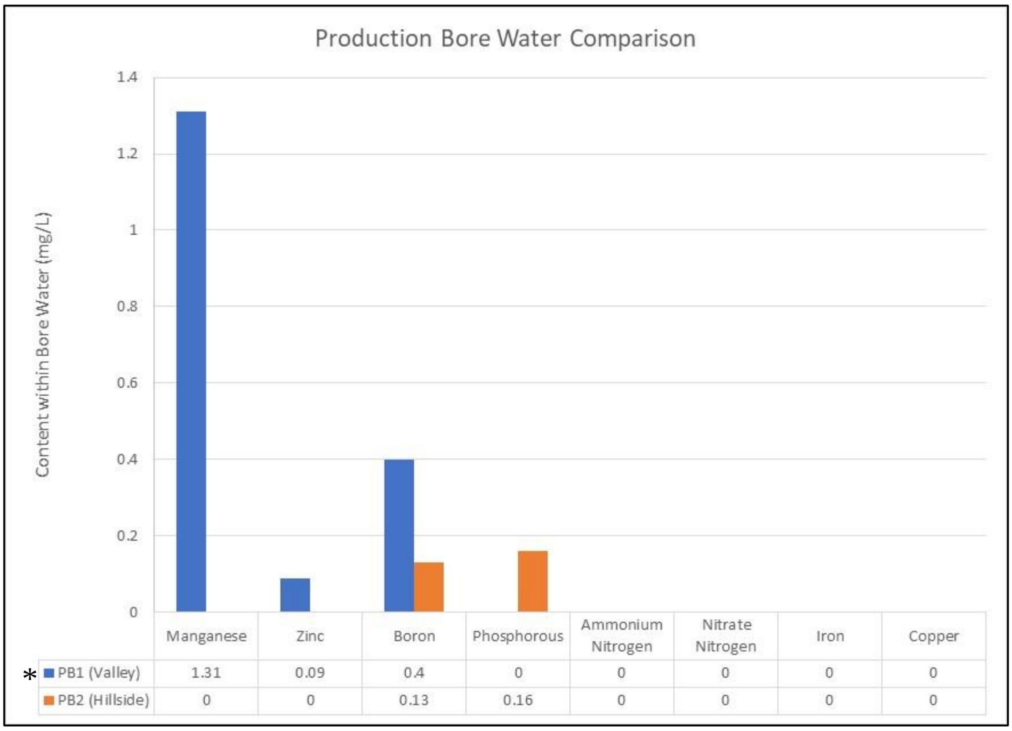
Water Sources (E.C. in dS/m)	**Raw**	**Corrected**
Mains Water supply (Standard)	0.3	0
Example Sea Water (Ref*)		55
PB1 (Valley) Water (CSBP)		9.03
PB2 (Hill) Water (CSBP)		1.34
PB1 (Valley) Water (into greenhouse)	8.2	7.9
Coir Substrate	0.6	0.3
Outside Greenhouse top 50mm soil	0.3	0
E.C Levels actively growing crops	**Raw**	**Corrected**
Karkalla 1	7.9	7.6
Karkalla 2	7.5	7.2
Karkalla 3	7.4	7.1
Heart leafed Iceplant 1	1.6	1.3
Heart leafed Iceplant 2	4.2	3.9
Slender Iceplant	2.5	2.2
In Greenhouse under Benches	3.6	3.3

Ref* - https://www.agric.wa.gov.au/soil-salinity/measuring-soil-salinity

Comparison of the bore water samples indicate that the mineral content and EC of PB1 (Valley) was substantially higher than that of PB2 (Hill) only 500 metres away with the exception of phosphorus. The pH of PB1 was slightly lower that than of PB2 (PB1 pH = 6.8, PB2 pH = 7.1). These have been presented in Figure 4.2.6.1 (a), and (b). The full composition analysis of the two production bores' water samples are contained within Table 12.2 in Appendix 6, Section 12.



(a)



(b)

Figure 4.2.6.1 (a) and (b): Plantation Site Production Bore Water Sampling Results.
** PB1 was used for Greenhouse irrigation.*

During the production bore drilling process, soils were extracted and deposited on the surface representing soil characteristics encountered every two meters. Soil samples from Production Bore 1 (PB1) were impacted by the break through water of the bore rendering them contaminated by adjacent soil sample mounds and production fluids. The samples from Production Bore 2 (PB2) remained intact. From the 30+ PB2 deposits, 10 depths were selected based on visually and textural discernible soil profile changes. The soil texture transitions from a sandy loam soil at 2 metres depth through a sandy clay loam (6, 24 metres) to a loamy sand at 54 meters. The pH had a generally increasing trend from 5.67 at 2 metres depth to 9.2 at 66 meters. See Figure 4.2.6.2.

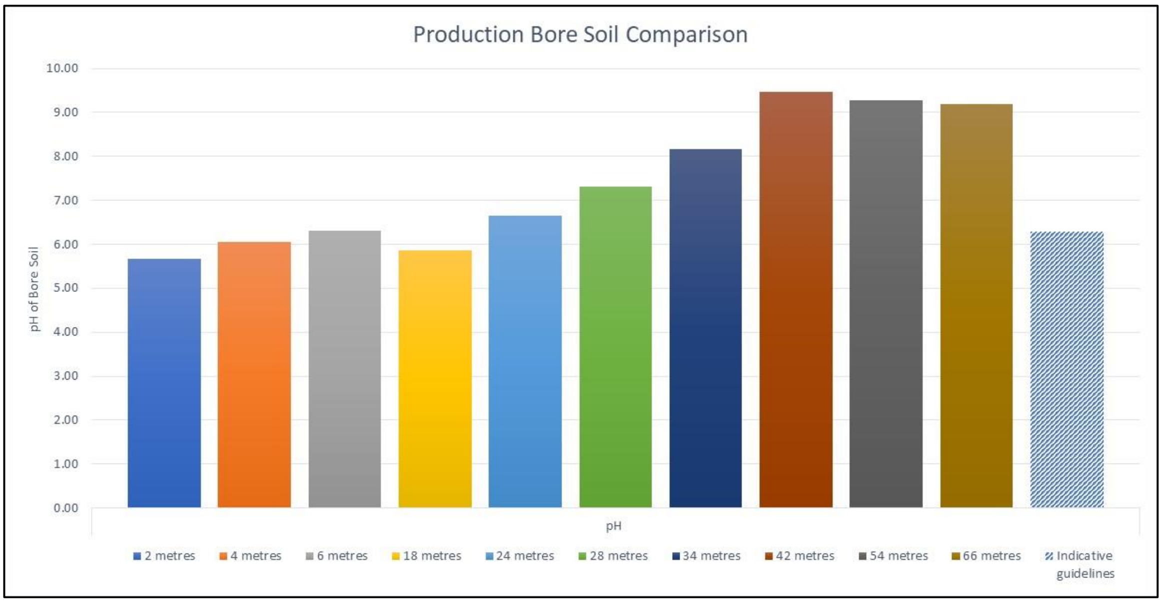


Figure 4.2.6.2: Plantation Site Production Bore Soil Sampling pH Results to Depth.

The soil EC had a moderately consistent decreasing trend from 0.46 dS/m at 2 metres depth to 0.17dS/m at 66 meters. It is suggested that the 6 meter low value, the main contrast to this trend, may be an aberration (potentially influenced by activity of extraction), as a result of it being on the transition of soils (orange/cream coloured sandy loam (10-20%clay) soils compared to the >6m white sandy clay loam (20-30%) soils) or an indication of a lateral soil change around the sampled location that impacted the infiltration of water to this location. The reducing trend from 2m to 42 m suggests the impact of salinity within run-off/surface waters infiltrating – i.e. the delivery of ions to depth reducing due to reducing bulk penetration depending on rainfall and attraction/filtration of ions as the water moves down through the soil. Alternately this may be an impact of agricultural practices similarly washed down through the soil profile. The step change at 54m reinforced by the 66m analysis suggests the potential capillary action of ions with the below ground water on contact or from fluctuating or dropping rainwater over time to the present day. It is noted that the Production Bore (Valley) 1 (PB1) has a pumped water EC of 9.03 dS/m thus the wicking impact of the capillary action was seen at these depths. See Figure 4.2.6.3.

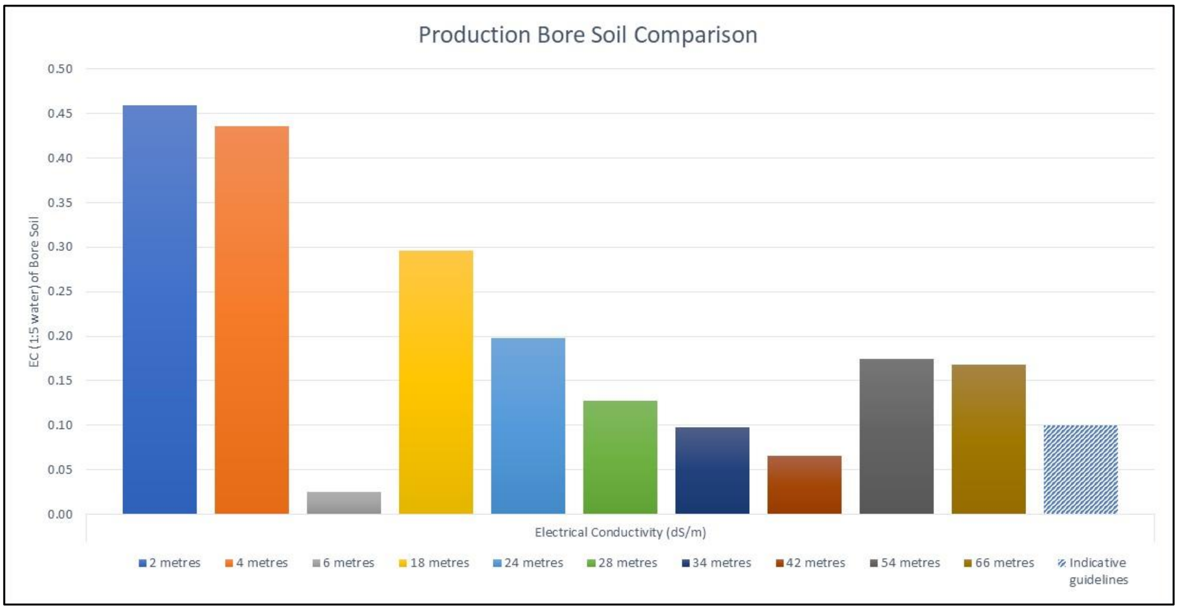


Figure 4.2.6.3: Plantation Site Production Bore Soil Sampling Electrical Conductivity Results to Depth.

Figure 4.2.6.4 presents the % content of Calcium, Magnesium, Potassium and Sodium to depth (2, 6, 24, 54 metres) within the bore soil samples. Whilst not strictly appropriate due to the changing depth, when this data was assessed relative to the indicative guideline, it was evident that at all depths, the sodium content was well in excess of the guideline, the magnesium percentage was greater than (or equal to) twice the guideline for all samples except that taken at 54m, and the calcium and potassium percentage are all less than or equal to the guideline. There was no consistent trend in the examined minerals content with depth – the calcium percentage was highest at 54m, magnesium at 6m, potassium at 54m (but deficient across the board) and sodium at 24m(but in excess across the board). As a result of these compositions the Calcium/Magnesium ratio was very low for the 2, 6 and 24 metre depths. The 54 metre depth was greater than twice the indicative guideline due to the very high calcium levels in the parent rock. Note that the location is within the East Katanning System (Percy, Wilson, and Griffin, 2000; Chin & Brakel, 1986) where the area geology is described as mainly colluvium with minor deposits of alluvium (Qc) and small areas of granite, adamellite and granodiorite (Age, Agn). Minor areas of laterite (Cz/) and reworked sandplain (Czs) and very small areas of conglomerate (Czc) and silcrete (Czb) from Chin and Brakel (1986).

The effective cation exchange capacity (ECEC) was also examined as part of the cumulative quantity of minerals present. The trend observed (See Figure 4.2.6.5), was a higher than guideline ECEC at 2 metres with a steep decline to 6 meters and an increasing trend with increasing depth. However the 6, 24, and 54 metre samples were all less than the guideline value provided.

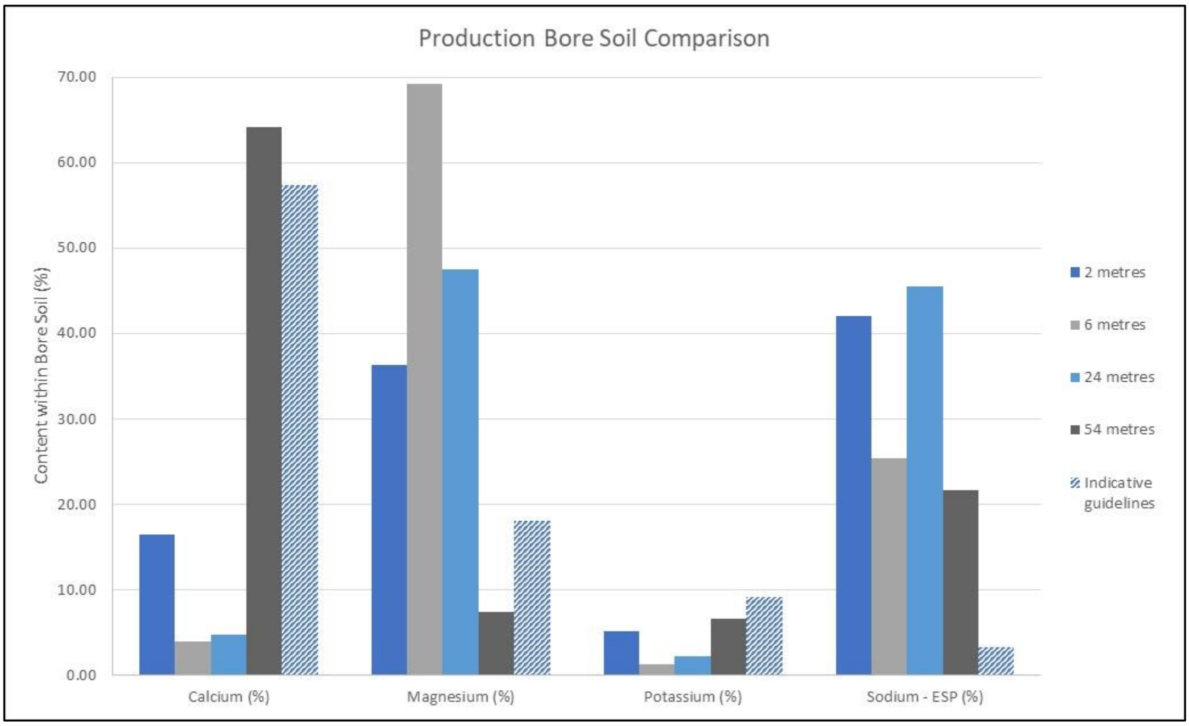


Figure 4.2.6.4: Plantation Site Production Bore Soil Sampling Mineral % Results to Depth.

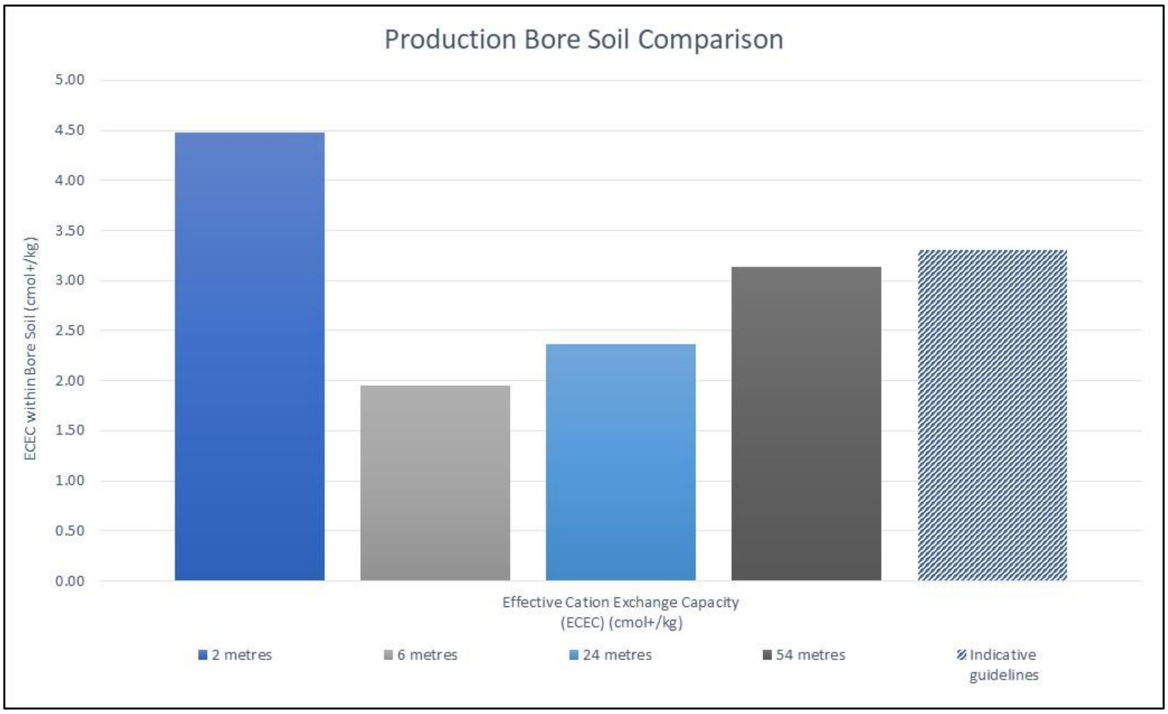


Figure 4.2.6.5: Plantation Site Production Bore Soil Sampling Effective Cation Exchange Capacity.

Further analysis was not deemed necessary for the purposes of this project. The full composition analysis of the two productions bore soil samples are contained within Table 12.1 in Appendix 6, Section 12.

4.3. Plantation Site Soil Bacteria DNA Diversity Profiling (2020/2021)

Quantification of the Plantation Site soil bacteria DNA diversity profiling displayed little variability between research plots. This meant that the replications could be increased and the enhancement of the evaluation of the effects of Soil depth (0 to 10 cm, 10 to 30 cm) with sampling location (between plants, under plants) and the interaction of soil depth with sampling location could be achieved.

4.3.1. Soil Bacteria Alpha Diversity (Plantation Site, 2020)

Alpha diversity describes how many species there are in a particular site or habitat. In soil ecology there is no specific species number that is an indicator of soil health, however soil ecologists do agree that the higher the species diversity is more beneficial for ecosystem resistance and resilience to abiotic and biotic stresses e.g. drought stress, pathogens. Whilst there were subtle differences in the alpha diversity indicies species evenness and inverse Simpson, these were statistically not relevant (See Figure 4.3.1 a,b,c,d and Table 4.3.1), thus the effect of soil depth and sampling location (under or between plant rows) had no impact at the sampling point in time.

Species richness (presented as OTU richness), and Fisher's alpha diversity displayed a decrease with these two diversity indices as a function of soil depth irrelevant of sampling location (i.e. no effect of under plant/between plant rows). Bacteria diversity decreasing as a function of soil depth is not unusual, and can be related to the organic carbon content and minerals present in the deeper soil horizons (Fierer et al., 2003).

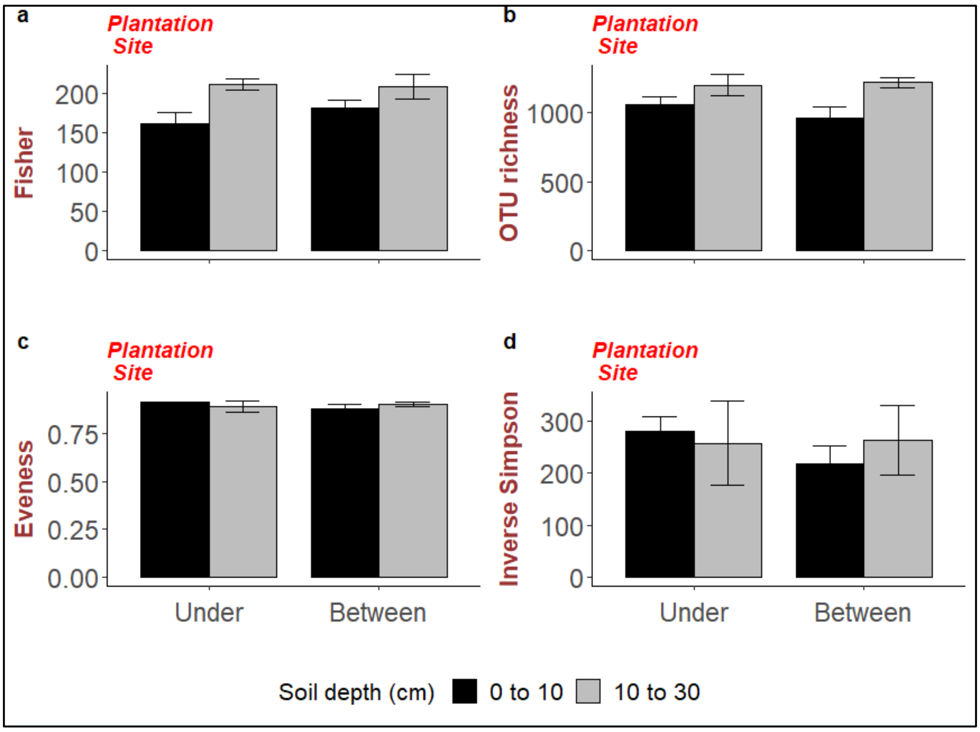


Figure 4.3.1: Alpha diversity indices1 a) Fisher, b) OTU richness (e.g. species richness), c) Evenness, and d) Inverse Simpson for the Plantation Site. Factors (soil depth & plant location) showed a marginal effect (for Fisher, and Richness), and no interactive effects of the factors were significant for other indicies. Bars represent the mean values across the plots, and the error bars are the standard error of the mean.

*Table 4.3.1: 2020 Soil bacteria two-way ANOVA results showing P values for alpha diversity calculators. Treatments consisted of 'Soil depth', and 'Sampling location'. Significant difference P values indicated by * and ** corresponding to P < 0.05 and < 0.01, respectively.*

Alpha Diversity Indicie	Treatment	Degrees of freedom	Sum of Squares	Mean Squares	F. Model	P
Fisher	Soil_depth	1	7985	7985	7.397	**0.013***
	Sample_location	1	919	919	0.851	**0.013***
	Soil_depth:Sample_location	1	661	661	0.612	**0.013***
	Residuals	20	21589	1080		
Richness	Soil_depth	1	213467	213467	6.547	**0.019***
	Sample_location	1	18371	18371	0.563	0.462
	Soil_depth:Sample_location	1	16024	16024	0.492	0.491
	Residuals	20	652084	32604		
Evenness	Soil_depth	1	0	0	0	0.986
	Sample_location	1	0	0	1.066	0.314
	Soil_depth:Sample_location	1	0	0	1.246	0.278
	Residuals	20	0	0		
Inverse Simpson	Soil_depth	1	665	665	0.057	0.815
	Sample_location	1	9238	9238	0.786	0.386
	Soil_depth:Sample_location	1	6022	6022	0.512	0.482
	Residuals	20	235132	11757		

4.3.2. Soil Bacteria Alpha Diversity (Plantation Site, 2021)

Soil depth showed no changes to alpha diversity indices, though there were slight increases in alpha diversity (Species richness, Fishers, and inverse Simpson) for samples underneath the saltbush Plantation Site (See Figure 4.3.2 a,b,c,d and Table 4.3.2).

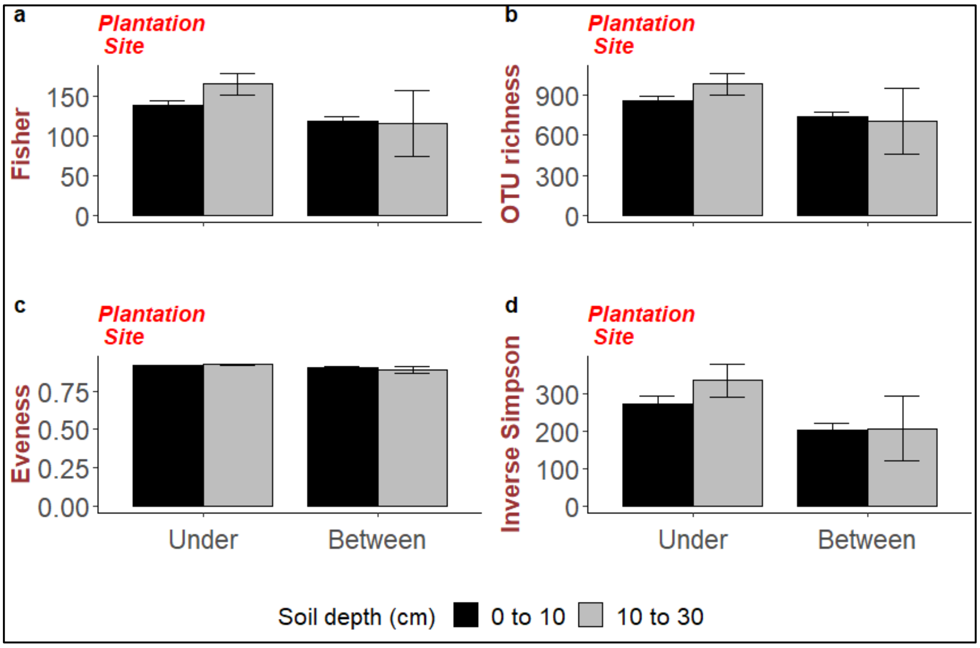


Figure 4.3.2. 2021 Alpha diversity indices1 a) Fisher, b) OTU richness (e.g. species richness), c) Evenness, and d) Inverse Simpson for the Plantation Site. Bars represent the mean values across the plots, and the error bars are the standard error of the mean.

*Table 4.3.2.: 2021 Soil bacteria two-way ANOVA results showing P values for alpha diversity calculators. Treatments consisted of 'Soil depth' , and 'Sampling location' . Significant difference P values indicated by * and ** corresponding to P < 0.05 and < 0.01, respectively.*

Alpha diversity indicie	Treatment	Degrees of freedom	Sum of Squares	Mean Squares	F. Model	P
Fisher	Soil_depth	1	12	12	0.003	0.958
	Sample_location	1	22586	22586	5.433	**0.038***
	Soil_depth:Sample_location	1	15	15	0.004	0.953
	Residuals	12	49888	4157		
Richness	Soil_depth	1	352	352	0.003	0.959
	Sample_location	1	692640	692640	5.305	**0.040***
	Soil_depth:Sample_location	1	1871	1871	0.014	0.907
	Residuals	12	1566695	130558		
Evenness	Soil_depth	1	<0.01	0	0.087	0.773
	Sample_location	1	0.005	0	2.687	0.127
	Soil_depth:Sample_location	1	<0.01	0	0.119	0.736
	Residuals	12	0.023	0		
Inverse Simpson	Soil_depth	1	8	8	0.001	0.975
	Sample_location	1	42686	42686	5.246	**0.041***
	Soil_depth:Sample_location	1	541	541	0.067	0.801
	Residuals	12	97641	8137		

4.3.3. Phylum Level Relative Abundance (Plantation Site, 2020)

The Phylum taxonomic level is commonly used to investigate large and broad level changes to soil bacteria from differing land management practices (Mickan et al., 2019) or soil amendments (Mickan et al., 2018). There were no major changes at the phylum level (data not presented), from sampling location (between and under plants), however there was a slight decrease in Actinobacteria at depth under the plant sampling location (See Figure 4.3.3). Whilst the decrease in Actinobacteria is marginal, it is likely to be related to changes in soil carbon at greater depth.

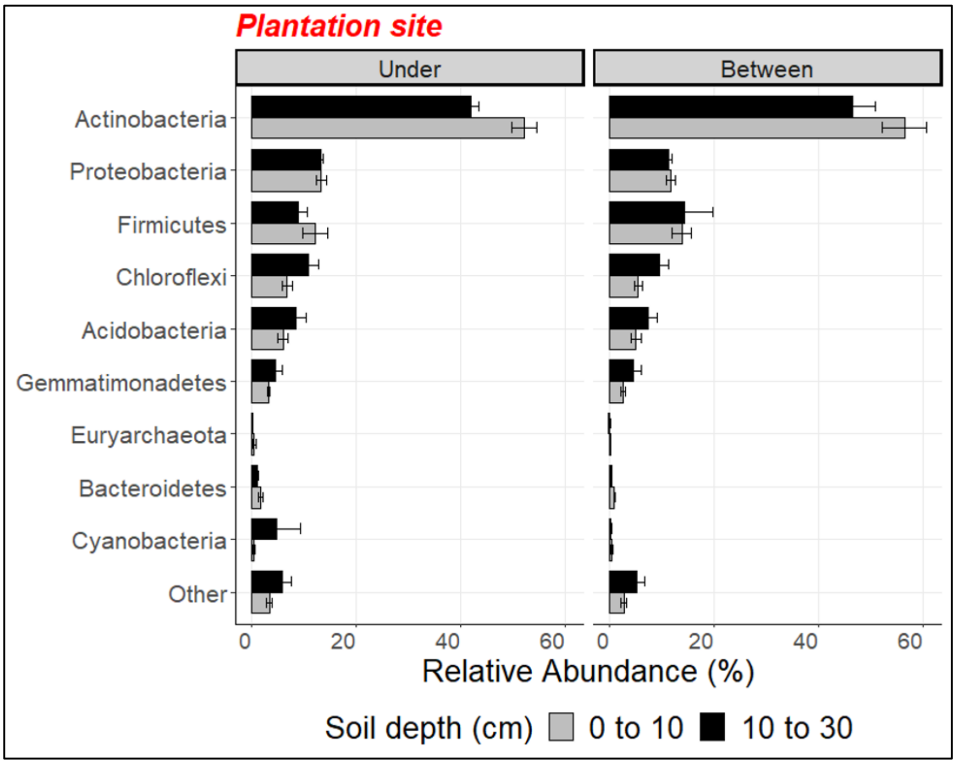


Figure 4.3.3: 2020 Plantation Site soil bacteria relative abundance response to soil sampling location (under & between plants) with soil depth (0 to 10 cm, 10 to 20 cm) and their interaction between sampling location and soil depth. Bars represent the mean value across the sampling site, and the error bars are the standard error of the mean.

4.3.4. Phylum Level Relative Abundance (Plantation Site, 2021)

Soil bacteria as assessed at the broad level of Phylum relative abundances showed alterations to Actinobacteria (P=0.004) and Firmicutes (P=0.03) with increases of these phyla in the shallow soil profile (0 to 10cm), though sample location (under or between plants) did not have any impact (See Figure 4.3.4). Proteobacteria also increased in the 0 to 10 cm profile, and this was more pronounced in the sample location under the plants. An opposite trend was observed for Acidobacteria, with increase in the deeper soil (10 to 30cm). Whilst all these phylum were shown to be different from 2020, the sampling site location having excess water conditions may of driven these changes.

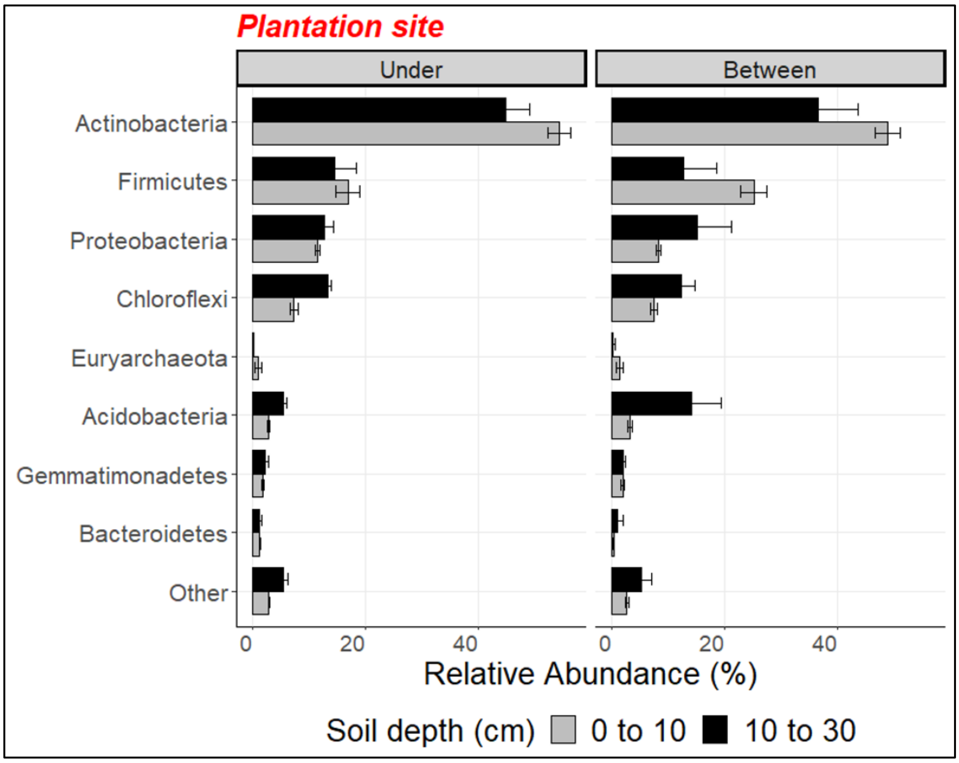


Figure 4.3.4: 2021 Plantation Site soil bacteria relative abundance response to soil sampling location (under & between plants) with soil depth (0 to 10 cm, 10 to 20 cm) and their interaction between sampling location and soil depth. Bars represent the mean value across the sampling site, and the error bars are the standard error of the mean.

4.3.5. Soil Bacteria Beta Diversity (Plantation Site, 2020)

Beta diversity measures the change in diversity of species from one environment (one sampling location or one soil depth) to another. It calculates the number of species that are not the same in two different environments. There are also indices which measure beta diversity on a normalized scale, usually from zero to one. Using a Bray Curtis dissimilarity matrix, coupled with a visual non-metric multidimensional scaling (NMDS) plot community assemblages can be displayed (See Figure 4.3.5).

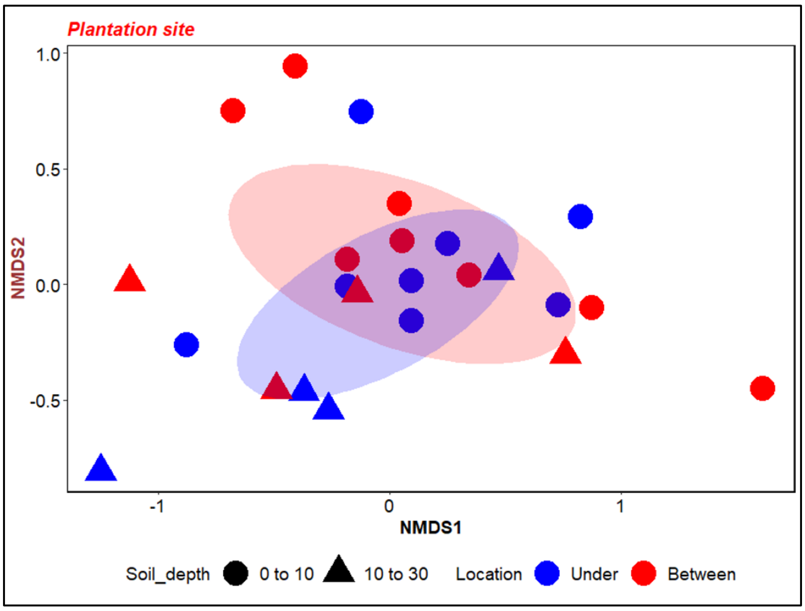


Figure 4.3.5: 2020 Non-metric multidimensional scaling (NMDS) plot of soil bacterial communities in two Sampling locations (Under and between the plants) and at two Soil depths (0 to 10 cm, 10 to 30cm using OTU based (97% similarity, e.g. species theory level).

For Figure 4.3.5, if the treatments are close to each other or the same, then these factors are similar and are considered identical in community composition. Hence for those factors that are far away (i.e. on the other side of the plot) are a differing community assemblage. A permutational analysis of variance revealed that plant proximity had no effect, however soil depth show a differing bacterial community assemblage (See Table 4.3.5).

Table 4.3.5: 2020 Plantation Site soil bacterial community analysis by PERMANOVA results based on 97% similarity OTU abundance data (square root transformed), using 999 permutations. Treatments consisted of 'Sample location' , and Soil depth' .
*Significant difference P values indicated by * and ** corresponding to P < 0.05 and < 0.01, respectively.*

Treatment	Degrees of freedom	Sum of Squares	Mean Squares	F. Model	R^2	P
Sample_location	1	0.229	0.229	0.866	0.037	0.596
Soil_depth	1	0.521	0.521	1.969	0.085	**0.013***
Sample_location:Soil_depth	1	0.097	0.097	0.368	0.016	1
Residuals	20	5.293	0.265	0.862		
Total	23	6.141	1			

4.3.6. Soil Bacteria Beta Diversity (Plantation Site, 2021)

Similar Beta diversity measurements (in respect to 2020) at the species (97% OTU) level were shown for community assemblages in 2021 with soil depth being responsible for large community changes (i.e. disparate communities between 0 to 10cm and 10 to 30cm). However, by 2021 the community was also impacted by sample location (i.e. disparate communities comparing under to between plants (See Figure 4.3.6 and Table 4.3.6).

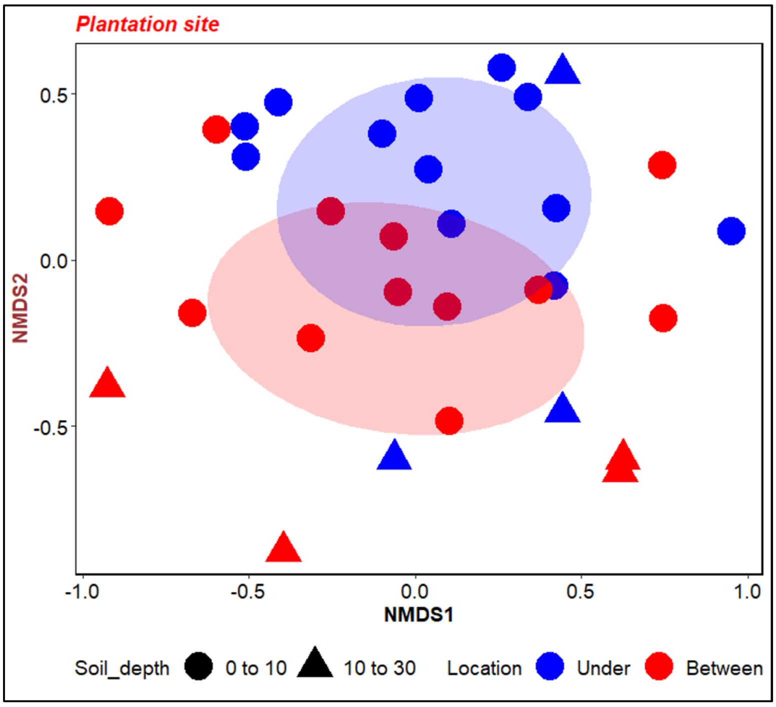


Figure 4.3.6: 2021 Non-metric multidimensional scaling (NMDS) plot of soil bacterial communities in two Sampling locations (Under and between the plants) and at two Soil depths (0 to 10 cm, 10 to 30cm using OTU based (97% similarity, e.g. species theory level).

Table 4.3.6:2021 Plantation Site soil bacterial community analysis by PERMANOVA results based on 97% similarity OTU abundance data (square root transformed), using 999 permutations. Treatments consisted of 'Sample location' , and Soil depth' .
*Significant difference P values indicated by * and ** corresponding to P < 0.05 and < 0.01, respectively.*

Treatment	Degrees of freedom	Sum of Squares	Mean Squares	F. Model	R^2	P
Sample_location	1	0.480	0.480	2.000	0.060	**0.007****
Soil_depth	1	0.890	0.890	3.700	0.110	**0.001****
Sample_location:Soil_depth	1	0.170	0.170	0.720	0.020	0.788
Residuals	28	6.720	0.240	0.810		
Total	31	8.260	1			

4.3.7. Putative C & N Cycling Genes (Plantation Site, 2020)

The next generation DNA sequencing was performed to allow insight into taxonomic bacterial data that is relevant to assess how differing management practice influences soil health. Utilizing an in silico, it is possible to predict the functional relevance in relation to carbon & nitrogen cycling processes based on a phylogenetic prediction tool using PICRUSt (Langille et al., 2013).

A range of putative carbon cycling genes were selected from the PICRUSt KO ortholog outputs, these were based on assessing the ability of detected the bacteria to degrade a range of carbon substrates from labile (e.g. starch) to recalcitrant (chitin, lignin) carbon sources. This is important information as to how management practice(s) influences of the potential for altering range of carbon substrates, which can indicate enhanced soil carbon depletion and nutrient mineralization. The sampling location, soil depths, and the interaction between the two factors (sampling location and soil depth) had no major effect on bacteria predicting carbon cycling potential, though there was a single minor influence of the greater soil depth decreasing Catalase (lignin degrading capacity) potential (See Figure 4.3.7.1 and Table 4.3.7.1).

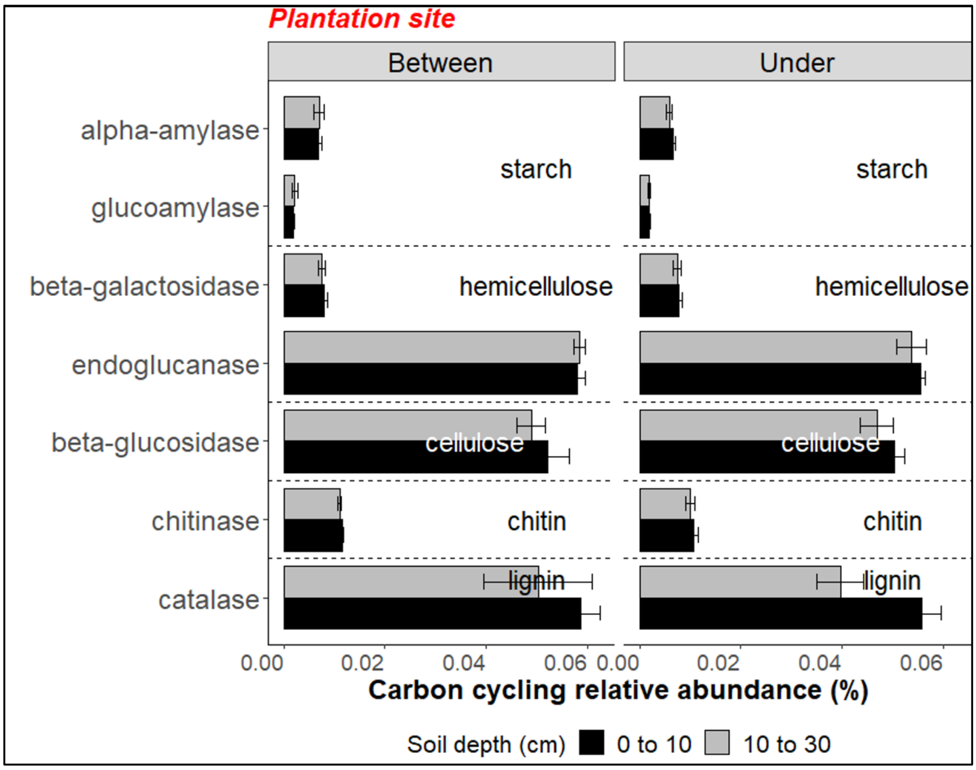


Figure 4.3.7.1: 2020 Plantation Site analysis of putative carbon cycling genes of bacteria DNA data using PICRUSt for the treatments; Soil depth (0 to 10cm, 10 to 30 cm), Plant location (under, between plants), and the interaction between. Bars represent the mean value across the Plantation Site, and error bars are the standard error of the mean.

*Table 4.3.7.1: 2020 Soil bacteria two-way ANOVA results showing P values for carbon cycling potential. Treatments consisted of 'Soil depth' , and 'Sampling location' . Significant difference P values indicated by * and ** corresponding to P < 0.05 and < 0.01, respectively.*

	Treatment	Degrees of freedom	Sum of Squares	Mean Squares	F. Model	P
alpha-amylase	Sample_location	1	2.54E-06	2.53E-06	0.987	0.332
	Soil_depth	1	4.81E-07	4.81E-07	0.188	0.670
	Sample_location:Soil_depth	1	8.05E-07	8.05E-07	0.313	0.582
	Residuals	20	5.13E-05	2.57E-06		
glucoamylase	Sample_location	1	3.93E-08	3.93E-08	0.084	0.775
	Soil_depth	1	5.60E-08	5.60E-08	0.12	0.733
	Sample_location:Soil_depth	1	1.88E-07	1.88E-07	0.402	0.533
	Residuals	20	9.37E-06	4.68E-07		
beta-galactosidase	Sample_location	1	2.22E-07	2.22E-07	0.107	0.748
	Soil_depth	1	1.15E-06	1.15E-06	0.55	0.467
	Sample_location:Soil_depth	1	1.08E-07	1.08E-07	0.052	0.822
	Residuals	20	4.17E-05	2.08E-06		
endoglucanase	Sample_location	1	6.30E-05	6.30E-05	4.102	0.056
	Soil_depth	1	2.20E-06	2.20E-06	0.143	0.709
	Sample_location:Soil_depth	1	6.14E-06	6.14E-06	0.4	0.534
	Residuals	20	3.07E-04	1.54E-05		
beta-glucosidase	Sample_location	1	1.96E-05	1.96E-05	0.273	0.607
	Soil_depth	1	6.08E-05	6.08E-05	0.845	0.369
	Sample_location:Soil_depth	1	1.70E-07	1.67E-07	0.002	0.962
	Residuals	20	0.00144	7.20E-05		
chitinase	Sample_location	1	5.25E-06	5.25E-06	1.843	0.190
	Soil_depth	1	1.64E-06	1.64E-06	0.575	0.457
	Sample_location:Soil_depth	1	3.60E-08	3.57E-08	0.013	0.912
	Residuals	20	5.69E-05	2.85E-06		
catalase	Sample_location	1	0.000188	0.000188	1.176	0.291
	Soil_depth	1	0.000797	0.000797	4.98	**0.037***
	Sample_location:Soil_depth	1	7.51E-05	7.51E-05	0.469	0.501
	Residuals	20	0.003199	0.00016		

Functional genes relating to nitrogen related processes (i.e. N fixation, nitrification, and denitrification) were also quantified using PICRUSt. There were also only minor alterations to putative nitrogen cycling processes, with no interactive effects of these treatments (i.e. sample location with soil depth) (See Figure 4.3.7.2 and Table 4.3.7.2). Nitrification is the process by which ammonia is converted to nitrites (NO_2-) and then nitrates (NO_3-). Two nitrification genes were altered, and increased for both sampling locations (between and under plants) at the greater depth of 10 to 30 cm by increasing the relative abundance of amoA & amoB, and HaO. Denitrification is a process where bacteria convert plant-available soil nitrate (NO_3-) into nitrogen (N) gases that are lost from the soil, and this process slightly increased with depth for nrfA, and also increased under the plant in sample location for nirK and nosZ (Figure 4.3.7.2).

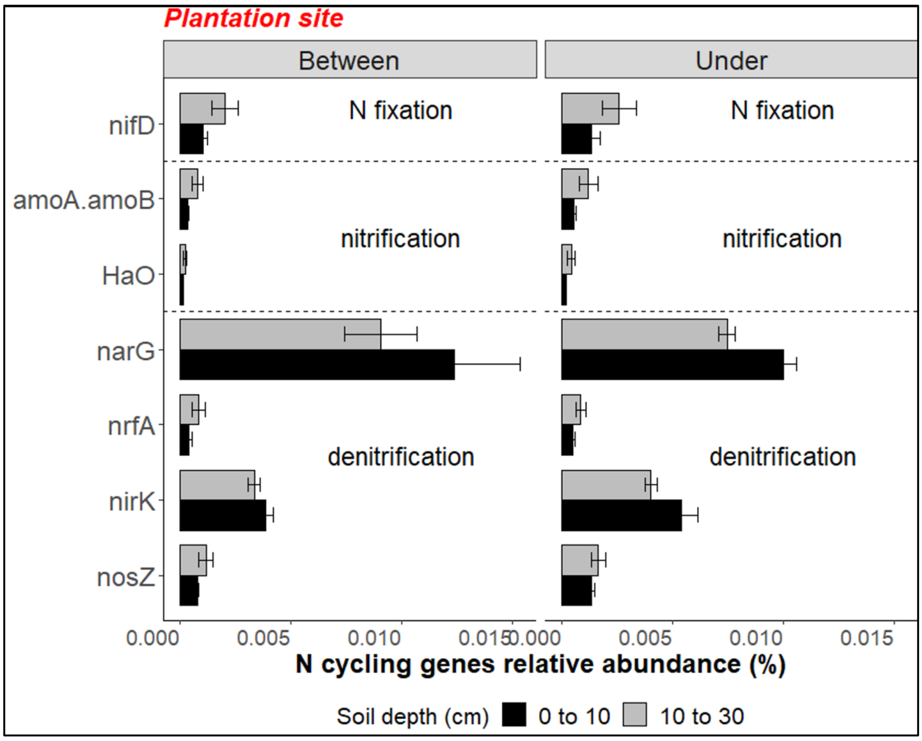


Figure 4.3.7.2: 2020 Plantation Site analysis of putative nitrogen cycling genes of bacteria DNA data using PICRUSt for the treatments; Soil depth (0 to 10cm, 10 to 30 cm), Plant location (under, between plants), and the interaction between. Bars represent the mean value across the Plantation Site, and error bars are the standard error of the mean.

*Table 4.3.7.2: 2020 Soil bacteria two-way ANOVA results showing P values for carbon cycling potential. Treatments consisted of 'Soil depth', and 'Sampling location'. Significant difference P values indicated by * and ** corresponding to P < 0.05 and < 0.01, respectively.*

	Treatment	Degrees of freedom	Sum of Squares	Mean Squares	F. Model	P
nifD	Sample_location	1	8.38E-07	8.38E-07	0.717	0.407
	Soil_depth	1	6.84E-06	6.84E-06	5.859	**0.025***
	Sample_location:Soil_depth	1	1.16E-07	1.16E-07	0.09	0.756
	Residuals	20	2.34E-05	1.17E-06		
amoA.amoB	Sample_location	1	4.18E-07	4.18E-07	2.33	0.142
	Soil_depth	1	1.57E-06	1.57E-06	8.77	**0.008****
	Sample_location:Soil_depth	1	7.02E-08	7.03E-08	0.3917	0.538
	Residuals	20	3.59E-06	1.79E-07		
HaO	Sample_location	1	5.20E-08	5.20E-08	2.0384	0.169
	Soil_depth	1	1.71E-07	1.71E-07	6.7119	**0.017***
	Sample_location:Soil_depth	1	2.53E-08	2.53E-08	0.9909	0.331
	Residuals	20	5.10E-07	2.55E-08		
narG	Sample_location	1	2.63E-05	2.63E-05	0.9531	0.341
	Soil_depth	1	4.61E-05	4.61E-05	1.6734	0.211
	Sample_location:Soil_depth	1	7.60E-07	7.64E-07	0.0277	0.869
	Residuals	20	5.52E-04	2.76E-05		
nrfA	Sample_location	1	1.32E-08	1.32E-08	0.097	0.759
	Soil_depth	1	8.39E-07	8.39E-07	6.1675	**0.022***
	Sample_location:Soil_depth	1	3.26E-09	3.26E-09	0.024	0.879
	Residuals	20	2.72E-06	1.36E-07		
nirK	Sample_location	1	9.51E-06	9.51E-06	4.8308	**0.040***
	Soil_depth	1	4.65E-06	4.65E-06	2.3648	0.140
	Sample_location:Soil_depth	1	1.04E-06	1.04E-06	0.528	0.476
	Residuals	20	3.94E-05	1.97E-06		
nosZ	Sample_location	1	1.79E-06	1.79E-06	9.3774	**0.006****
	Soil_depth	1	6.51E-07	6.51E-07	3.4046	0.080
	Sample_location:Soil_depth	1	1.12E-08	1.12E-08	0.0585	0.811
	Residuals	20	3.82E-06	1.91E-07		

4.3.8. Putative C & N Cycling Genes (Plantation Site, 2021)

By 2021 there were substantial changes to the putative functions of soil bacteria to influence carbon cycling processes. For 2021 increases in beta-galactosidase degrading capacity (easily available carbon) increased in the 0 to 10 cm soil profile irrespective of sample location (i.e. under or between salt bush). The trend for beta-glucosidase degradability (i.e. ability degrade plant or microbe derived cellulose) was increased in the under plant sample location (i.e. increasing under the salt bush), for both soil profiles which is likely to be in relation to positive impacts of the saltbush plant. (See Figure 4.3.8.1)

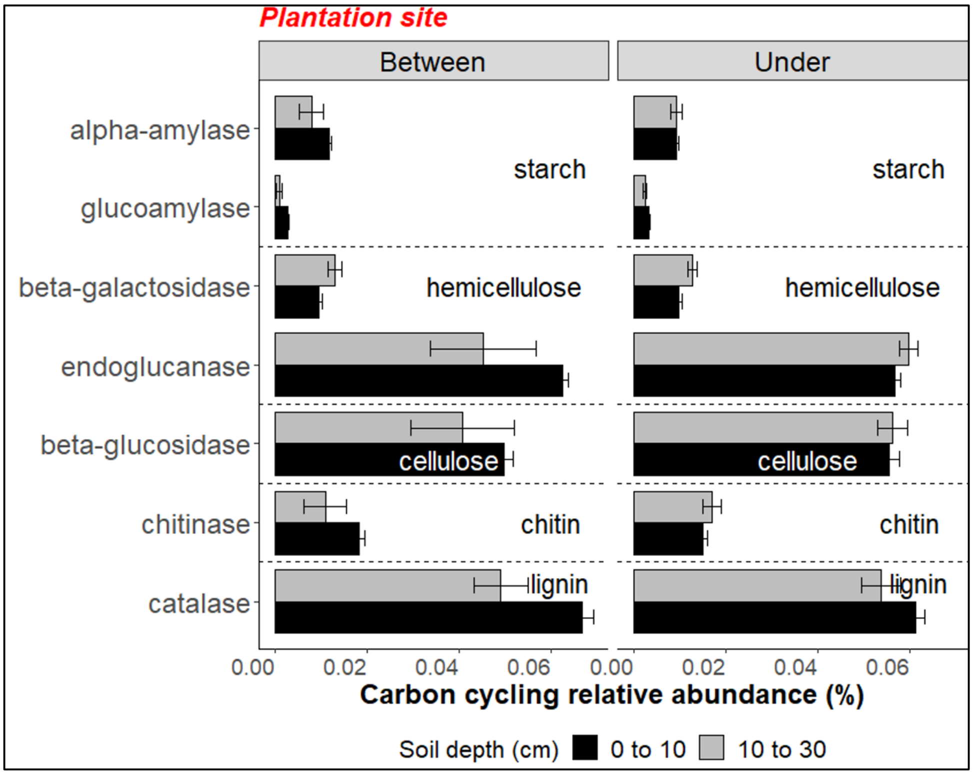


Figure 4.3.8.1: 2021 Plantation Site analysis of putative carbon cycling genes of bacteria DNA data using PICRUSt for the treatments; Soil depth (0 to 10cm, 10 to 30 cm), Plant location (under, between plants), and the interaction between. Bars represent the mean value across the Plantation Site, and error bars are the standard error of the mean.

During 2021 within the Plantation Site there were only minor changes to N cycling potential observed, with increases in N fixation (nifD) at the deeper soil depth 10 to 30cm, and decreases of nirK (denitrification), again with soil depth (Figure 4.3.8.2). Whilst these alterations were significant, they were only minor. Additionally, there was no effect of the plant location (i.e. between or under the saltbush) of saltbush on any nitrogen cycling potential.

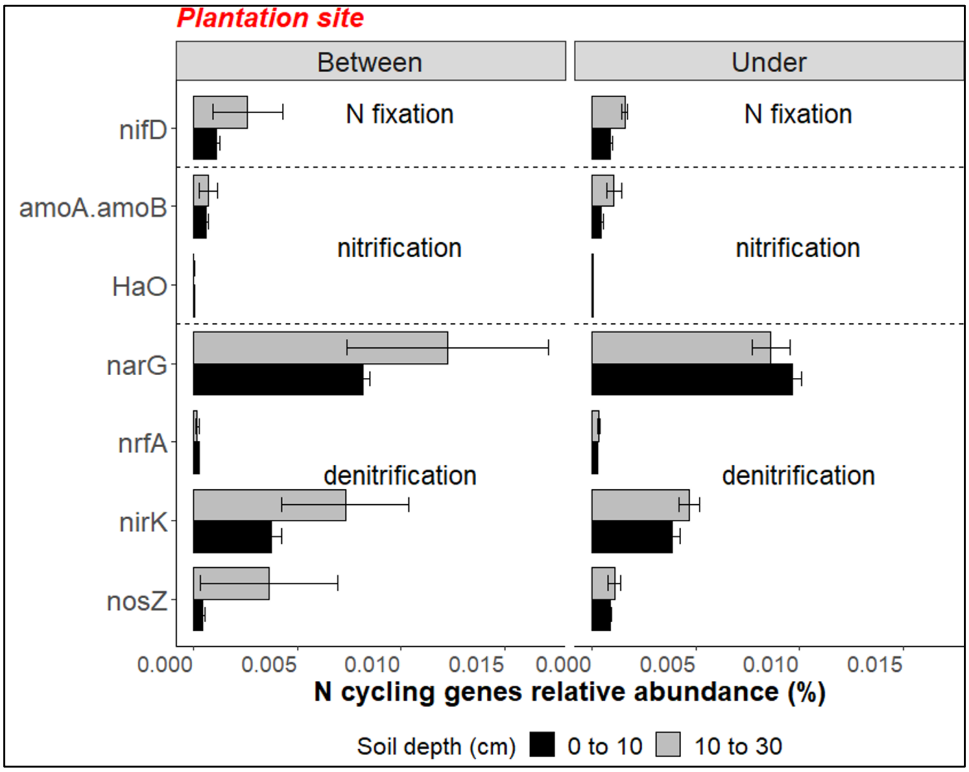


Figure 4.3.8.2: 2021 Plantation Site analysis of putative nitrogen cycling genes of bacteria DNA data using PICRUSt for the treatments; Soil depth (0 to 10cm, 10 to 30 cm), Plant location (under, between plants), and the interaction between. Bars represent the mean value across the Plantation Site, and error bars are the standard error of the mean.

4.4. Wild Harvest Site Results (2020/2021)

Soil samples were taken from the Wild Harvest Site in 2020 and 2021 with a designated baseline for the location's soil properties (non-scarified area) and the change from that baseline with the implementation of soil scarification. It was noted that conclusions drawn at this point are done so acknowledging the relatively brief timeframe of soil impact/response and the significant disturbance implemented at the commencement of the trial - ~ 4 months post scarification for 2020 and 18 months for 2021. It was not anticipated that significant change would be noted as a result of the scarification activity in 2020, however there was the hope that a further 12 months would demonstrate the development of a recovery/future trajectory trend. There has also been a significant seasonal weather pattern difference between 2020 and 2021, as noted previously, making long term predictions of the impact of scarification on soil properties difficult to distil.

Additionally, as the application of disturbance was soil scarification rather than plant scarification, the majority of plants were removed from the scarified area limiting the locations available for under plant sampling and making the historical between plant locations difficult to discern in the 2020 sampling round. However, it was possible to conduct limited sampling and compare the two treatment regimens with respect to under versus between plants to present an indicative baseline and degree of change within the first timestamp sampling. This enabled two points on the graph to be identified for 2020 and then a subsequent two points for 2021. Where trends were identified between the non-scarified for 2020 and 2021, this provided insights into the annual/recent weather impact potential on the scarified results in combination with the scarification effect. This allows a comparative understanding of the impact of the plants and the more general site treatment impacts with either a 1 year consistent trend between the two treatments or a contrasting 1 year trend.

Note: Where greater than half the samples have been noted as less than the detectable level have been excluded from the analysis. Where these "<" values are present in less than half the samples, then 0.85% of the "<" value has been assumed to acknowledge the presence of these low range values and enable the statistical analysis to be completed. Note also that a repeat of the clay and gravel identified as causing potential contamination of two samples within the 2020 data set, was not observed in the 2021 data where any gravel impacted sample was discarded and a replacement extracted after the soil sampling tools were cleaned.

4.4.1. 2020 Baseline Wild Harvest Site Overall Nutrient Content

General soil comparison to laboratory recommended values for clay loam type indicates: (See Graphs 4.4.1.1 (a) – (d))

- High - electrical conductivity (EC), Carbon/nitrogen ratio, soluble magnesium, exchangeable magnesium, sulfur and exchangeable sodium.
- 50-100% - effective cation exchange capacity (ECEC) and boron.
- 25-50% - total carbon, silicon, plant available phosphorus, nitrate nitrogen, ammonium nitrogen and exchangeable potassium.
- Remainder less than 25%.
- Typically the scarified samples were determined to have higher nutrient content.

An additional general soil comparison to laboratory recommended values for clay loam type was completed for the total data set analysed - including the Plantation Site samples from 2019 and 2020, the total Wild Harvest Site data set and the subsets of the Wild scarified and non-scarified samples. This comparison indicates: (See Graphs 4.4.1.2 (a) – (c))

- Very High, >200%
    - Total data sets -EC, sulfur and exchangeable sodium.
- High, 100-200%
    - Total data sets - Carbon/nitrogen ratio, soluble magnesium, and exchangeable magnesium.
    - Boron and Silicon from Plantation Site 2020 - ~ double other sets
- Moderate to Low, 50-100%
    - Total data sets – ECEC, and exchangeable potassium.
    - Total carbon and nitrogen %; available phosphorus; and the Nitrate and ammonium nitrogen for Plantation Site 2019 set.
    - Remaining boron except non-scarified Wild Harvest Site.
    - Silicon, plant available phosphorus and ammonium nitrogen for Plantation Site 2020 set.
- Very Low, 25-50% -
    - Total data sets - exchangeable potassium.
    - Soluble calcium from both Plantation Site dates.
    - Calcium/Magnesium ratio, exchangeable calcium, from Plantation Site 2019.

        - Remaining total carbon, boron, silicon, available phosphorus.
        - Total nitrogen for Plantation Site 2020 set.
        - Nitrate nitrogen from scarified Wild Harvest Site area and from Plantation Site 2019.
        - Ammonium nitrogen from non-scarified and total Wild Harvest Site data set.
    - Remainder less than 25%.
    - On average the soil nutrient content was poor highlighting the value in finding an alternate, low fertility, hardy production option for this location as discussed in the 2019 and 2020 Plantation Site Plot Results.
    - The Plantation Site results identified that the majority of soil nutrients are greater than in the Wild Harvest Site:
        - Total Carbon, total nitrogen, the calcium/magnesium ratio, zinc, manganese, soluble calcium, and exchangeable calcium all displayed greater results within both the Plantation Site sampling regimens relative to the Wild Harvest Site with the 2019 sample recording a higher value than the 2020.
        - Copper, silicon, phosphorus, nitrate nitrogen and ammonium nitrogen all displayed greater results within both the Plantation Site sampling regimens relative to the Wild Harvest Site with the 2020 sample recording a higher value than the 2019.
    - The EC was higher within the Wild Harvest Site.
    - The soluble magnesium, sulfur and exchangeable sodium results identified all 2020 results to be similar. These results were lower than that identified within the 2019 Plantation Site results. This may indicate a seasonal difference over-shadowing a location based (i.e. under versus between) difference.
    - It is noted that the Wild Harvest Site has exhibited poorer nutrient and saline properties as would be expected from the visual assessment of the area.

a)

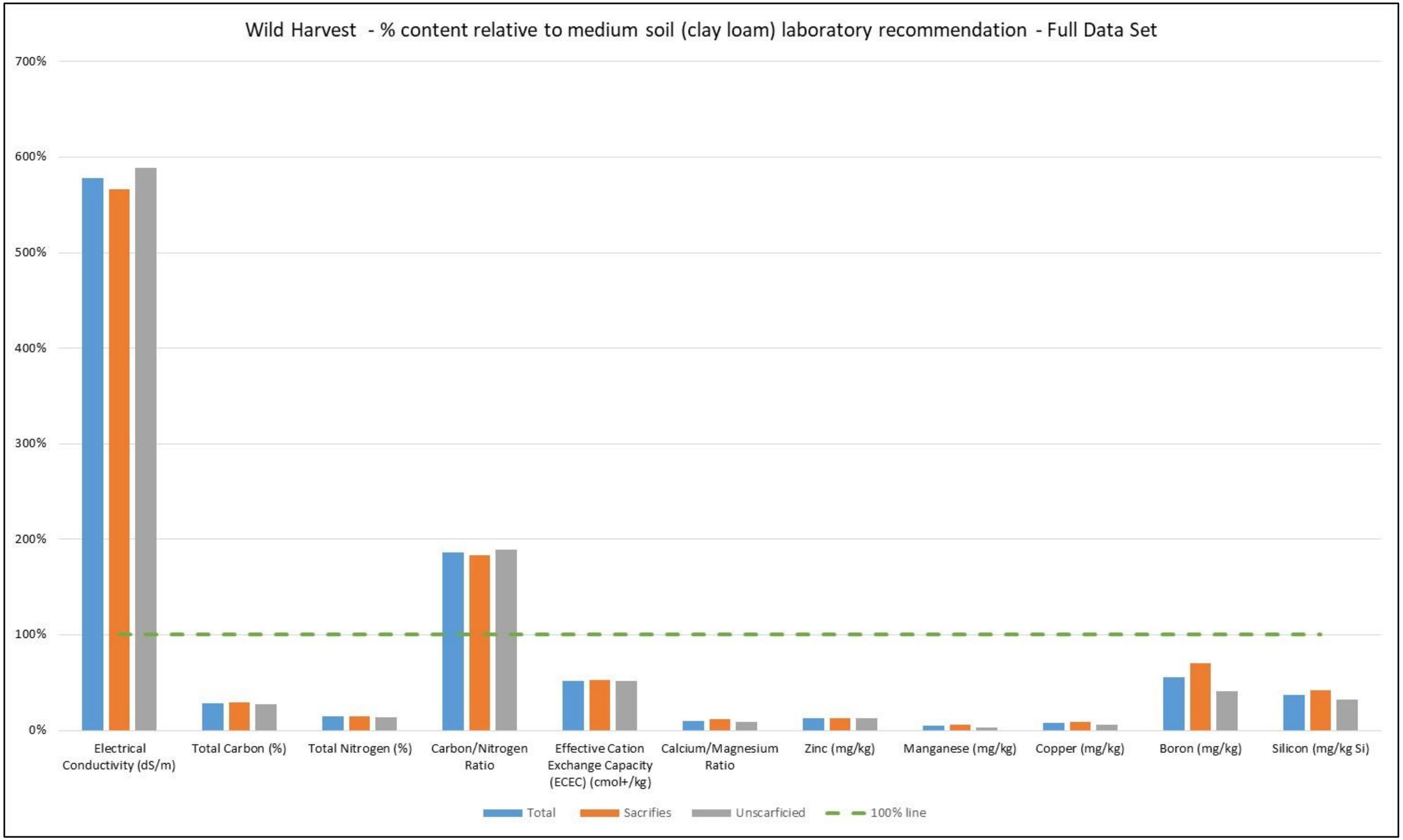
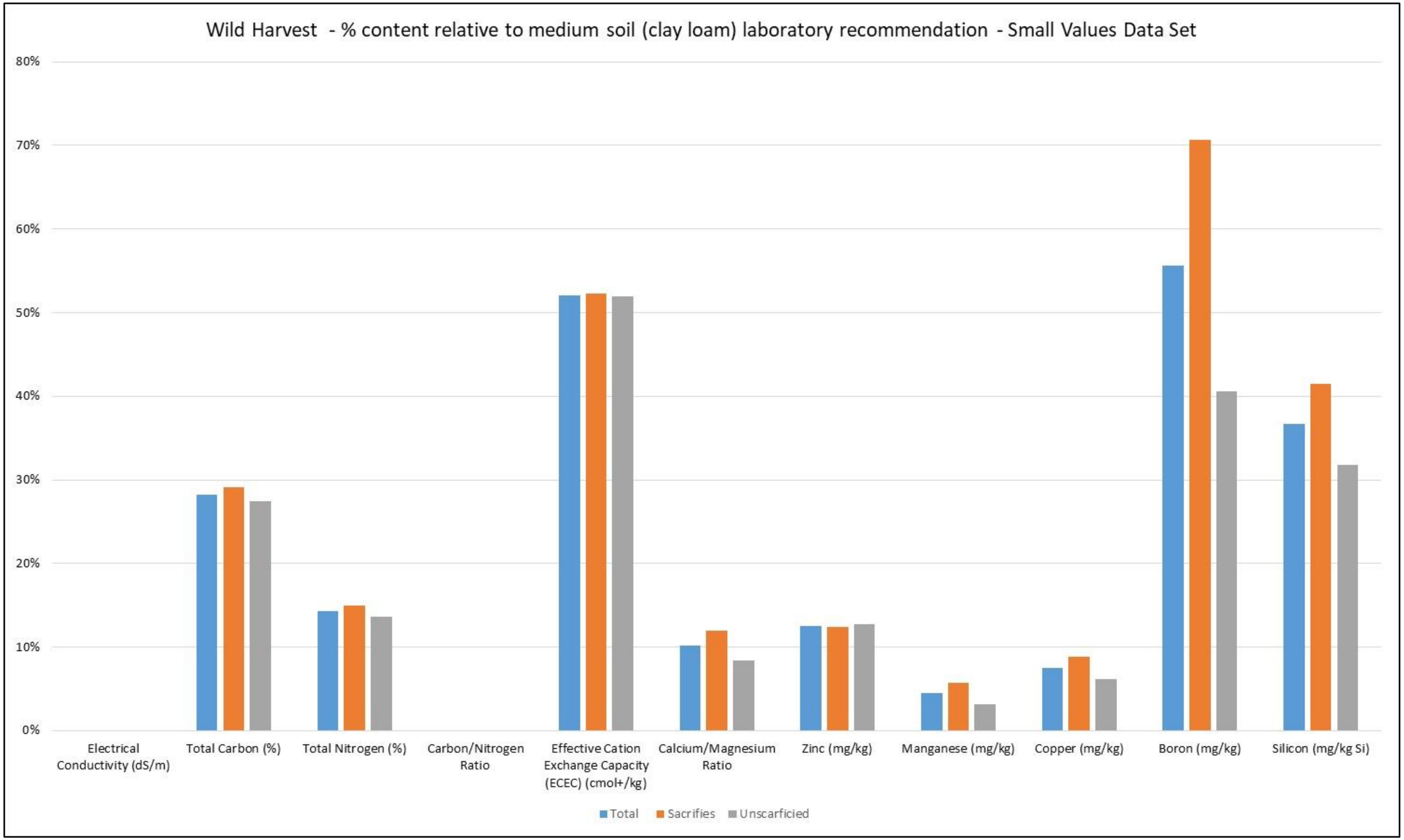


Figure 4.4.1.1 (a), (b), (c) and (d): Wild Harvest Site - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines- Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



b)

Figure 4.4.1.1 (a), (b), (c) and (d): Wild Harvest Site - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines- Part 2- As per graph (a) with Electrical Conductivity and Carbon Nitrogen ratio high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

c)

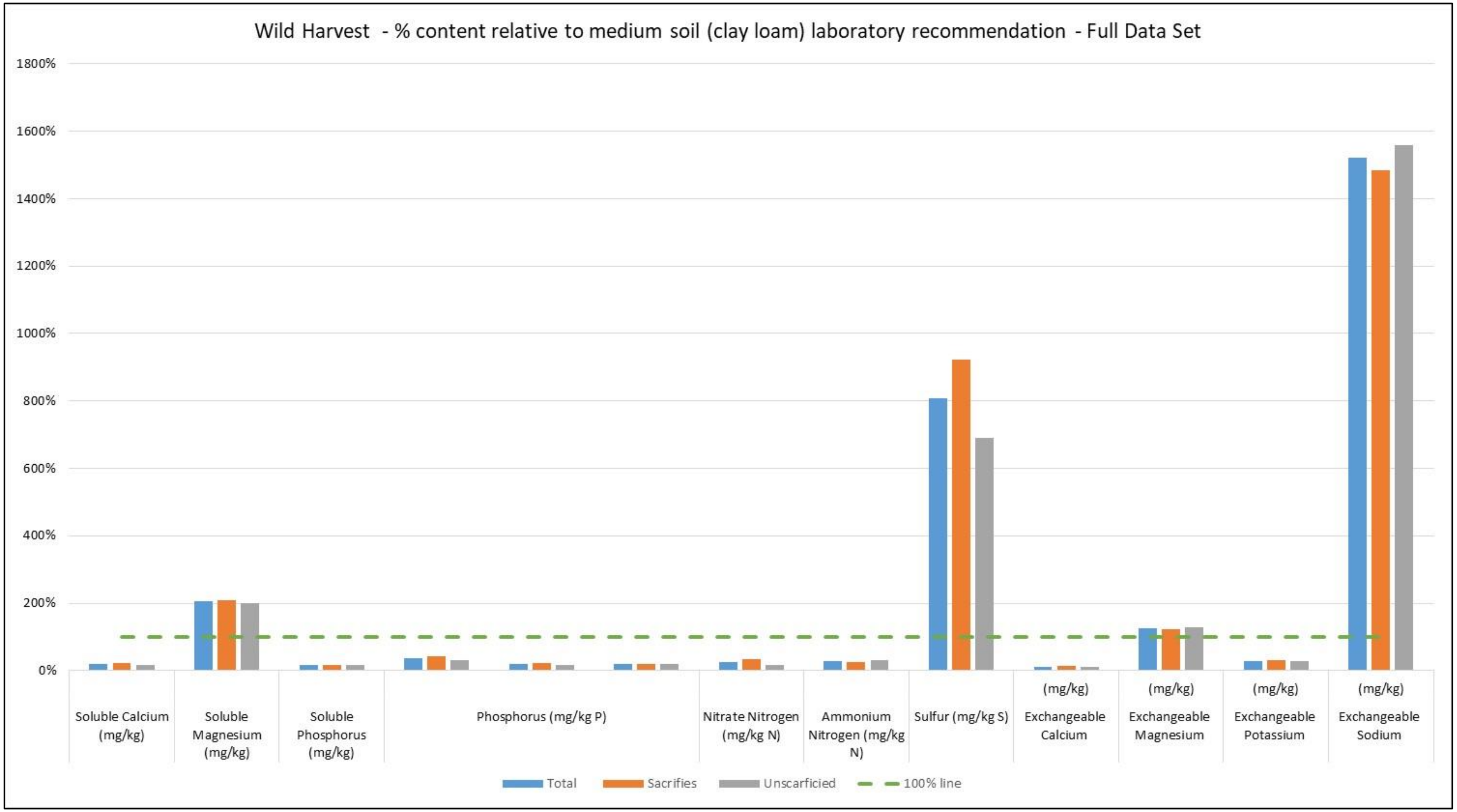


Figure 4.4.1.1 (a), (b), (c) and (d): Wild Harvest Site - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines-Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

d)

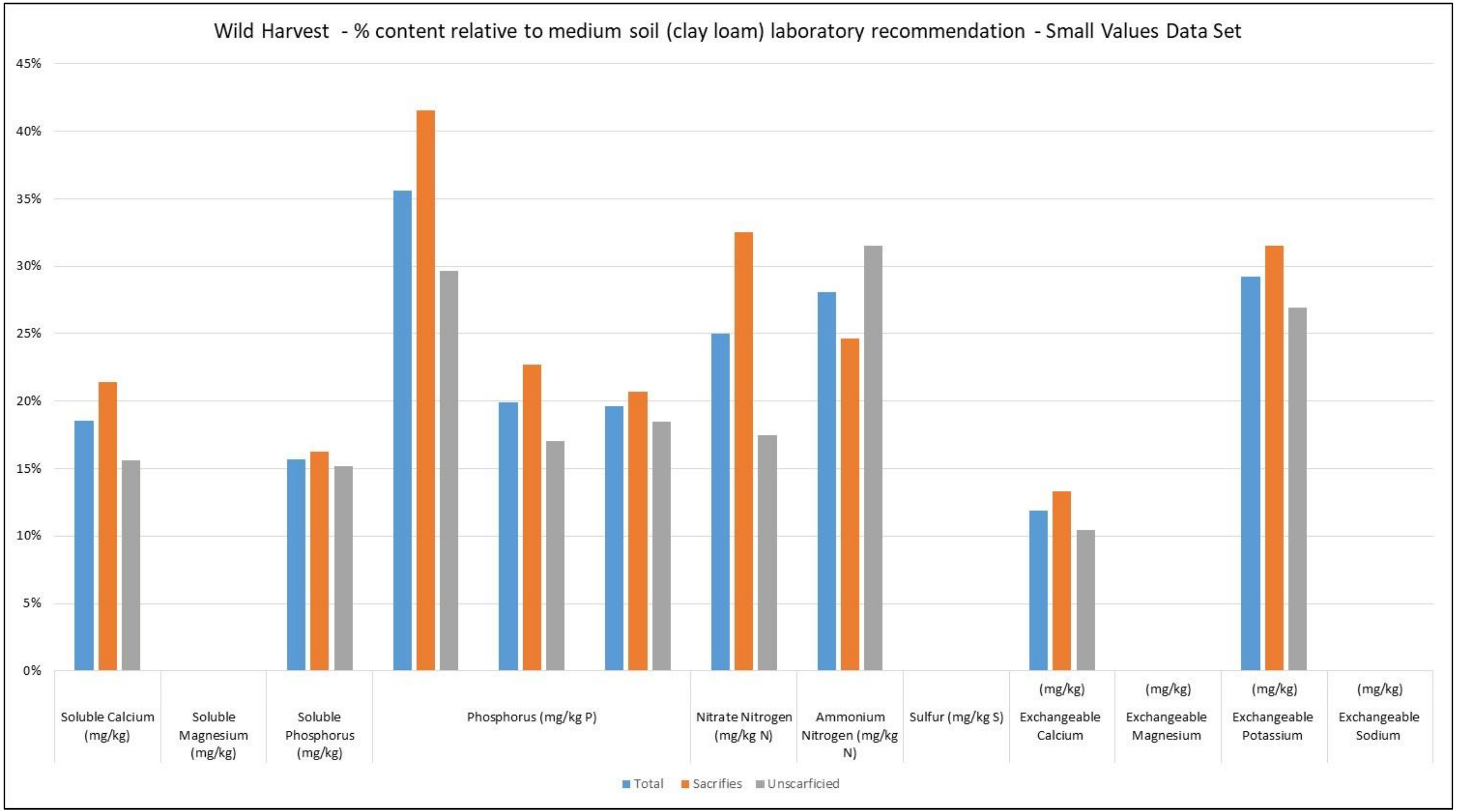
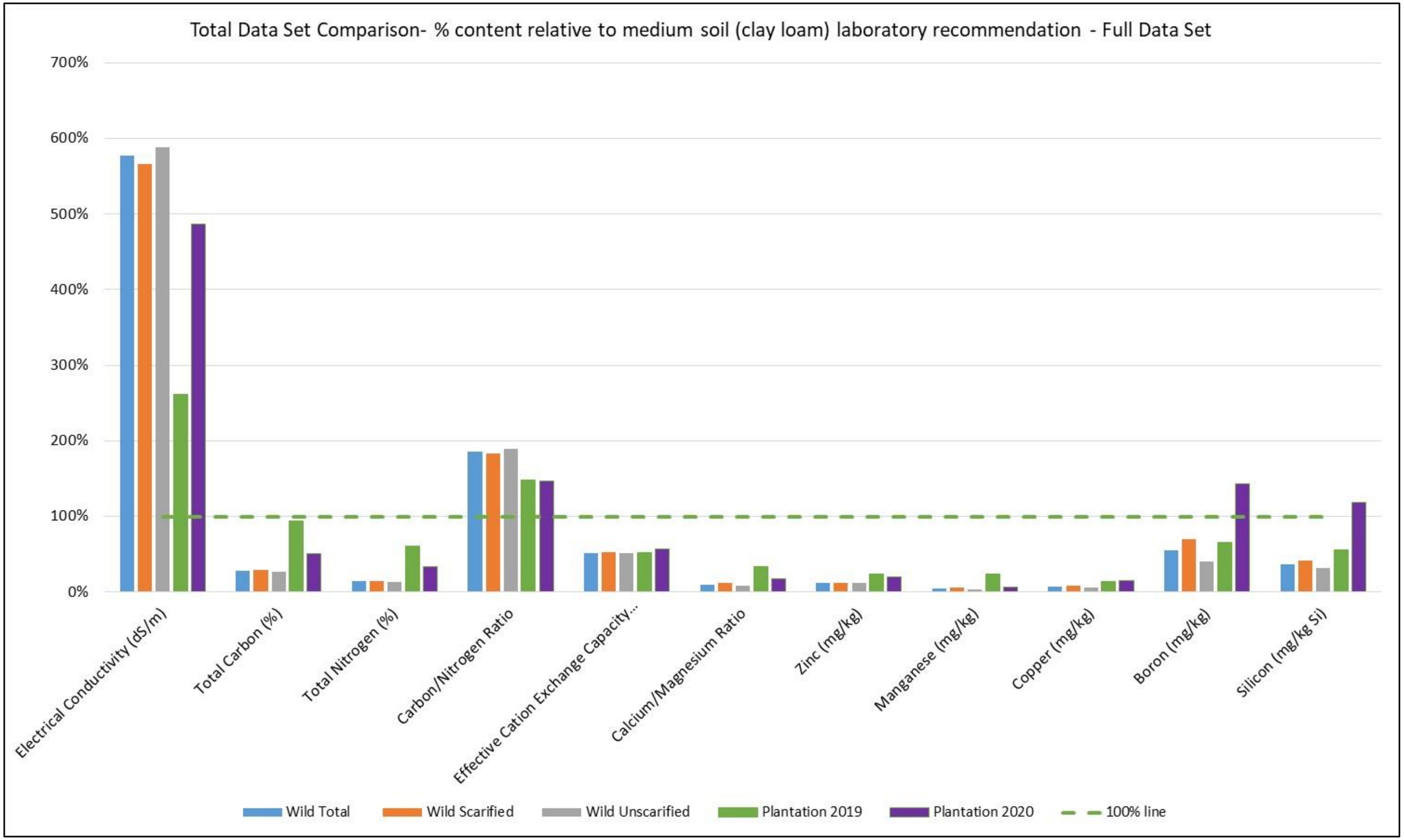


Figure 4.4.1.1 (a), (b), (c) and (d): Wild Harvest Site - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines- Part 2 - As per graph (b) with Soluble Magnesium, Sulfur, Exchangeable Magnesium and Exchangeable Sodium high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



a)

Figure 4.4.1.2 (a), (b), and (c): Total Data - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines- Part 1 – Full Data Set (No subset Part 2 required). Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

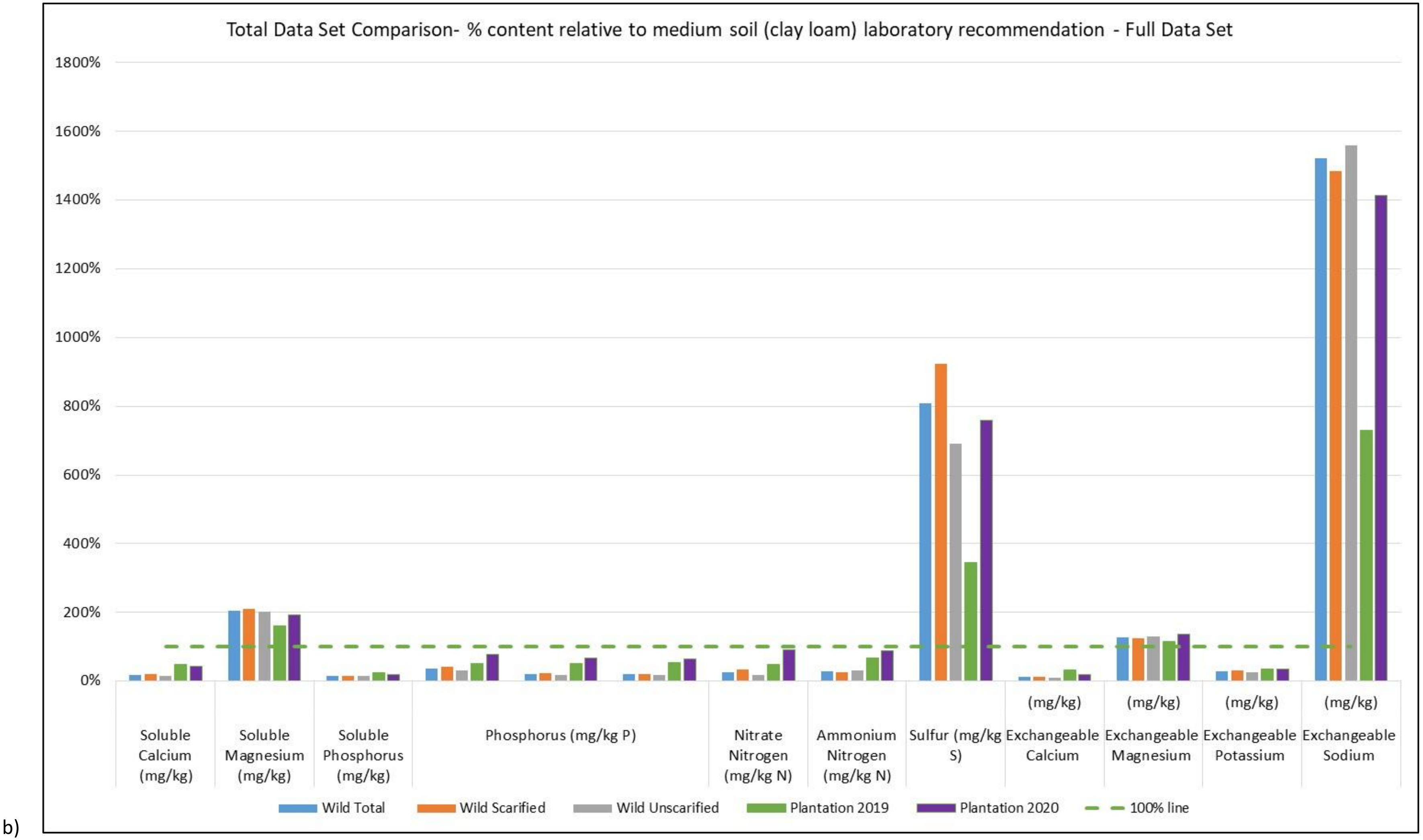


Figure 4.4.1.2 (a), (b) and (c): Total Data - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines- Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

c)

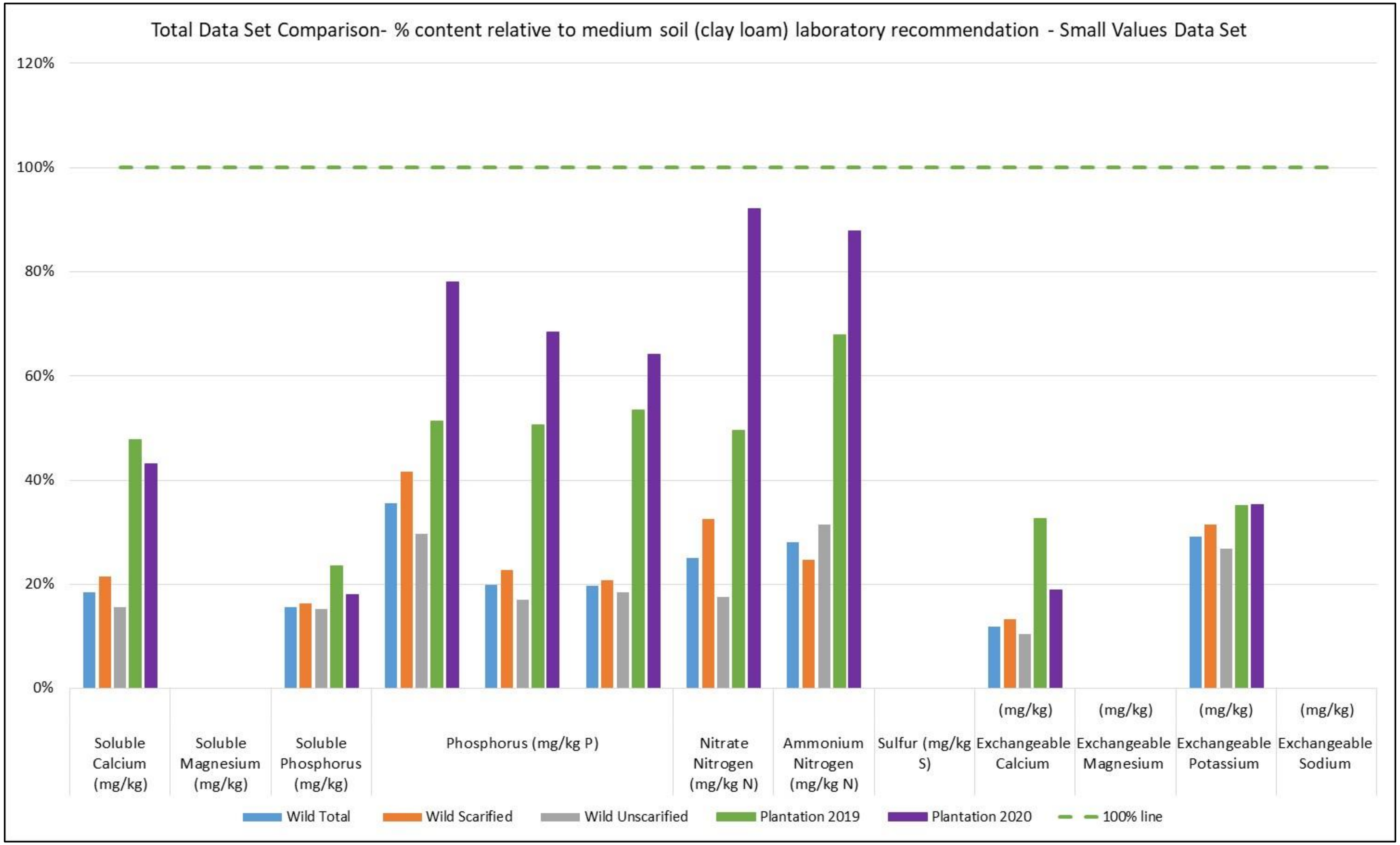


Figure 4.4.1.2 (a), (b) and (c): Total Data - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines- Part 2 - As per graph (b) with Soluble Magnesium, Sulfur, Exchangeable Magnesium and Exchangeable Sodium high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

4.4.2. Wild Harvest Site 2021 Overall Nutrient Content

A second data set of soil samples were taken from the Wild Harvest Site in 2021. General soil comparison to laboratory recommended values for sandy soil type indicates (See Graphs 4.4.2.1 (a) – (f)):

- High – pH; electrical conductivity (EC); Carbon/nitrogen ratio; effective cation exchange capacity (ECEC); iron; boron; soluble and % calcium; soluble, exchangeable and % of ECEC magnesium; sulfur; and exchangeable and percent sodium.
- 50-100% - soluble potassium, soluble phosphorus, exchangeable calcium, exchangeable potassium and silicon.
- 25-50% - total carbon, total nitrogen, and plant available phosphorus, and ammonium nitrogen.
- Remainder less than 25%.

The relationships between the 2020 and 2021 data are evident in Figure 4.4.2.1 (a) to (f), but have also been presented in Table 4.4.2.1 with the examination of statistical differences between the total data sets for the two years. 11 soil properties showed a significant difference between the two years of sampling as a total data set. Namely:

- 2021 higher than 2020 – EC*, total nitrogen %**, exchangeable sodium^, ECEC*, aluminium %^^^, manganese^^^, and boron^^^.
- 2020 higher than 2021 – carbon nitrogen ratio**, plant available phosphorus***, nitrate nitrogen*, and magnesium %^^.

Further analysis of the 2021 data will be presented in the subsequent sections of this report as a comparison to the 2020 data with respect to scarification Vs Non-Scarification, under Vs between plants, 0-10cm and 10-30cm depths, and the Wild Harvest Site Vs Plantation Site Data. It will be noted in these sections that the total significant differences are present in conjunction with:

* A significant difference in the scarified area data set – i.e. potential activity induced change.

** A significant difference in the scarified, unscarified, under and between data sets – i.e. potential climate induced change.

*** A significant difference in the under plant data set – i.e. potential location induced change. (Due to less plants in Scarified this may also represent a total area activity induced change)

^ A significant difference in the other subset – scarified/under – i.e. potential activity/location induced change.

^^ A significant difference in the between plant data set – i.e. potential location induced change. (Due to less plants in Scarified this may also represent a total area activity induced change)

^^^ A significant difference in the non-scarified and under area data set – i.e. potential activity induced reduction in change.

Note: the comparison of the Total Wild Harvest Site mean is presented in Figure 4.4.2.1 as relative percentages of the Laboratory Guidelines. Whilst the soil samples extracted within 2020 were defined as a mixture of sandy soil, loam, and clay (hence the comparison of the laboratory guidelines for clay loam for ease of Wild Harvest / Plantation Site comparison), all samples extracted in 2021 were classified as sandy soils. This may be due to some degree of erosion or (purposely) choosing non-identical sampling locations, however it is important to note that for the 2021 Wild Harvest Site data the Laboratory Guidelines selected were the "Sandy Soil". This has not impacted the individual soil property comparison, only the relative percentage of the Guidelines between different soil properties.

(a)

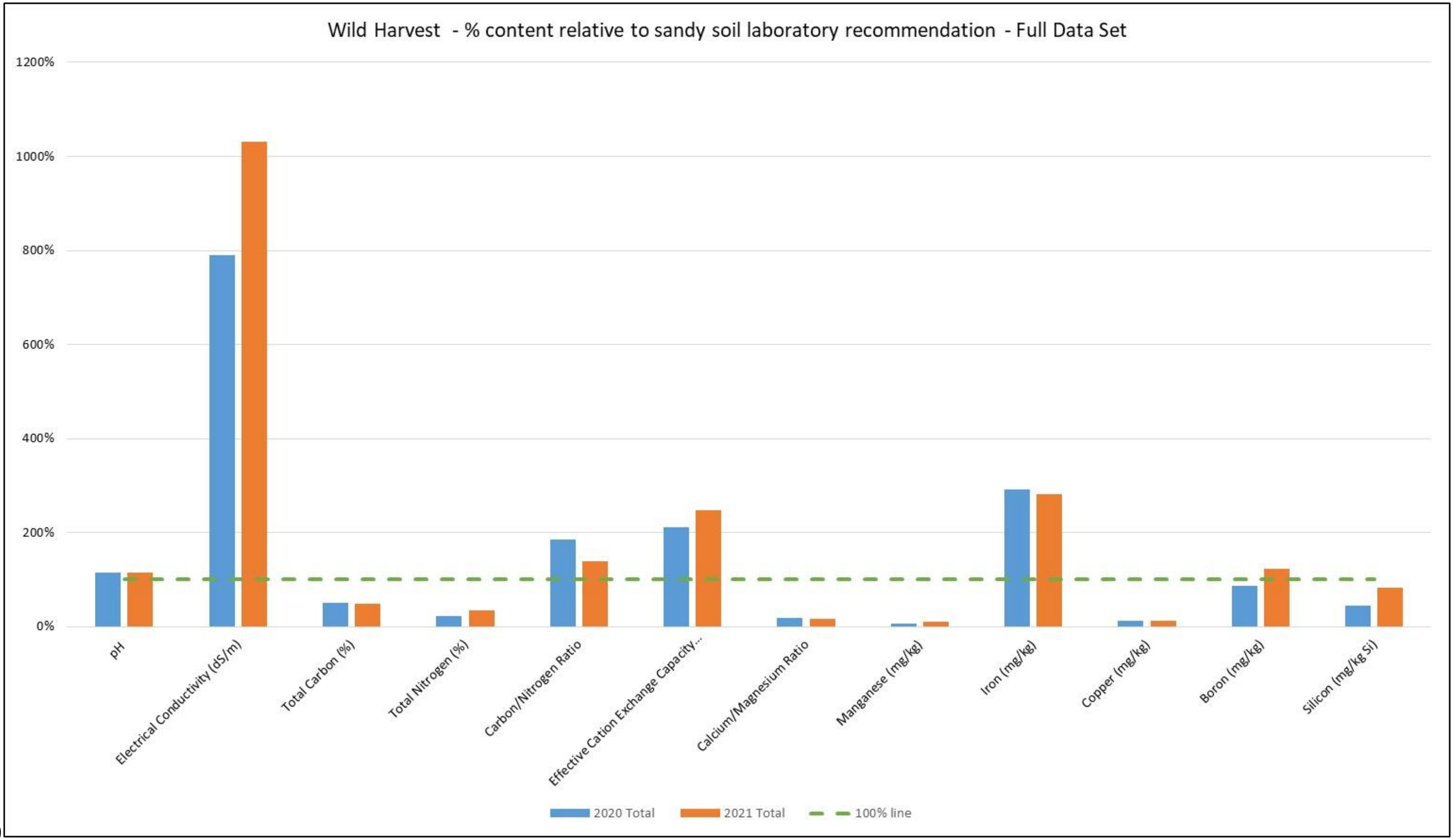
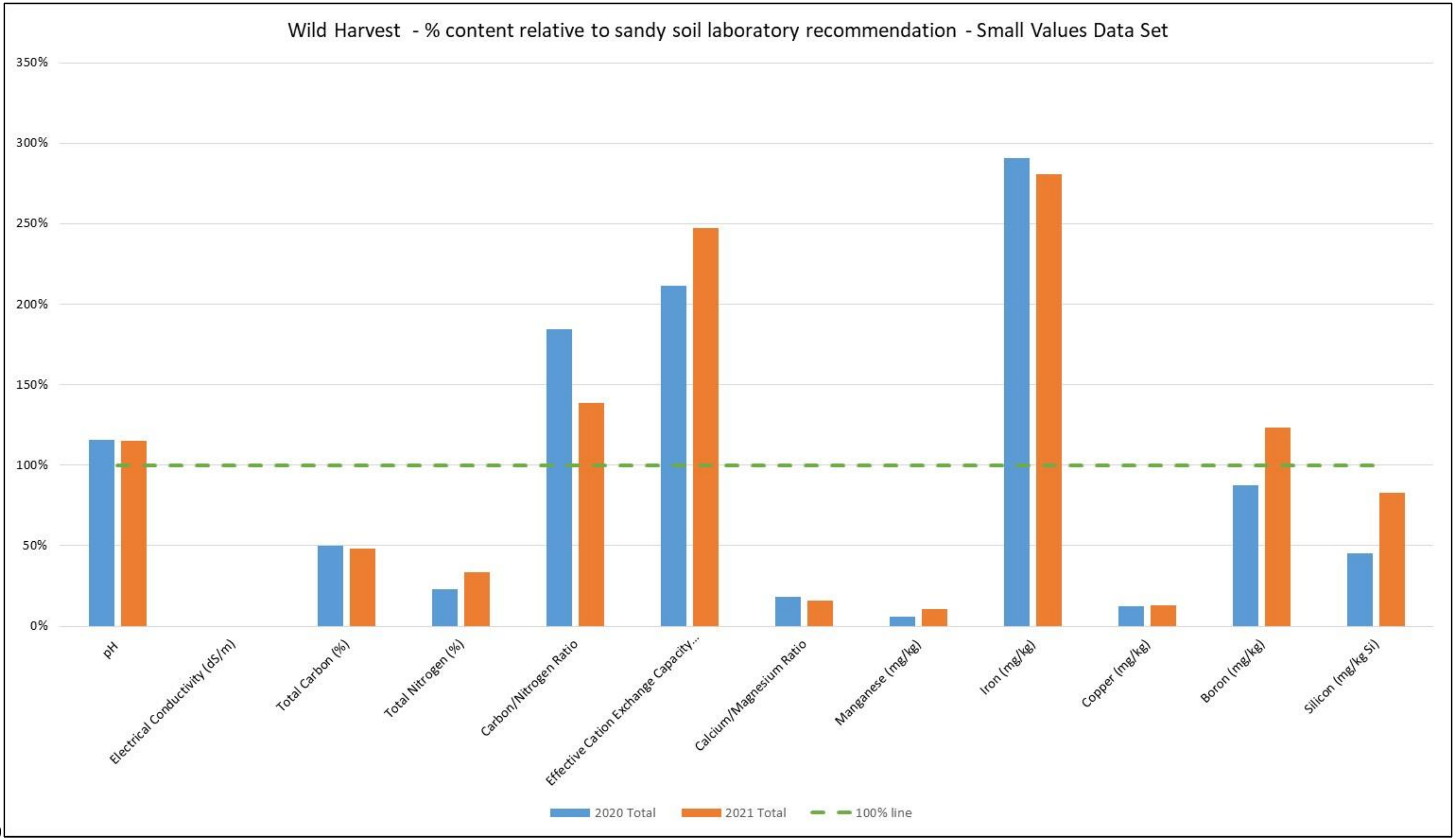


Figure 4.4.2.1 (a) to (f): Wild Harvest Site 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines- Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



(b)

Figure 4.4.2.1 (a) to (f): Wild Harvest Site - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines- Part 2- As per graph (a) with Electrical Conductivity high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

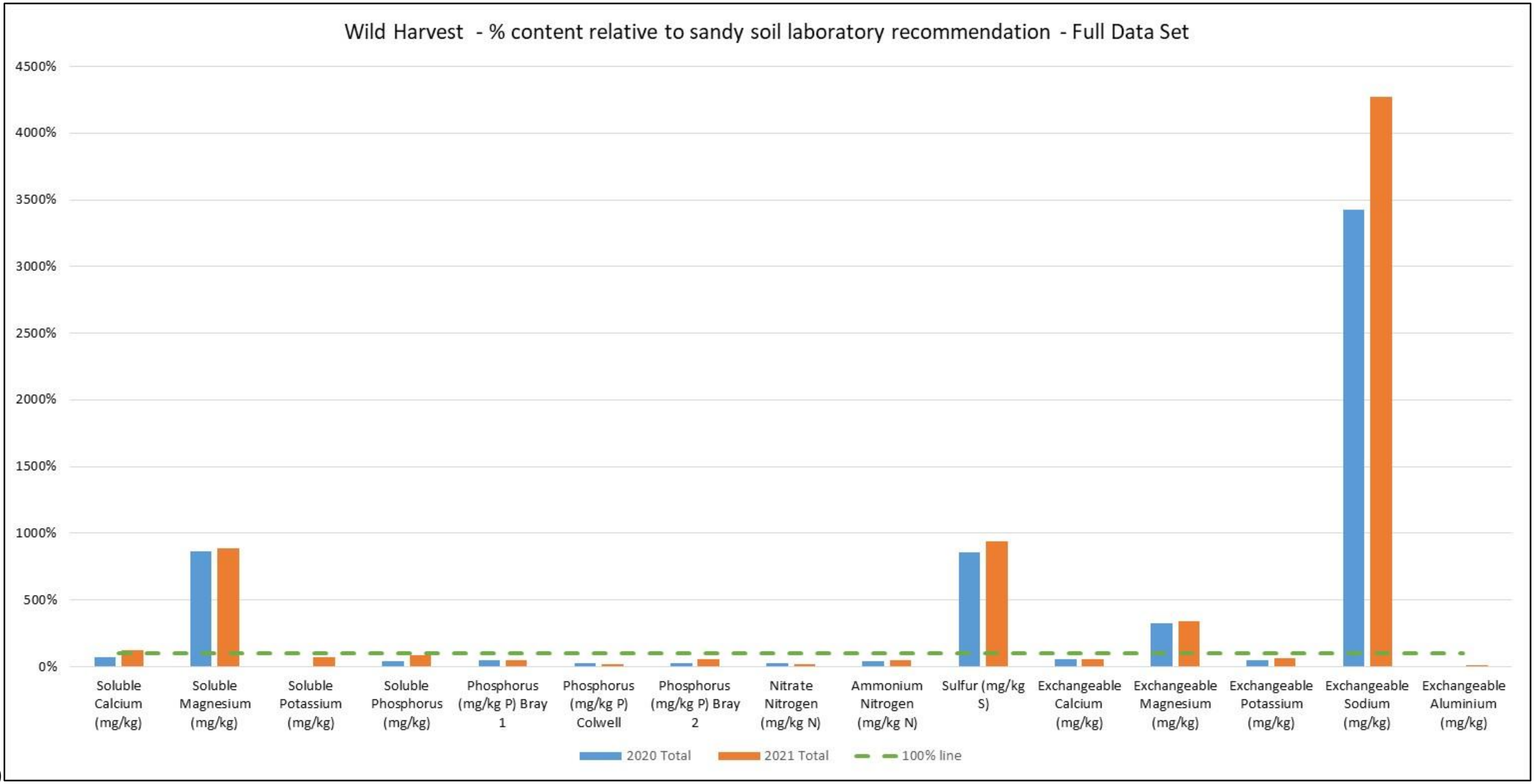
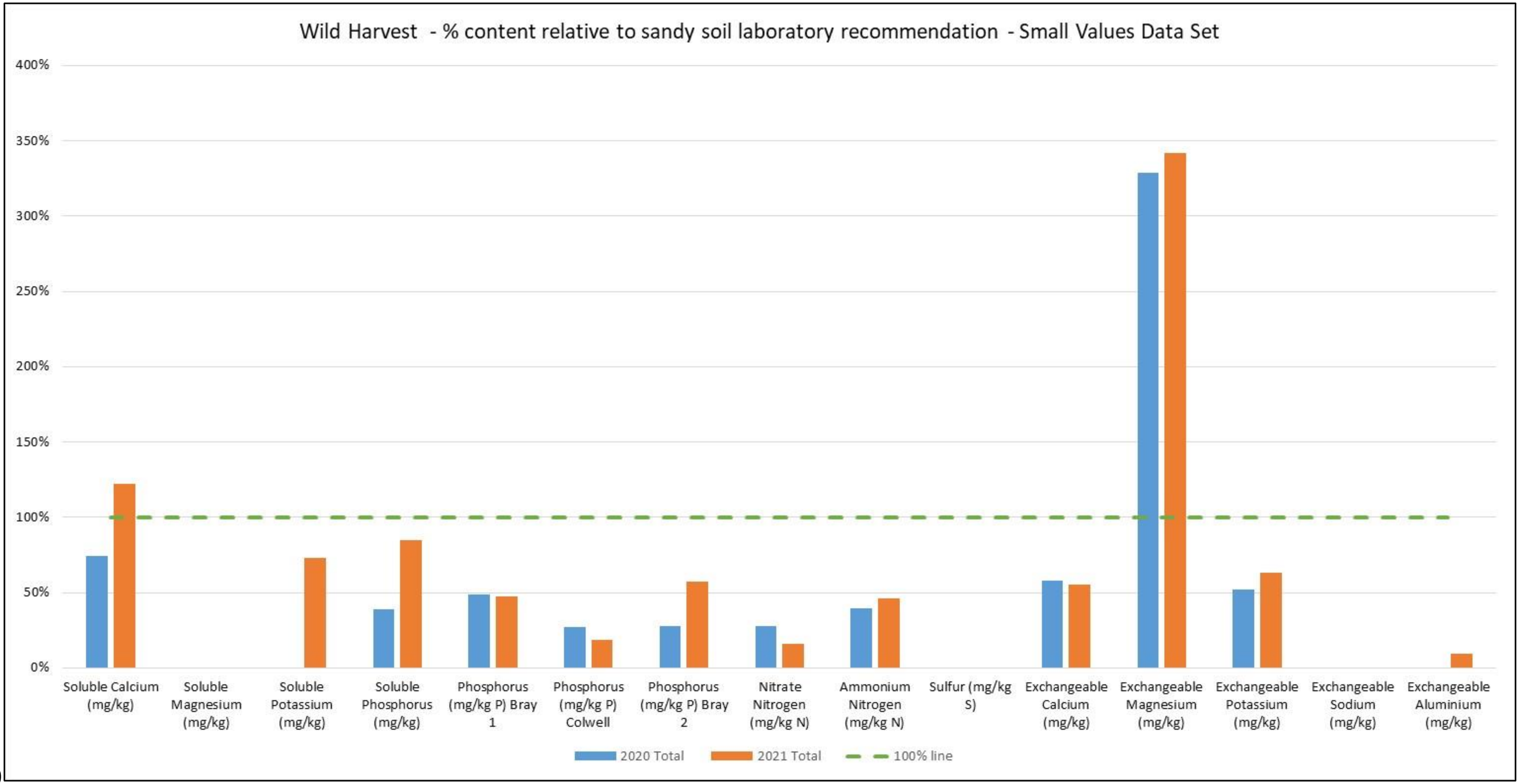
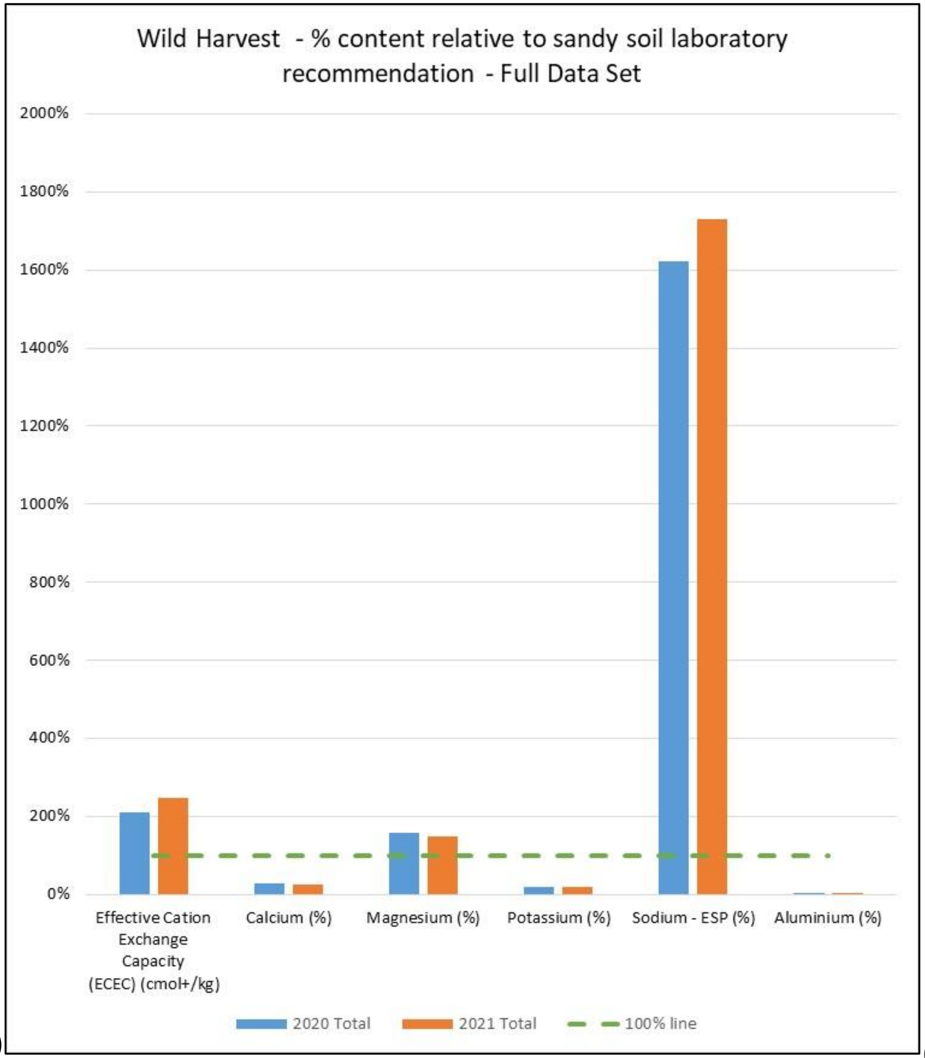
(c)


Figure 4.4.2.1 (a) to (f): Wild Harvest Site 2021 - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines-Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



(d)

Figure 4.4.2.1 (a) to (f): Wild Harvest Site - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines-
Part 2 - As per graph (b) with Soluble Magnesium, Sulfur, and Exchangeable Sodium high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

(e)


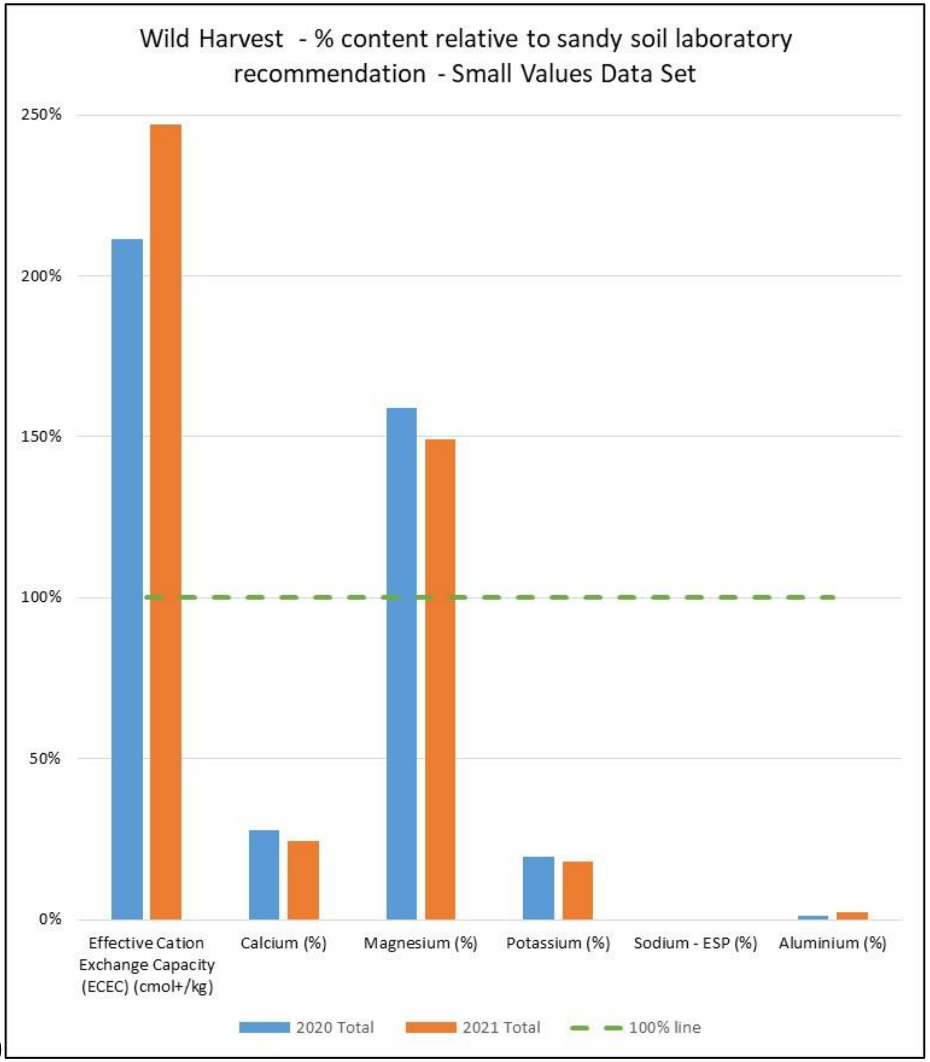
(f)


Figure 4.4.2.1 (a) to (f): Wild Harvest Site 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines- Part 1 – Full Data Set and Subset minus Sodium ESP% for better visual on other differences. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

Table 4.4.2.1(a): Wild Harvest Site – 2020 to 2021 Sample Comparison

Location	Significant Data	Wild Harvest Analysis - 2021						
		Electrical Conductivity (dS/m)	**Total Nitrogen (%)**	**Carbon/Nitrogen Ratio**	**Phosphorus Colwell (mg/kg P)**	**Nitrate Nitrogen (mg/kg N)**	**Exchangeable Magnesium**	**Exchangeable Sodium**
	Average 2020	0.789	0.035	20.3	9.38	2.80		867
Total Data	Average 2021	1.031	0.051	15.2	6.56	1.62		1080
	P(T<=t) two-tail	3.28E-02	1.58E-04	3.69E-07	3.91E-03	2.33E-02		3.92E-02
	Average 2020	0.78	0.035	20.40		4.06		
Scarified	Average 2021	1.40	0.053	15.59		0.938		
	P(T<=t) two-tail	3.04E-03	1.02E-02	1.08E-03		4.83E-03		
	Average 2020		0.033	20.434				
Non-Scarified	Average 2021		0.051	14.865				
	P(T<=t) two-tail		1.15E-03	9.07E-05				
	Average 2020		0.042	20.49	11.808			
Under	Average 2021		0.056	15.67	6.513			
	P(T<=t) two-tail		1.80E-02	4.96E-04	6.19E-03			
	Average 2020		0.027	20.11		2.61		
Between	Average 2021		0.046	14.78		0.948		
	P(T<=t) two-tail		5.92E-04	4.06E-04		2.51E-03		
	Average 2020					5.27	213.9	743.3
Scarified / Under	Average 2021					0.919	312.7	1289
	P(T<=t) two-tail					3.93E-02	7.80E-03	2.86E-02
	Average 2020			20.43		2.86		
Scarified / Between	Average 2021			14.53		0.958		
	P(T<=t) two-tail			4.04E-03		3.31E-02		
	Average 2020			21.06			32.8	
Non-scarified / Under	Average 2021			14.70			29.9	
	P(T<=t) two-tail			5.06E-04			3.50E-02	
	Average 2020		0.024	20.53				
Non-scarified / Between	Average 2021		0.045	15.03				
	P(T<=t) two-tail		9.42E-03	2.29E-02				

Table 4.4.2.1(b): Wild Harvest Site – 2020 to 2021 Sample Comparison

Location	Significant Data	Wild Harvest Analysis - 2021								
		Cation Exchange Capacity	**Calcium (%)**	**Magnesium (%)**	**Potassium (%)**	**Sodium - ESP (%)**	**Aluminium (%)**	**Manganese (mg/kg)**	**Boron (mg/kg)**	**Silicon (mg/kg)**
	Average 2020	6.98		28.8			0.136	0.89	0.875	
Total Data	Average 2021	8.15		27.0			0.265	1.58	1.231	
	P(T<=t) two-tail	4.36E-02		4.64E-02			7.71E-03	6.04E-03	3.33E-02	
	Average 2020	7.07			1.97	53.24				18.68
Scarified	Average 2021	10.21			1.37	59.56				25.27
	P(T<=t) two-tail	2.22E-03			2.22E-02	4.62E-02				2.10E-02
	Average 2020						0.130	0.704	0.690	14.30
Non-Scarified	Average 2021						0.312	1.561	1.106	30.11
	P(T<=t) two-tail						9.46E-03	1.49E-02	1.07E-01	1.93E-03
	Average 2020						0.138	0.956	0.953	18.32
Under	Average 2021						0.277	2.114	1.468	33.13
	P(T<=t) two-tail						3.41E-02	3.50E-03	1.61E-03	4.38E-03
	Average 2020		13.1	27.2		56.34				14.66
Between	Average 2021		9.30	24.65		64.14				24.90
	P(T<=t) two-tail		3.95E-02	7.81E-03		7.50E-03				6.18E-04
	Average 2020	6.86								
Scarified / Under	Average 2021	10.33								
	P(T<=t) two-tail	1.93E-02								
	Average 2020					56.48				16.41
Scarified / Between	Average 2021					64.51				26.25
	P(T<=t) two-tail					3.36E-02				2.83E-02
	Average 2020							0.848	0.767	15.70
Non-scarified / Under	Average 2021							1.990	1.404	36.67
	P(T<=t) two-tail							1.65E-02	1.22E-02	4.25E-03
	Average 2020			27.7			0.128			12.91
Non-scarified / Between	Average 2021			25.31			0.184			23.55
	P(T<=t) two-tail			3.54E-02			2.88E-02			1.65E-02

4.5. Wild Harvest Site Scarification Vs Non-Scarification (Control)

4.5.1. 2020 Baseline

For those macro and micro nutrients, where a statistically significant difference was present, there were more nutrients in the scarified versus non scarified area for the 2020 sample set. Within the total data set these were the soluble calcium and exchangeable potassium only. The scarified area samples had higher values than non-scarified control within the 0-10cm depth for the plant available phosphorus, plus the micronutrients copper and boron. The scarified area samples also had higher values than non-scarified control within the 10-30cm depth for available phosphorus, calcium (total %), and the calcium/magnesium ratio. Whilst limited differences were exhibited as would be expected with the short timeframe since the scarification activity, these may be due to the lack of plants present to take up these nutrients as little growth had commenced at the time of sampling. See Table 10.1.1 within Section 10, Appendix 4 for the average values and statistical significance with and without outliers.

4.5.2. 2021 Delta

The impact of the post-scarification recovery process was captured within the 2021 sampling regime in conjunction with the impact of a greater winter rainfall across the 2021 winter. A soil comparison to laboratory recommended values for the sandy soil type was completed for the 2021 data set analysed to compare the subsets of the Wild Harvest Site scarified and non-scarified samples, and the soil property variation over the two sampling time-stamps. See Graphs 4.5.2.1 (a) – (d) in conjunction with Table 4.4.2.1 previously presented. This comparison indicates significant difference as:

- 2021 higher than 2020
  - Scarified - electrical conductivity (EC) (0.78 to 1.40dS/m), total nitrogen % (0.035 to 0.053), effective cation exchange capacity (ECEC, 7.1 to 10.2 cmol+/kg), sodium - ESP % (53% to 60%), and silicon (19mg/kg to 25mg/kg).
  - Non-Scarified - total nitrogen % (3.3% to 5.1%), aluminium % (0.13 to 0.31%), Manganese (0.7mg/kg to 1.6mg/kg), Boron (0.7mg/kg to 1.1mg/kg) and silicon (14mg/kg to 30mg/kg).
- 2020 higher than 2021
  - Scarified - carbon nitrogen ratio (20.4 to 15.6 due to increased N %), nitrate nitrogen (4.06mg/kg, to 0.94mg/kg), and potassium % (2.0% to 1.4%).
  - Non-Scarified - Nil

(a)

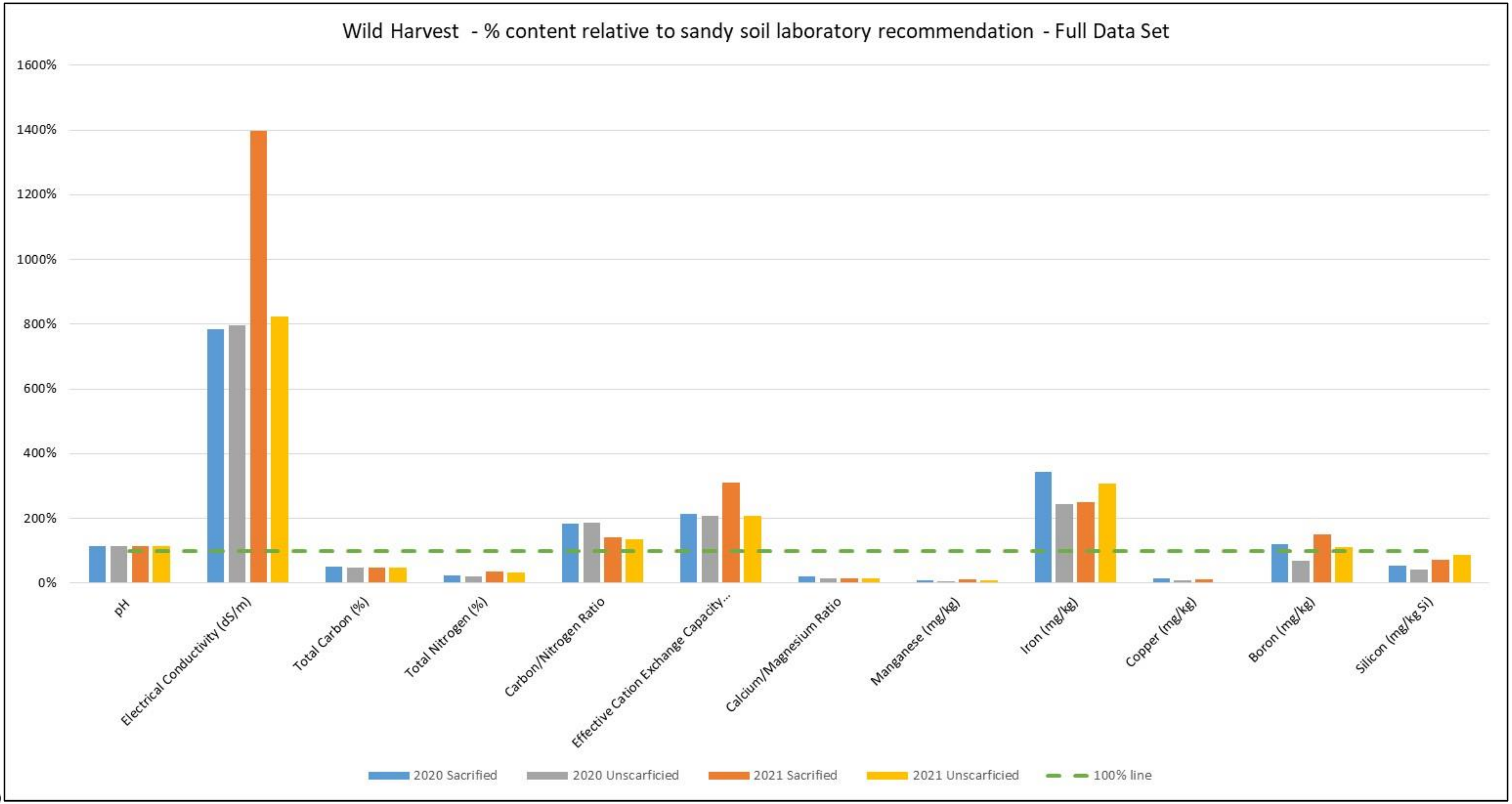


Figure 4.5.2.1 (a), (b), (c) and (d): Wild Harvest Site 2020 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Scarified and Non-Scarified Results- Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

(b)

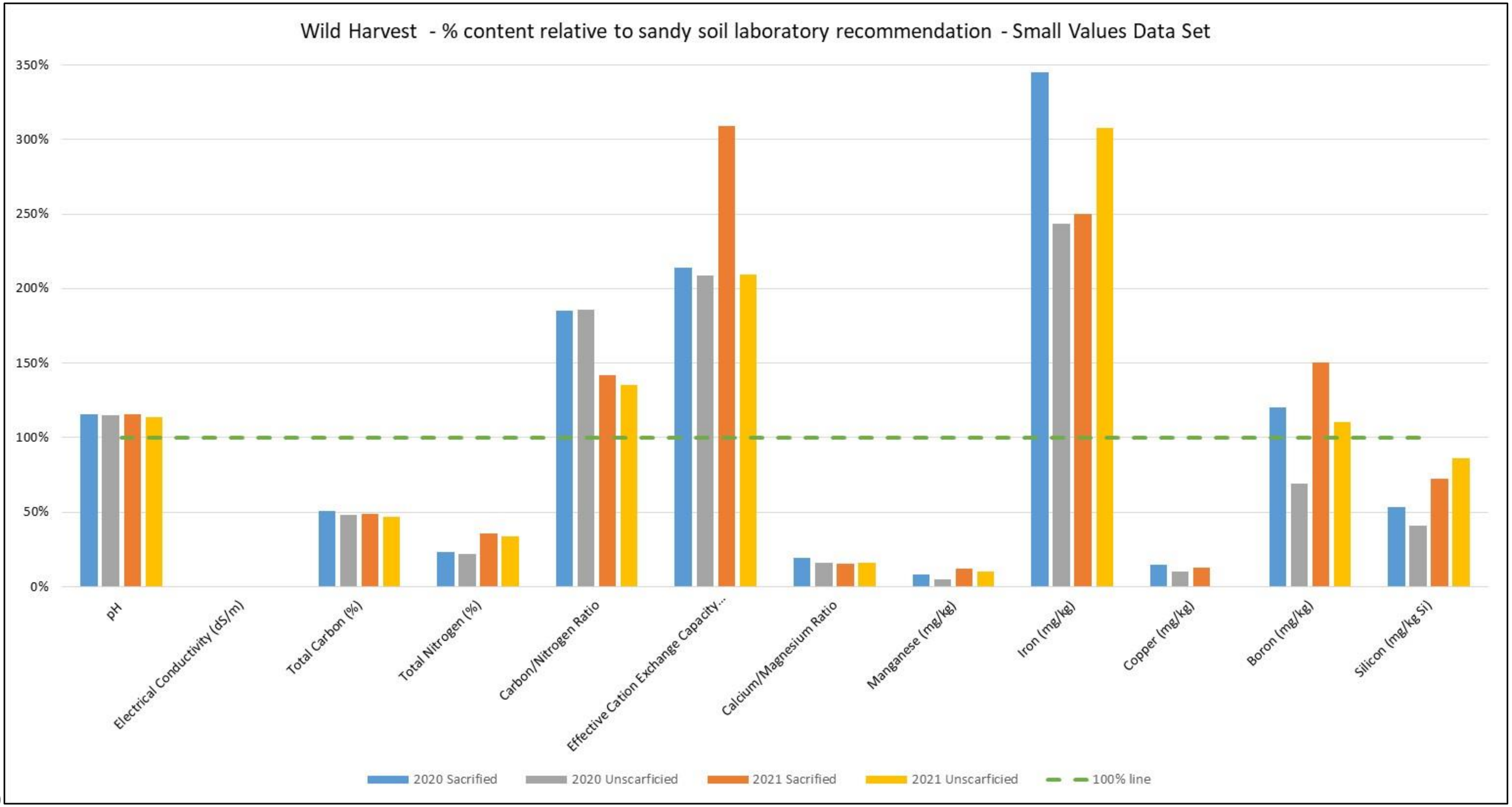
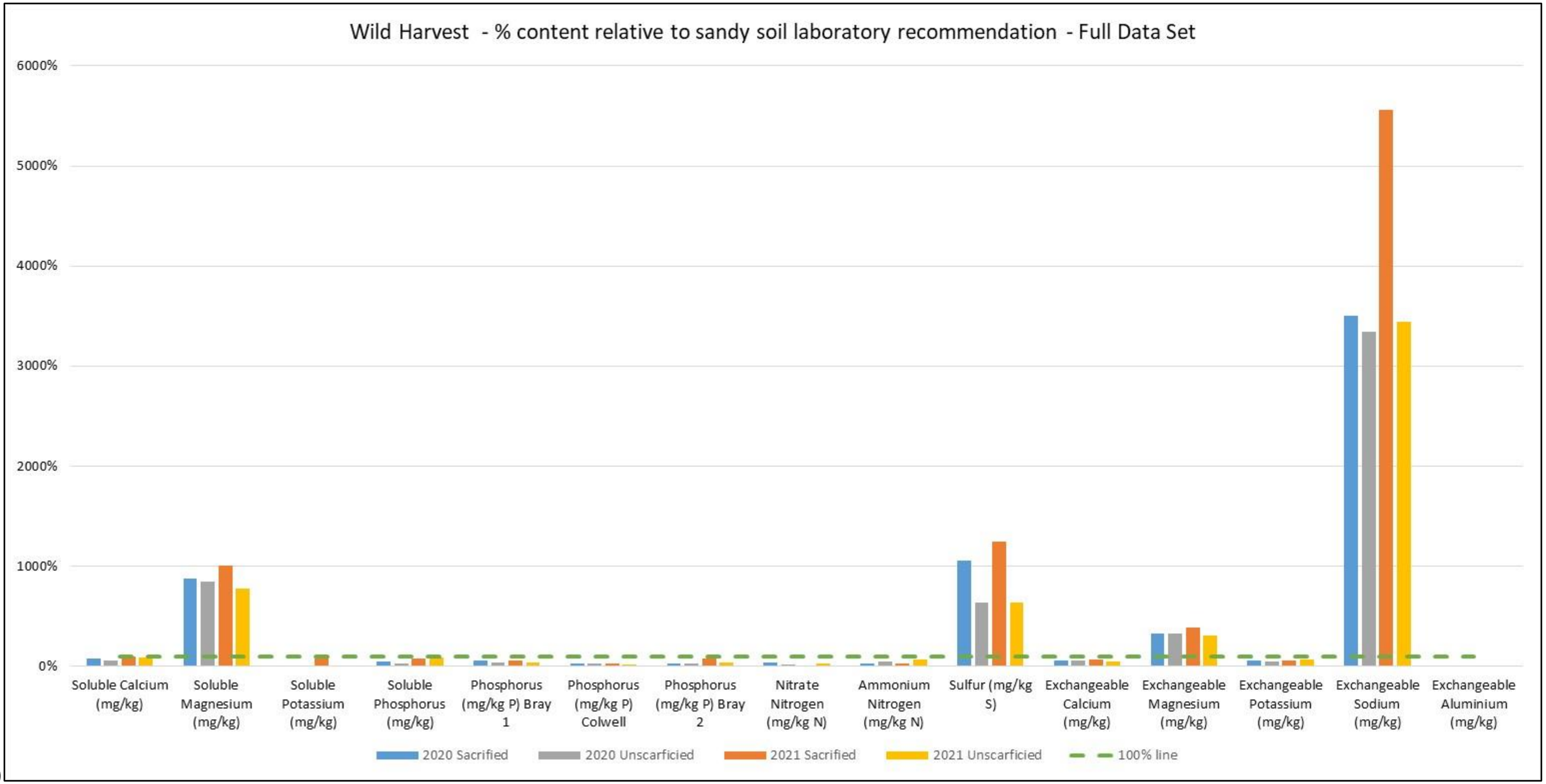
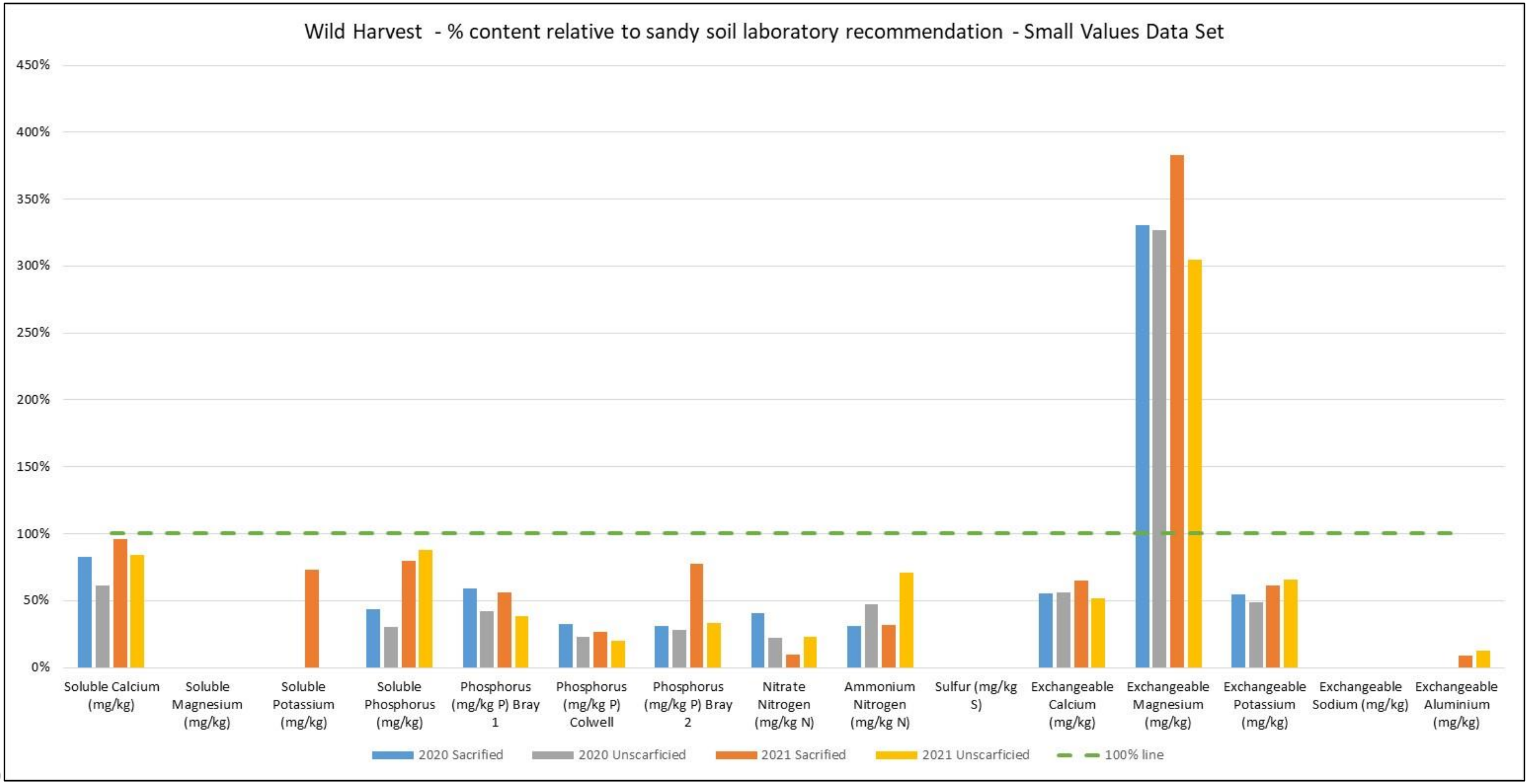


Figure 4.5.2.1 (a), (b), (c) and (d): Wild Harvest Site 2020 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Scarified and Non-Scarified Results - Part 2- As per graph (a) with Electrical Conductivity high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



(c)

Figure 4.5.2.1 (a), (b), (c) and (d): Wild Harvest Site 2020 Vs 2021 - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Scarified and Non-Scarified Results - Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



(d)

Figure 4.5.2.1 (a), (b), (c) and (d): Wild Harvest Site 2020 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Scarified and Non-Scarified Results - Part 2 - As per graph (b) with Soluble Magnesium, Sulfur, and Exchangeable Sodium high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

Note: The elevation in EC and sodium % within the Scarified area from 2020 to 2021. Also the total nitrogen elevation and carbon/nitrogen ratio depression identified within control non-scarified to same degree between 2020 and 2021. A similar comparison of Scarified to Non-scarified can be made for the silicon result.

A soil comparison to laboratory recommended values for the sandy soil type was completed for the 2021 data set analysed to compare the subsets of the Wild Harvest Site under and between plant soil samples and the soil property variation over the two sampling time-stamps. See Graphs 4.5.2.2 (a) – (d) in conjunction with Table 4.4.2.1 previously presented. This comparison indicates:

- 2021 higher than 2020
  - Under - total nitrogen % (0.042 to 0.056), aluminium % (0.14 to 0.28%), Manganese (0.96mg/kg to 2.1mg/kg), Boron (0.95mg/kg to 1.5mg/kg), and silicon (18mg/kg to 33mg/kg).
  - Between - total nitrogen % (0.027 to 0.046), sodium ESP% (56% to 64%) and silicon (15mg/kg to 25mg/kg).
- 2020 higher than 2021
  - Under - carbon nitrogen ratio (20.1 to 14.8 due to increased N %), and plant available phosphorus (11.8mg/kg to 6.5mg/kg).
  - Between - carbon nitrogen ratio (20.5 to 15.7 due to increased N %), Nitrate Nitrogen (2.6mg/kg to 0.95mg/kg.), calcium % (13.1% to 9.3%), and magnesium % (27% to 65%).

This soil comparison has been broken down further into the year, scarified/non-scarified, and under/between results for the comparison to the laboratory recommended values for the sandy soil. This data is presented in Graphs 4.5.2.3 (a) – (h) and in conjunction with Table 4.4.2.1 previously presented. This comparison is discussed in the following sections.

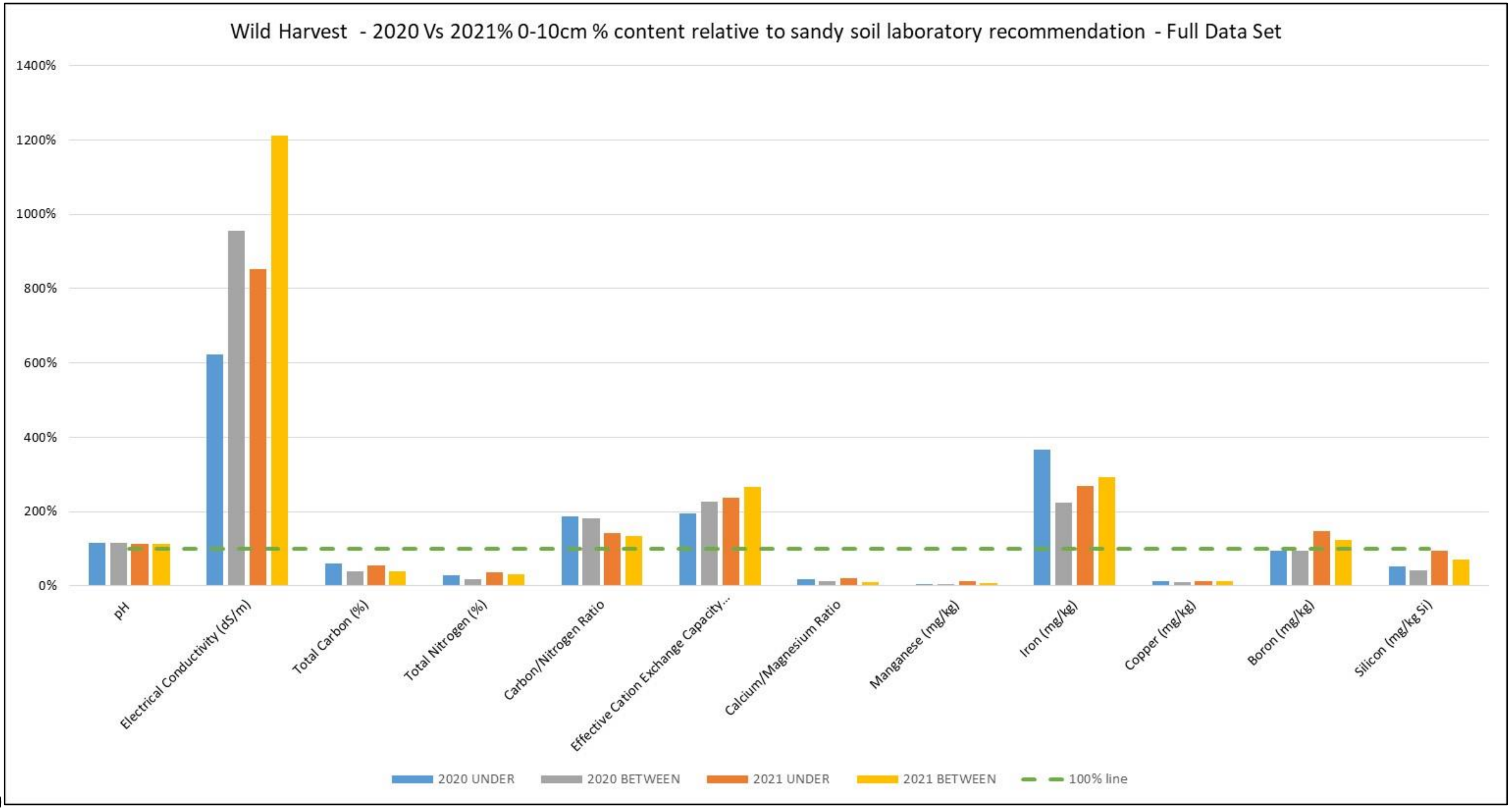
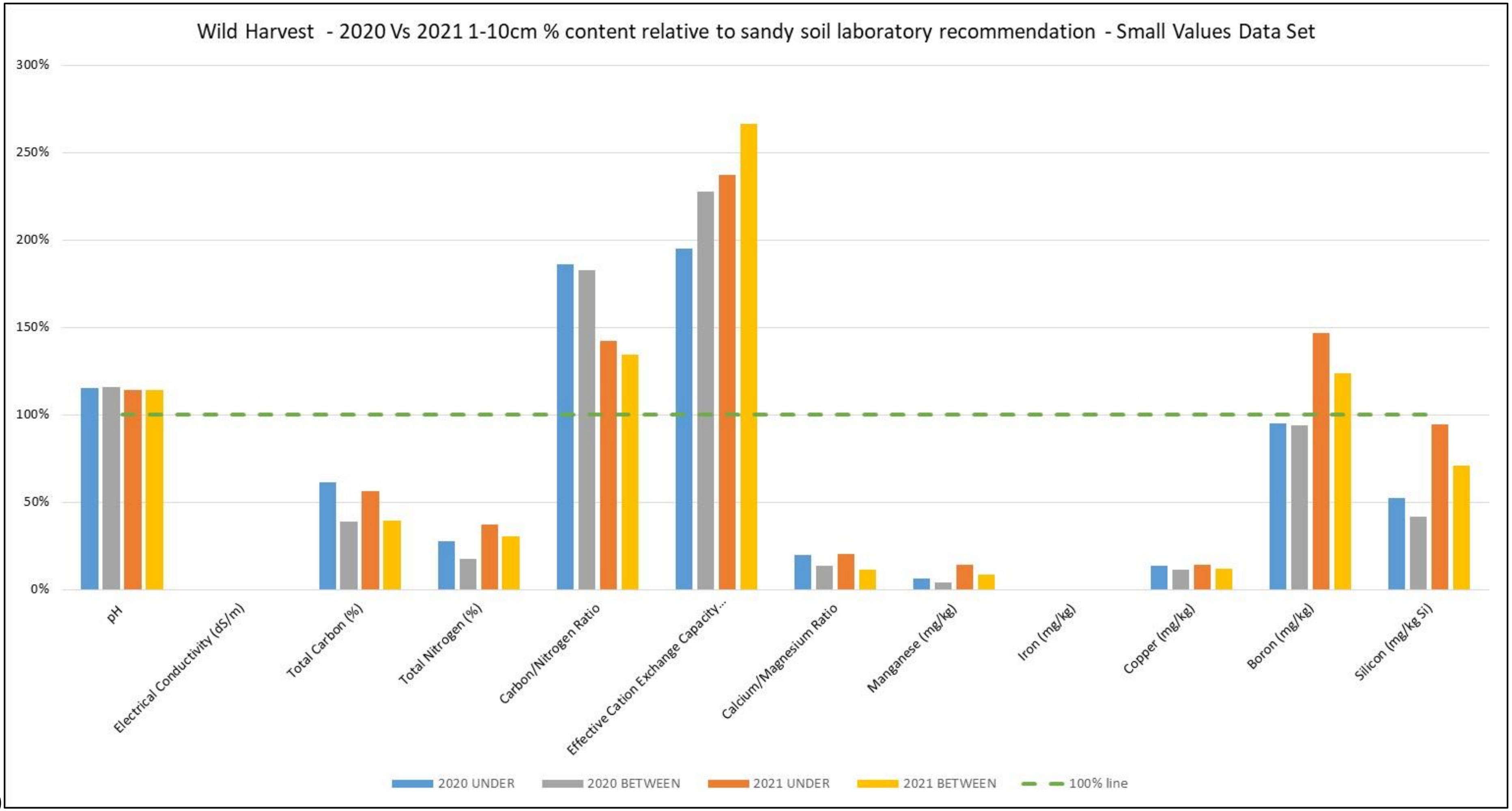
(a)


Figure 4.5.2.2 (a), (b), (c) and (d): Wild Harvest Site 2020 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Total Under and Between Results- Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



(b)

Figure 4.5.2.2 (a), (b), (c) and (d): Wild Harvest Site 2020 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Total Under and Between Results - Part 2- As per graph (a) with Electrical Conductivity and Iron high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

(c)

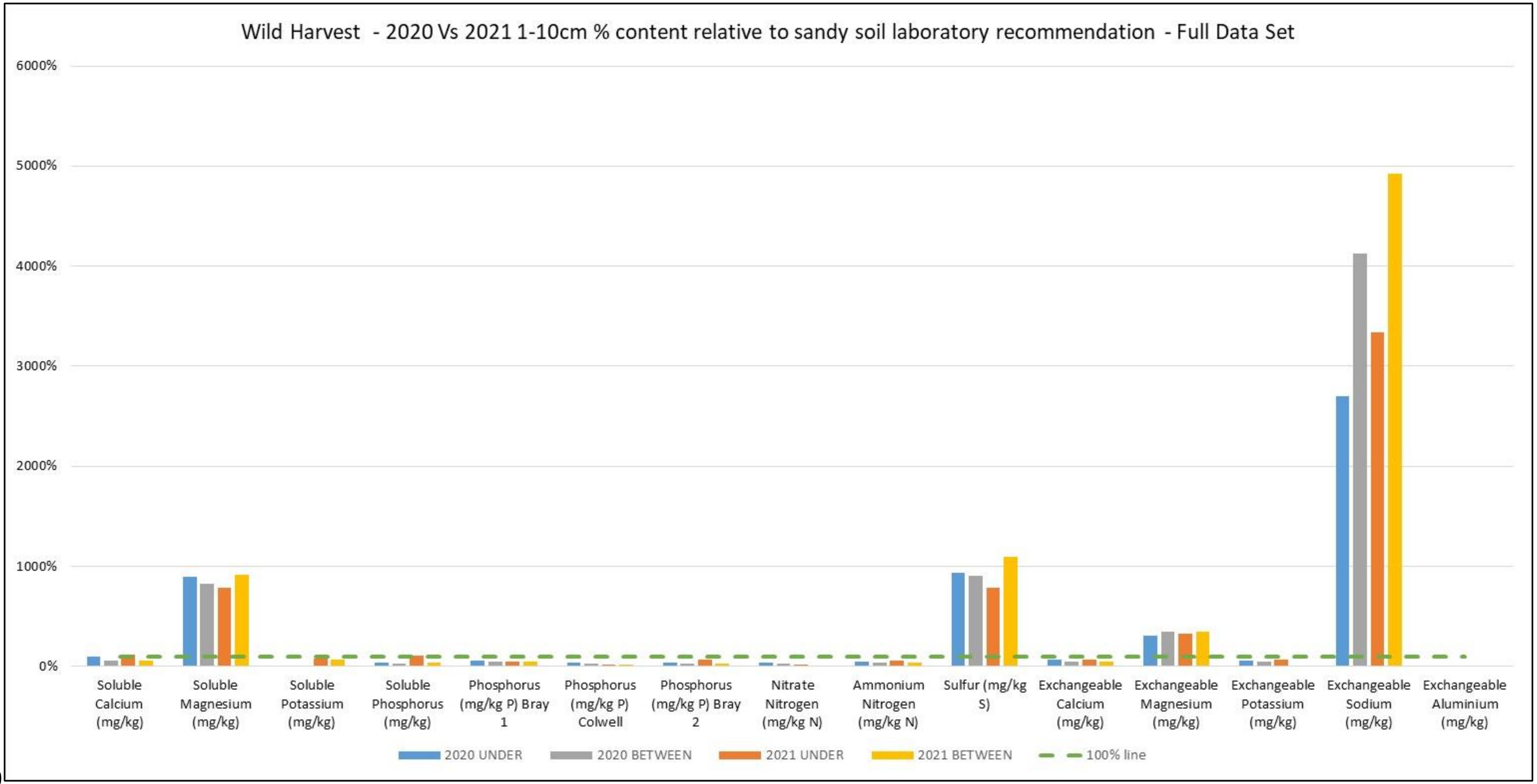
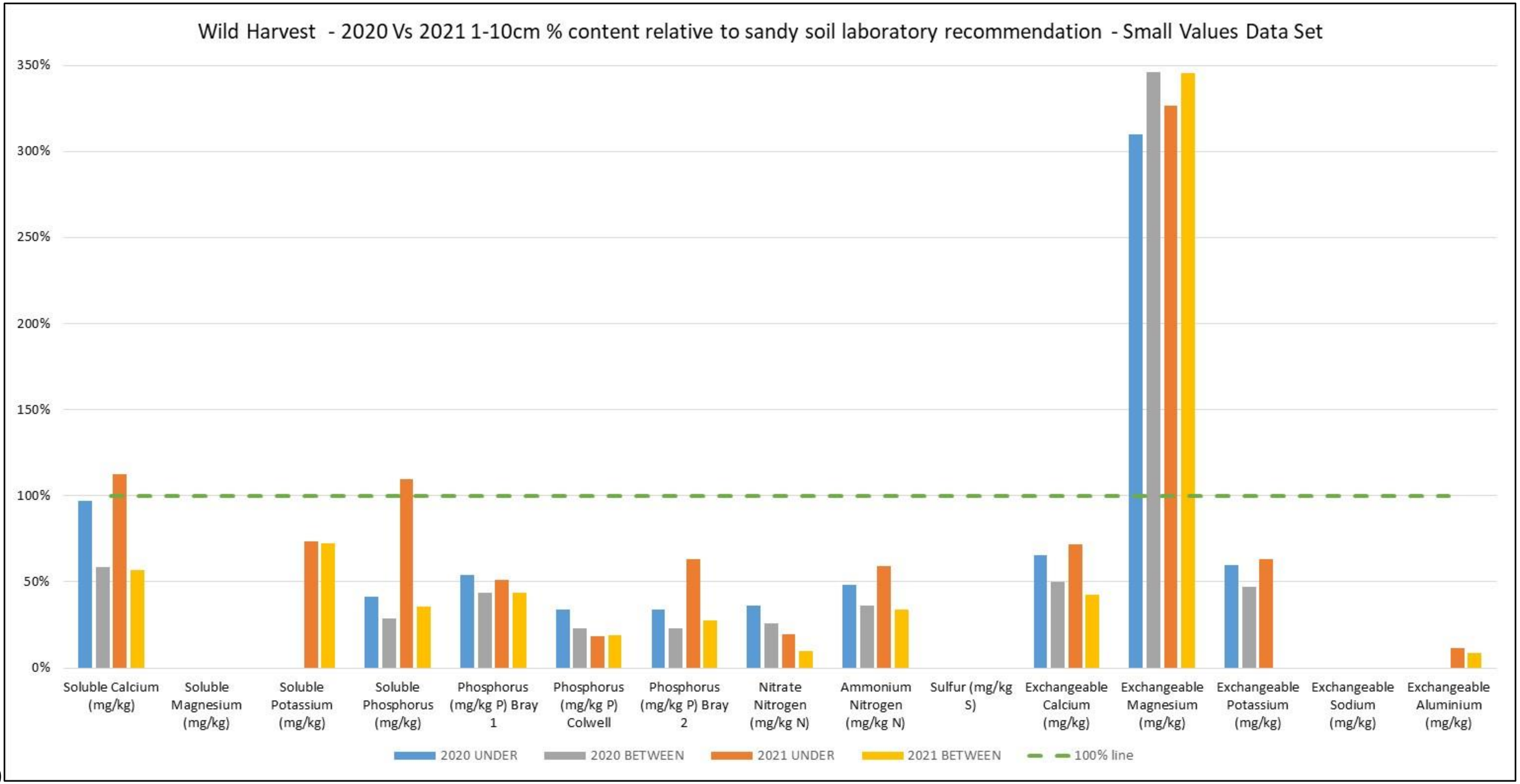
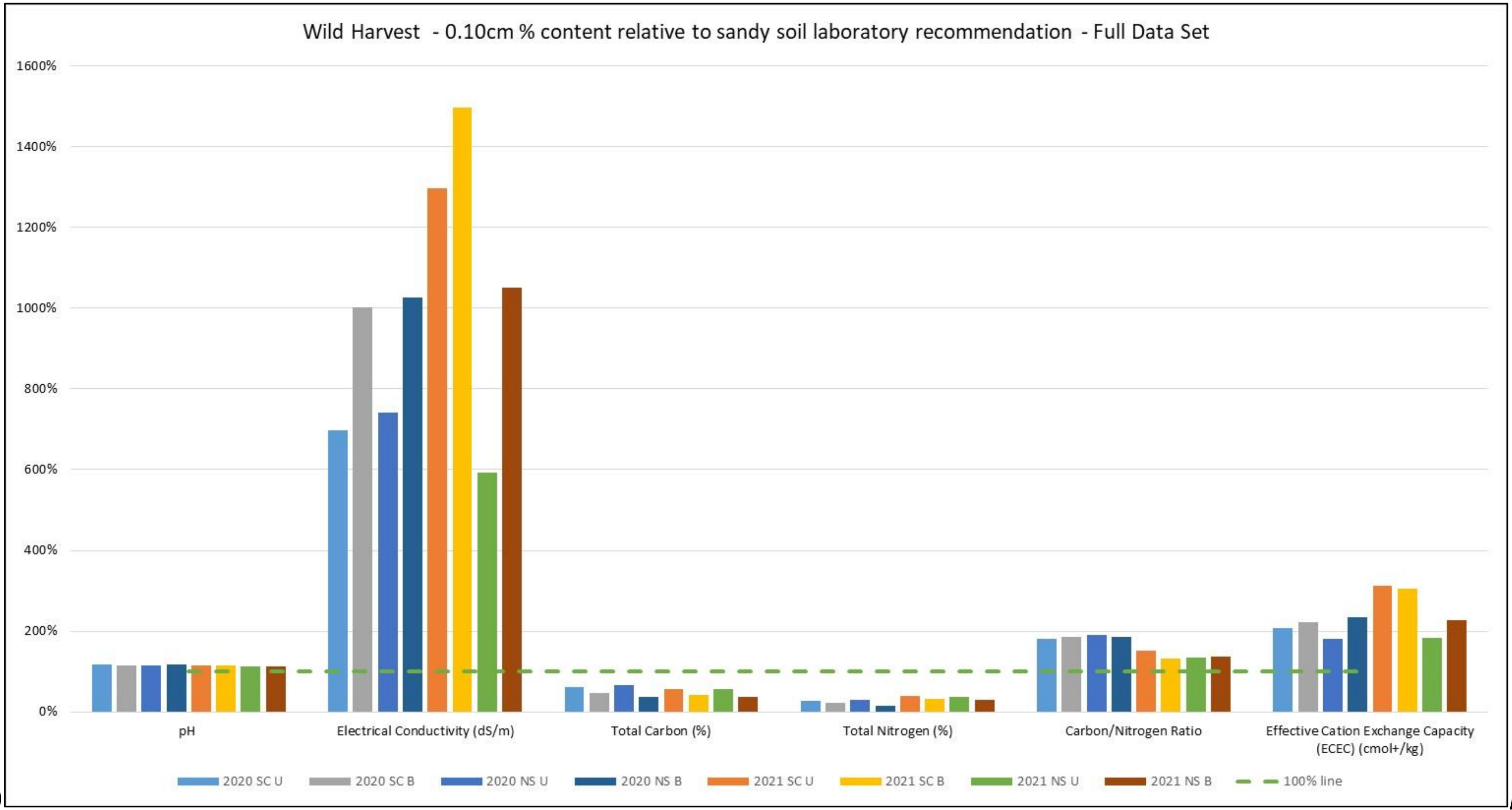


Figure 4.5.2.2 (a), (b), (c) and (d): Wild Harvest Site 2020 Vs 2021 - Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Total Under and Between Plant Results - Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

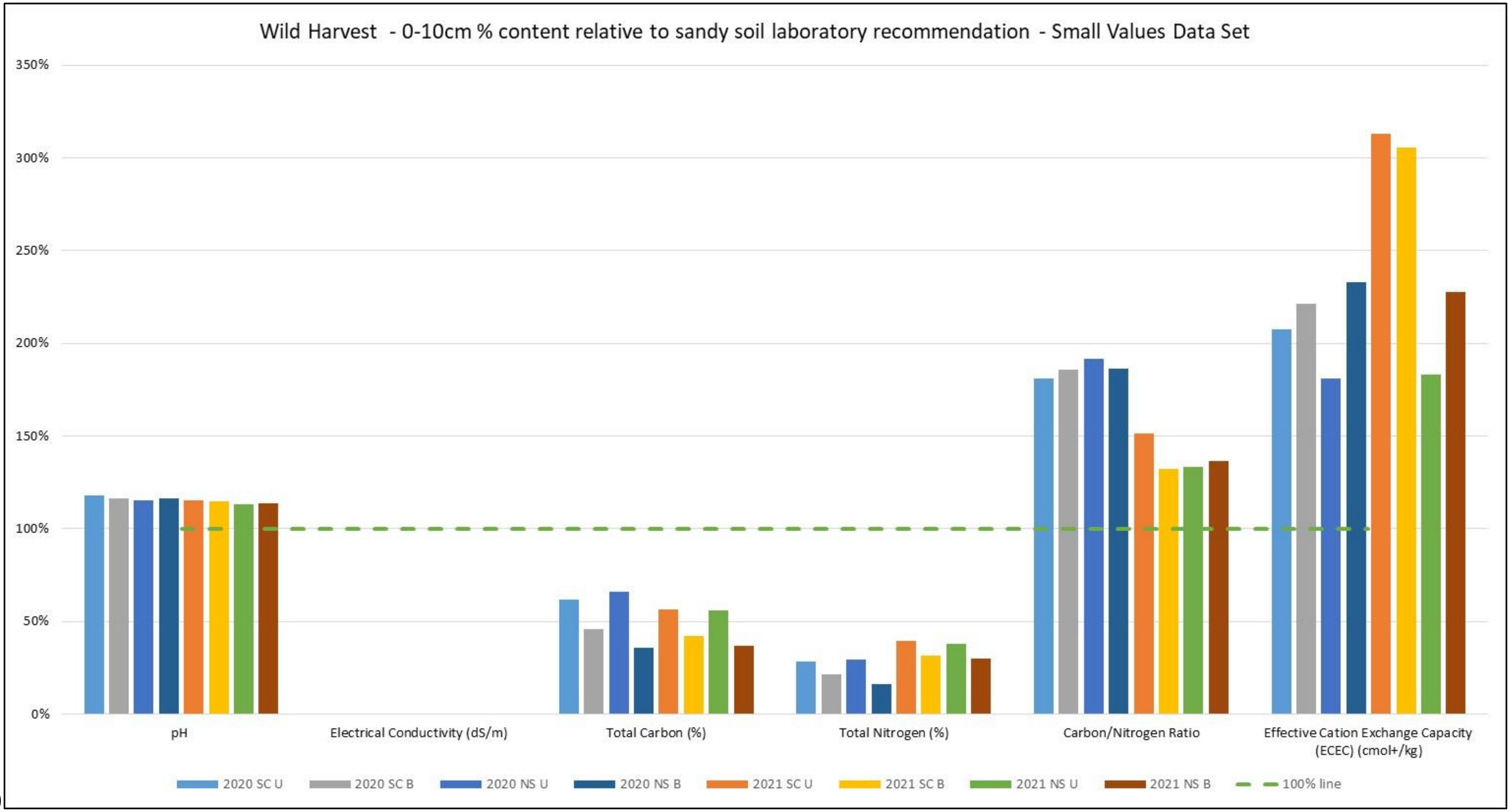


(d)

Figure 4.5.2.2 (a), (b), (c) and (d): Wild Harvest Site 2020 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Under and Between Plant Results - Part 2 - As per graph (b) with Soluble Magnesium, Sulfur, and Exchangeable Sodium high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

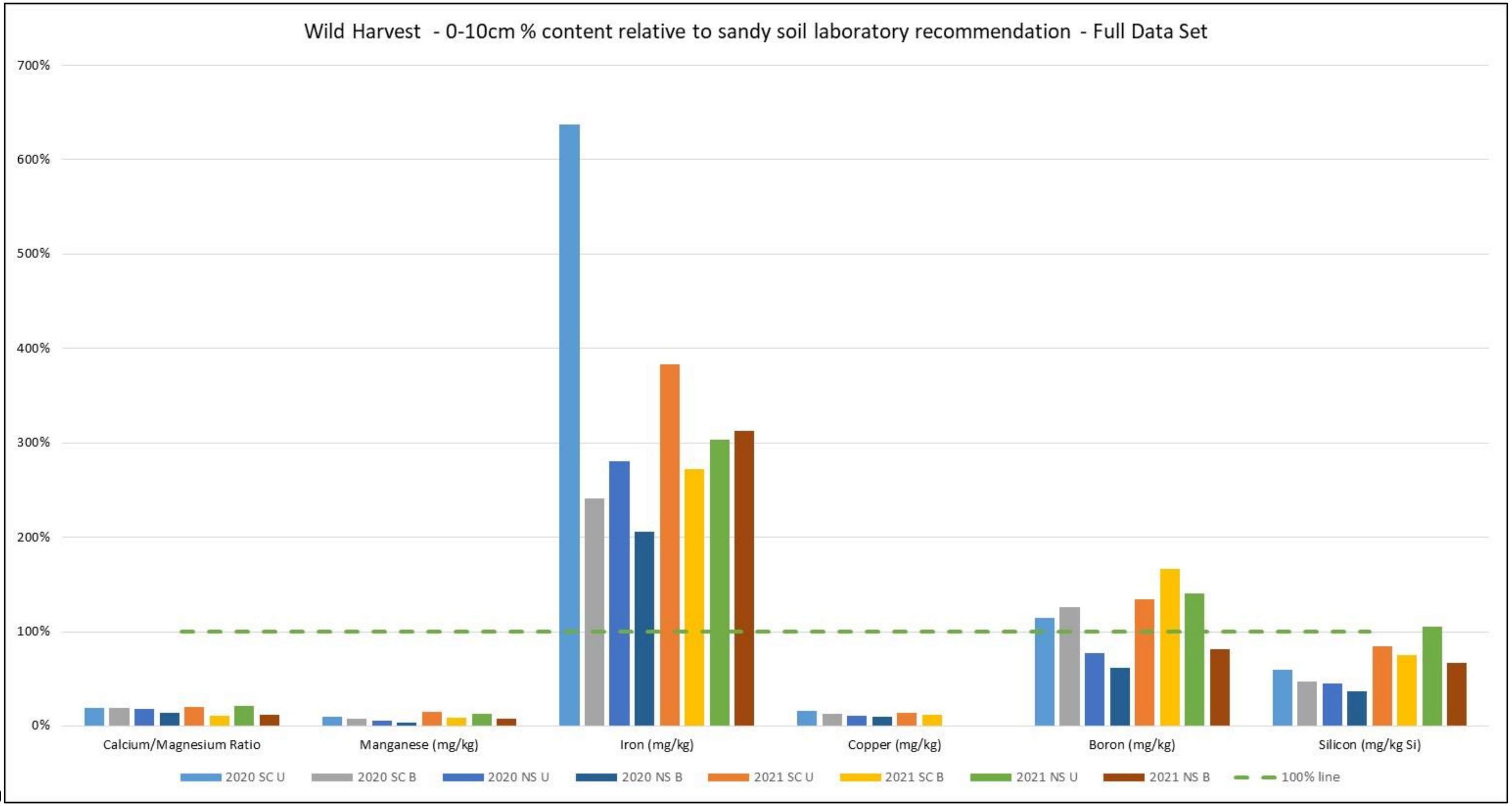


(a) Figure 4.5.2.3 (a) - (h): Wild Harvest Site 2020 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Scarification/Non-Scarification, Under/Between and Year Results- Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



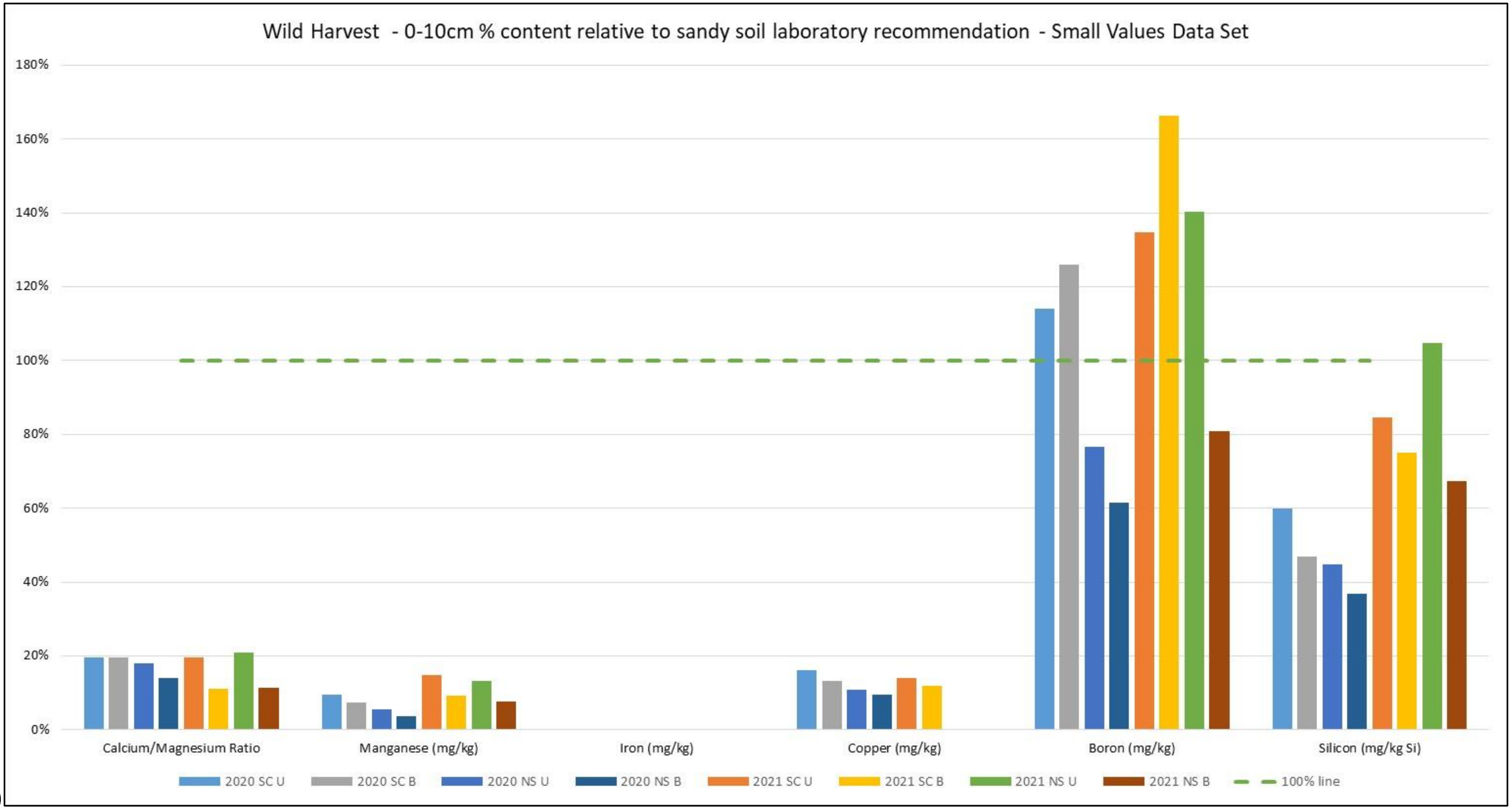
(b)

Figure 4.5.2.3 (a) - (h): Wild Harvest Site 2020 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Scarification/Non-Scarification, Under/Between and Year Results - Part 2- As per graph (a) with Electrical Conductivity high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



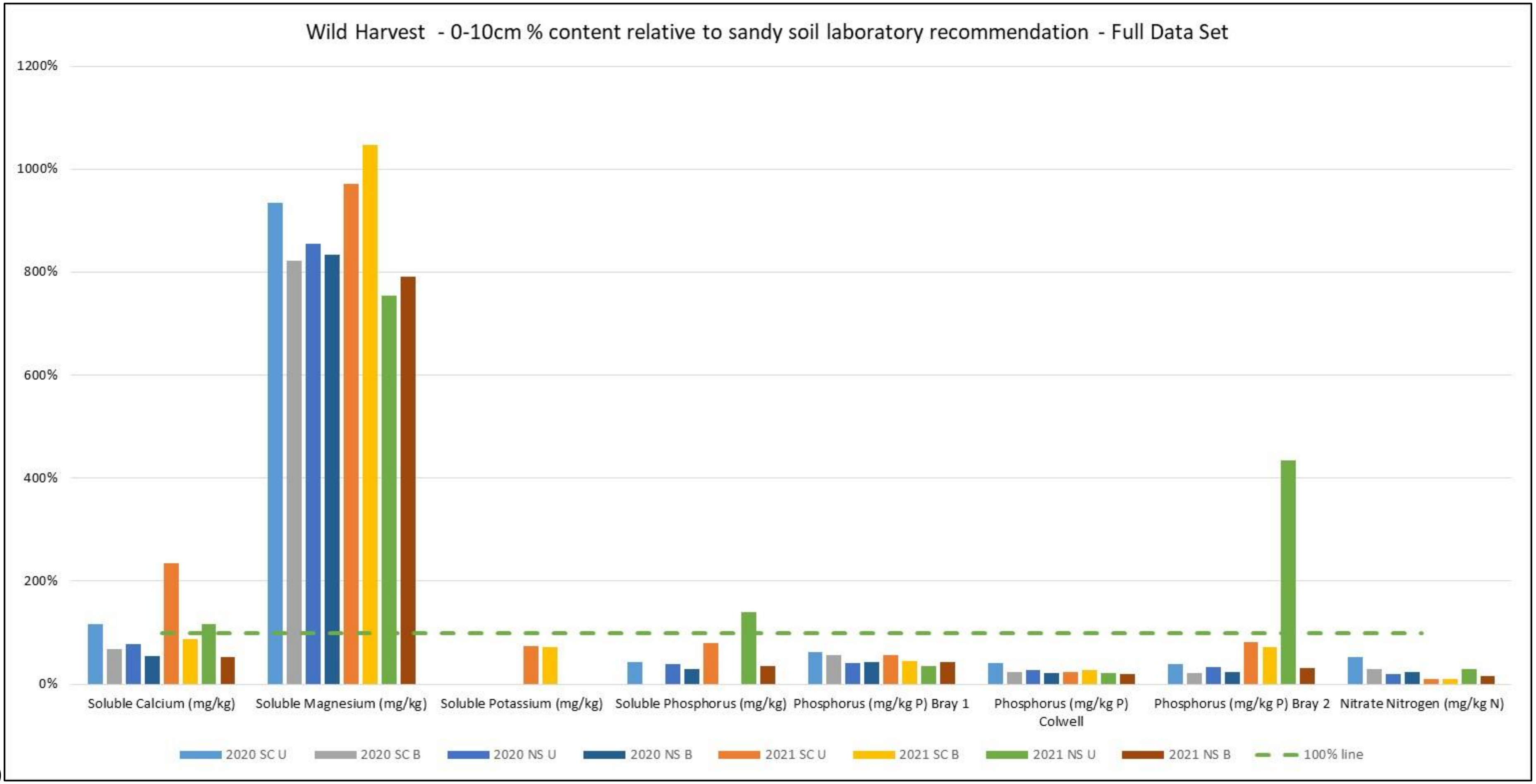
(c)

Figure 4.5.2.3 (a) - (h): Wild Harvest Site 2020 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Scarification/Non-Scarification, Under/Between and Year Results- Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



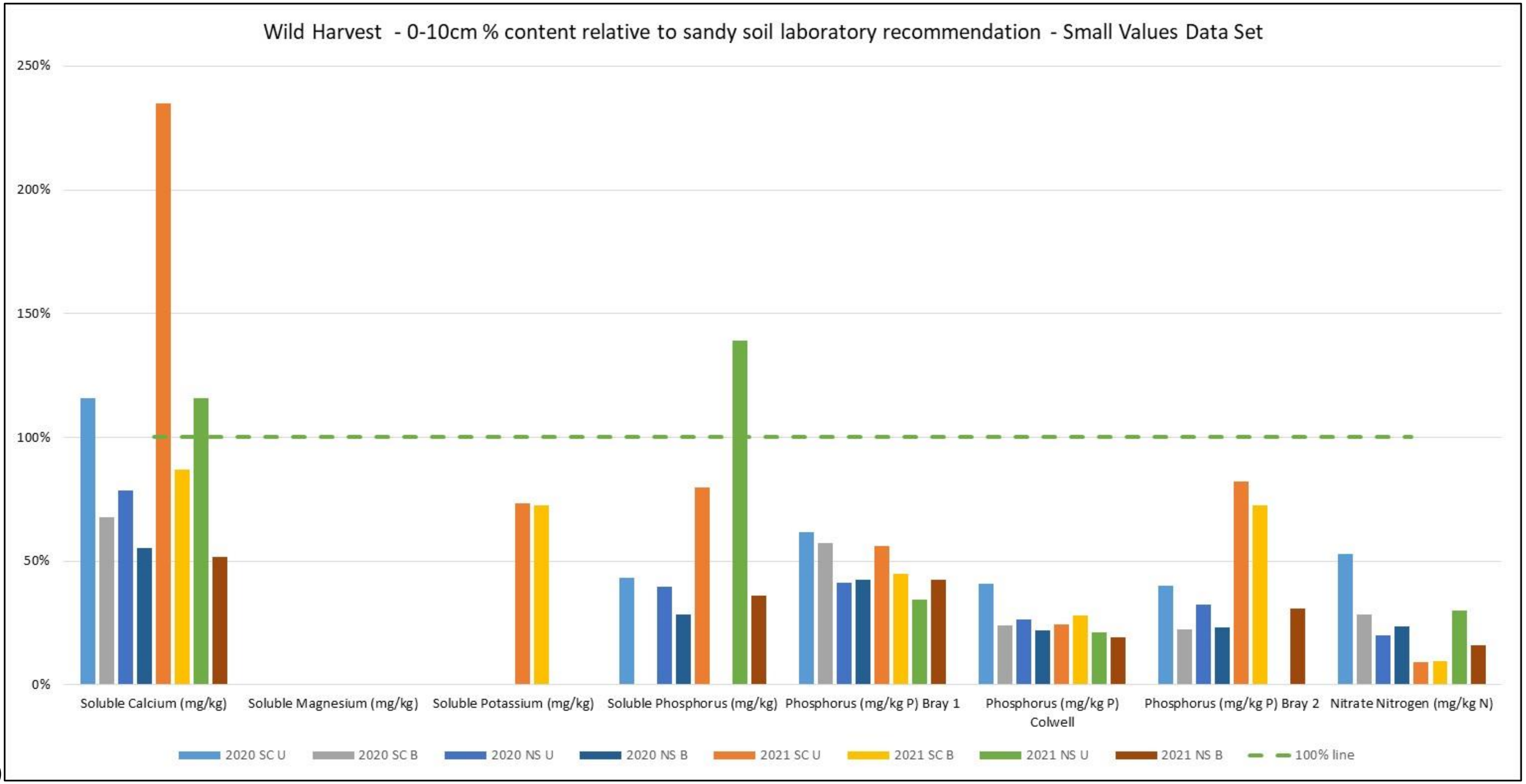
(d)

Figure 4.5.2.3 (a) - (h): Wild Harvest Site 2020 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Scarification/Non-Scarification, Under/Between and Year Results - Part 2- As per graph (c) with Iron high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



(e)

Figure 4.5.2.3 (a) - (h): Wild Harvest Site 2020 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Scarification/Non-Scarification, Under/Between and Year Results- Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



(f)

Figure 4.5.2.3 (a) - (h): Wild Harvest Site 2020 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Scarification/Non-Scarification, Under/Between and Year Results - Part 2- As per graph (e) with Soluble Magnesium high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

(g)

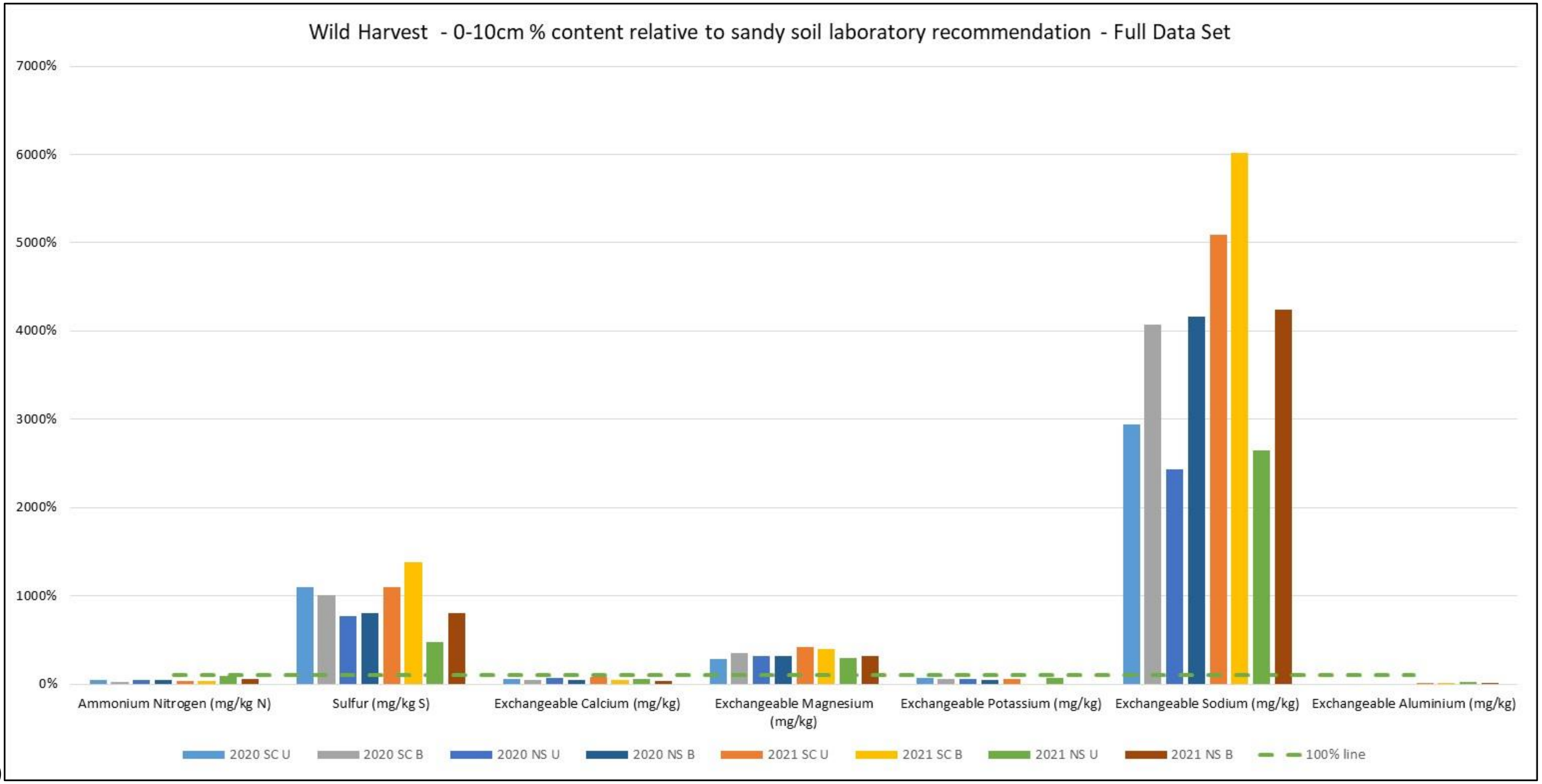
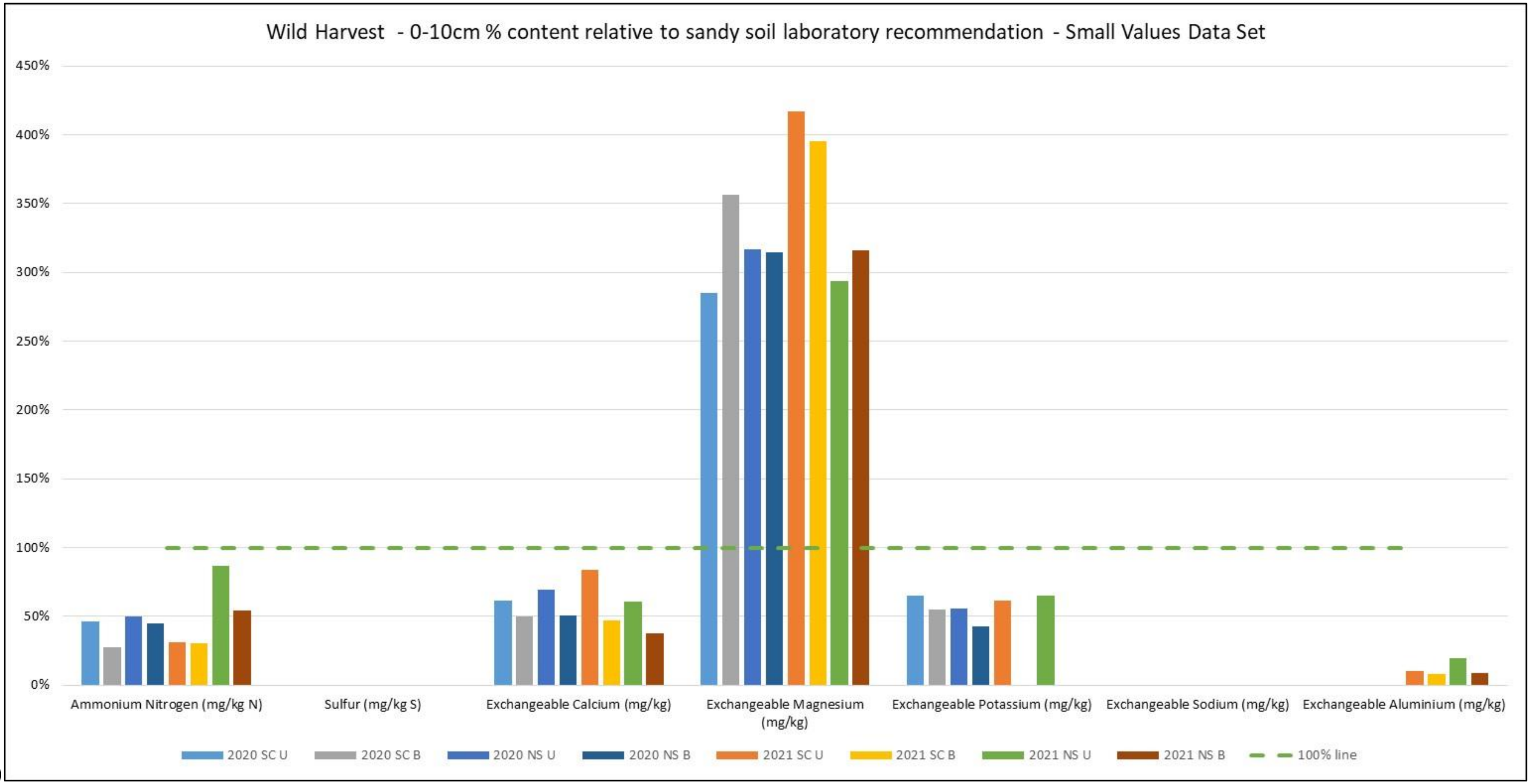


Figure 4.5.2.3 (a) - (h): Wild Harvest Site 2020 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Scarification/Non-Scarification, Under/Between and Year Results- Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



(h)

Figure 4.5.2.3 (a) - (h): Wild Harvest Site 2020 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Comparing Scarification/Non-Scarification, Under/Between and Year Results - Part 2- As per graph (e) with Exchangeable Sodium high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

4.6. Wild Harvest Site Scarification Area

Within the scarified areas, it is important to note that the scarification process removed the majority of the plant material and led to a differential in both the trafficking of the area compared to the control, but also the presentation of tyre tread undulations leading to the minor runoff and pooling of rainfall (and/or dew) into the more depressed areas of the tractor imprints. Representative photographs have been included in Appendix 5, Section 11 to demonstrate this effect.

4.6.1. Scarification Area Under Vs Between Plants

4.6.1.1. 2020 Baseline

Within the 0-10cm depth, the under-plant samples value was higher than the between-plant soils sampled for soluble calcium, available phosphorus and exchangeable phosphorus. Within the deeper samples, 10-30cm, the under-plant samples value was higher than the between-plant soils sampled for the carbon/nitrogen ratio, available phosphorus and exchangeable phosphorus. There was no soil characteristic for which between the plants was higher than that found under the plants.

See Table 4.6.1.1 for tabulated summary and Table 10.1.2 within Section 10, Appendix 4 for the average values and statistical significance with and without outliers.

Table 4.6.1.1: Scarification Area Under Vs Between Plants 2020

Analysis	0-10cm Depth Under Higher than Between	0-10cm Depth Between Higher than Under	10-30cm Depth Under Higher than Between	10-30cm Depth Between Higher than Under
Carbon/ Nitrogen Ratio			✓	
Soluble Calcium (mg/kg)	✓			
Phosphorus (mg/kg P, Colwell)	✓		✓	
Phosphorus (mg/kg P, Bray 2)			✓	
Nitrate Nitrogen (mg/kg N)	✓		✓	

4.6.1.2. 2021 Delta

Within the 0-10cm depth, the under-plant samples value was higher than the between-plant soils sampled for exchangeable calcium, calcium as a % of ECEC and the calcium magnesium ratio. The between plant soil was higher than the under for the sodium as a % of ECEC. Within the deeper samples, 10-30cm, no difference was identified. See Table 4.6.1.2. (Additional Data is presented in Appendix 4 Table 10.2.2.)

Table 4.6.1.2: Scarification Area Under Vs Between Plants 2021

Analysis	0-10cm Depth Under Higher than Between	0-10cm Depth Between Higher than Under	10-30cm Depth Under Higher than Between	10-30cm Depth Between Higher than Under
Exchangeable Calcium (mg/kg)	✓			
Calcium (%)	✓			
Sodium - ESP (%)		✓		
Calcium/ Magnesium Ratio	✓			

Soil calcium content was the only consistent property identified both in 2020 and 2021 sample data.

For the comparison of 2020 to 2021 data set for under and between the Scarified data set:

- 2021 higher than 2020
  - Under – exchangeable magnesium (214mg/kg to 313mg/kg), Exchangeable sodium (743mg/kg to 1289mg/kg), and effective cation exchange capacity (ECEC, 6.9 to 10.3 cmol+/kg).
  - Between - sodium - ESP % (56% to 65%), and silicon (16mg/kg to 26mg/kg).
- 2020 higher than 2021
  - Under - nitrate nitrogen (5.27mg/kg, to 0.92mg/kg).
  - Between - carbon nitrogen ratio (20.4 to 14.5), and nitrate nitrogen (2.9 mg/kg, to 0.96mg/kg).

4.6.2. Scarification Area 0-10cm Vs 10-30

4.6.2.1. 2020 Baseline

Within the scarification area a comparison was performed for the depth profile separately for the under-plant samples and for the between-plant samples. Within the under-plant sample set, the 0-10cm samples were higher than the 10-30cm samples for available phosphorus, exchangeable phosphorus and ammonium based nitrogen. Within the between-plant sample set, the 0-10cm samples were higher than the 10-30cm samples for total carbon %, carbon/nitrogen ratio, available phosphorus, and exchangeable phosphorus. Within the under-plant sample set, the 10-30cm samples were higher than the 0-10cm samples for the exchangeable sodium % (ESP) only.

See Table 4.3.2.1 (a) and (b) for tabulated summary and Table 10.1.2 within Section 10, Appendix 4 for the average values and statistical significance with and without outliers. It must be noted that two of the scarification area deep samples were extracted out of heavy clay, leading to some contamination of the samples with soil sampling equipment abraded fines.

4.6.2.2. 2021 Delta

Within the Scarified Area, the 0-10cm samples were higher than the 10-30cm samples for total carbon %, plant available phosphorus, exchangeable calcium and the calcium % as a proportion of ECEC.

Soil total carbon, plant available phosphorus and sodium ESP are recurrent differentials in the 2020 and 2021 sample data.

A more detailed analysis of the impact of depth on the under versus between plant soils was completed in Section 4.5.2 with specific comparison of the Scarified and Non-Scarified areas.

Table 4.6.2.1 (a): Scarification Area 0-10cm Vs 10-30cm

Analysis	Under Plant 0-10cm Depth Higher than 10-30cm	Under Plant 10-30cm Depth Higher than 0-10cm	Between Plant 0-10cm Depth Higher than 10-30cm	Between Plant 10-30cm Depth Higher than 0-10cm
Total Carbon (%)			✓	
Carbon/ Nitrogen Ratio			✓	
Phosphorus (mg/kg P, Bray 1)	✓		✓	
Phosphorus (mg/kg P, Bray 2)	✓		✓	
Ammonium Nitrogen (mg/kg N)	✓			
Sodium - ESP (%)				✓

Table 4.6.2.1 (b): Scarification Area 0-10cm Vs 10-30cm

Analysis	0-10cm Depth higher than 10-30cm	10-30cm Depth higher than 0-10cm
pH		✓
Total Carbon (%)	✓	
Phosphorus (mg/kg P, Bray 1)	✓	
Exchangeable Calcium (mg/kg)	✓	
Calcium (%)	✓	
Sodium - ESP (%)		✓

4.7. Wild Harvest Site Non-Scarification Area

The non-scarified / control blocks were preserved with plant residues and a significantly greater soil coverage, both for soil temperature moderation and the catchment of wind eroded soils from other areas. The balance of soil health versus plant productivity in the comparison of a highly impacted area versus one preserved was anticipated to be inverse due to the lagging soil property migration compared to plant stimulus within the short term timeframe of this project and based on the land managers experience of historical scarification activities. However, the longer term impact, which may not be captured within this trial, with respect to root infiltration within the soil structure for soil based eco-system / resilience support versus plant based ecosystems, impacted by harvesting regimes will define the true impact on the holistic eco-system health. The comparison of the non-scarified area was anticipated to show a snapshot of this transition over the 18 months of the Wild Harvest Site.

4.7.1. Non-Scarification Area Under Vs Between Plants

4.7.1.1. 2020 Baseline

Within the 0-10cm depth, the 2020 under-plant samples value was higher than the between-plants soil sample for total carbon %, total nitrogen %, exchangeable phosphorus, calcium %, magnesium%, and potassium %. For the same depth profile, the between-plant samples value was higher than the under-plants soil sample for exchangeable sodium % (ESP).

Within the deeper samples, 10-30cm, the under-plant samples value was higher than the between-plants soil sample for the carbon/nitrogen ratio, available phosphorus, and aluminium %. For the same depth profile, the between-plant samples value was higher that the under-plants soil sample for electrical conductivity (EC); soluble calcium and magnesium; sulfur; and exchangeable calcium, magnesium and sodium.

See Table 4.7.1.1 for tabulated summary and Table 10.1.3 within Section 10, Appendix 4 for the average values and statistical significance with and without outliers.

4.7.1.2. 2021 Delta

Within the 0-10cm depth, the 2021 under-plant samples value was higher than the between-plants soil sample for total carbon %, soluble calcium, exchangeable calcium, calcium %, magnesium%, potassium %, aluminium %, the calcium/magnesium ratio, boron content and silicon content. For the same depth profile, the between-plant samples value was higher than the under-plants soil sample for the electrical conductivity (EC), sulfur content, exchangeable sodium, the effective cation exchange capacity (ECEC) and the exchangeable sodium % (ESP).

Within the 2021 deeper samples, 10-30cm, the under-plant samples value was higher than the between-plants soil sample for the calcium % and aluminium % only. For the same depth profile, the between-plant samples value was higher that the under-plants soil sample for EC; sulfur content, exchangeable sodium, ECEC and the effective sodium % (ESP). See Table 4.7.1.2. (Additional Data is presented in Appendix 4 Table 10.2.2.)

It is important to note that indicators of salinity, EC and sodium contents are significantly higher between the plants compared to under them at both depths. This provides an indication of the natural state in the undisturbed environment.

Table 4.7.1.1: Non-Scarification Area Under Vs Between Plants Sampled in 2020

Analysis	0-10cm Depth Under Higher than Between	0-10cm Depth Between Higher than Under	10-30cm Depth Under Higher than Between	10-30cm Depth Between Higher than Under
Electrical Conductivity (dS/m)				✓
Total Carbon (%)	✓			
Total Nitrogen (%)	✓			
Carbon/ Nitrogen Ratio			✓	
Soluble Calcium (mg/kg)				✓
Soluble Magnesium (mg/kg)				✓
Phosphorus (mg/kg P, Bray 1)			✓	
Phosphorus (mg/kg P, Colwell)			✓	
Phosphorus (mg/kg P, Bray 2)	✓			
Sulfur (mg/kg S)				✓
Exchangeable Calcium (mg/kg)				✓
Exchangeable Magnesium (mg/kg)				✓
Exchangeable Sodium (mg/kg)				✓
Calcium (%)	✓			
Magnesium (%)	✓			
Potassium (%)	✓			
Sodium - ESP (%)		✓		
Aluminium (%)			✓	

Table 4.7.1.2: Non-Scarification Area Under Vs Between Plants Sampled in 2021

Non-Scarified Analysis	0-10cm Depth Under Higher than Between	0-10cm Depth Between Higher than Under	10-30cm Depth Under Higher than Between	10-30cm Depth Between Higher than Under
Electrical Conductivity (dS/m)		✓		✓
Total Carbon (%)	✓			
Soluble Calcium (mg/kg)	✓			
Sulfur (mg/kg S)		✓		✓
Exchangeable Calcium (mg/kg)	✓			
Exchangeable Sodium (mg/kg)		✓		✓
Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		✓		✓
Calcium (%)	✓		✓	
Magnesium (%)	✓			
Potassium (%)	✓			
Sodium - ESP (%)		✓		✓
Aluminium (%)	✓		✓	
Calcium/ Magnesium Ratio	✓			
Boron (mg/kg)	✓			
Silicon (mg/kg)	✓			

4.7.2. Non-Scarification Area 0-10cm Vs 10-30cm

4.7.2.1. 2020 Baseline

Within the non-scarification / control area, a comparison was performed for the depth profile separately for the under-plant samples and for the between-plant samples. Within the under-plant sample set, the 0-10cm samples were higher than the 10-30cm samples for total carbon%; total nitrogen%; soluble calcium; available and exchangeable phosphorus; exchangeable calcium, calcium %, magnesium%, and calcium/magnesium ratio. The 0-10cm samples were lower than the 10-30cm samples for exchangeable sodium % (ESP) only.

In the between-plant sample set, the 0-10cm samples were higher than the 10-30cm samples for carbon/nitrogen ratio, available and exchangeable phosphorus, calcium %, aluminium %, and calcium/magnesium ratio. The 0-10cm samples were lower than the 10-30cm samples for electrical conductivity (EC); soluble calcium and magnesium; sulfur; exchangeable sodium; effective cation exchange capacity (ECEC); exchangeable sodium % (ESP) and chloride estimate.

It is noted that there was a higher proportion of properties displaying statistically significant difference within the non-scarified control plots. This could be attributed to the lack of inversion of soil within the profile of the harsh scarification area where plants were torn out by the roots. Additionally in the scarified area no differential in coverage was available and hence the benefit of protection from solar radiation and the diurnal temperature fluctuations through plant coverage was not present.

See Table 4.7.2.1 for tabulated summary and Table 10.1.3 (a) and (b) within Section 10, Appendix 4 for the average values and statistical significance with and without outliers.

4.7.2.2. 2021 Delta

Within the non-scarification / control area, the 0-10cm samples were higher than the 10-30cm samples for total carbon %, total nitrogen, soluble calcium, plant available phosphorus, exchangeable calcium, exchangeable magnesium, the calcium % as a proportion of ECEC, the calcium magnesium ratio and the silicon content. Only the sodium – ESP was higher in the 10-30cm depth. See Table 4.7.2.2 for tabulated summary and Table 10.2.2 within Section 10, Appendix 4 for the average values and statistical significance with and without outliers.

Soil total carbon, total nitrogen, soluble calcium, plant available phosphorus, exchangeable calcium, calcium %, magnesium % and the calcium magnesium ratio are recurrent differentials in the 2020 and 2021 sample data. In this comparison of data sets, the sodium ESP was the only property identified in all sets as greater in the more deep soil sample. A more detailed analysis of the impact of depth on the under versus between plant soils has been completed in Section 4.4.6 with specific comparison of the Scarified and Non-Scarified areas.

Table 4.7.2.1: Non-Scarification Area 0-10cm Vs 10-30cm in 2020

Analysis	Under Plant 0-10cm Depth Higher than 10-30cm	Under Plant 10-30cm Depth Higher than 0-10cm	Between Plant 0-10cm Depth Higher than 10-30cm	Between Plant 10-30cm Depth Higher than 0-10cm
Electrical Conductivity (dS/m)				✓
Total Carbon (%)	✓			
Total Nitrogen (%)	✓			
Carbon/ Nitrogen Ratio			✓	
Soluble Calcium (mg/kg)	✓			✓
Soluble Magnesium (mg/kg)				✓
Phosphorus (mg/kg P, Bray 1)	✓		✓	
Phosphorus (mg/kg P, Colwell)	✓		✓	
Phosphorus (mg/kg P, Bray 2)	✓		✓	
Sulfur (mg/kg S)				✓
Exchangeable Calcium (mg/kg)	✓			
Exchangeable Sodium (mg/kg)				✓
Effective Cation Exchange Capacity (ECEC) (cmol+/kg)				✓
Calcium (%)	✓		✓	
Magnesium (%)	✓			
Sodium - ESP (%)		✓		✓
Aluminium (%)			✓	
Calcium/ Magnesium Ratio	✓		✓	
Chloride Estimate (equiv. mg/kg)				✓

Table 4.7.2.2: Non-Scarification Area 0-10cm Vs 10-30cm in 2021

Non-Scarified Analysis	0-10cm Depth higher than 10-30cm	10-30cm Depth higher than 0-10cm
Total Carbon (%)	✓	
Total Nitrogen (%)	✓	
Soluble Calcium (mg/kg)	✓	
Phosphorus (mg/kg P, Bray 1)	✓	
Exchangeable Calcium (mg/kg)	✓	
Exchangeable Magnesium (mg/kg)	✓	
Calcium (%)	✓	
Magnesium (%)	✓	
Sodium - ESP (%)		✓
Calcium/ Magnesium Ratio	✓	
Silicon (mg/kg)	✓	

4.8. Comparison of Significant Differentials within the 2021 data.

The detailed comparison of the Scarified versus Non-Scarified area soil samples with respect to position relative to plants and soil depth enables the determination of the impact of scarification as compared to that of the climate or other impacts common to both areas – the ultimate objective of the project scope within the Wild Harvest Site.

For the comparison of total data set for the 2021 sampling:

- Under higher than between:
  - 0-10cm – total carbon (0.79% to 0.56%), soluble calcium (197mg/kg to 99mg/kg), exchangeable calcium (270mg/kg to 160mg/kg), Magnesium % of ECEC (28% to 25%), Potassium % of ECEC (2.2% to 1.1%), the calcium magnesium ratio (0.64 to 0.37) and manganese content.
  - 10-30cm – Electrical Conductivity (EC, 0.91dS/m to 1.40dS/m), aluminium % (0.23% to 0.16%), and the calcium magnesium ratio (0.45 to 0.26).
- Between higher than under:
  - 0-10cm - Exchangeable sodium (913mg/kg to 1247mg/kg), and sodium - ESP % (50% to 64%).
  - 10-30cm – soluble magnesium (172mg/kg to 229mg/kg), sulfur (61mg/kg to 95mg/kg), exchangeable magnesium (174mg/kg to 271mg/kg), exchangeable sodium (863mg/kg to 1245mg/kg), effective cation exchange capacity (ECEC, 6.5cmol/kg to 9.5cmol/kg), and Sodium – ESP% (65% to 70%).

For the comparison of under plant data set for the 2021 sampling:

- Scarified higher than Non-Scarified / Control:
  - 0-10cm – EC (1.3dS/m to 06dS/m), exchangeable magnesium (313mg/kg to 220mg/kg), exchangeable sodium (1290mg/kg to 670mg/kg), and the ECEC (10.3cmol/kg to 6.1cmol/kg).
  - 10-30cm – pH (7.7 to 7.0), exchangeable sodium (1105mg/kg to 755mg/kg), and the ECEC (7.7cmol/kg to 5.3cmol/kg).
- Non-Scarified higher than Scarified / Control:
  - 0-10cm - Potassium % of ECEC (1.7% to 2.7%) only.
  - 10-30cm – Aluminium % of ECEC (0.19% to 0.31%).

For the comparison of between plant data set for the 2021 sampling:

- Scarified higher than Non-Scarified / Control:
  - 0-10cm – exchangeable sodium (1523mg/kg to 1074mg/kg), and the ECEC (10.1cmol/kg to 7.5cmol/kg).
  - 10-30cm – soluble calcium (114mg/kg to 81mg/kg), exchangeable calcium (144mg/kg to 106mg/kg), and silicon content (22mg/kg to 16mg/kg).
- Non-Scarified higher than Scarified / Control:
  - 0-10cm – Nil.
  - 10-30cm – Aluminium % (0.19% to 0.31%).

The consistent presentation of higher exchangeable sodium and ECEC within the scarified compared to non-scarified areas is notable. As well as the higher EC, exchangeable sodium and ECEC under the plants within the deeper soils than in between. The full data is presented in Table 4.8.1 as a subset of Table 10.2.2 in Appendix 4.

It was important to consider the 2021 in context with the change from the 2020 levels as discussed in the previous sections. It is evident in Figure 4.5.2.1 that there was a steeper rise in EC, the ECEC and the exchangeable sodium of the soil sampled from 2020 to 2021 within the scarified area as compared to the non-scarified. The rise for total nitrogen, manganese, boron, silicon, and soluble calcium was more consistent between the two areas. In contrast the soluble phosphorus, exchangeable potassium and exchangeable aluminium displayed a greater increase within the non-scarified / control plot.

From Figure 4.5.2.2, whilst the EC, exchangeable sodium and ECEC was higher in soil sampled from between the plants to under them, the change in these values from 2020 to 2021 was a consistent significant rise for both locations. The total nitrogen, boron and silicon contents of the soils sampled under the plants was higher than that found between in 2020 and both demonstrated a consistent rise across the areas.

In the comparison of the individual year, scarification and relative plant location samples, pH, the carbon nitrogen ratio, and the plant available phosphorus was identified as having decreased for all sets between 2020 and 2021 as per Figure 4.5.2.3. In contrast, the total nitrogen, manganese, boron, and silicon demonstrated an increased for all sets between 2020 and 2021.

It is noted that whilst the ECEC (reflected in the exchangeable sodium content) demonstrated a rise from 2020 to 2021 within both the under and between locations of the scarified area, whilst the non-scarified remained relatively consistent.

Table 4.8.1: Wild Harvest Site 0-10cm Vs 10-30cm in 2021

Wild Harvest Location	Significant Data	Analysis									
		pH	Electrical Conductivity (dS/m)	Total Carbon (%)	Total Nitrogen (%)	Soluble Calcium (mg/kg)	Soluble Magnesium (mg/kg)	Phosphorus (mg/kg P, Bray 1)	Sulfur (mg/kg S)	Exchangeable Calcium (mg/kg)	Exchangeable Magnesium (mg/kg)
	Average U			0.788		197.0				269.8	
0-10cm Total U v B	Average B			0.557		99.1				159.8	
	P(T<=t) two-tail			5.13E-04		3.97E-03				2.09E-04	
	Average U		0.91				172		61.3		174
10-30cm Total U v B	Average B		1.40				229		95.5		271
	P(T<=t) two-tail		1.37E-02				7.51E-03		2.29E-02		1.54E-02
	Average SC		1.30								313
0-10cm Under SC v NS	Average NS		0.59								220
	P(T<=t) two-tail		2.33E-02								8.29E-03
	Average SC										
0-10cm Between SC v NS	Average NS										
	P(T<=t) two-tail										
	Average SC	7.66									
10-30cm Under SC v NS	Average NS	7.05									
	P(T<=t) two-tail	4.71E-02									
	Average SC					114.1				143.7	
10-30cm Between SC v NS	Average NS					81.4				105.8	
	P(T<=t) two-tail					2.48E-02				3.89E-02	

Location	Significant Data	Analysis										
		Exchangeable Sodium (mg/kg)	Effective Cation Exchange	Calcium (%)	Magnesium (%)	Potassium (%)	Sodium - ESP (%)	Aluminium (%)	Calcium/ Magnesium Ratio	Manganese (mg/kg)	Boron (mg/kg)	Silicon (mg/kg)
	Average U	913			28.05	2.166	49.9		0.643	2.11		
0-10cm Total U v B	Average B	1247			25.07	1.073	64.1		0.366	1.25		
	P(T<=t) two-tail	3.47E-02			2.90E-02	3.68E-04	2.49E-06		1.35E-05	3.09E-02		
	Average U	863	6.517				65.0	0.230	0.446			
10-30cm Total U v B	Average B	1245	9.489				70.3	0.161	0.263			
	P(T<=t) two-tail	2.38E-02	6.18E-03				2.65E-02	1.99E-02	4.11E-03			
	Average SC	1289	10.331			1.663						
0-10cm Under SC v NS	Average NS	669	6.052			2.668						
	P(T<=t) two-tail	1.42E-02	4.61E-03			3.56E-02						
	Average SC	1523	10.082									
0-10cm Between SC v NS	Average NS	1074	7.507									
	P(T<=t) two-tail	4.88E-02	4.52E-02									
	Average SC	1105	7.749					0.192				
10-30cm Under SC v NS	Average NS	755	5.286					0.314				
	P(T<=t) two-tail	4.70E-02	9.79E-03					2.91E-02				
	Average SC							0.140				22.4
10-30cm Between SC v NS	Average NS							0.183				16.2
	P(T<=t) two-tail							1.90E-02				4.79E-02

Note:	SC	Scarified
	NS	Non-Scarified / Control Scarification
	U	Under
	B	Between

4.9. Wild Harvest Site Soil Salinity

Within the 2021 sampling regime there was a statistically significant difference identified between the electrical conductivity (EC) of the scarified and non-scarified soil samples taken from the shallow depth soil under plants (1.30dS/m and 0.59dS/m respectively). Additionally both in the 0-10cm depth and the 10-30cm depth, there was a significantly higher EC identified between the plants as opposed to under them (0.59dS/m to 1.05dS/m and 0.75dS/m to 1.40dS/m respectively). It was also noted that between the 2020 and 2021 sampling, there was an overall increase in the EC for the total data set and for the scarified data set (0.79dS/m to 1.03dS/m and 0.78dS/m to 1.4dS/m respectively. All results, irrespective of depth, plant proximity or scarification indicated elevated salinity compared to the laboratory recommended guideline of 0.200 dS/m for clay or 0.100 dS/m for loamy/sand. Graphically it was evident that the 10-30cm samples had a lower EC in 2021 compared to 2020 for the scarified area, whereas the inverse was true for the non-scarified area. See Figures 4.9.1 and 4.9.2 for the graphical comparison.

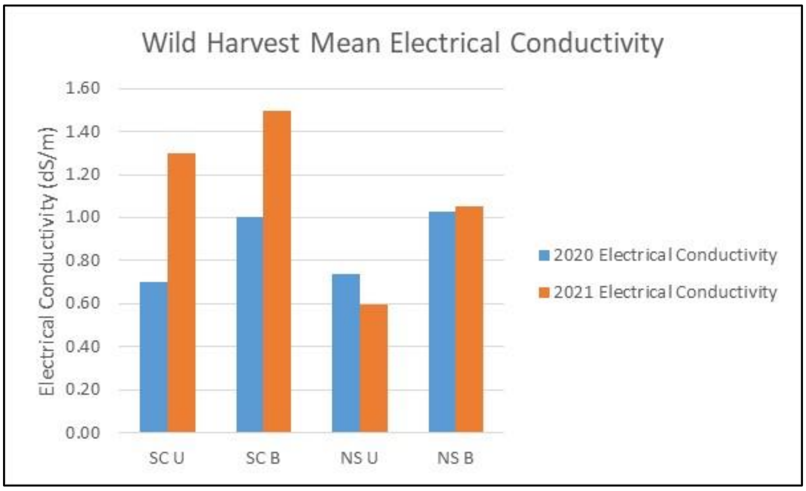


Figure 4.9.1 Mean Electrical Conductivity for Scarified Under Plant (SC U), Scarified Between Plant (SC B), Non-Scarified Under Plant (NS U), Non-Scarified Between Plant (NS B) for the two sampling timestamps and 0-10cm depth samples.

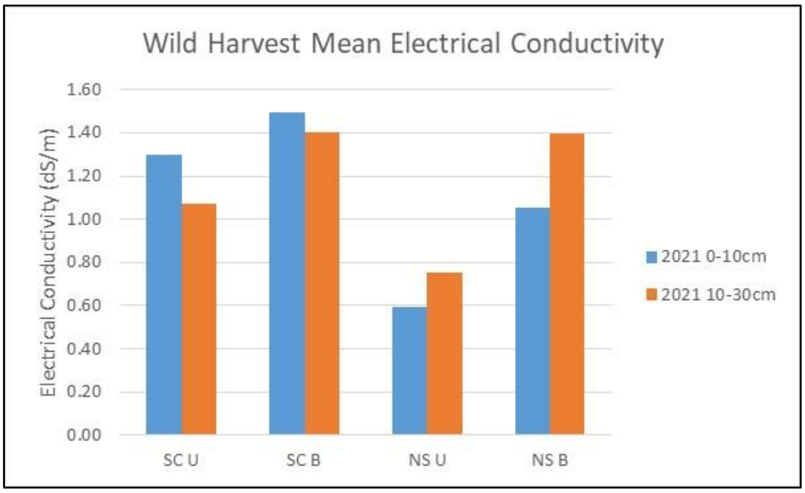


Figure 4.9.2 Mean Electrical Conductivity for Scarified Under Plant (SC U), Scarified Between Plant (SC B), Non-Scarified Under Plant (NS U), Non-Scarified Between Plant (NS B) for the 0-10cm and 10-30cm depth samples assessed in 2021.

In contrast to the 2020 samples, there was no depth differential nor outliers identified for the EC either in the scarified or non-scarified soils. Examination of the data from each individual locations, identified a higher variability with the 2020 samples compared to those taken in 2021. See Figure 4.9.3. It is noted that when the four random samples from each location are arranged in order of magnitude, the under and between elements highlight a relative lesser and greater value respectively for all scenarios.

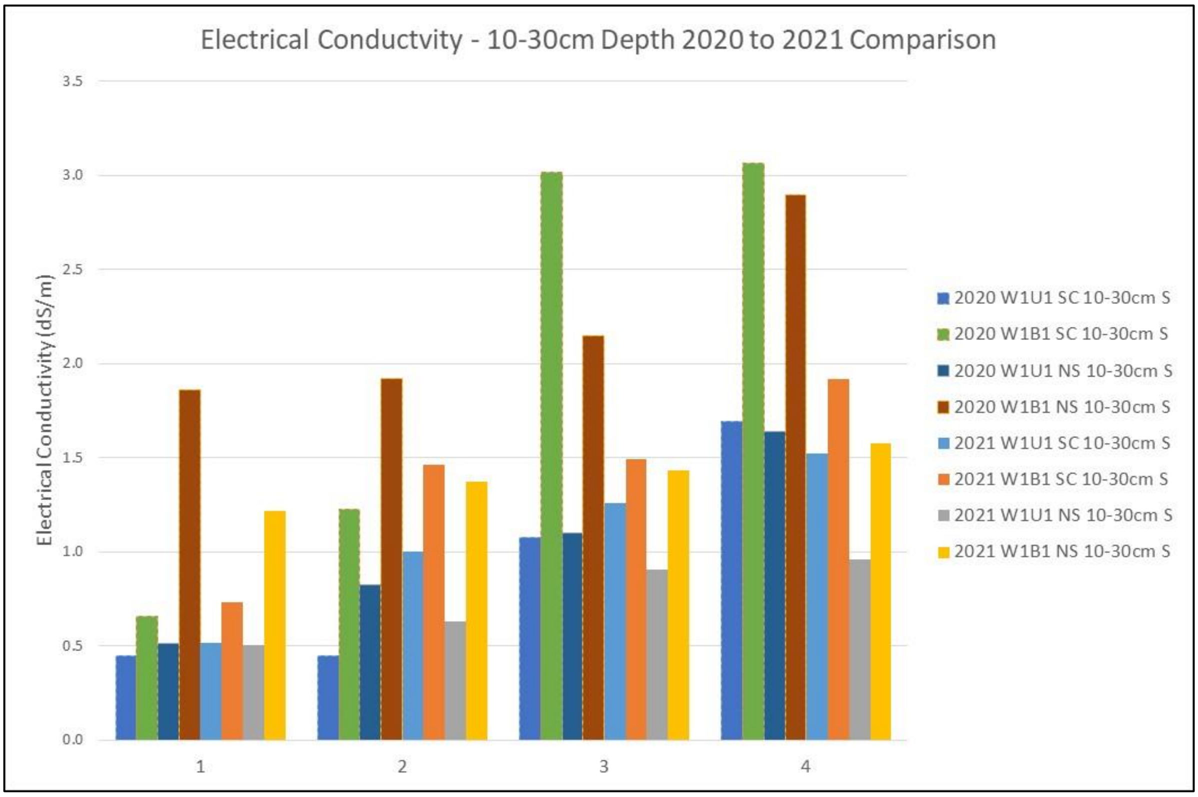


Figure 4.9.3 Individual Electrical Conductivity for Scarified Under Plant (U1 SC), Scarified Between Plant (B1 SC), Non-Scarified Under Plant (U1 NS), Non-Scarified Between Plant (B1 NS) for the two sampling timestamps and 10-30cm depth samples.

Due to the limited number of samples to depth and large fluctuations, the assessment has therefore been conducted on the basis of means and with the assumption that the findings are indicative only further to a longer period of comparison. However from the mean of the 2020 and 2021 data with depth, it was apparent that for the 2020 data set all locations identified a higher EC with depth, whilst in the 2021 data this was only apparent in the Non-scarified area. Similarly, the comparison of the EC for the 0-10cm samples showed a higher EC for the scarified samples only, whereas the 10-30cm samples had 3 of the 4 sample sets indicating a lower EC (2x non-scarified and scarified between plant set). See Figure 4.9.4.

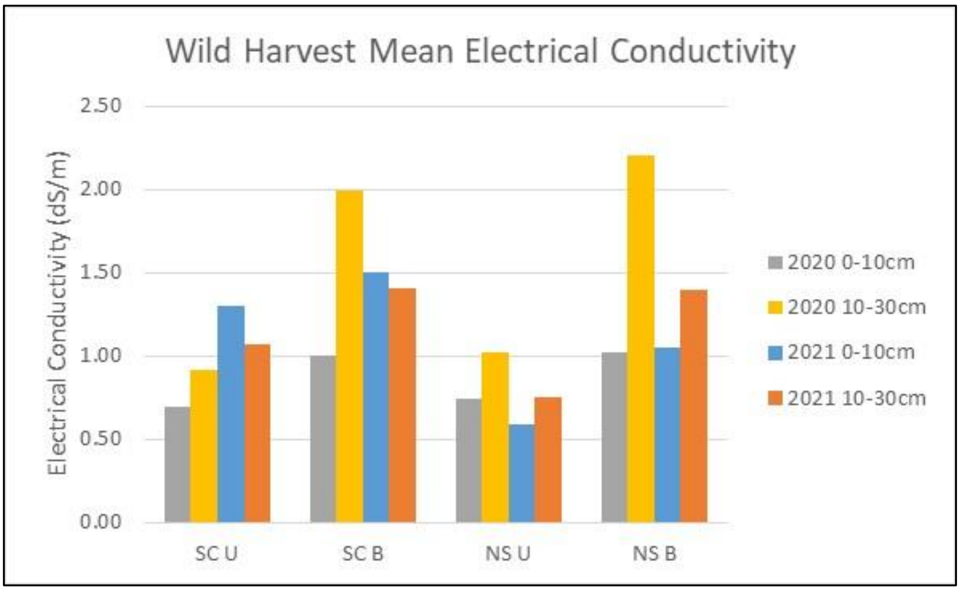


Figure 4.9.4 Mean Electrical Conductivity for Scarified Under Plant (SC U), Scarified Between Plant (SC B), Non-Scarified Under Plant (NS U), Non-Scarified Between Plant (NS B) for the 0-10cm and 10-30cm depth samples assessed in 2020 and 2021.

In conjunction with a high EC, an exchangeable sodium % (ESP) in excess of 5% indicates a potential salt issue (EAL Laboratory guideline). Therefore a detailed review of the statistically significant difference for (i) the exchangeable sodium and (ii) the exchangeable sodium % as a portion of the total effective cation exchange capacity (ECEC) for the 2021 sampling regime is summarised here:

- 0-10cm Total Wild Harvest Site – Under (i-913 mg/kg, ii-50%) less than between (1247 mg/kg, ii-64%).
- 10-30cm Total Wild Harvest Site – Under (i-863 mg/kg, ii-65%) less than between (1245 mg/kg, ii-70%).
- 0-10cm Under Plants – Non-Scarified (i-669 mg/kg) less than Scarified (1289 mg/kg).
- 0-10cm Between Plants – Non-Scarified (i-1074 mg/kg) less than Scarified (1523 mg/kg).
- 10-30cm Under Plants – Non-Scarified (i-755 mg/kg) less than Scarified (1105 mg/kg).
- Scarified Set – 0-10cm (ii-60%) less than 10-30cm (ii-68%).
- Non-Scarified Set – 0-10cm (ii-56%) less than 10-30cm (ii-66%).
- Scarified Set 0-10cm – Under (ii-52%) less than between (ii-64.5%).
- Non-Scarified Set 0-10cm – Under (i-669 mg/kg, ii-49%) less than between (1074 mg/kg, ii-64%).
- Non-Scarified Set 0-10cm – Under (i-755 mg/kg, ii-62%) less than between (1432 mg/kg, ii-70%).

The outcome suggests the under plant, non-scarified area and shallower soils consistently exhibited a lower salinity.

Unlike the EC data where the total and scarified data sets were noted, (i) the exchangeable sodium identified the total data and the scarified under plant data to have a significant increase from 2020 to 2021 (867 to 1080mg/kg and 743 to 1289 mg/kg respectively) and (ii) the exchangeable sodium % as a portion of the total ECEC identified the scarified data, the between plant data and the scarified between plant data to have increased between 2020 and 2021 (53 to 60%, 56 to 64% and 56 to 65% respectively). All results, irrespective of depth, plant proximity or scarification indicated elevated salinity compared to the laboratory recommended guideline of 23.5mg/kg and 3.3% dS/m sandy soils). See Figures 4.9.5 and 4.9.6 for the graphical comparison.

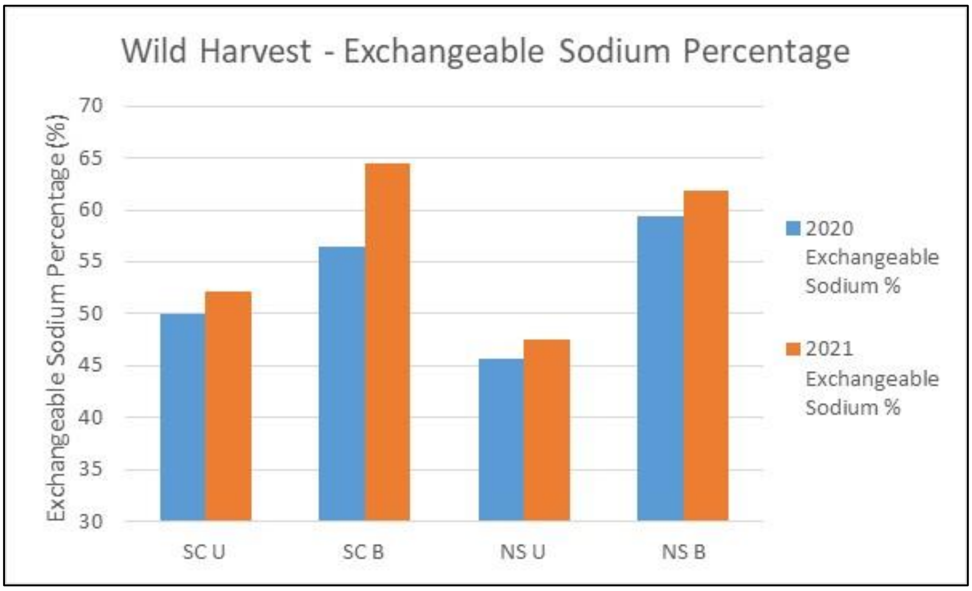


Figure 4.9.5 Mean Exchangeable Sodium as a Percentage of Cation Exchange Capacity for Scarified Under Plant (SC U), Scarified Between Plant (SC B), Non-Scarified Under Plant (NS U), Non-Scarified Between Plant (NS B) for the two timestamps and 0-10cm depth samples.

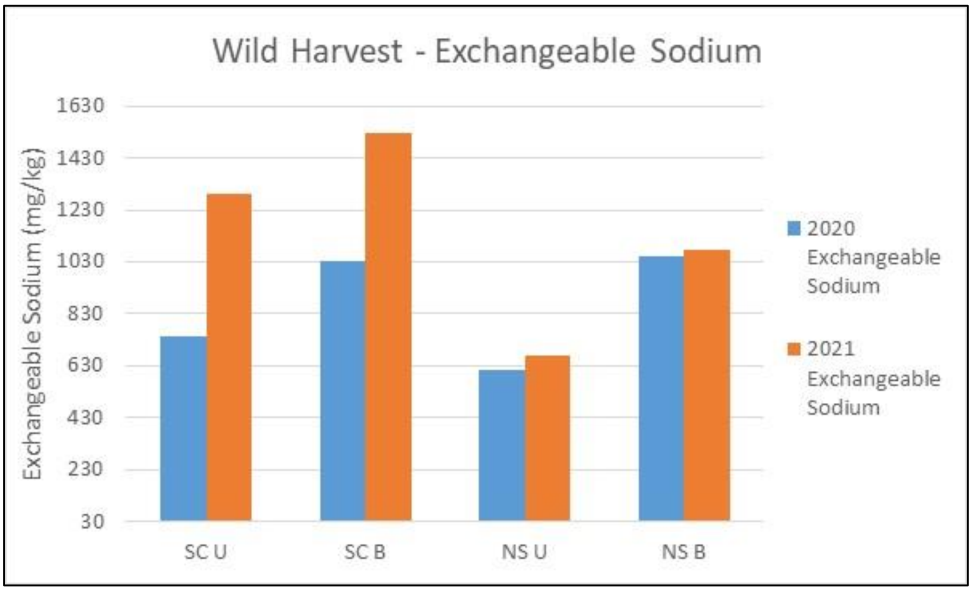


Figure 4.9.6 Mean Total Exchangeable Sodium for Scarified Under Plant (SC U), Scarified Between Plant (SC B), Non-Scarified Under Plant (NS U), Non-Scarified Between Plant (NS B) for the two sampling and 0-10cm depth samples.

A graphical analysis suggests an elevation across all areas and plant proximities between 2020 and 2021. The greatest differential was apparent within the exchangeable sodium data within the scarified area both under and between the plants as in Figure 4.9.6.

A graphical examination of sodium at depth demonstrates a higher content was identified in the exchangeable sodium as a percentage (ESP) of the ECEC for all areas and plant proximities. This difference was greatest in the non-scarified under plant samples and least in the scarified between samples – a finding reinforced by the statistical analysis. The 10-30cm depth samples had a greater exchangeable sodium content for the non-scarified between plant sample set than the shallow sample set, whilst that for the scarified under plant sample set had the opposite trend. Minimal difference was identified graphically for the exchangeable sodium content for the non-scarified under plant samples and scarified between samples. See Figures 4.9.7 and 4.9.8 for the graphical comparison.

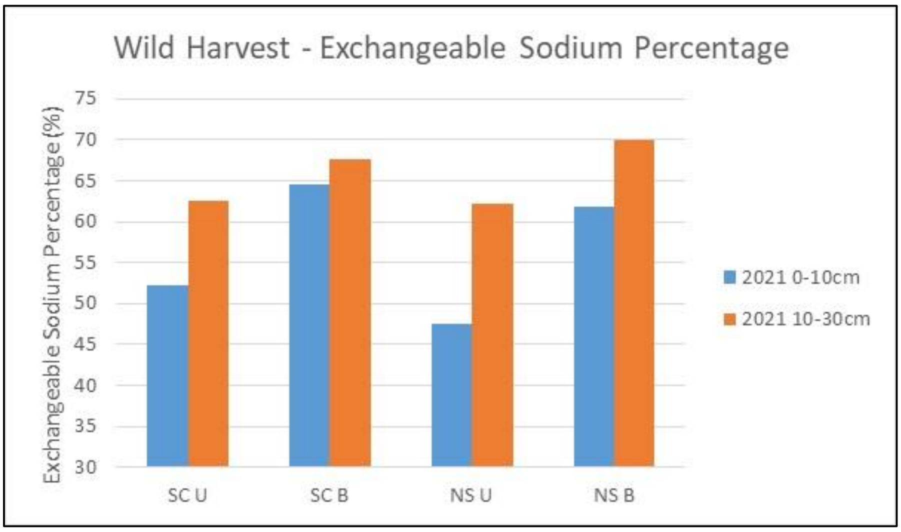


Figure 4.9.7: Mean Exchangeable Sodium as a Percentage of Cation Exchange Capacity for Scarified Under Plant (SC U), Scarified Between Plant (SC B), Non-Scarified Under Plant (NS U), Non-Scarified Between Plant (NS B) for the 0-10cm and 10-30cm depth samples 2021.

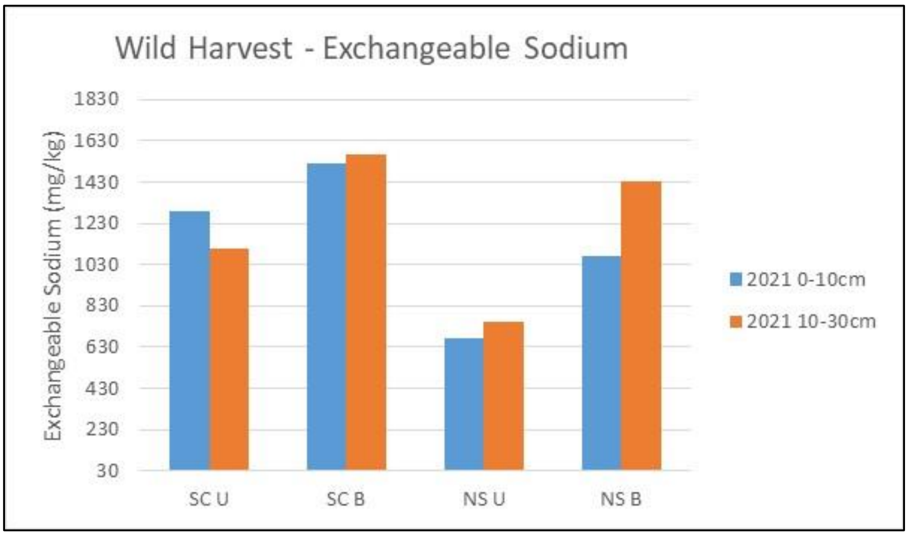


Figure 4.9.8: Mean Exchangeable Sodium for Scarified Under Plant (SC U), Scarified Between Plant (SC B), Non-Scarified Under Plant (NS U), Non-Scarified Between Plant (NS B) for the 0-10cm and 10-30cm depth samples 2021.

Similar to the EC, when the four random samples from each location are arranged in order of magnitude, the under and between elements highlight a relative lesser and greater value respectively for all scenarios with the exception of the 2021 Under and Between scarified area greatest two values which were approximately equal. See Figure 4.9.9.

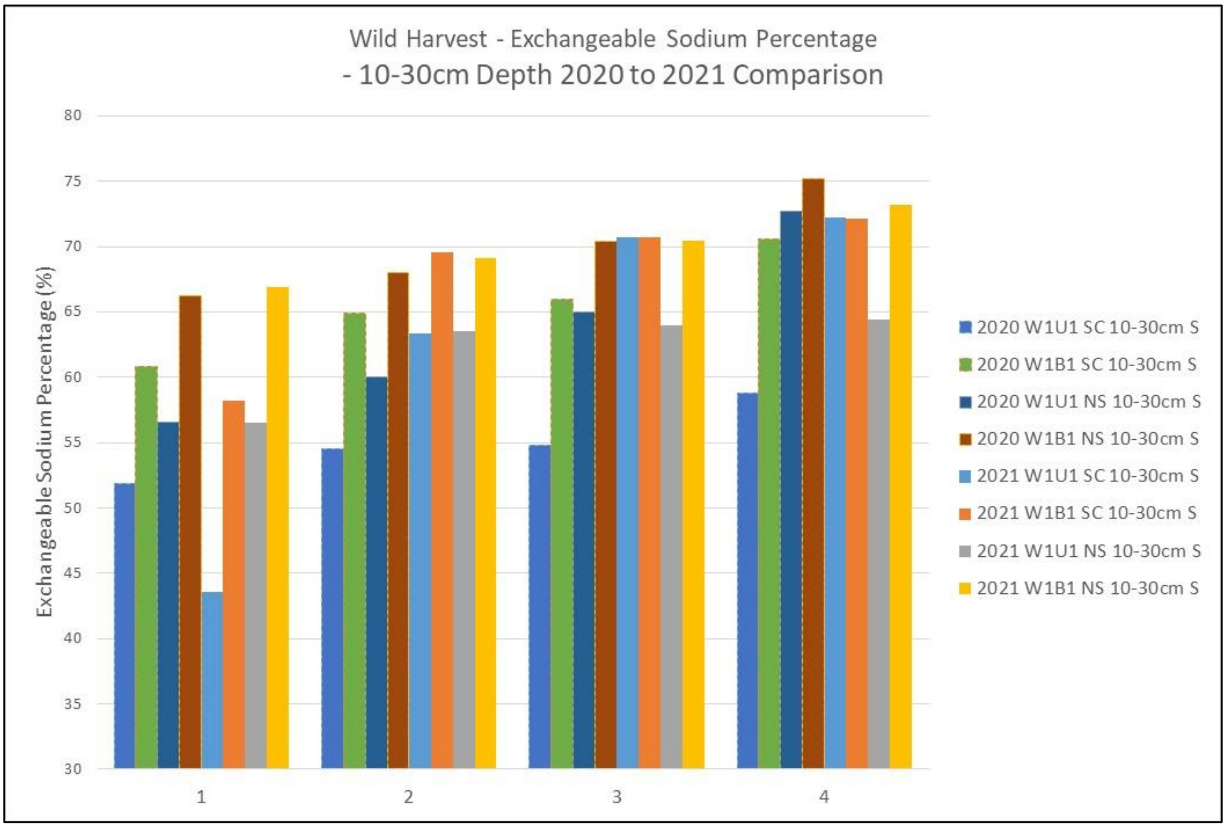


Figure 4.9.9 Individual Exchangeable Sodium as a Percentage of Cation Exchange Capacity for Scarified Under Plant (U1 SC), Scarified Between Plant (B1 SC), Non-Scarified Under Plant (U1 NS), Non-Scarified Between Plant (B1 NS) for the two sampling timestamps and 10-30cm depth samples.

Unlike the EC, the ESP had all the 10-30cm depth samples recording a greater mean exchangeable sodium content. The non-scarified under plant sample set had the most differential in both 2020 and 2021. All the sample sets had a higher 2021 content than that identified in 2020 for the 0-10cm samples. This was also the case for the 10-30cm scarified data sets, however for the non-scarified, the under plant sample content dropped slightly, while the between plant sample set mean was approximately equal. See Figure 4.9.10.

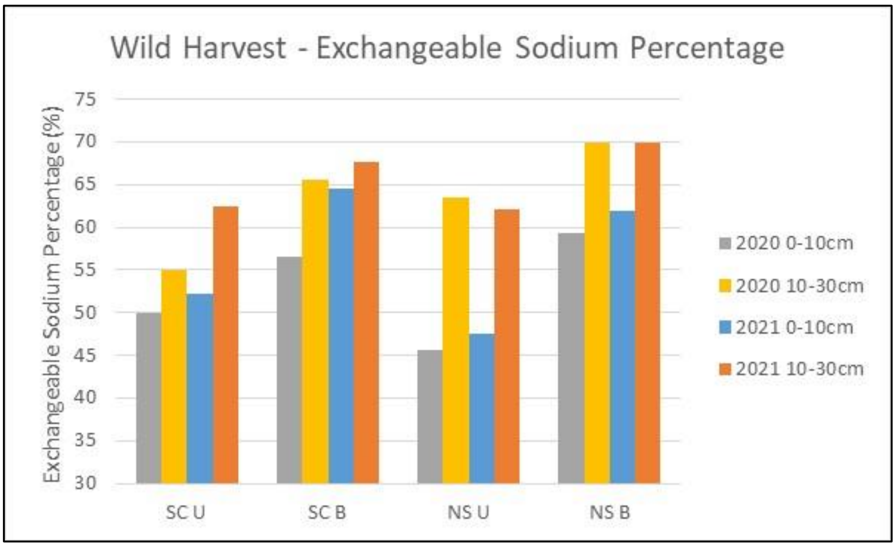


Figure 4.9.10 Mean Exchangeable Sodium as a Percentage of Cation Exchange Capacity for Scarified Under Plant (SC U), Scarified Between Plant (SC B), Non-Scarified Under Plant (NS U), Non-Scarified Between Plant (NS B) for the 0-10cm and 10-30cm depth samples assessed in 2020 and 2021.

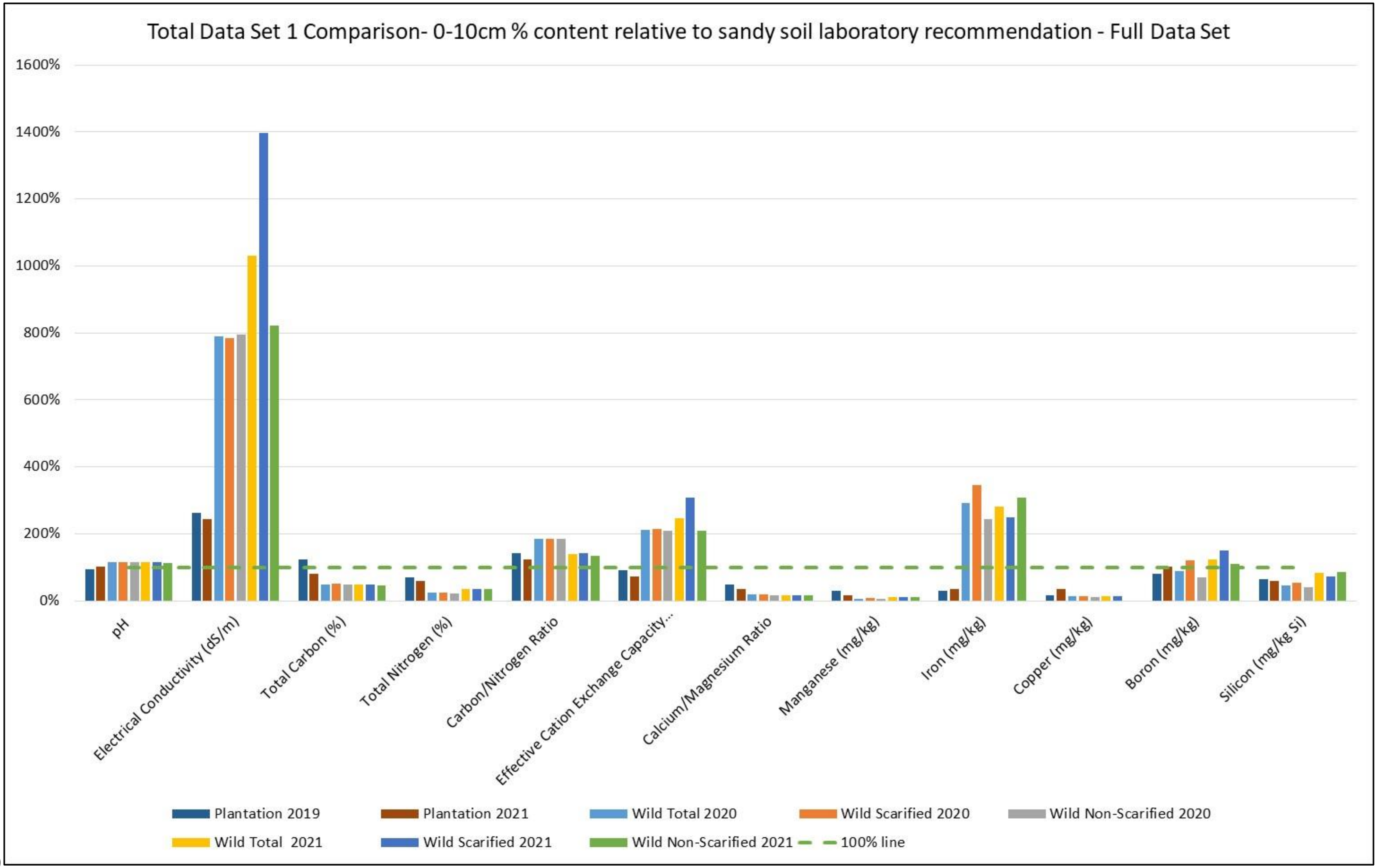
4.10. Overall Plantation Site Vs Wild Harvest Site 2019 to 2021 Comparison

The comparison of the Wild Harvest Site results to the Plantation Site serves only to define the variation of the soil properties across a wider area and the difference in soil response to different soil preparation strategies. The soils themselves were very different and it is not intended that a line can be drawn between the two outcomes. It is also reiterated that there was no control allocated within the Plantation Site and hence a relative difference is difficult to infer between the two locations. However it was evident that there have been some inverse trends between the two areas of interest.

Graphically (Figures 4.10.1) it was evident that:

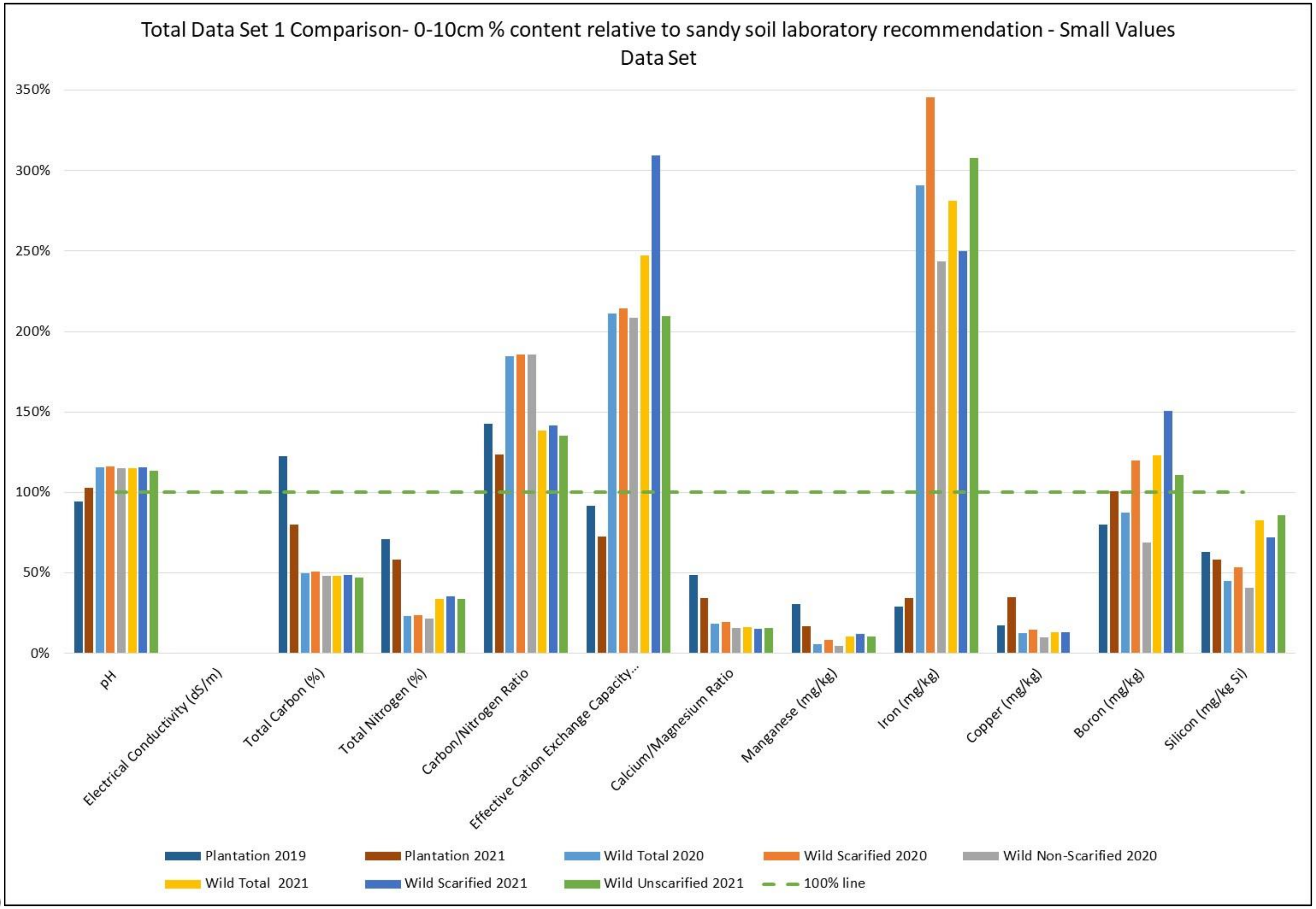
- pH - the Plantation Site increased in pH from 2019 to 2021 (95% to 103%), but remained less than that within the Wild Harvest Site (114-116%) which was relatively consistent from 2020 to 2021.
- Electrical Conductivity (EC) - the Plantation Site decreased from 2019 to 2021 (263% to 243%), but was always well below than that within the Wild Harvest Site which increased from 2020 (783%-795%) to 2021 (822-1397%).
- Total Carbon - the Plantation Site decreased from 2019 to 2021 (123% to 80%), but was well above than that within the Wild Harvest Site (47-51%) which was relatively consistent from 2020 to 2021.
- Total Nitrogen - the Plantation Site decreased from 2019 to 2021 (71% to 58%), but was well above than that within the Wild Harvest Site which increased from 2020 (22-24%) to 2021 (34-36%).
- Effective cation exchange capacity (ECEC) - the Plantation Site decreased from 2019 to 2021 (92% to 72%), but was always well below than that within the Wild Harvest Site which had a dominant increase in the scarified area from 2020 (214%) to 2021 (309%) with the non-scarified remaining the similar on average.
- For the mineralogy:
    - Higher in the Plantation Site than Wild Harvest Site
        - Manganese (Plantation Site value dropped, Wild Harvest Site did not).
    - Higher in the Wild Harvest Site than in the Plantation Site:
        - Iron (Plantation Site value increased, Wild Harvest Site did not),
        - Soluble magnesium (Plantation Site value increased, Wild Harvest Site showed greater scarified versus non-scarified disparity),
        - Exchangeable magnesium (Plantation Site value dropped, Wild Harvest Site showed greater scarified versus non-scarified disparity),
        - Soluble phosphorus (Plantation Site value dropped, Wild Harvest Site increased),

        - Exchangeable potassium (Plantation Site value dropped, Wild Harvest Site increased) and
        - Exchangeable sodium (Plantation Site value dropped, Wild Harvest Site showed dominant increase in the scarified area).
    - Similar Values:
        - Copper (Plantation Site value increased, Wild Harvest Site did not),
        - Boron (Plantation Site and Wild Harvest Site increased),
        - Silicon (Plantation Site value dropped, Wild Harvest Site increased),
        - Soluble Calcium (Plantation Site value dropped, Wild Harvest Site increased),
        - Plant available phosphorus (Plantation Site value increased, Wild Harvest Site did not),
        - Phosphorus (Bray 2) (Plantation Site value increased, Wild Harvest Site lead by scarified area increase),
        - Nitrate Nitrogen (Plantation Site and Wild Harvest Site value dropped),
        - Ammonium Nitrogen (Plantation Site value dropped, Wild Harvest Site showed greater scarified versus non-scarified disparity),
        - Sulfur (Plantation Site and Wild Harvest Site average showed no change),
        - Exchangeable calcium (Plantation Site value dropped, Wild Harvest Site showed greater scarified versus non-scarified disparity) and
        - Exchangeable aluminium (Plantation Site value dropped, Wild Harvest Site increased).



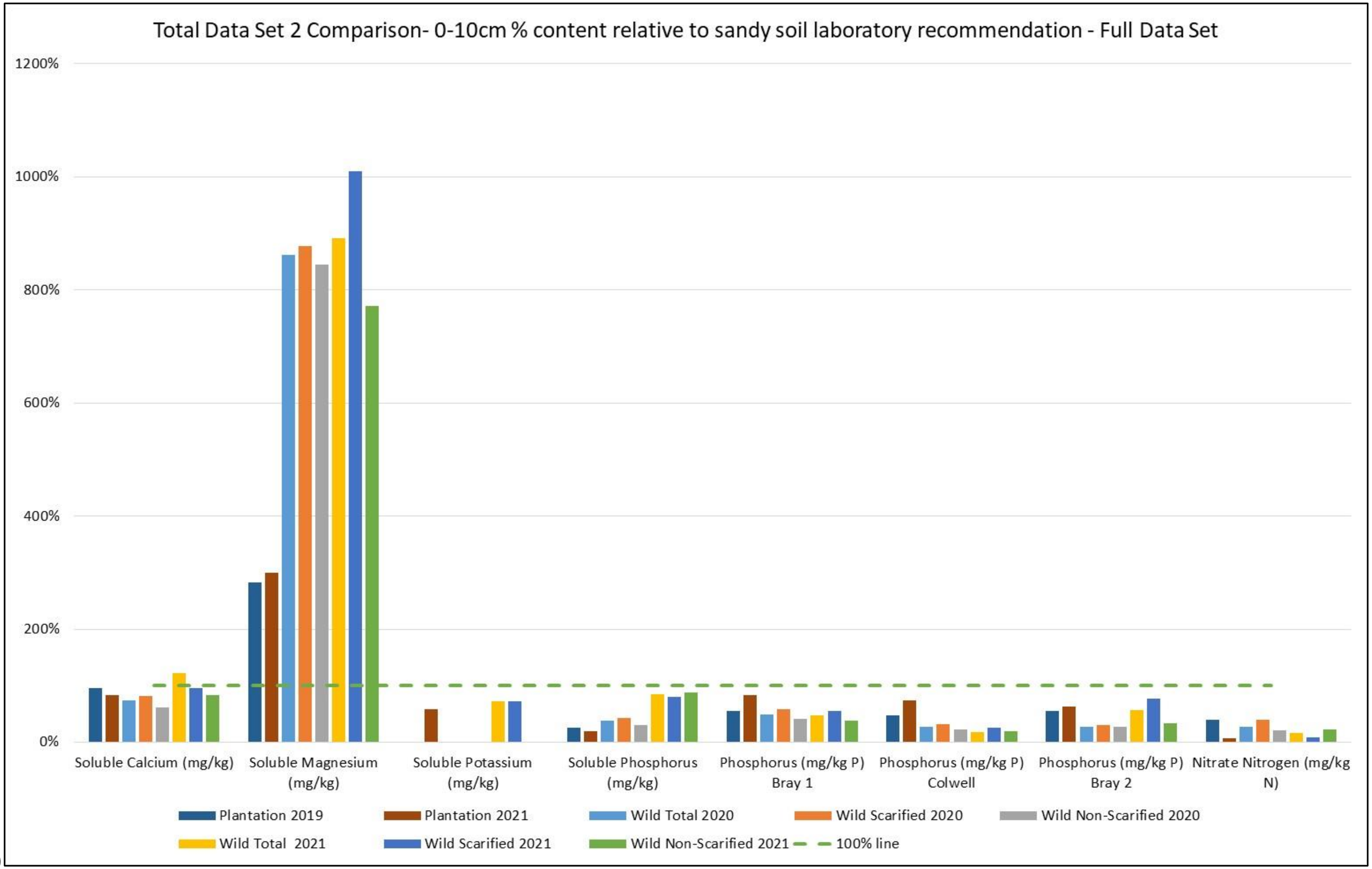
(a)

Figure 4.10.1 (a) - (f): Plantation Site Versus Wild Harvest Site 2019 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines - Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



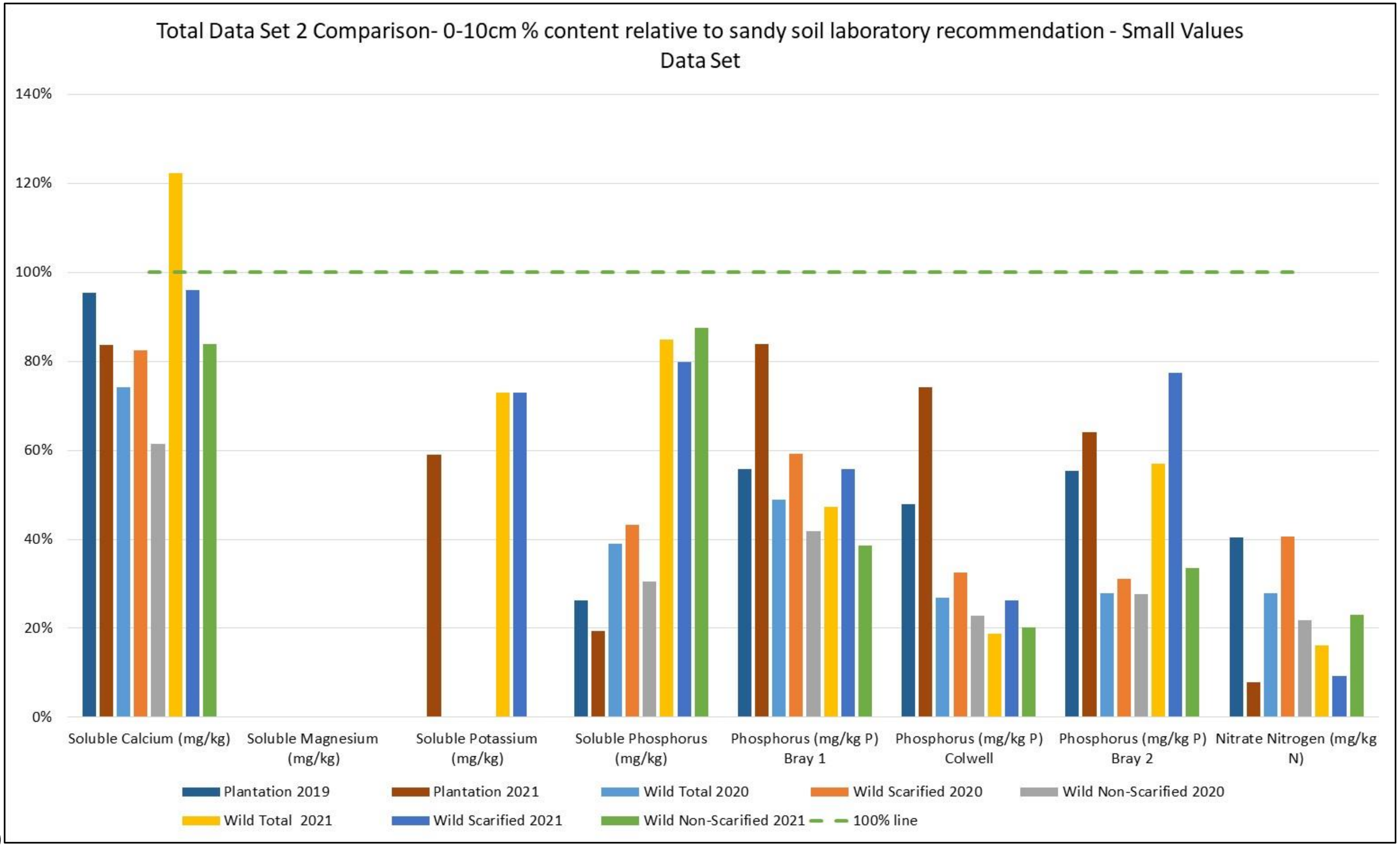
(b)

Figure 4.10.1 (a) - (f): Plantation Site Versus Wild Harvest Site 2019 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Part 2- As per graph (a) with Electrical Conductivity (EC) high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



(c)

Figure 4.10.1 (a) - (f): Plantation Site Versus Wild Harvest Site 2019 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines - Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



(d)

Figure 4.10.1 (a) - (f): Plantation Site Versus Wild Harvest Site 2019 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Part 2- As per graph (c) with Soluble Magnesium high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

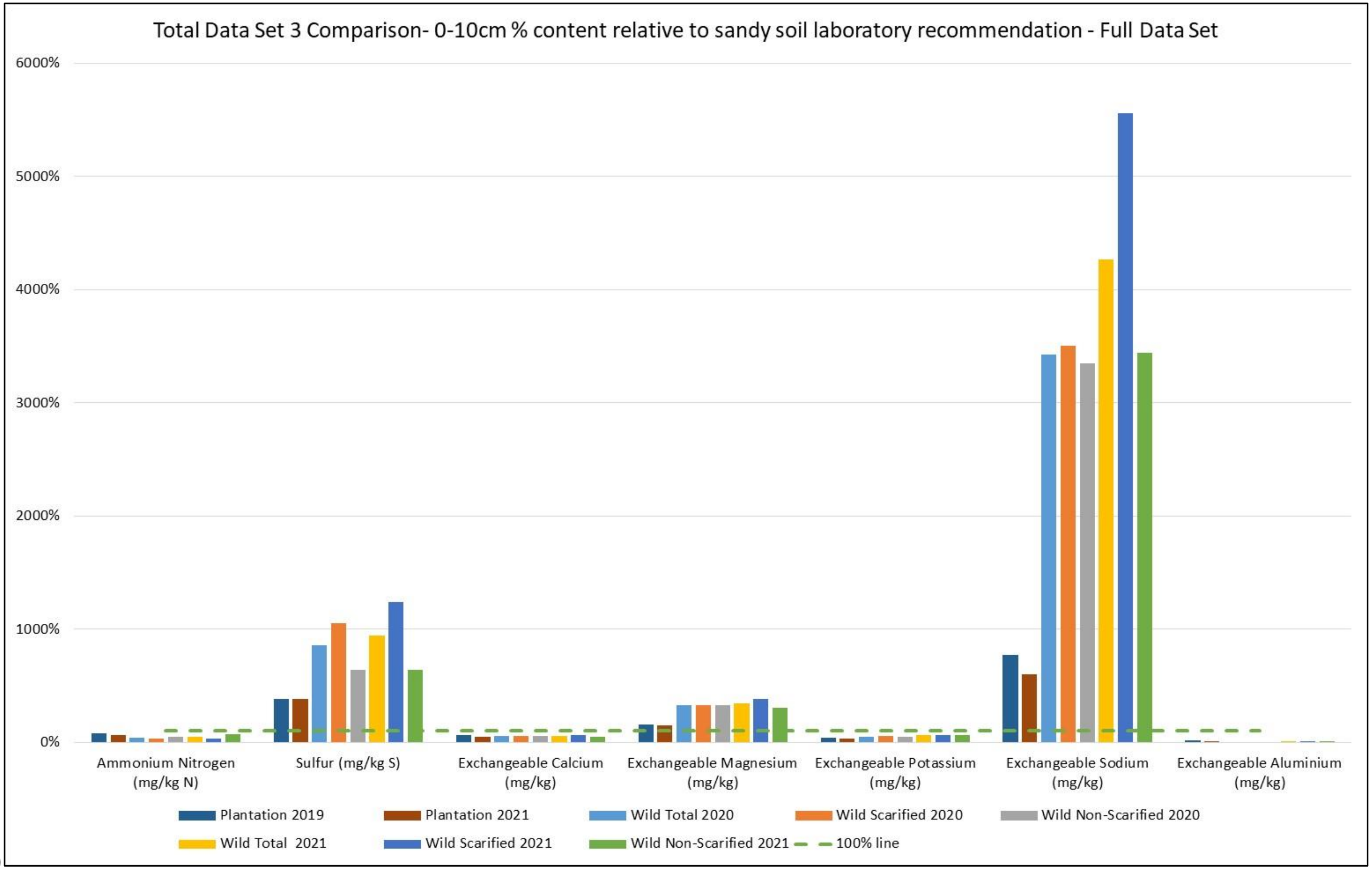
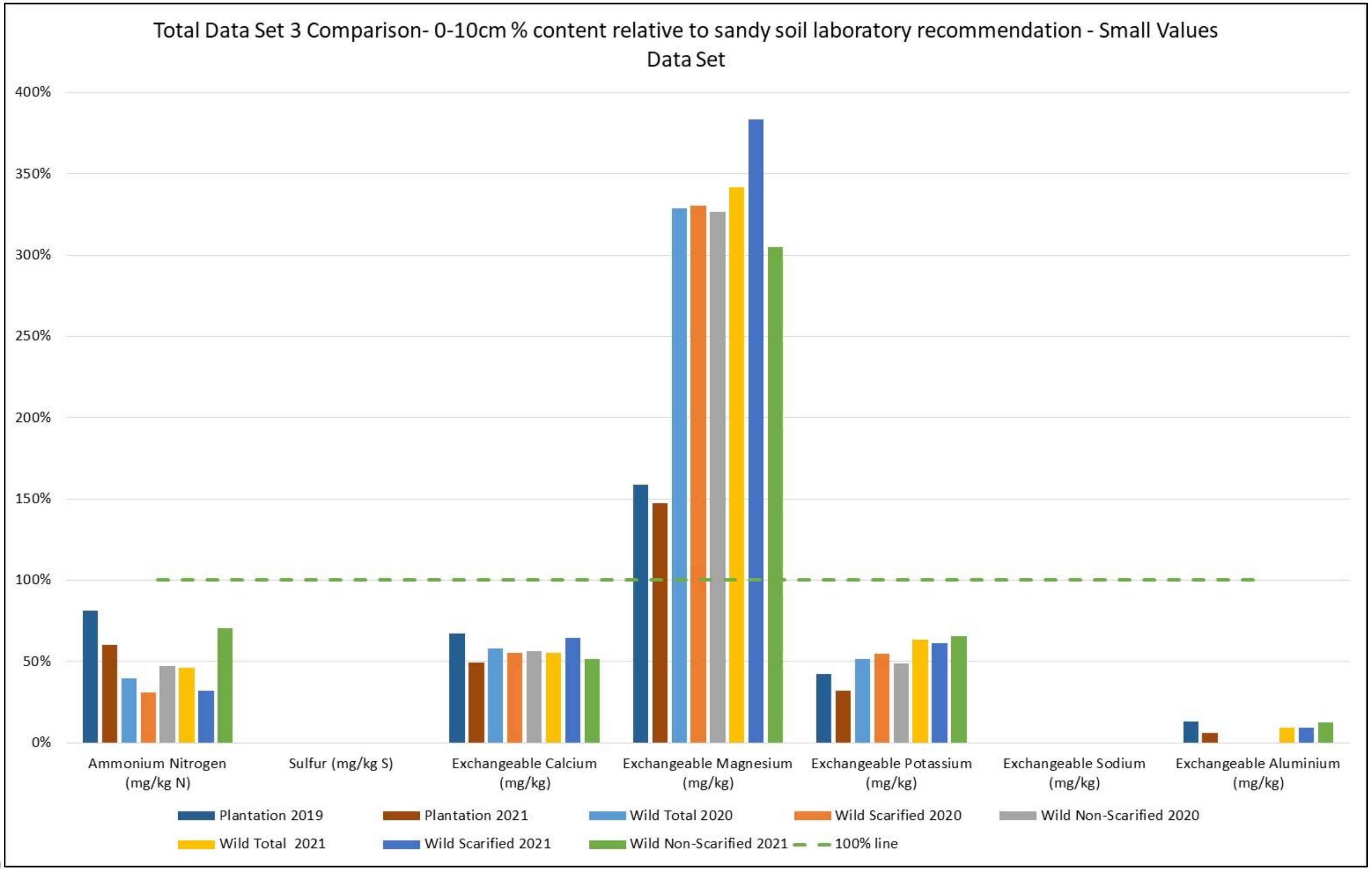
(e)


Figure 4.10.1 (a) - (f): Plantation Site Versus Wild Harvest Site 2019 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines - Part 1 – Full Data Set. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.



(f)

Figure 4.10.1 (a) - (f): Plantation Site Versus Wild Harvest Site 2019 Vs 2021- Average 0-10cm sample data as a Percentage of the Laboratory Indicative Guidelines Part 2- As per graph (e) with Exchangeable Calcium and Sodium high values removed to provide better visual accuracy within smaller % parameters. Note Lab Guidelines can be found in Section 9.3, Appendix 2. Note: Green line highlights 100% of Guideline.

4.11. Wild Harvest Site Soil Bacteria DNA Diversity Profiling (2020/2021)

The Wild Harvest Site also showed little variation between transects across the area and was also grouped as a whole of site location, which gave the replications a higher count and translates to a greater veracity of data being reported. Additionally, the Wild Harvest Site had another variable (factor) of disturbance (scarified versus non-scarified), this brought upon a statistical challenge of too many factors (sample location, soil depth, disturbance). Therefore, in this analysis the main management practices of sample location and disturbance, as such each of these combinations were tested for each soil depth (0 to 10 cm, 10 to 30 cm) independently (i.e. there was no soil depth comparison performed). As the Wild Harvest Site showed less significant results, not all statistical tables are presented, though they are available upon request.

4.11.1. Soil Bacteria Alpha Diversity - 0 to 10 cm (Wild Harvest Site, 2020)

Similar values for alpha diversity at the 0 to 10 cm soil depth to the Plantation Site were observed in the Wild Harvest Site. However, there was no detectable change in all alpha diversity indices (Fisher, OTU richness, Evenness, and Inverse Simpson) with Sampling location (under or between plants), or disturbance (undisturbed or scarified (Figure 4.11.1).

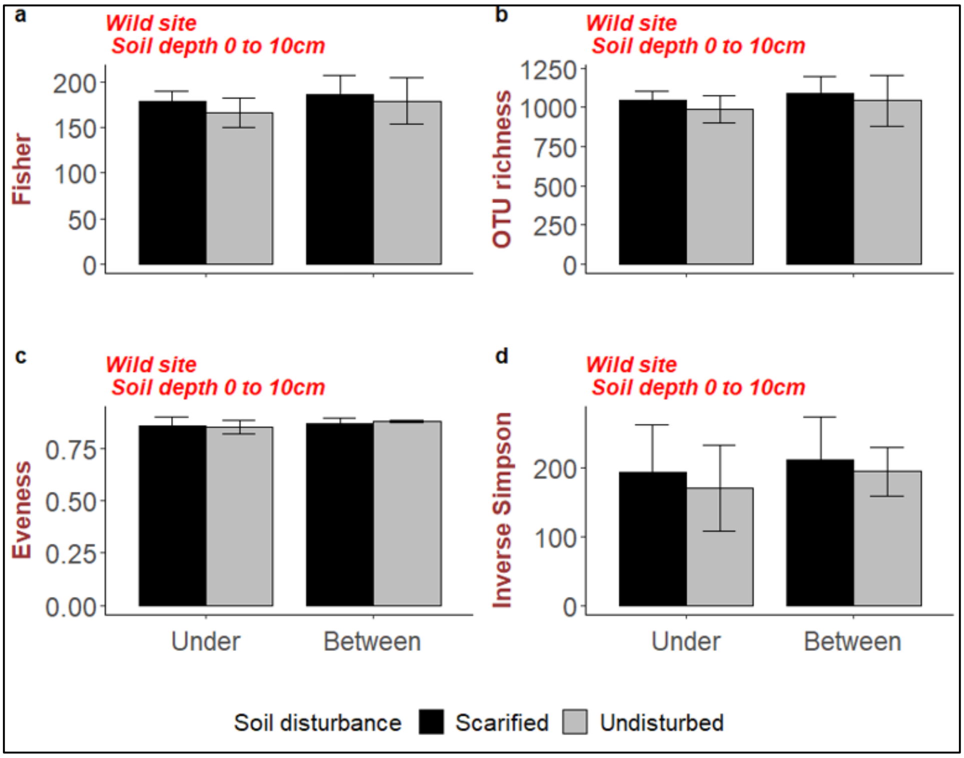


Figure 4.11.1: 2020 Alpha diversity indices at the soil depth 0 to 10 cm, a) Fisher, b) OTU richness (e.g. species richness), c) Evenness, and d) Inverse Simpson for the Wild Harvest Site. Bars represent the mean values across the plots, and the error bars are the standard error of the mean.

4.11.2. Soil Bacteria Alpha Diversity - 0 to 10 cm (Wild Harvest Site, 2021)

For the 0 to 10cm soil profile during the 2021 sampling time there were no observed significant (i.e. no $P<0.05$) alterations to alpha diversity for either soil disturbance (scarification, or unscarified) or for sample location (sampling location between or under the plants) (Figure 4.11.2).

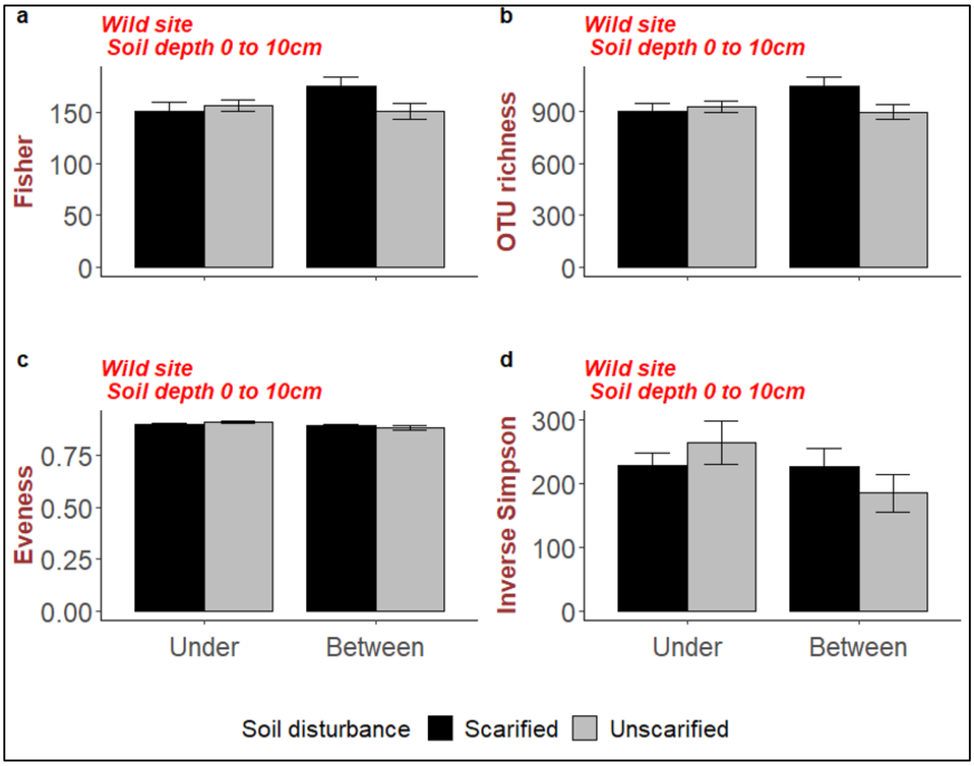


Figure 4.11.2 2021 Alpha diversity indices at the soil depth 0 to 10 cm, a) Fisher, b) OTU richness (e.g. species richness) c) Evenness, and d) Inverse Simpson for the Wild Harvest Site. Bars represent the mean values across the plots, and the error bars are the standard error of the mean.

4.11.3. Soil Bacteria Alpha Diversity - 10 to 30 cm (Wild Harvest Site, 2020)

Soil bacteria alpha diversity indices (Fisher, Richness, evenness, Inverse Simpson) were also not influenced with the soil depth 10 to 30 cm (Figure 4.11.3) statistics not presented. Whilst the graphs (Figure 4.11.3) appear to show changes to both soil disturbance and sample location, there was a larger amount of variation in these data that (e.g. large error bars) that made these results inconclusive.

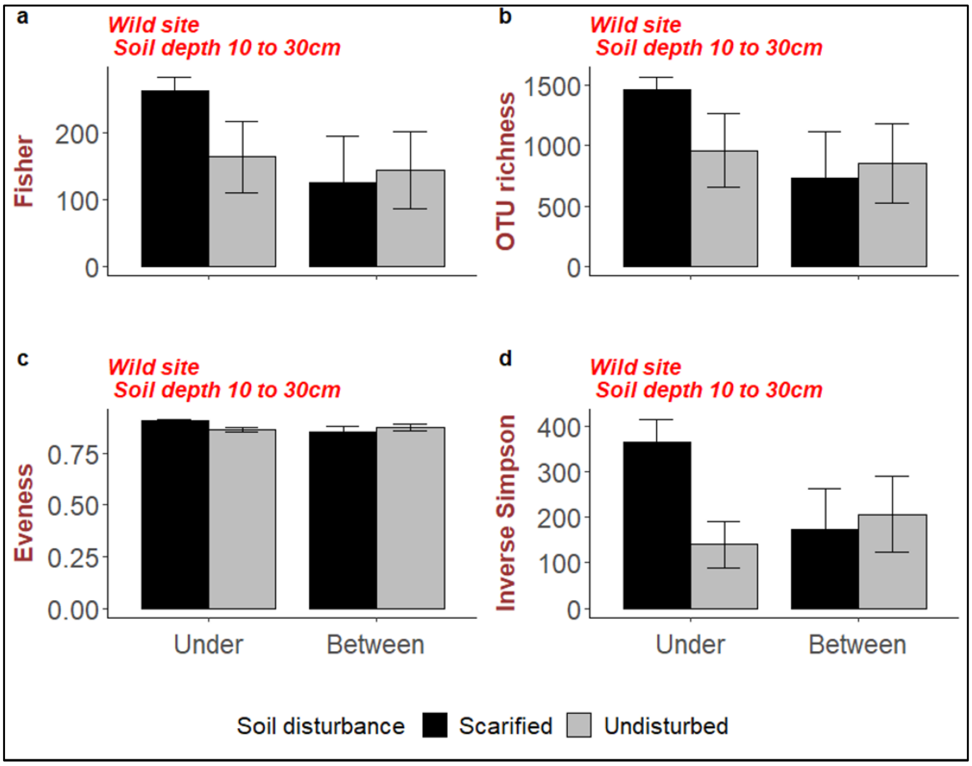


Figure 4.11.3 2020 Alpha diversity indices at the soil depth 10 to 30 cm, a) Fisher, b) OTU richness (e.g. species richness) c) Evenness, and d) Inverse Simpson for the Wild Harvest Site. Bars represent the mean values across the plots, and the error bars are the standard error of the mean.

4.11.4. Soil Bacteria Alpha Diversity - 10 to 30 cm (Wild Harvest Site, 2021)

For the sampling period of 2021, the deeper soil profile (10 to 30 cm) saw a reduction in alpha diversity (Fisher, Richness, Inverse Simpson) for the soil bacteria between plants, indicating that plants effecting the deeper soil have a positive impact on soil alpha diversity (Figure 4.11.4). Additionally, soil disturbance (i.e. scarified and unscarified) did not impact any alpha diversity calculator (within the 10 to 30cm soil profile), this indicates no negative impact on soil alpha diversity within the deeper soil profile to the management practice of scarification (Table 4.11.4).

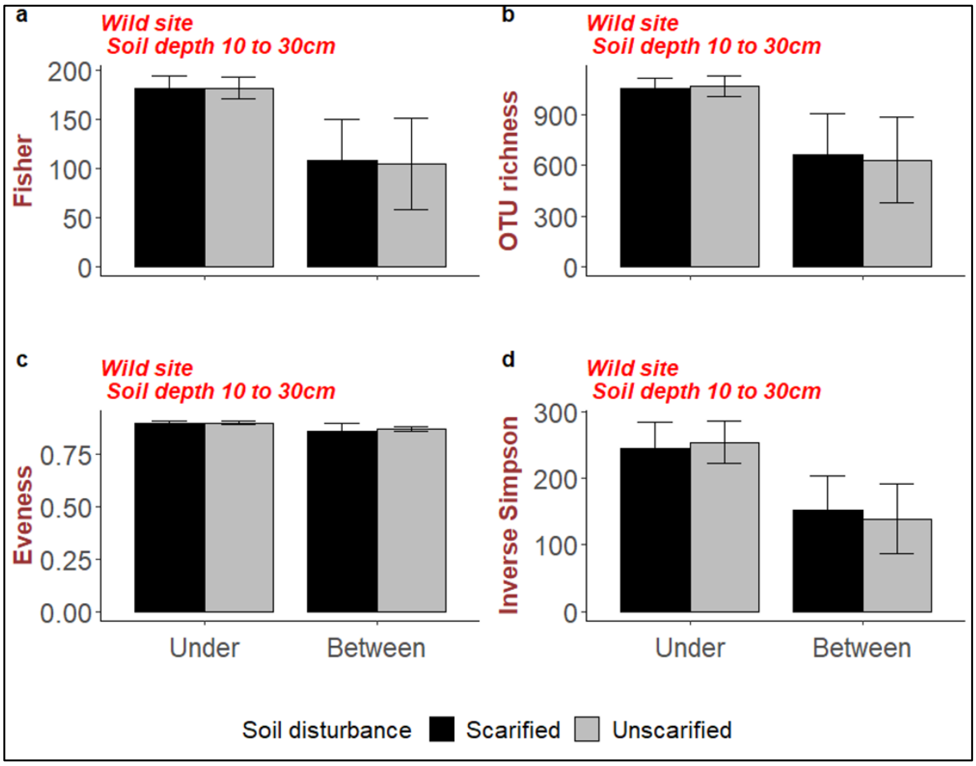


Figure 4.11.4 2021 Alpha diversity indices at the soil depth 10 to 30 cm, a) Fisher, b) OTU richness (e.g. species richness) c) Evenness, and d) Inverse Simpson for the Wild Harvest Site. Bars represent the mean values across the plots, and the error bars are the standard error of the mean.

*Table 4.11.4. 2021 Wild Harvest Site Soil bacteria two-way ANOVA results showing P values for alpha diversity calculators for depth profile 10 to 30 cm. Treatments consisted of 'Soil depth' , and 'Sampling location'. Significant difference P values indicated by * and ** corresponding to P < 0.05 and < 0.01, respectively.*

Alpha diversity indicie	Treatment	Degrees of freedom	Sum of Squares	Mean Squares	F. Model	P
Fisher	Disturbance_treatment	1	12	12.2	0	0.958
	Sample_location	1	22586	22586.1	5.43	**0.038***
	Disturbance:location	1	15	15.1	0	0.953
	Residuals	12	49888	4157.3		
Richness	Disturbance_treatment	1	352	352	0	0.959
	Sample_location	1	692640	692640	5.31	**0.039***
	Disturbance:location	1	1871	1871	0.01	0.907
	Residuals	12	1566695	130558		
Eveness	Disturbance_treatment	1	1.64E-04	1.64E-04	0.09	0.773
	Sample_location	1	5.06E-03	5.06E-03	2.69	0.127
	Disturbance:location	1	2.24E-04	2.24E-04	0.12	0.736
	Residuals	12	2.26E-02	1.88E-03		
Inverse Simpson	Disturbance_treatment	1	8	8	0	0.975
	Sample_location	1	42686	42686	5.25	**0.041***
	Disturbance:location	1	541	541	0.07	0.801
	Residuals	12	97641	8137		

4.11.5. Phylum Level Relative Abundance - 0 to 10 cm (Wild Harvest Site, 2020)

At the phylum level there were some minor changes to the relative abundance of some major groups of bacteria. Actinobacteria was the most dominant phyla and are ubiquitous gram-positive bacteria with high guanine and cytosine contents in DNA, having a characteristic filamentous morphology. Actinobacteria have several important functions, including decomposition of all sorts of organic substances. In this trial Actinobacteria increased in the relative abundance for the scarification treatment (Figure 4.11.5, Table 4.11.5), suggesting that the disturbance could have exposed some organic matter for microbial degradation. The overall distribution of major phyla is common in agricultural soils.

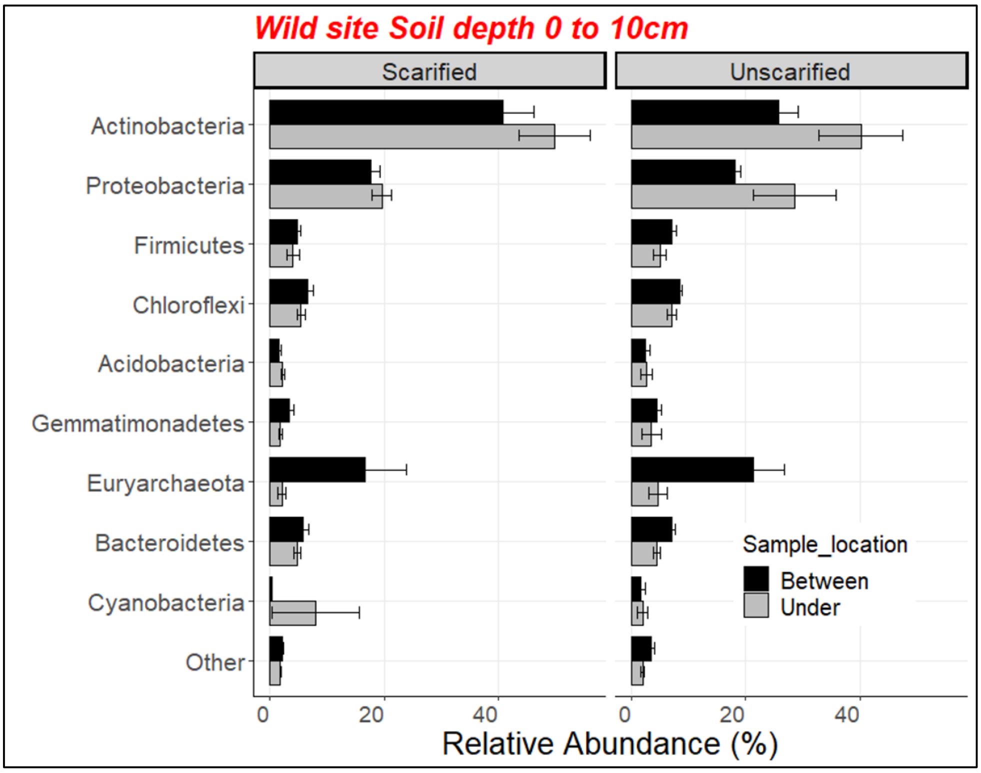


Figure 4.*11.5:* 2020 Wild Harvest Site soil bacteria relative abundance response at soil depth 0 to 10cm of plant location (under & between plants) with soil disturbance (Undisturbed, scarified) and their interaction between sampling location and disturbance. Bars represent the mean value across the sampling site, and the error bars are the standard error of the mean.

Table 4.11.5: Soil bacteria at the 0 to 10cm soil depth two-way ANOVA results showing P values fixed at Phylum resolution of relative abundance. Treatments consisted of 'Disturbance' (undisturbed, scarified), and 'Sample location' (between and under plants).
*Significant difference P values indicated by * and ** corresponding to P < 0.05 and < 0.01, respectively.*

Taxonomy	Treatment	Degrees of freedom	Sum of Squares	Mean Squares	F. Model	P
Actinobacteria	Disturbance_treatment	1	1721	1720.9	12.3	**0.002****
	Sample_location	1	465	464.9	3.3	0.079
	Disturbance: location	1	10	10.3	0.1	0.788
	Residuals	28	3906	139.5		
Proteobacteria	Disturbance_treatment	1	202	201.8	1.1	0.293
	Sample_location	1	8	7.9	0	0.834
	Disturbance: location	1	137	136.6	0.8	0.386
	Residuals	28	4924	175.9		
Firmicutes	Disturbance_treatment	1	16	15.8	1	0.324
	Sample_location	1	21	21.4	1.4	0.252
	Disturbance: location	1	0	0.2	0	0.912
	Residuals	28	438	15.6		
Chloroflexi	Disturbance_treatment	1	28	27.7	2.2	0.148
	Sample_location	1	20	20.2	1.6	0.214
	Disturbance: location	1	4	4.3	0.3	0.564
	Residuals	28	350	12.5		
Acidobacteria	Disturbance_treatment	1	1	1.3	0.1	0.730
	Sample_location	1	0	0.2	0	0.885
	Disturbance: location	1	0	0.1	0	0.907
	Residuals	28	289	10.3		
Gemmatimonadetes	Disturbance_treatment	1	73	73.1	8.8	**0.006****
	Sample_location	1	1	1	0.1	0.733
	Disturbance: location	1	1	0.8	0.1	0.766
	Residuals	28	233	8.3		
Euryarchaeota	Disturbance_treatment	1	26	25.8	0.3	0.581
	Sample_location	1	519	519.4	6.3	**0.018***
	Disturbance: location	1	8	8	0.1	0.759
	Residuals	28	2320	82.9		
Bacteroidetes	Disturbance_treatment	1	0	0.4	0.1	0.791
	Sample_location	1	17	17.2	3.4	0.075
	Disturbance: location	1	5	4.7	0.9	0.343
	Residuals	28	141	5		
Cyanobacteria	Disturbance_treatment	1	3	2.9	0.1	0.758
	Sample_location	1	31	30.6	1	0.318
	Disturbance: location	1	38	37.5	1.3	0.270
	Residuals	28	829	29.6		

To a lesser extent Gemmatimonadetes decreased under disturbance (but this phyla had a low relative abundance), and Euryarchaeota which contain a group of extreme halophiles (salt tolerant) which were quantified as Halobacteriaceae, and ammonia oxidizing Archaea Nitrososphaeraceae spp. Both of these groups within Euryarchaeota decreased in the sample location underneath the plant (Table 4.11.5, Figure 4.11.5).

4.11.6. Phylum Level Relative Abundance - 0 to 10 cm (Wild Harvest Site, 2021)

The soil bacteria phylum relative abundance during the 2021 sampling period showed Actinobacteria displayed large increases, especially pronounced in the unscarified treatment for samples collected from under the plant (See Figure 4.11.6). This is an opposite trend to the previous year sampling time, and represents the dynamics of fast growing bacteria to change in response to environmental conditions (e.g. water availability and management practices). The overall distribution of major phyla is common in agricultural soils, and whilst there are changes from 2020, none of these changes are fundamentally large.

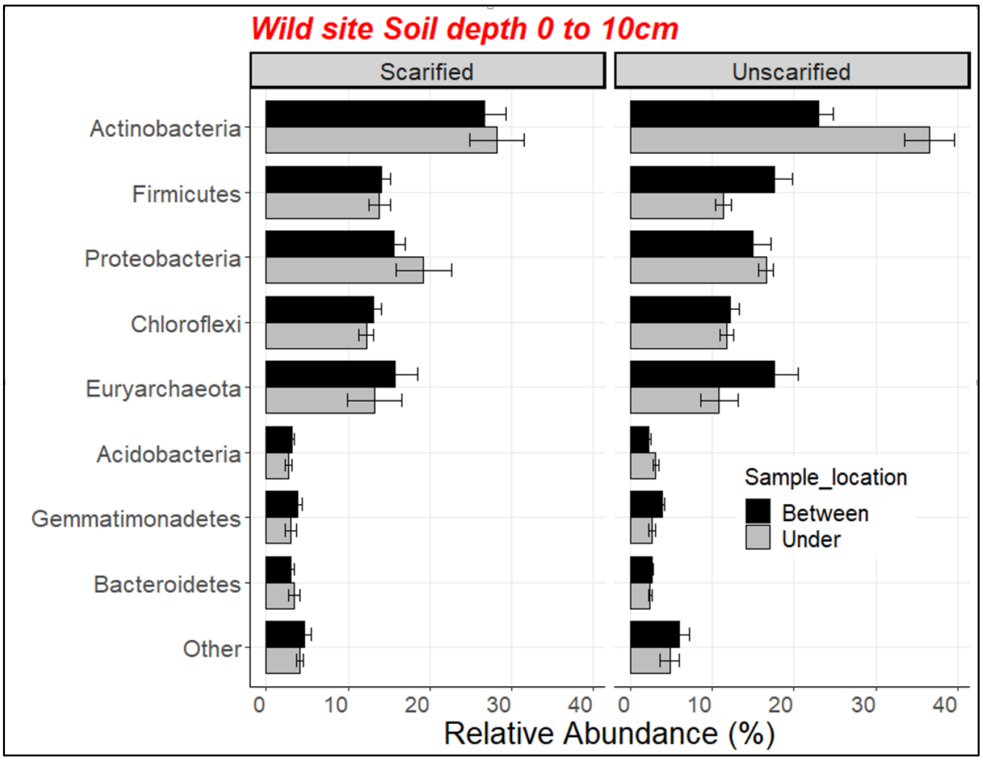


Figure 4.11.6: 2021 Wild Harvest Site soil bacteria relative abundance response at soil depth 0 to 10cm of plant location (under & between plants) with soil disturbance (Undisturbed, scarified) and their interaction between sampling location and disturbance. Bars represent the mean value across the sampling site, and the error bars are the standard error of the mean.

4.11.7. Phylum Level Relative Abundance - 10 to 30 cm (Wild Harvest Site, 2020)

In this trial at the deeper soil profile of 10 to 30 cm Actinobacteria increased (relative to the 0 to 10cm soil profile) in the relative abundance for the scarification treatment (See Figure 4.11.7 and Table 4.11.7). This suggests that the disturbance could have exposed some organic matter for microbial degradation similar to the shallower soil profile. Whilst there are changes to major phyla at the deeper soil profile, this is likely driven by soil type and chemistry, not management practice.

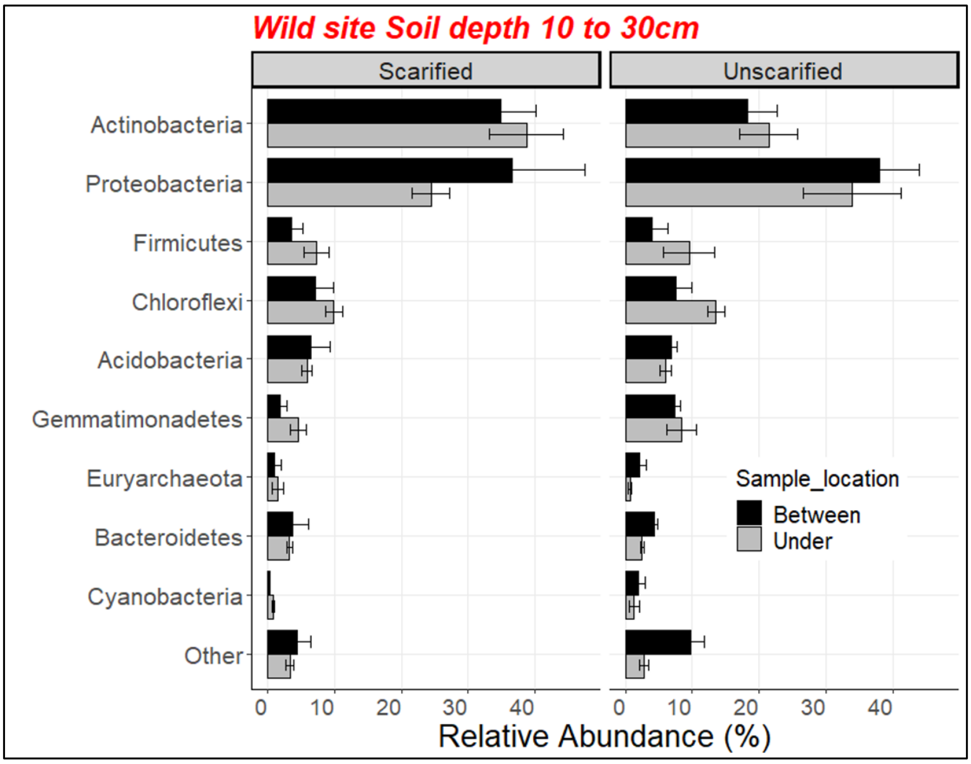


Figure 4.11.7: 2020 Wild Harvest Site soil bacteria relative abundance response at soil depth 10 to 30cm of plant location (under & between plants) with soil disturbance (Undisturbed, scarified) and their interaction between sampling location and disturbance. Bars represent the mean values across the plots, and the error bars are the standard error of the mean.

Chloroflexi (a diverse group of bacteria) had an increase in relative abundance when there was a plant above for both disturbance treatments, though this effect was marginally significant (P = 0.049, Figure 4.11.7, Table 4.11.7). There were no other noteworthy changes to the phylum level for sample location or disturbance treatments.

Table 4.11.7: 2020 Soil bacteria at the 0 to 10cm soil depth two-way ANOVA results showing P values fixed at Phylum resolution of relative abundance. Treatments consisted of 'Disturbance' (undisturbed, scarified), and 'Sample location' (between and under plants).
*Significant difference P values indicated by * and ** corresponding to P < 0.05 and < 0.01, respectively.*

Taxonomy	Treatment	Degrees of freedom	Sum of Squares	Mean Squares	F. Model	P
Actinobacteria	Disturbance_treatment	1	1151	1151	12	**0.005****
	Sample_location	1	50	50	1	0.489
	Disturbance:location	1	1	1	0	0.939
	Residuals	12	1175	98		
Proteobacteria	Disturbance_treatment	1	118	118	1	0.475
	Sample_location	1	268	268	1	0.288
	Disturbance:location	1	64	64	0	0.597
	Residuals	12	2593	216		
Firmicutes	Disturbance_treatment	1	6	6	0	0.627
	Sample_location	1	86	86	3	0.094
	Disturbance:location	1	3	3	0	0.734
	Residuals	12	312	26		
Chloroflexi	Disturbance_treatment	1	15	15	1	0.355
	Sample_location	1	79	79	5	**0.049***
	Disturbance:location	1	11	11	1	0.431
	Residuals	12	197	16		
Acidobacteria	Disturbance_treatment	1	0	0	0	0.881
	Sample_location	1	2	2	0	0.672
	Disturbance:location	1	0	0	0	0.956
	Residuals	12	130	11		
Gemmatimonadetes	Disturbance_treatment	1	86	86	11	0.070
	Sample_location	1	15	15	2	0.198
	Disturbance:location	1	3	3	0	0.553
	Residuals	12	97	8		
Euryarchaeota	Disturbance_treatment	1	0	0	0	0.948
	Sample_location	1	1	1	0	0.628
	Disturbance:location	1	4	4	1	0.289
	Residuals	12	34	3		
Bacteroidetes	Disturbance_treatment	1	0	0	0	0.925
	Sample_location	1	5	5	1	0.402
	Disturbance:location	1	2	2	0	0.598
	Residuals	12	73	6		
Cyanobacteria	Disturbance_treatment	1	5	5	3	0.095
	Sample_location	1	0	0	0	0.919
	Disturbance:location	1	2	2	1	0.329
	Residuals	12	18	2		

4.11.8. Phylum Level Relative Abundance - 10 to 30 cm (Wild Harvest Site, 2021)

During the 2021 sampling period there were no significant ($P<0.05$) alterations to the relative abundance of the phylum level soil bacteria composition (See Figure 4.11.8). Whilst the data does show potential changes, these were not significant, as there were large amounts of variation with these data, this may have been driven by the sampling time having excess water availability within the sampling site.

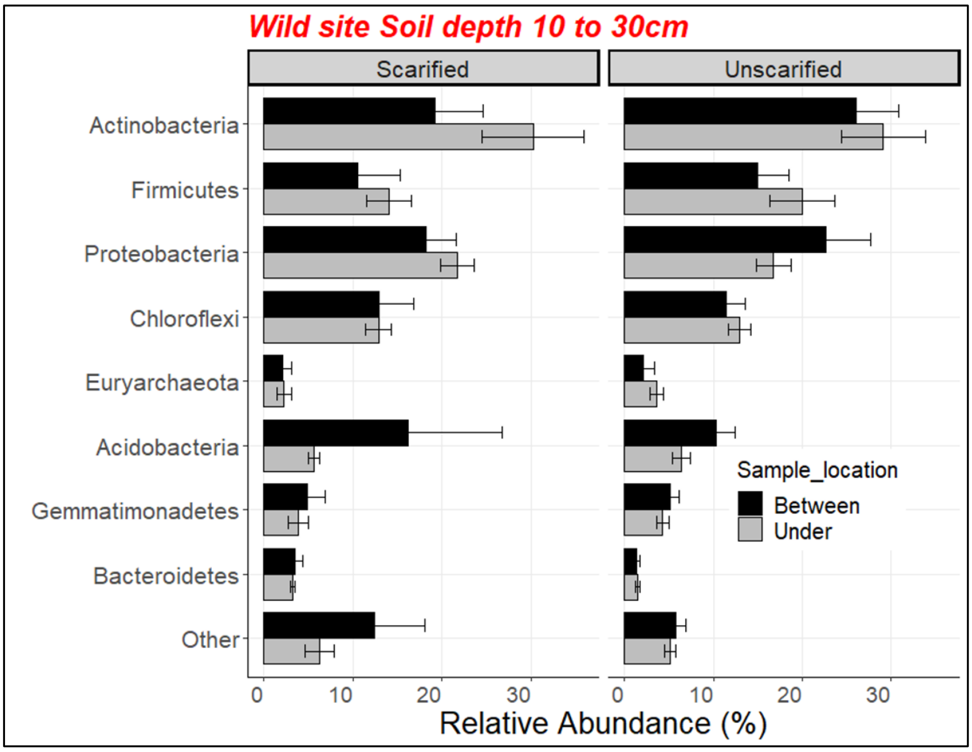


Figure 4.11.8: 2021 Wild Harvest Site soil bacteria relative abundance response at soil depth 0 to 10cm of plant location (under & between plants) with soil disturbance (Undisturbed, scarified) and their interaction between sampling location and disturbance. Bars represent the mean values across the plots, and the error bars are the standard error of the mean.

4.11.9. Soil Bacteria Beta Diversity (Wild Harvest Site, 2020)

The Beta diversity measures the change in diversity of species from one environment to another (i.e. for the Wild Harvest Site between sampling locations (under and between plants), and disturbance (scarified or non-scarified) treatments at each soil depth). It calculates the number of species that are not the same in two different environments. Using a Bray Curtis dissimilarity matrix, coupled with a visual non-metric multidimensional scaling (NMDS) plot, community assemblages can be displayed as per Figure 4.11.9.

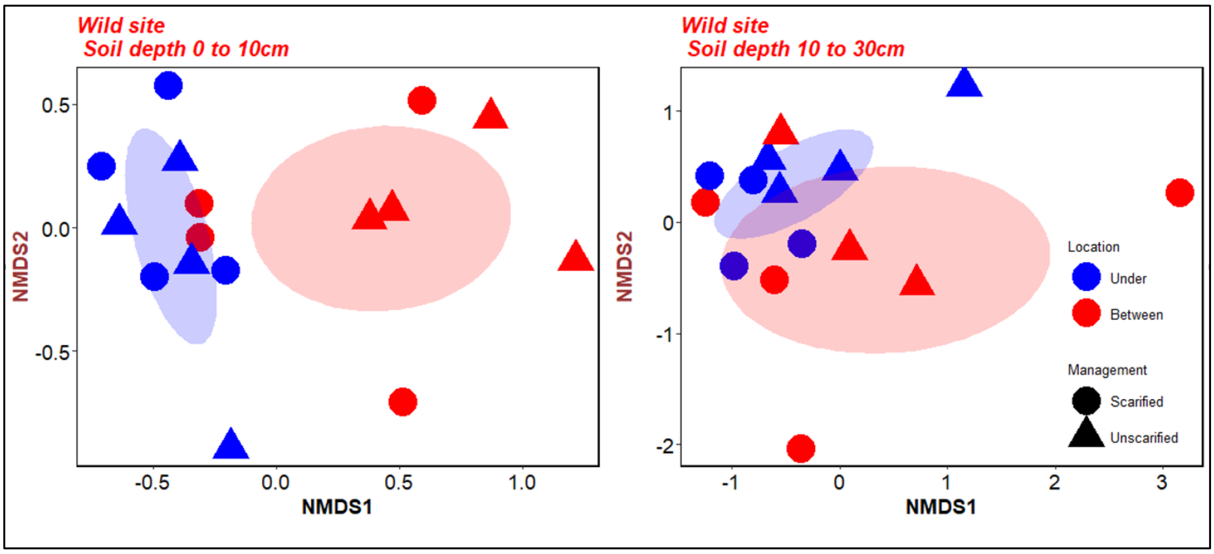


Figure 4.11.9: Non-metric multidimensional scaling (NMDS) plots of soil bacterial communities at separate soil depths (left plate is 0 to 10cm, right plate is 10 to 30cm) testing the effect of two Sampling locations (Under and between the plants) and the influence of soil disturbance (undisturbed, scarified) at 2020 using OTU based (97% similarity, e.g. species theory level) Bray Curtis dissimilarities distances.

As seen in the Plantation Site results, interpreting Figure 4.11.9 (a Non-metric multidimensional scaling plot) involves (a) if the treatments are presented clustered together or in the same location, then these factors are similar or identical in community composition, or (b) if the factors far apart (i.e. on the other side of the plot), then these factors are a differing community assemblage. A permutational analysis of variance revealed that at the 0 to 10cm soil depth the sample location had the greatest effect (P= 0.005) on community composition, with disturbance barely having any influence (P= 0.055), though there were no interactive between the two (sample location and soil disturbance) (See Table 4.11.9.). There were no treatment effects (sample location, disturbance) observed for the 10 to 30cm soil depth.

*Table 4.5.3: 2020 Wild Harvest Site soil bacterial community analysis by PERMANOVA results based on 97% similarity OTU abundance data (square root transformed), using 999 permutations. Soil depth was divided into two separate profiles and the treatments consisted of 'Sample location', and 'Disturbance'. Significant difference P values indicated by * and ** corresponding to P < 0.05 and < 0.01, respectively.*

	Treatment	Degrees of freedom	Sum of Squares	Mean Squares	F. Model	R2	Pr(>F)
0 to 10 cm	Sample_location	1	0.590	0.590	2.210	0.130	**0.005****
	Disturbance_treatment	1	0.420	0.420	1.550	0.090	0.055
	Location:Disturbance	1	0.270	0.270	1.010	0.060	0.404
	Residuals	12	3.220	0.270	0.720		
	Total	15	4.500	1			
10 to 30 cm	Sample_location	1	0.490	0.490	1.270	0.080	0.091
	Disturbance_treatment	1	0.500	0.500	1.310	0.080	0.073
	Location:Disturbance	1	0.310	0.310	0.810	0.050	0.866
	Residuals	12	4.590	0.380	0.780		
	Total	15	5.890	1			

4.11.10. Soil Bacteria Beta Diversity (Wild Harvest Site, 2021)

Analysis of the species level community assemblage during 2021 shares the exact similarity as the previous sampling time of 2020, with the following exception - during the 2021 period the scarification and an interaction between scarification and sampling location occurred (See Figure 4.11.10 and Table 4.11.10). At the deeper soil profile (10 to 30cm) there was a significant change to any the scarification treatment, though sampling location either underneath or between plants was not influenced, and remained similar in species level community composition.

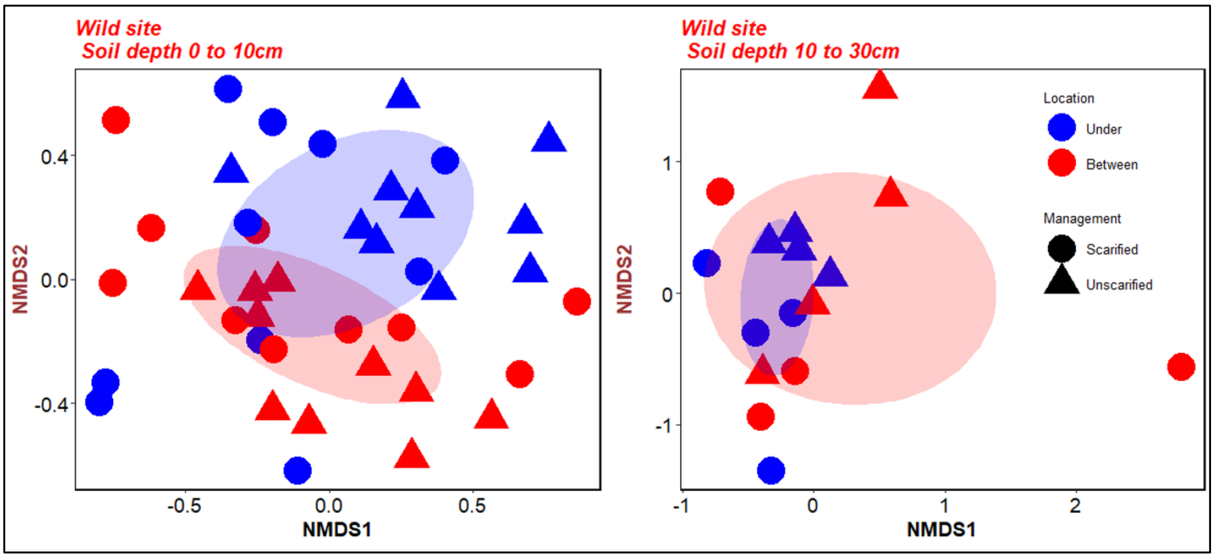


Figure 4.11.10: Non-metric multidimensional scaling (NMDS) plots of soil bacterial communities at separate soil depths (left plate is 0 to 10cm, right plate is 10 to 30cm) testing the effect of two Sampling locations (Under and between the plants) and the influence of soil disturbance (undisturbed, scarified) at 2021 using OTU based (97% similarity, e.g. species theory level) Bray Curtis dissimilarities distances.

*Table 4.11.10: 2021 Wild Harvest Site soil bacterial community analysis by PERMANOVA results based on 97% similarity OTU abundance data (square root transformed), using 999 permutations. Soil depth was divided into two separate profiles and the treatments consisted of 'Sample location', and 'Disturbance'. Significant difference P values indicated by * and ** corresponding to P < 0.05 and < 0.01, respectively.*

	Treatment	Degrees of freedom	Sum of Squares	Mean Squares	F. Model	R2	Pr(>F)
0 to 10 cm	Sample_location	1	0.675	0.675	2.544	0.061	**0.001****
	Disturbance_treatment	1	0.468	0.468	1.762	0.042	**0.009****
	Location:Disturbance	1	0.393	0.393	1.481	0.035	**0.040***
	Residuals	36	9.559	0.266	0.862		
	Total	39	11.095	1			
10 to 30 cm	Sample_location	1	0.409	0.409	1.150	0.074	0.191
	Disturbance_treatment	1	0.567	0.567	1.596	0.102	**0.025***
	Location:Disturbance	1	0.305	0.305	0.857	0.055	0.742
	Residuals	12	4.264	0.355	0.769		
	Total	15	5.544	1			

4.11.11. Putative C & N Cycling Genes (Wild Harvest Site, 2020)

Exactly the same range of putative carbon cycling genes were selected from the PICRUSt KO orthologs (e.g. functional genes) outputs as the Plantation Site, these were based on assessing the ability of the detected bacteria to degrade a range of carbon substrates from labile (starch) to recalcitrant (chitin, lignin) carbon sources. Again, treatments were separated into the two soil depths (0 to 10cm, and 10 to 30cm). The sampling location, disturbance treatments, and the interaction between these two factors had no significant effect on bacteria predicting carbon cycling potential (See Figures 4.11.11.1 and 4.11.11.2).

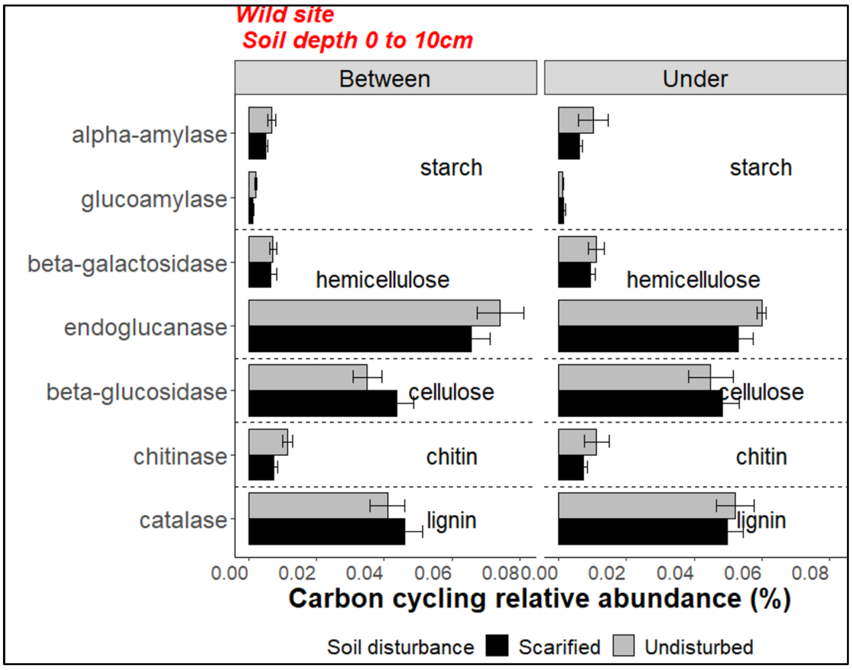


Figure 4.11.11.1: 2020 Wild Harvest Site analysis of putative carbon cycling genes of bacteria DNA data using PICRUSt for the treatments at Soil depth 0 to 10cm, to evaluate the effect of Plant location (under, between plants), and soil disturbance (undisturbed, scarified). Bars represent the mean value across the Wild Harvest Site, and error bars are the standard error of the mean.

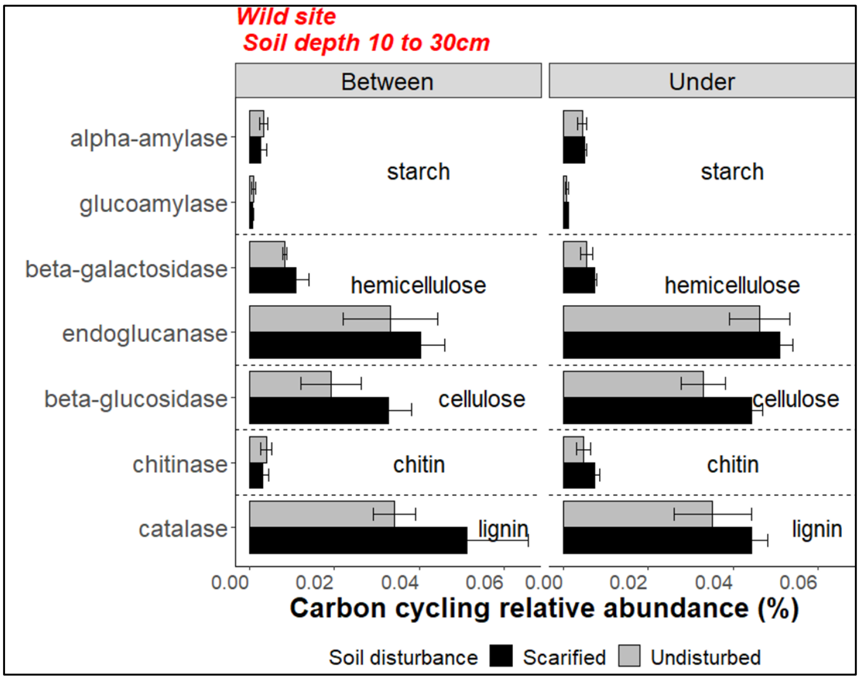


Figure 4.11.11.2: 2020 Wild Harvest Site analysis of putative carbon cycling genes of bacteria DNA data using PICRUSt for the treatments at Soil depth 10 to 30cm, to evaluate the effect of Plant location (under, between plants), and soil disturbance (undisturbed, scarified). Bars represent the mean value across the Wild Harvest Site, and error bars are the standard error of the mean.

Functional genes relating to nitrogen (as per the Plantation Site) related processes (i.e. N fixation, nitrification, and denitrification) were also quantified using PICRUSt. There were also only minor alterations to putative nitrogen cycling processes (soil depth 0 to 10cm), with no interactive effects of these treatments (sample location with soil disturbance) (See Figures 4.11.11.3 and 4.11.11.4). Statistical data has not been shown as minor or no changes observed. All functional genes involved in the nitrogen cycling process were observed, and represent the soil having a high functional capacity.

Predicted nitrogen cycling for 2020 within 10 to 30cm soil profile, and the impact of scarification and the sample location showed only marginal impacts. Again, all nitrogen cycling genes were detected in this soil, and the abundance is typical within agricultural soils. There were no major changes for the soil depth or sample location.

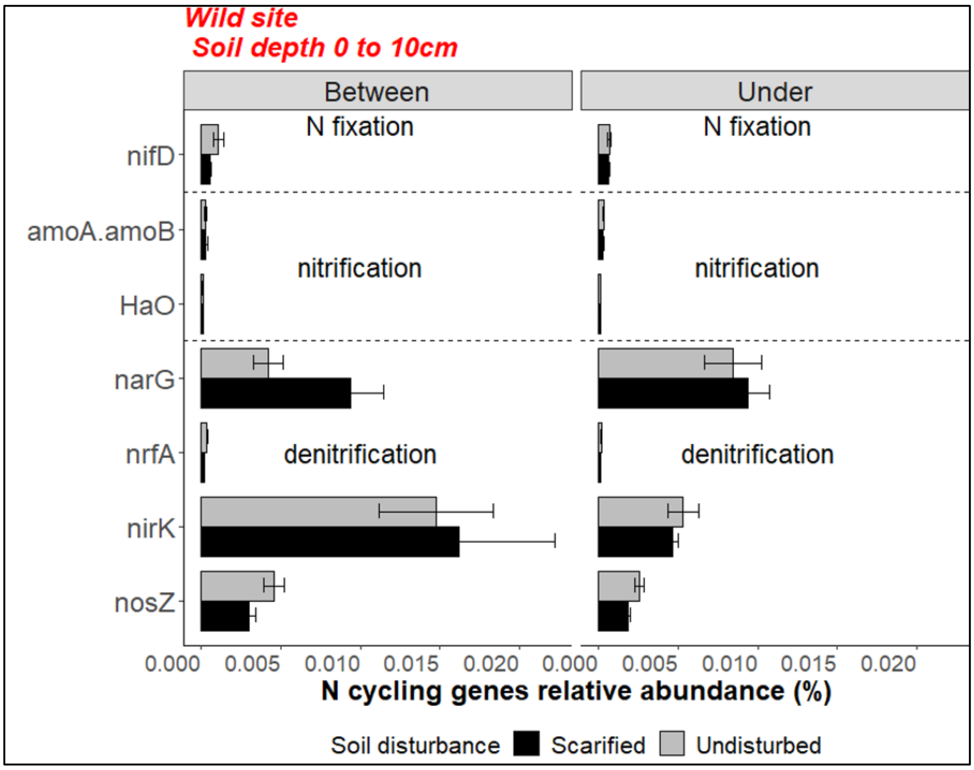


Figure 4.11.11.3: 2020 Wild Harvest Site analysis of putative nitrogen cycling genes of bacteria DNA data using PICRUSt for the treatments at Soil depth 0 to 10cm, to evaluate the effect of Plant location (under, between plants), and soil disturbance (undisturbed, scarified). Bars represent the mean value across the Wild Harvest Site, and error bars are the standard error of the mean.

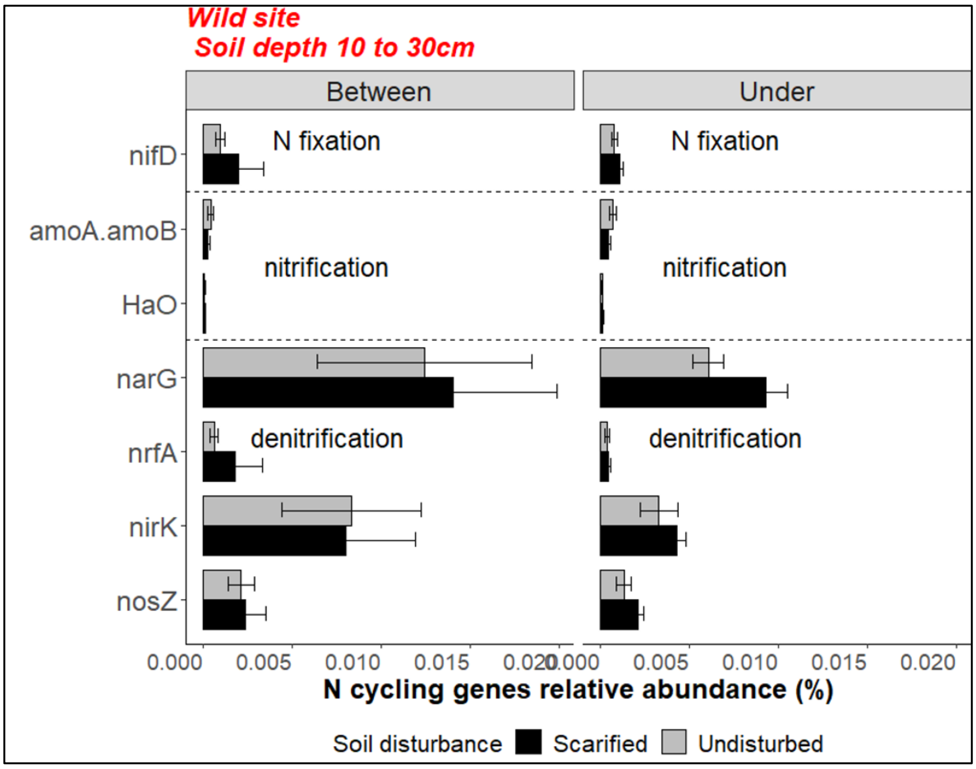


Figure 4.11.11.4: 2020 Wild Harvest Site analysis of putative nitrogen cycling genes of bacteria DNA data using PICRUSt for the treatments at Soil depth 10 to 30cm, to evaluate the effect of Plant location (under, between plants), and soil disturbance (undisturbed, scarified). Bars represent the mean value across the Wild Harvest Site, and error bars are the standard error of the mean.

4.11.12. Putative C & N Cycling Genes (Wild Harvest Site, 2021)

During 2021 potential carbon cycling alterations were observed for some carbon cycling genes for sample location, with no impact for soil scarification at both depths seen. For the shallow soil profile (0 to 10cm) there was a net reduction in easily digestible carbon cycling capacity for starch like carbon through minor increases in glucoamylase. This was offset by decreases in alpha-amylase for the sampling location under the plant (Figure 4.11.12.1). A similar trend of reduction of hemicellulose (endoglucanase) for the same treatment (0 to 10cm, under plant). There was an increase in carbon cycling in the bacteria able to degrade cellulose through increasing betaglucosidase. Whilst there was increasing potential carbon cycling capacity in the soil, these alterations were not impacted by scarification and were only minor fluctuations thus should be interpreted as natural fluxes to carbon cycling potential.

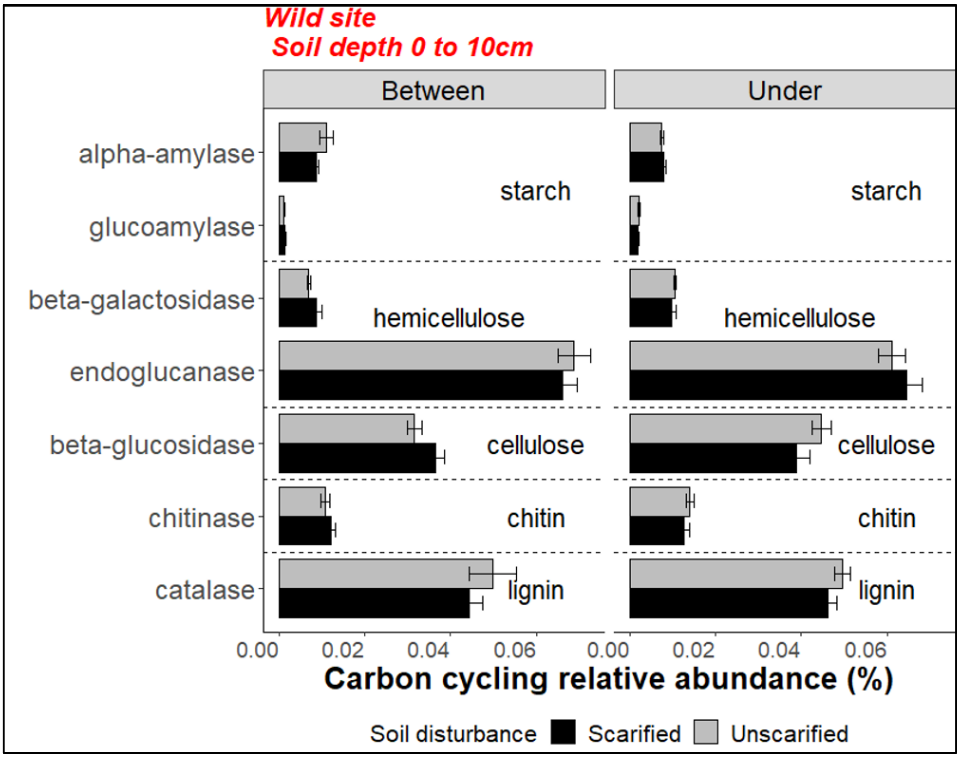


Figure 4.11.12.1: 2021 Wild Harvest Site analysis of putative nitrogen cycling genes of bacteria DNA data using PICRUSt for the treatments at Soil depth 0 to 10cm, to evaluate the effect of Plant location (under, between plants), and soil disturbance (undisturbed, scarified). Bars represent the mean value across the Wild Harvest Site, and error bars are the standard error of the mean.

During the 2021 sampling within the deeper soil profile of 10 to 30cm only one gene known for carbon cycling process was observed for the treatments of sample location (between or under the plants). Indeed, only one significant result was observed at this depth and it was an increase in the ability to degrade more recalcitrant carbon (e.g. lignin) (Figure 4.11.12.2). The management practice of scarification had no impact on carbon cycling process by 2021. All putative carbon cycling genes were present ranging from labile to recalcitrant and represents a high functional capacity of the soil.

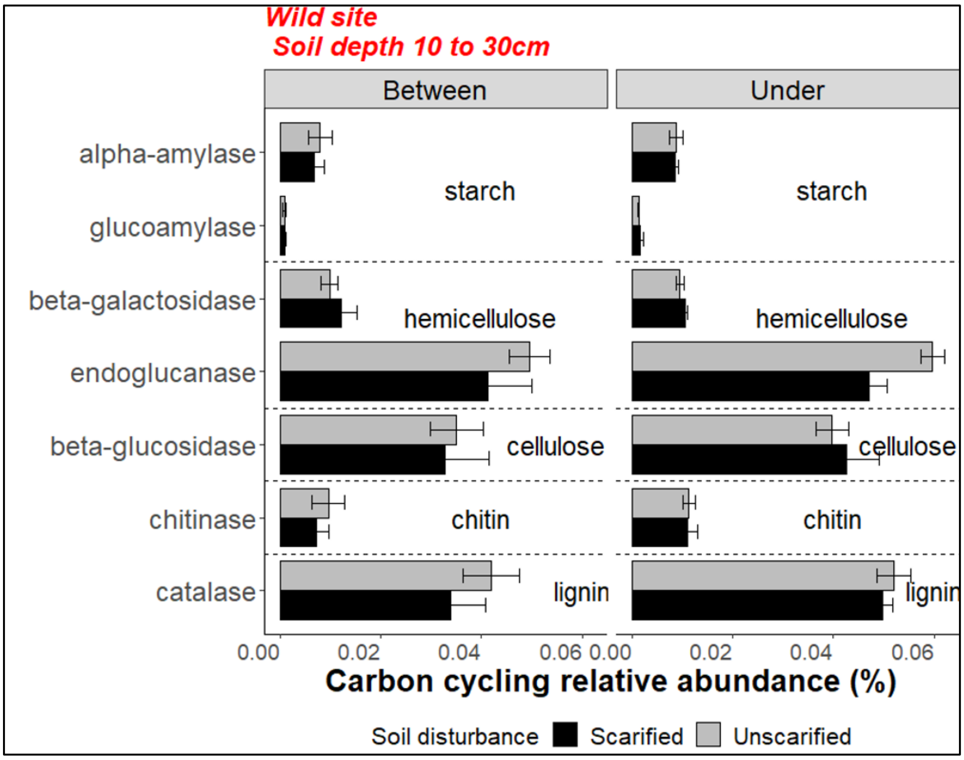


Figure 4.11.12.2: 2021Wild Harvest Site analysis of putative nitrogen cycling genes of bacteria DNA data using PICRUSt for the treatments at Soil depth 10 to 30cm, to evaluate the effect of Plant location (under, between plants), and soil disturbance (undisturbed, scarified). Bars represent the mean value across the Wild Harvest Site, and error bars are the standard error of the mean.

Predicted nitrogen cycling for 2021 within the 0 to 10cm soil profile, and the impact of scarification and the sample location showed only a couple of impacts. Denitrification (the conversion of nitrate to gas) was not impacted by soil scarification, though there was increases for samples located under the plant for nitrate reduction (P=0.01, narG), and decreases for under the plant for nitrite reduction (P= 0.01, nirK) (See Figure 4.11.12.3). All nitrogen cycling genes were present in this soil and the abundance is typical within agricultural soils. There were no major changes to the previous sampling event of 2020.

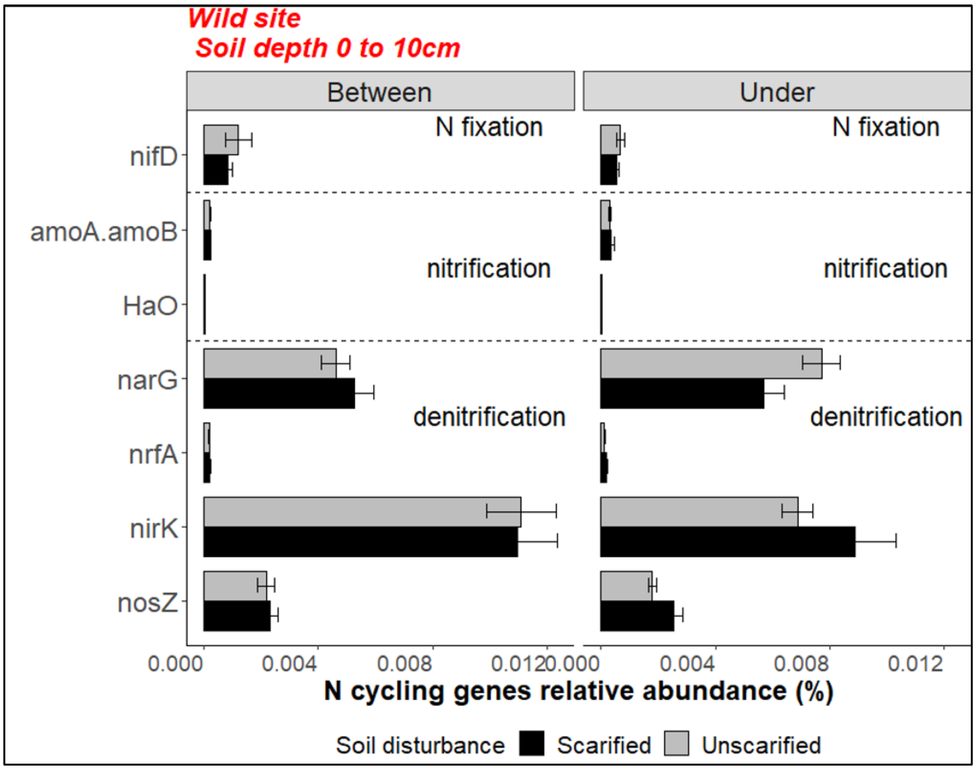


Figure 4.11.12.3: 2021 Wild Harvest Site analysis of putative nitrogen cycling genes of bacteria DNA data using PICRUSt for the treatments at Soil depth 0 to 10cm, to evaluate the effect of Plant location (under, between plants), and soil disturbance (undisturbed, scarified). Bars represent the mean value across the Wild Harvest Site, and error bars are the standard error of the mean.

Predicted nitrogen cycling for 2021 within 10 to 30cm soil profile, and the impact of scarification and the sample location showed only a single effect. Denitrification was impacted by soil scarification, identified by an increases for samples located under the plant for encoding nitrous oxide reductase, a key enzyme for denitrification (P<0.001, nosZ) (See Figure 4.11.12.4). Again, all nitrogen cycling genes were detected in this soil, and the abundance is typical within agricultural soils. There were no major changes to the previous sampling event of 2020.

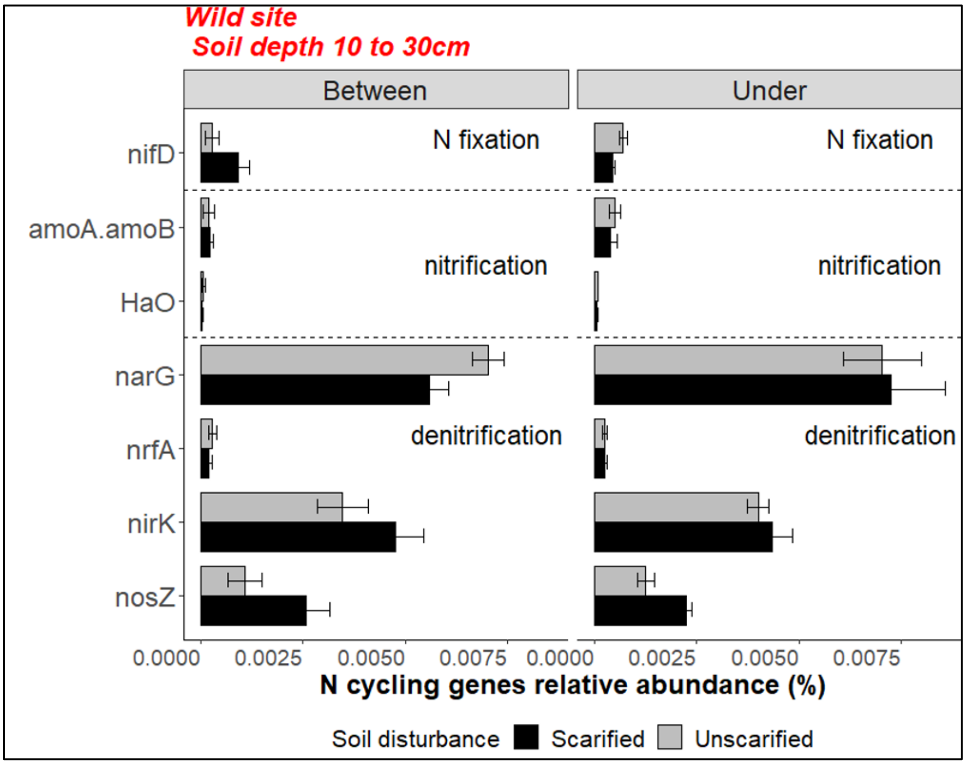


Figure 4.11.12.4: 2021 Wild Harvest Site analysis of putative nitrogen cycling genes of bacteria DNA data using PICRUSt for the treatments at Soil depth 10 to 30cm, to evaluate the effect of Plant location (under, between plants), and soil disturbance (undisturbed, scarified). Bars represent the mean value across the Wild Harvest Site, and error bars are the standard error of the mean.

4.12. Observation Well Water Data

Seven water sampling expeditions were completed by the terrific personnel from Katanning Landcare for the observation wells between February and November 2021. Both Plantation Site observation wells and the single Wild Harvest Site observation well were sampled, however due to access to the Wild Harvest Site being impassable in late winter/spring, only 5 data points are available for that location. As only one year's data was available and that year had abnormal climate conditions (See Section 4.0), this data is provided for future comparisons and was considered an interesting means of capturing what was a very unusual season as described previously.

The observation well surface water depth within the Plantation Site dropped (i.e. higher measured length below the soil surface level) until late May and then rose for the remainder of the year until November when the first decline in water level was observed in the lead up to summer. In contrast, the well adjacent to the Plantation Site water level rose from the start of the sampling in February until September with only a slight elevation in the July sample. Again the November analysis revealed a large drop in level back to the May/June recorded values. The Wild Harvest Site results are more consistent across the duration of sampling with no trend up or down observed. The depth below soil level was at its maximum for the November reading. See Figure 4.12.1.

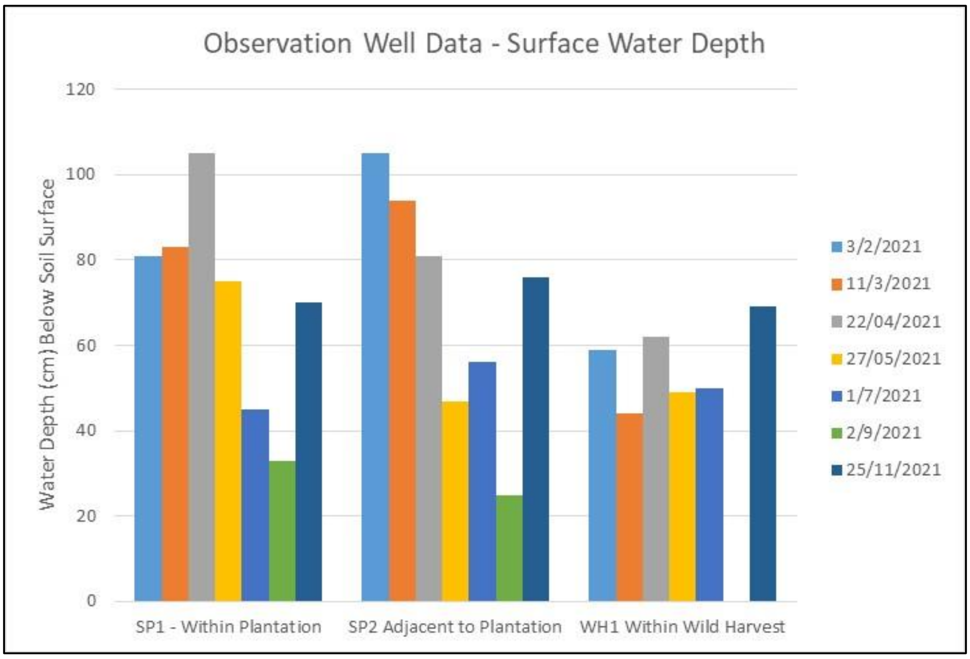


Figure 4.12.1: Observation Well Data: Water Depth (cm) Below Soil Surface Comparison Over 2021.

Both the Plantation Site observation wells have identified a general trend of reducing EC throughout the duration of sampling with an increase commencing towards the end of the year reflecting the reducing water level / dilution. The observation well within the Plantation Site had a significantly higher EC than that of the water extracted from the well adjacent to this area. The Wild Harvest Site observation well water had a greater EC recorded that for the Plantation Site well and did not reveal a consistent upward or downward trend over the duration of sampling. See Figure 4.12.2.

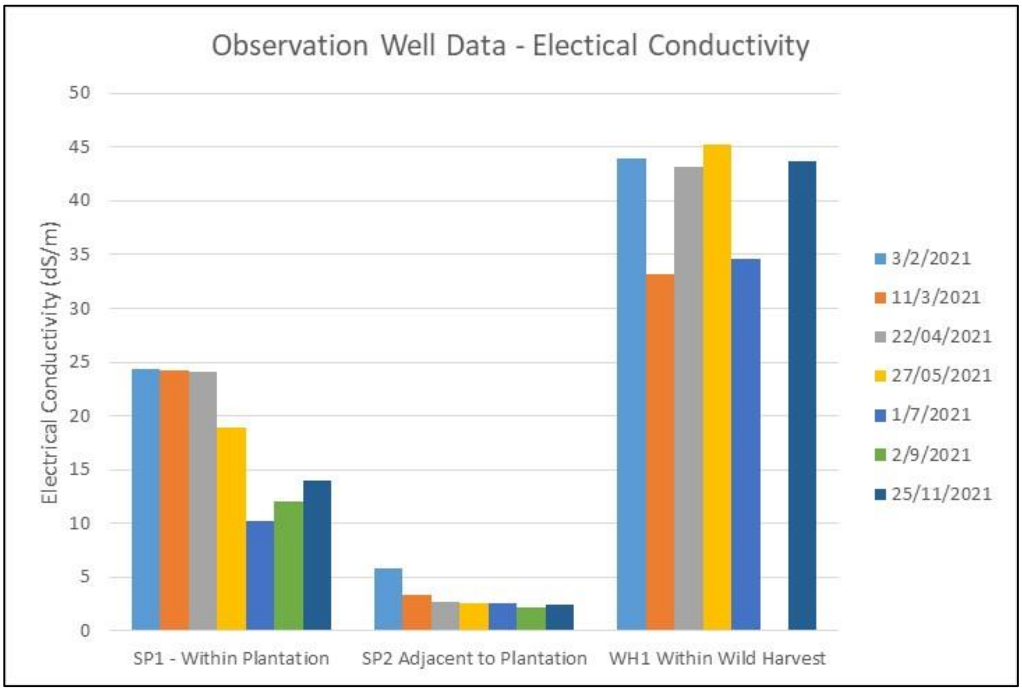


Figure 4.12.2: Observation Well Data: Electrical Conductivity (dS/m) Comparison Over 2021.

It is noted that there is a significant elevation in water level between the July and October data points across all three wells, which is accompanied by significant drop in pH for those same points. This may be a result of the unusual season where anaerobic biological activities may have led to short-term acidification in surface soils, however this would need to be confirmed in a subsequent year of testing as the degree of change is surprising. Over the course of the records, the Plantation Site has a greater degree of variation in pH than that observed within the Wild Harvest Site. See Figure 4.12.3.

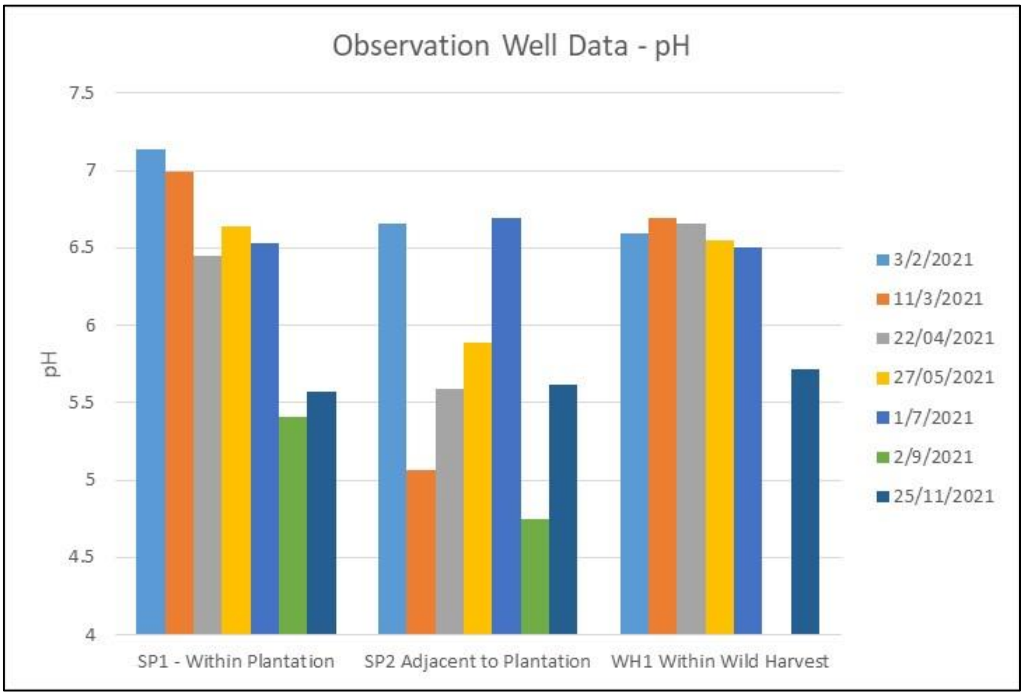


Figure 4.12.3: Observation Well Data: pH Comparison Over 2021.

4.13. Plant Tissue Analysis

Saltbush is typically described as having a leaf salt content of up to 28% and a good crude protein content (AWI & CRC Salinity, 2006). Samples of the Plantation Site Saltbush were taken from multiple random plants within each plot and combined to provide a plot based sample analysis outcome. The timing of the sampling was August 2021, approximately two years after planting and at the same time as the final soil sampling regime and plant coverage study was conducted. Such an analysis enables the definition of both an overall anticipated removal of salts and other soil components per kg harvested and an indication of variation across the Plantation Site. The outcomes of the analysis is presented in Table 4.13. These results were compared against those published by the CSIRO for comparison purposes relative to other saltbush performances for context in this location (Norman et al, 2004). This reference study was conducted in Tammin, south Western Australia with samples taken in the May/June period which may explain some differences in conjunction with the higher rainfall of the 2021 season for the Katanning location relative to previous years. Whilst this was only intended as an indicative assessment as no production data was available for the Plantation Site or the specified plots, a high level review was added to the project scope for future reference.

Table 4.13: Plantation Site Saltbush Leaf Tissue Sample Analysis

Parameter	Plantation Plot 1	Plantation Plot 2	Plantation Plot 3	Plantation Plot 4	Mean
Nitrogen (%)	4.60	4.87	4.60	4.55	4.66
Phosphorus (%)	0.66	0.55	0.85	0.83	0.72
Potassium (%)	2.46	2.62	2.42	1.93	2.36
Sulfur (%)	0.41	0.45	0.42	0.42	0.43
Carbon (%)	42.3	40.8	39.3	40.5	40.7
Calcium (%)	0.67	0.71	0.57	0.59	0.63
Magnesium (%)	0.61	0.78	0.82	0.72	0.73
Sodium (%)	4.90	6.15	6.88	6.99	6.23
Copper (mg/kg)	5.8	7.2	7.4	7.1	6.88
Zinc (mg/kg)	82	80	108	85	88.9
Manganese (mg/kg)	220	143	152	181	174
Iron (mg/kg)	58	57	53	61	57.2
Boron (mg/kg)	30	33	38	36	34.4
Molybdenum (mg/kg)	3.2	3.4	4.0	2.9	3.36
Cobalt (mg/kg)	0.83	0.50	0.63	0.85	0.70
Silicon (mg/kg)	394	370	383	385	383
Nitrogen : Sulfur Ratio	11.1	10.9	10.8	10.9	11.0
Nitrogen : Phosphorus Ratio	7.0	8.9	5.4	5.5	6.69
Nitrogen : Potassium Ratio	1.9	1.9	1.9	2.4	2.00
Carbon : Nitrogen Ratio	9.2	8.4	8.5	8.9	8.75
Crude Protein (%)	28.8	30.4	28.8	28.4	29.1
Chloride (mg/kg)	48,698	65,226	73,329	71,101	64588

Salinity within the Wheatbelt Region is typically associated with sodium chloride. The sodium content of the leaves was determined to have a mean of 6.23%. The samples ranged from a low of 4.90% in Plot 1 to a high of 6.99% in plot 4 and a consistently increasing trend from west to east across the Plantation Site. The comparative study (Norman et al., 2004) had 6.89 - 7.25% and 5.93 - 7.04% in the Old Man and River Saltbush respectively, similar to this project data.

The Chloride content mean was 64,588mg/kg (6.46%). Again a low was identified in Plot 1 of 4.87%, however there was not the consistent trend across the Plantation Site, with a high of 7.33% identified within Plot 3. The comparative study (Norman et al., 2004) had 11.6-11.8% and 10.3-12.35% in the Old Man and River Saltbush respectively, higher than this project data.

Other key minerals – Calcium mean was 0.63% (0.73 to 0.85%, Norman et al., 2004), Magnesium was 0.73% (0.77-1.17%, Norman et al., 2004) and Potassium was 2.36% (2.66 to 3.83%, Norman et al., 2004)

The mean nitrogen content was generally consisted across the Plantation Site with a mean of 4.66%. Plot 2 had the highest value of 4.87%. Comparative data had Old man at 2.03 to 2.46% and River saltbush at 1.55 to 1.62. The mean carbon content was also generally consisted across the Plantation Site with a mean of 40.7%. Plot 1 had the highest value of 42.3%.

A subset of the plant tissue mineralogy was considered in comparison to the soil samples and highlights are presented for interest in the Figure 4.13.1 and 4.13.2. The zinc and magnesium plots have been included due to the example provided of a close nutrient relationship between plant and soil data varying with location. A further study of this would provide insights into the value of soil versus plant tissue sampling for the purposes of this context. More data is available in the 2021 Data Summary.

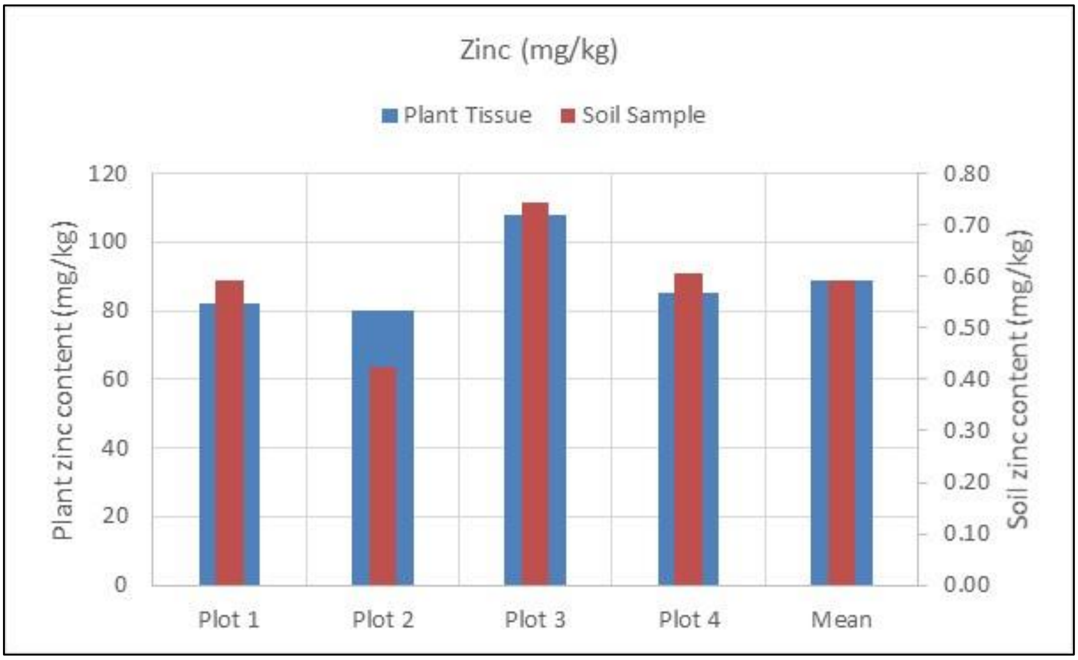


Figure 4.13.1: Comparison of Plant (left axis) and Soil (right axis) Zinc content (mg/kg) for Plots 1 to 4 and the Mean.

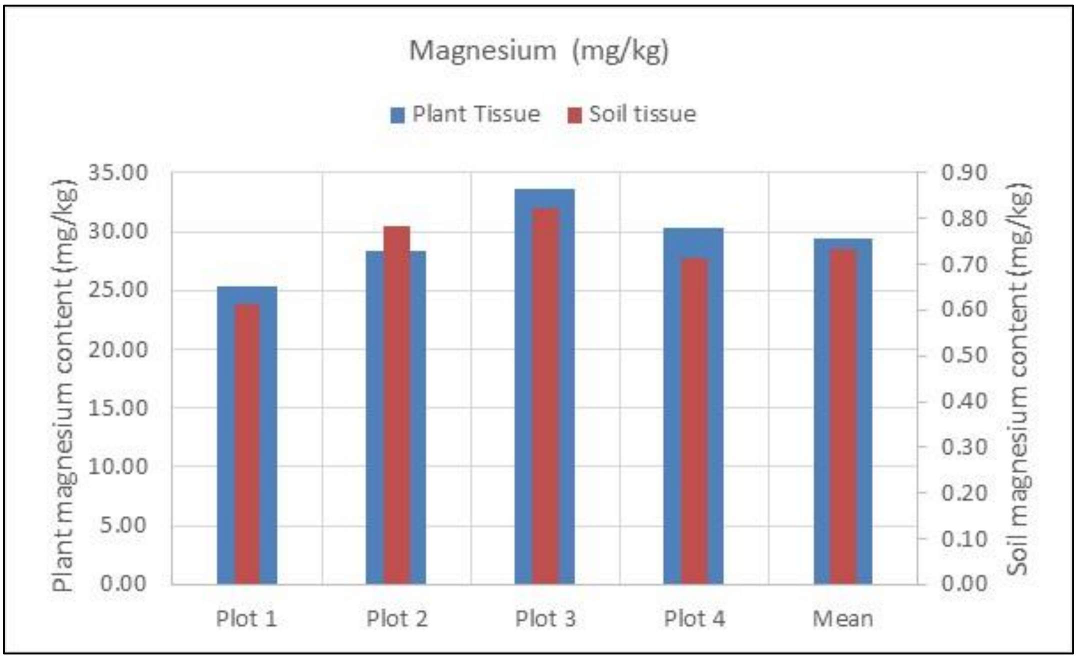


Figure 4.13.2: Comparison of Plant (left axis) and Soil (right axis) Magnesium content (%) for Plots 1 to 4 and the Mean.

4.14. Soil Coverage and Plant Growth

Throughout the trial photographs were taken on a yearly basis to capture the progress of the trial, the external impacts on the soil due to the nature of the trial, the degree of soil coverage and the development of habitat through plant growth.

4.14.1. Soil Coverage

Soil coverage was monitored through the comparison of the ratio of soil covered across the plots within the Plantation Site and within the sampling transects of the Wild Harvest Site. This ratio was considered as a % coverage for each photo and averaged across each plot/transect. It is noted that soil coverage is critical to moderate the diurnal temperature changes of the soil and hence promote a liveable environment for soil flora and fauna. Additionally, soil coverage provides habitat for the fauna and flora that resides immediately above the soil as well as those that traverse below the soil surface. Soil coverage also holds water on the soil surface extending the soaking in period as well as a humid layer benefiting decomposition and limiting evaporation, plus resisting topsoil wind erosion. See Figure 4.14.1.

Figure 4.14.1: Example of Plant Coverage Assessment

Areas of no coverage (or coverage if that was the lesser) were marked and then the histogram was used to isolate the coverage pixels – i.e. Figure 4.14.1 black area Vs total area. Each plot and transect were made up of a series of photos taken at 1m intervals along the length and then presented as an average within Table 4.14.1.1.

Table 4.14.1.1: Plantation Site and Wild Harvest Site Soil Plant Cover and Tree Height.

Plantation 2020	PLOT 1	PLOT 2	PLOT 3	PLOT 4	TOTAL
Mean Coverage	73%	58%	70%	79%	70%
Mean Tree Ht (cm)	77.5	72.5	75.5	78.5	76.0
Plantation 2021	**PLOT 1**	**PLOT 2**	**PLOT 3**	**PLOT 4**	**TOTAL**
Mean Coverage	88%	85%	92%	85%	87%
Mean Tree Ht (cm)	126	120	133	117	124.1
Wild Harvest 2020	**Scarified**	**Non Scar 1**	**Non Scar 2**	**Ratio S:N**	**TOTAL**
Mean Coverage	24%	76%	64%	80m to 6m	27%
Mean Tree Ht (cm)	N/A	50.6	51.7	Non-Scar Ave=	51.1
Wild Harvest 2021	**Scarified**	**Non Scar 1**	**Non Scar 2**	**Ratio S:N**	**TOTAL**
Mean Coverage	64%	77%	80%	80m to 6m	65%
Mean Tree Ht (cm)	37.65	59.8	65.8	Non-Scar Ave=	62.8

The statistical difference of each of the plots/transects, years and comparison to control is presented in Table 4.14.1.2.

Plantation Plot 4 had a higher soil coverage than Plot 2 and 3 in 2020 (83% compared to 58% and 72% respectively). No other difference was determined for 2020 and none was found in the 2021 data. Given Plot 4 had the highest soil coverage in 2020, it was not surprising that it was the only plot that did not show a significant increase in soil coverage between 2020 and 2021 (Plot 1: 73% to 88%, Plot 2: 58% to 85%, and Plot 3: 72% to 92%). The Total area showed a significant increase from 71% to 87% coverage from 2020 to 2021 (up from an assumed 0% in 2019 following the preparation of the area for planting and a coarsely estimated 10-20% following the initial planting of the saltbush immediately following).

In 2020, the Non-Scarified plots had greater coverage than the scarified (76% and 64% for Non-Scar Plot 1 and 2 respectively, and 70% for the total compared to 24%). The Non-Scarified area 1 had a higher coverage than Non-Scarified control area 2. After a year's growth, the soil coverage within the scarified versus individual non-scarified plots were no longer significantly different, nor was there a difference between the Non-Scarified areas, however the combined non-scarified areas combined did demonstrate a higher coverage (78% versus 64%). This suggests that the coverage was evening out following the scarification process, leading to increased soil protection however this coverage must also be considered with the plant heights for the consideration of environmental benefit and habitat/micro-climate creation. Between the sampling regimes of 2020 and 2021, the Scarified area increased in coverage (24% to 64%), the Non-Scarified Control Area 2 increased in coverage (64% to 77%), the combined Non-Scarified Control Area data increased in coverage (70% to 78%) and the overall Wild Harvest Site coverage increased (56% to 74%). The significance of the increase within only one of the control areas suggests that some (i.e. the Non-Scarified Control Area 2 had a significant increase), but not all (i.e. the Non-Scarified Control Area 1 had no significant change) of the improvement in coverage could be attributed to the different weather experienced within the growing season of 2021. This potential weather impact witnessed within one of the two control areas suggests that a degree of coverage within the scarified area can also be attributed to this

Table 4.14.1.2: Plantation Site and Wild Harvest Site Soil Plant Cover Statistical Difference Assessment Outcomes.

Location	Significant Data	Plot 1 (A) Vs Plot 2 (B)	Plot 1 (A) Vs Plot 3 (B)	Plot 1 (A) Vs Plot 4 (B)	Plot 2 (A) Vs Plot 4 (B)	Plot 2 (A) Vs Plot 4 (B)	Plot 3 (A) Vs Plot 4 (B)
	Average A				58%		72%
Plantation (2020)	Average B				83%		83%
	P(T<=t) two-tail				1.35E-02		2.39E-02
	Average A						
Plantation (2021)	Average B						
	P(T<=t) two-tail						
Location	**Significant Data**	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Total Plantation**	
	Average 2020	73%	58%	72%		71%	
Plantation	Average 2021	88%	85%	92%		87%	
	P(T<=t) two-tail	1.02E-02	5.25E-03	3.51E-06		3.70E-07	
Location	**Significant Data**	**Scar (A) Vs Non-Scar 1 (B)**	**Scar (A) Vs Non-Scar 2 (B)**	**Scar (A) Vs Total Non-Scar (B)**	**Non-Scar 1 (A) Vs Non-Scar 2 (B)**		
	Average A	24%	24%	24%	76%		
Wild Harvest (2020)	Average B	76%	64%	70%	64%		
	P(T<=t) two-tail	1.42E-09	3.08E-07	7.51E-11	1.31E-02		
	Average A			64%			
Wild Harvest (2021)	Average B			79%			
	P(T<=t) two-tail			2.21E-02			
Location	**Significant Data**	**Scarified**	**Non-Scarified 1**	**Non-Scarified 2**	**Total Non-Scarified**	**Total Wild Harvest**	
	Average 2020	24%		64%	70%	56%	
Wild Harvest	Average 2021	64%		77%	79%	74%	
	P(T<=t) two-tail	7.52E-04		1.01E-02	1.60E-02	1.21E-03	
Location	**Significant Data**	**Planation (A) Vs Wild Harvest (B)**					
	Average A	87%					
Total Property (2021)	Average B	74%					
	P(T<=t) two-tail	6.99E-05					

weather rather than solely the recovery process from the scarification impact of denuding the soil and then allowing growth from Autumn 2020.

In the comparison of the 2021 data, the Plantation Site had a higher plant coverage than that identified in the Wild Harvest Site (87% compared to 74% respectively).

4.14.2. Plant Growth

Plantation plant growth assessments were hampered within the first year by harvest activities. Within the second year soil sampling (2021) and photographs were captured in August, after which point it is understood that a degree of plant death was noted due to water logging of the soils and a subsequent trim of these plants was conducted to promote regrowth where possible. It must therefore be accepted that the photographs and comments made on them apply only to that timestamp. A relative degree of environmental benefit through habitat creation is obviously negated by hard trimming. Similarly whilst habitat creation can be commented on within the Wild Harvest Site without the imposition of harvesting (no harvest was undertaken for the duration of the trial), it is noted that the total area with the exception of the smaller control plots was scarified approximately 6 months into the trial. This process was soil scarification rather than plant scarification and hence the majority of plants were removed from the scarified area setting back the habitat potential of the area part way through the trial. Hence the roping off of the controlled areas to retain a comparative benchmark.

Photographs were taken with a measuring tool in situ to define plant structure. Heights were recorded. The taller the plant the broader the inferred impact due to both volume of habitat, diurnal shaded areas and wind diversion/buffering. An example of the activity has been presented in Figure 4.14.2.1 and the average measurements for each plot have been summarised previously in Table 4.14.1.1. Table 4.14.2 outlines the significant differences seen across the plots, areas and years.

Whilst there was no significant difference between the plots in 2020, Plot 3 was determined to have a taller selection of trees measured than Plot 4 in 2021 (133cm versus 117cm). In the comparison of 2020 to 2021 data, Plots 1, 3 and 4 as well as the total Plantation Site tree height were determined to be taller in 2020. This was not surprising given the tree growth over that period, however it indicates that even with harvesting occurring at various times in between the two sampling regimes, a generally larger vertical habitat was evident in 2021 than in previous years. With both a greater soil coverage and tree height, the increase in habitat available which was visually evident has been reinforced through an objective analysis. As was mentioned previously, the trees at the stage of measurement were struggling with water logged soils and subsequent to this analysis it is understood that a pruning event occurred to recover as many trees as possible. Thus any comments on habitat and micro-climate creation as part of the conversion of salt scarred landscapes to salt tolerant treed systems are highly dependent on the economical drivers influencing harvest timing, degree of harvest and tree treatments in the wake of climate conditions which have adverse effects on the ability of salt tolerant plants to thrive.

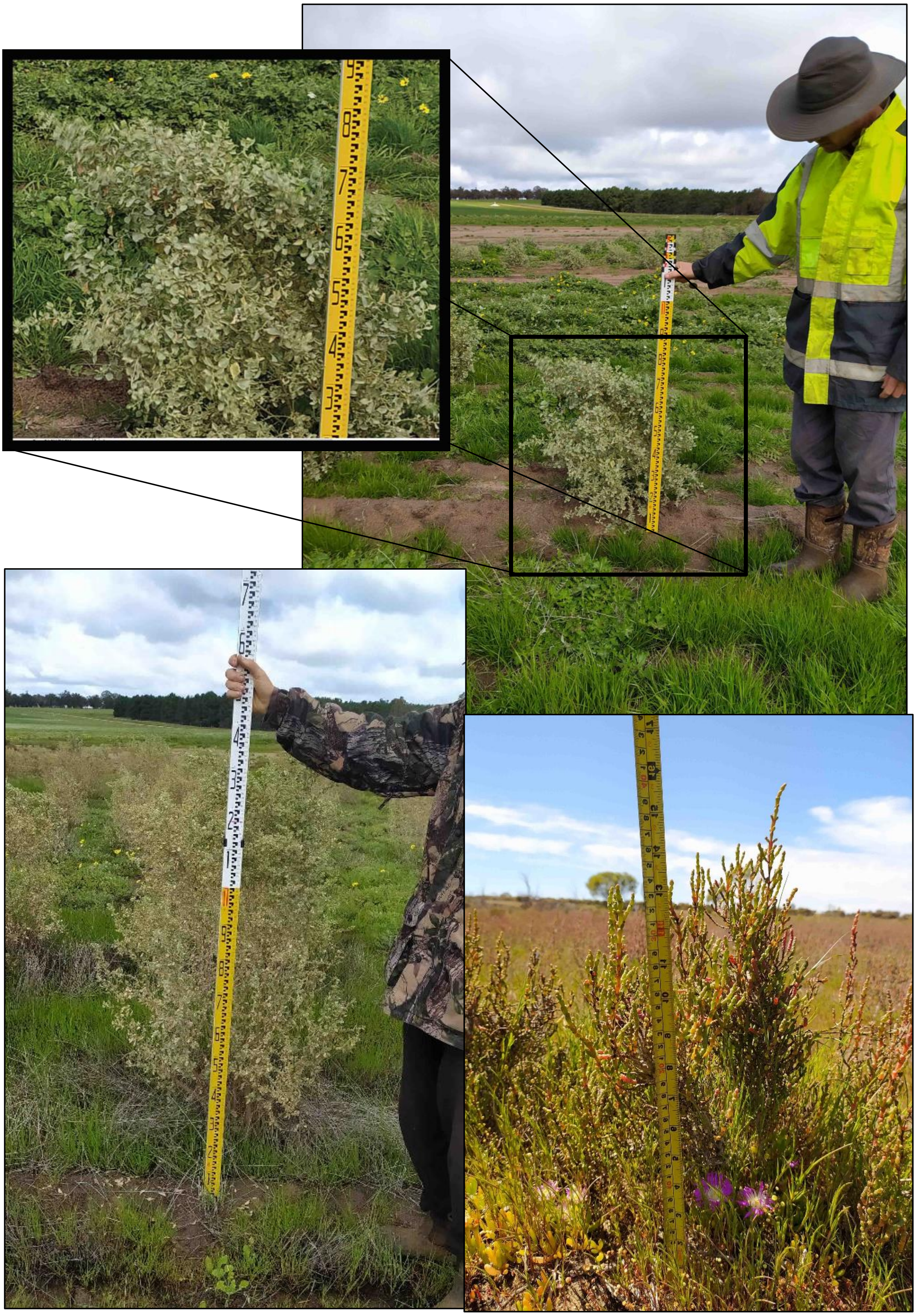


Figure 4.14.2.1: Example of Tree Height assessment

Table 4.14.2: Plantation Site and Wild Harvest Site Tree Height Statistical Difference Assessment Outcomes.

Location	Significant Data	Plot 1 (A) Vs Plot 2 (B)	Plot 1 (A) Vs Plot 3 (B)	Plot 1 (A) Vs Plot 4 (B)	Plot 2 (A) Vs Plot 4 (B)	Plot 2 (A) Vs Plot 4 (B)	Plot 3 (A) Vs Plot 4 (B)
	Average A (cm)						
Plantation (2020)	Average B (cm)						
	P(T<=t) two-tail						
	Average A (cm)						133
Plantation (2021)	Average B (cm)						117
	P(T<=t) two-tail						6.47E-03
Location	**Significant Data**	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Total Plantation**	
	Average 2020 (cm)	77.5		75.5	78.5	76.0	
Plantation	Average 2021 (cm)	126		133	117	124	
	P(T<=t) two-tail	1.04E-06		1.33E-07	9.51E-04	3.71E-14	
Location	**Significant Data**	**Scar (A) Vs Non-Scar 1 (B)**	**Scar (A) Vs Non-Scar 2 (B)**	**Scar (A) Vs Total Non-Scar (B)**	**Non-Scar 1 (A) Vs Non-Scar 2 (B)**		
	Average A (cm)	25.2	25.2	25.2			
Wild Harvest (2020)	Average B (cm)	51	51.7	51.1			
	P(T<=t) two-tail	7.04E-05	6.53E-06	2.17E-06			
	Average A (cm)	37.7	37.7	37.7			
Wild Harvest (2021)	Average B (cm)	60	65.8	62.8			
	P(T<=t) two-tail	5.81E-05	6.20E-06	3.67E-07			
Location	**Significant Data**	**Scarified**	**Non-Scarified 1**	**Non-Scarified 2**	**Total Non-Scarified**	**Total Wild Harvest**	
	Average 2020 (cm)	25.2			51.1		
Wild Harvest	Average 2021 (cm)	37.7			62.8		
	P(T<=t) two-tail	2.77E-03			1.90E-02		
Location	**Significant Data**	**Planation (A) Vs Wild Harvest (B)**	**2020 (A) Vs 2021 (B)**				
	Average A (cm)	113	52.8				
Total Property (2021)	Average B (cm)	45.7	95.9				
	P(T<=t) two-tail	4.22E-31	8.92E-13				

There had been no harvesting undertaken within the Wild Harvest Site, however as mentioned previously a significant impact was made by the soil scarification which determined that limited trees were present in the non-control areas in 2020 and that only small plants were present within this area in the 2021 sampling regime. Not surprisingly, in the 2020 analysis (4 months post scarification), the plant heights recorded for the Non-Scarified areas were approximately double that identified within the limited number of plants in the Scarified area (51cm, 52cm, and 51cm for the Non-Scar 1, Non-Scar 2 and Combined Non-Scar respectively relative to the 25cm height of the Scarified areas). There was no significant difference between the two Non-Scarified areas, making them an acceptable combined control for future reference. A similar relative presentation was recorded for 2021 (60cm, 66cm, and 63cm for the Non-Scar 1, Non-Scar 2 and Combined Non-Scar respectively relative to the 28cm height of the Scarified areas). Whilst the comparison in a previous section of the report outline under versus between relationships for the scarified and non-scarified data, it is critical to note that for the scarified area there were approximately 5-10% (smaller) trees than those (larger) trees present within the non-scarified area. A photo of the boundary between the scarified area and non-scarified area is presented in Figure 4.8.2.2(a). However whilst trees/bushes were limited within the scarified area, soil coverage was good in some areas and poor in others as demonstrated in Figure 4.8.2.2 (b) and (c).

In the comparison of the 2020 to 2021 data, the height of both the Scarified Area plants and the combined Non-Scarified Area plants had both increased by approximately 12cm. It is noted that this was not a reflection on the potential harvest material from this area and so cannot be defined as a positive or negative reflection on the financial aspect of scarification, only the ecological impact.

From an overall plant height data perspective, the Plantation Site had more than double the mean plant height when compared to the total Wild Harvest Site assessment across the two years, and 2021 demonstrated an 80% increase from the combined Plantation and Wild Harvest Site plant heights of 2020.

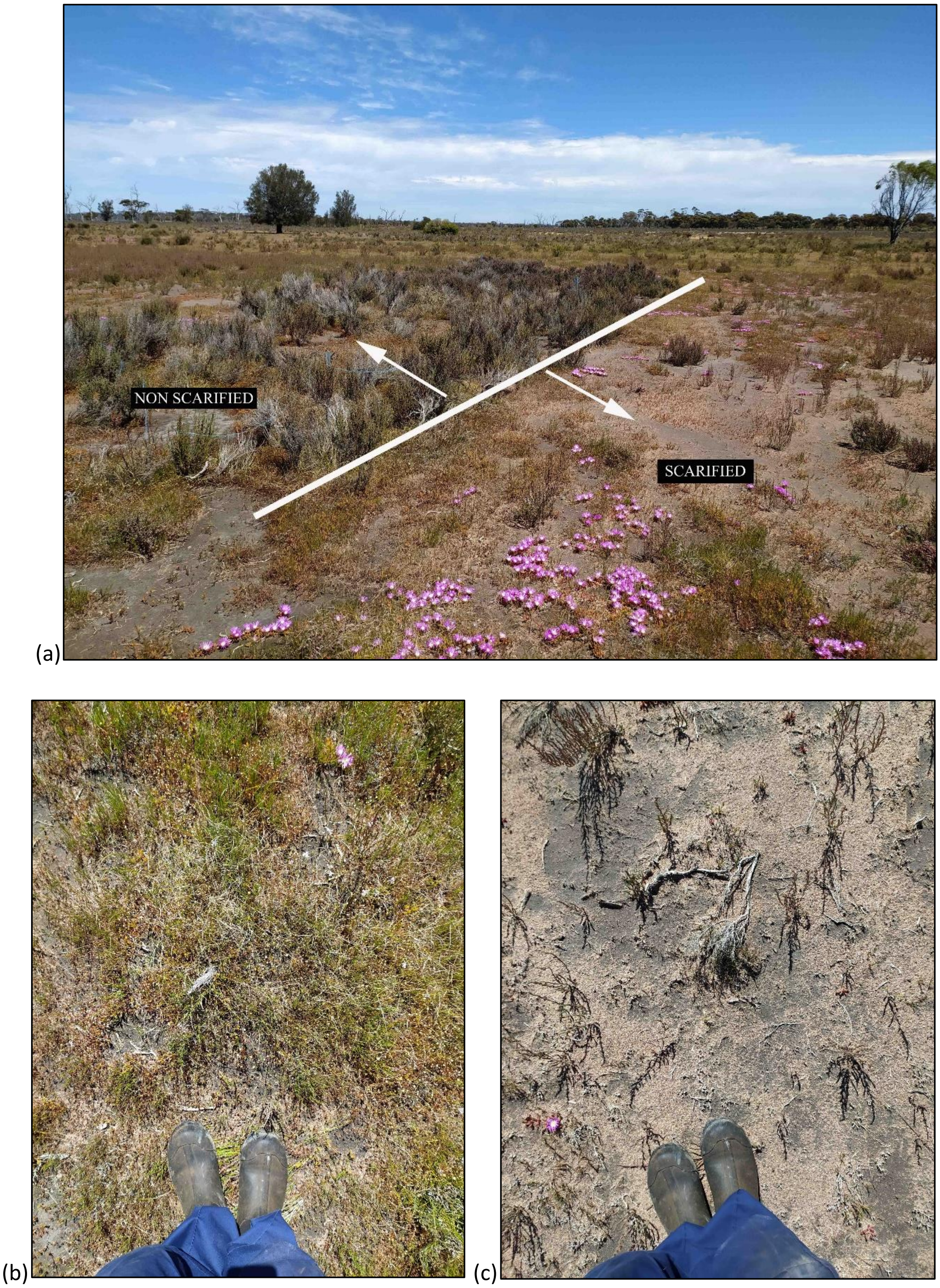


Figure 4.14.2.2– (a) Comparative Scarified to Non-Scarified coverage, (b) Example of Good Scarified Area Soil Coverage (c) Example of Poor Scarified Area Soil Coverage

5. DISCUSSION / CONCLUSIONS

The data has been provided within this report as an indication of the short term response of a soil system to a series of changes. In the case of the Plantation Site, these changes were in the form of, firstly, tilling in preparation for planting and a step change in traffic within the system potentially leading to differential compaction. No representative area within the Plantation Site was retained to represent the original ecosystem, thus there was no baseline/control for this area. In the case of the Wild Harvest Site the change was in the form of a dramatic soil scarification which not only disturbed the topsoil, but also removed much of the plant material from above the surface and some below. This change occurred in the second quarter of 2020 and was done prior to the first soil sampling of this area. There were however two representative sub-areas within the Wild Harvest Site that were cordoned off and not subject to scarification, which served as controls against which the impact of the scarification was compared.

The climate conditions for the duration of the trial are critical to note in the light of the transition from El Niño to La Niña within the Pacific Region between 2020 and 2021 which brought greater rainfall for Australia in the second year of the trial. Such a transition was inferred to have significantly influenced the results of the project and highlight the importance of the comparison with control areas and the importance of differentiation within both the 2020 and 2021 data sets. The climate influence was obvious in the visual comparison of the two years and highlights the care that must be taken in making assumptions based on trends during such a short trial period, after a significant impact has been applied and subject to a distinct climate variation between the two years of the trial – the combination of short to medium term weather fluctuations within the longer term ecosystem evolution in response to the Plantation and Wild Harvest Sites implemented changes.

In addition to the soil sampling, observations have been recorded, and summarised in this report, for water table properties via the observation wells, plant tissue samples, soil coverage and mean plant growth.

5.1. Plantation Site Outcomes (2019)

The key findings of the analysis of the 2019 Plantation Site sampling regimen are:

- Significant differences between the individual plots across the Plantation Site were noted. This is not uncommon within natural and agricultural landscapes.
- These differences were apparent in pH; total carbon; carbon/nitrogen ratio; effective cation exchange capacity (ECEC); exchangeable and base saturation calcium; magnesium and potassium; base saturation aluminium; plant available phosphorus; and the calcium / magnesium ratio.
- Plot 2 was the most extreme variant for many of the soil properties.
- This difference indicates that a more detailed comparison across the Plantation Site will be of value in addition to the comparison to the total data set with future sampling results.
- A baseline for both the Plantation Site as a whole and plot specifically has been established within this data set.
- The overall analysis identified high salinity soil and poor nutrient availability compared to a standard agricultural / productive soil expectation. This highlights the appropriateness of the location for alternate production options from which value can be obtained within activities tailored to these conditions without exorbitant expense for that production to be sustainable.

5.2. Plantation Site Outcomes (2020)

The key findings of the analysis of the 2020 Plantation Site sampling regimen are:

- A variety of parameters were higher under the plants than between them which may be a result of the impact of the preparation for planting activities which may have altered the soil ecosystem through a change in structure and exposure to air. Namely pH, electrical conductivity (EC); carbon nitrogen ratio; exchangeable magnesium, potassium, and sodium; effective cation exchange capacity (ECEC); total potassium %; boron and silicon.
- A variety of parameters were lower under the plants compared to between them which may represent the between plant soil profile potentially representing the seasonal change from 2019 and/or providing evidence of increased vehicular or foot traffic. Namely total carbon %, plant available phosphorus, ammonium nitrogen, exchangeable aluminium, total magnesium, aluminium %, the calcium / magnesium ratio, zinc, iron, and copper.
- The examination of the change from 2019-2020 demonstrated:
    - an increase for the total data set for pH, EC, sulfur, and sodium %, Note: pH and EC were associated with the under plant compared to the between.
    - a decrease for the total data set for total carbon %; total nitrogen %; plant available phosphorus; calcium and aluminium (exchangeable and total %); and calcium magnesium ratio. Note: total carbon %, plant available phosphorus, aluminium, (exchangeable and total %), and the calcium / magnesium ratio were associated with the under plant compared to the between.
- The plots did not display a consistent trend for all parameters, however the most notable trend observed was the drop in total carbon %, total nitrogen %, exchangeable calcium and aluminium % within Plots 1, 2, and 3 from 2019 to 2020.
- The initial Plantation Site event showed decreases in the alpha diversity (0 to 10cm) soil, as compared to the deeper soil profile, which is likely driven by the initial disturbance of the Plantation Site. Broad scale phylum level relative abundance showed no variation for both soil depth and also the sampling location. Carbon cycling potential showed no changes, though there was a slight increase in lignin degrading capacity at the 0 to 10cm soil profile.

5.3. Plantation Site Findings at Project Conclusion (2021)

The key findings of the analysis of the 2021 Plantation Site sampling regimen are:

- At the conclusion of the project, the Plantation Site average for the pH, electrical conductivity (EC), Carbon/nitrogen ratio, boron, magnesium (soluble, exchangeable and percent ECEC), sulfur and sodium (exchangeable and percent ECEC) were higher than the recommended laboratory guidelines for light loam type soils (See Appendix 2, Section 8.3). Total carbon %, and soluble calcium were between 75% and 100% of recommendation. Total nitrogen %, effective cation exchange capacity (ECEC), phosphorus, silicon, and ammonium nitrogen were between 50% and 75% of recommendation. All other parameters were less than 50% that recommended.
- It was apparent that the impact of the planting activities was possibly not yet reversed by the final year of the project for many soil properties as a consistent decreasing trend was only identified for ECEC, zinc, silicon and exchangeable potassium over the three sample times. Only the copper content had a consistent increasing trend in mean values for the 0-10cm depth samples across the project. Additionally the under plant samples for phosphorus consistently increased. Otherwise the trend for the data from 2019 to 2020 was reversed for the 2020 to 2021 comparison.
- At the conclusion of the project the Plantation Site under plant data sets were higher than those sampled between plants for the pH, EC, nitrate nitrogen, ammonium nitrogen, calcium (soluble, exchangeable), magnesium (exchangeable, %ECEC), potassium (soluble, exchangeable), phosphorus (soluble, Colwell, Bray 2), sulfur, ECEC, sodium (exchangeable and ESP), and silicon. The inverse (between plants higher than under plants for) was the case for the exchangeable aluminium, total magnesium and aluminium %, the calcium / magnesium ratio, zinc, iron, and copper.
- It is noted that the higher total carbon identified between the plants in 2020 has now become a less consistent result with Plots 1 and 2 now exhibiting a higher content under plants. With the understanding that all results in 2021 are still below the original 2019 data, it was concluded that the system is still building carbon in recovery from the 2019 project preparation impact. The 2021 total nitrogen demonstrated a similar trend with the 2021 data sets all higher than those from 2020 and approaching the 2019 original levels. Such information highlights the importance of minimum tillage and keeping soil coverage in place to minimize the impact of topsoil (and its ecosystem's) exposure to temperature swings, wind and sunlight.
- Importantly, the EC, the exchangeable sodium and the exchangeable sodium as a percentage (ESP) of the ECEC, as indicators of salinity, are all higher under the plants rather than between. This was considered most likely due to the combination of the

tilling of the soil bringing up the more saline subsoil (dominant cause), the plants drawing up groundwater through capillary action as the roots remove water from the soil and the protection of the area of soil below the plants from rainfall partially reducing the soil washing effect. It was not anticipated that in the short duration of the trial that the impact of salt removal from the soil by the plants would be detectable. Whilst the under plant samples are higher than the between plant samples, the high under plant values of 2020 in three of the four plots, well above the 2019 level, have fallen back to the 2019 level within the 2021 round of sampling. This would suggest the system is recovering from the initial impact and is establishing a new trajectory.

- If it assumed that the 2020 to 2021 trajectory best represents the recovery of the Plantation Site system, then this snapshot indicates:
  - Increasing **2020 to 2021**, total data set – total nitrogen %, exchangeable calcium, exchangeable aluminium, calcium %, aluminium %, hydrogen %, Manganese and Copper
  - Decreasing **2020 to 2021**, total data set – EC, sulfur, exchangeable sodium, and sodium %.
  - The Total Nitrogen, aluminium (exchangeable and total %), and calcium % results were replicated both under and between plants.
- In looking at the plot specific trends, the consistency of statistically significant results in Plots 1 and 2 suggest that the more western end of the Plantation Site has a greater propensity to recover and build ecosystems following a disturbance.
- Soil biological responses through analysis of bacteria and functional genes relating to Carbon and Nitrogen
  - Overall the Plantation Site has observed positive results from the inclusion of saltbush. Increases in alpha diversity, especially species richness within the sampling underneath the plants occurred at both soil sampling depths by 2021.
  - Increases in Actinobacteria, Firmicutes and Proteobacteria by 2021 at the greater soil depth is likely to continue and represents a very common distribution of major phyla at the 0 to 10cm soil profile.
  - Carbon and nitrogen cycling potential did increase over time, and is indicative of a healthy soil able to functionally provide carbon and nitrogen cycling process, these responses were more prominent in the upper soil profile and also under the plant location. All carbon and nitrogen related genes were observed in high quantities and reflects the soil at this site to be healthy in its ability to perform carbon and nitrogen cycling processes.

- The increase in nitrogen cycling potential over time was reflected in the total nitrogen % of the soil chemical analysis, although in contrast, the carbon content across the area was not yet consistently evident of the soil biological result for carbon related genes.

5.4. Wild Harvest Site and Overall Comparison Results (2020)

The key findings of the analysis of the 2020 Wild Harvest Site sampling regimen are:

- The Plantation Site results identified that the majority of soil nutrients are greater than in the Wild Harvest Site.
  - Total Carbon, total nitrogen, the calcium/magnesium ratio, zinc, manganese, soluble calcium, exchangeable calcium all displayed greater results within the Plantation Site sampling regimens relative to the Wild Harvest Site with the 2019 sample recording a higher value than the 2020.
  - Copper, silicon, phosphorus, nitrate nitrogen and ammonium nitrogen all displayed greater results within both the Plantation Site sampling regimens relative to the Wild Harvest Site with the 2020 sample recording a higher value than the 2019.
- The electrical conductivity (EC) was higher within the Wild Harvest Site.
- The soluble magnesium, sulfur and exchangeable sodium levels identified Plantation Site and Wild Harvest Site 2020 results are to be similar with the 2019 Plantation Site sample location to have lower values. (* Note: no fertilizer has been applied to the in ground Plantation Site – A. Mercieca, 2021).
- For those macro and micro nutrients, where a statistically significant difference was present, there was a higher nutrient content in the scarified versus non scarified area soils.
  - For the 0-10cm depth - available phosphorus, copper and boron.
  - For the 10-30cm depth - available phosphorus, calcium (total %), and the calcium/magnesium ratio.
- In the Scarified Area, the 0-10cm depth under-plant samples value was higher than the between-plants soil sample for soluble calcium, available phosphorus and exchangeable phosphorus with the latter two replicated within the deeper samples.
- No soil property showed a significantly higher value within the deeper profile for the Scarified Area.
  - Within the under-plant sample set, the 0-10cm samples were higher than the 10-30cm samples for available phosphorus, exchangeable phosphorus and ammonium based nitrogen.
  - Within the between-plant sample set, the 0-10cm samples were higher than the 10-30cm samples for total carbon %, carbon/nitrogen ratio, available phosphorus, and exchangeable phosphorus.
- In the Non-Scarified Area the samples taken demonstrated a higher proportion of consistency of trend for the under Vs between plant comparison:

        - The 0-10cm depth under-plant samples value was higher than between for total carbon %, total nitrogen %, exchangeable phosphorus, calcium %, magnesium %, and potassium %. The between-plant samples value was higher than under for sodium %.
        - The 10-30cm under-plant samples value was higher than between for carbon/nitrogen ratio, available phosphorus, and aluminium %. The between-plant samples value was higher EC; soluble calcium and magnesium; sulfur; and exchangeable calcium, magnesium and sodium.
    - Again in the Non-Scarified Area the samples taken demonstrated a higher proportion of consistency of trend for the shallow (0-10cm) Vs deeper (10-30cm) parameters:
        - Within the under-plant sample set, the 0-10cm samples were higher for total carbon%; total nitrogen%; soluble calcium; available and exchangeable phosphorus; exchangeable calcium; calcium %; magnesium%; and calcium/magnesium ratio. The samples were lower for total sodium % only.
        - Within the under-plant sample set, the 0-10cm samples were higher for carbon/nitrogen ratio; available and exchangeable phosphorus; calcium %; aluminium %; and calcium/magnesium ratio. The samples were lower for EC; soluble calcium and magnesium; sulfur; exchangeable sodium; ECEC; and exchangeable sodium.
    - The overall analysis identified high salinity soil based on the EC and exchangeable sodium percentage (ESP) across both the scarified and non-scarified/control, and the under versus between analysis. Higher values were generally evident within the deeper soil sample profile.

5.5. Wild Harvest Site Findings at Project Conclusion (2021)

The key findings of the analysis of the 2021 Wild Harvest Site sampling regimen and hence project conclusion findings are:

- At the conclusion of the project, the Wild Harvest Site average for the pH, electrical conductivity (EC), Carbon/nitrogen ratio, effective cation exchange capacity (ECEC)*, iron*, boron, calcium (soluble and percent ECEC)*, magnesium (soluble, exchangeable and % ECEC), sulfur and sodium (exchangeable and percent ECEC) were higher than the recommended laboratory guidelines for sandy type soils (See Appendix 2, Section 8.3). The asterisks indicate the properties not identified as higher within the Plantation Site findings for 2021. Potassium (soluble and exchangeable), soluble phosphorus, exchangeable calcium and silicon were between 50% and 100% of recommendation. All other parameters were less than 50% that recommended.
- For the total Wild Harvest Site data set: the EC, total nitrogen %, exchangeable sodium, ECEC, the aluminium (percent of ECEC), manganese and boron contents increased between 2020 and 2021. The C/N ratio (due directly to the increase in total nitrogen), nitrate nitrogen, phosphorus, and magnesium % decreased between the 2020 and 2021 sample sets.
    - The change in the total nitrogen and C/N ratio were reflected in changes within both the scarified and non-scarified data sets as well as the subsets of under versus between plants and so can be confidently related to climate.
    - The increase in EC and ECEC as well as the decrease in the nitrate nitrogen, were only reflected in the scarified data set. The increase in aluminium %, manganese and boron were only reflected in the non-scarified data set. Significant contrasting results in the silicon content for the scarified and non-scarified data sets leading to no difference in the total data set were also evident. Additionally the scarified area demonstrated an increase in sodium - ESP % (53% to 60%), and a decrease in potassium % (2.0% to 1.4%) where there was not significant trend seen in the non-scarified. Therefore these changes are confidently related to the trajectory brought about by the scarification impact.
- For the total under versus between plant assessment, an increased aluminium % (0.14 to 0.28%), manganese (0.96mg/kg to 2.1mg/kg), and boron (0.95mg/kg to 1.5mg/kg) content; and a decreased plant available phosphorus (11.8mg/kg to 6.5mg/kg) was identified between 2020 and 2021 only in the under plants samples. In contrast, an increased sodium ESP% (56% to 64%) content; and a decreased nitrate nitrogen (2.6mg/kg to 0.95mg/kg.); calcium % (13.1% to 9.3%), and magnesium % (27% to 65%), was identified between 2020 and 2021 in the between plants samples.

    - In 2021, both the scarified and non-scarified areas demonstrated a higher exchangeable calcium, calcium as a % of ECEC and the calcium magnesium ratio under the plants compared to between, as well as a higher sodium content as a % of ECEC between plants as compared to under.
    - In 2020, the non- scarified area demonstrated a higher total carbon %, soluble calcium, magnesium%, potassium %, aluminium %, boron content and silicon content under the plants compared to between. The non- scarified area also had a higher between-plant result for the EC, sulfur content, exchangeable sodium, and the ECEC than that identified under plants. These trends were not reflected in the scarified area.
- The impact of both plant proximity and scarification were considered on a depth specific basis for the 2021 data set. The consistent presentation of higher exchangeable sodium and ECEC within the scarified compared to non-scarified areas was notable. As well as the higher EC, exchangeable sodium and ECEC under the plants within the deeper soils than in between.
    - In 2021, both the scarified and non-scarified areas, the total carbon %, plant available phosphorus, exchangeable calcium and the calcium % as a proportion of ECEC were higher in the 0-10cm samples compared to 10-30cm samples. In contrast and likely reflecting the impact of scarification, the non-scarification / control area demonstrated a higher total nitrogen, soluble calcium, exchangeable magnesium, the calcium magnesium ratio and the silicon content in the 0-10cm samples. This non-scarified area also highlighted a higher sodium – ESP in the 10-30cm depth.
    - Within the 0-10cm sample depth total data set, total carbon (0.79% to 0.56%), soluble calcium (197mg/kg to 99mg/kg), exchangeable calcium (270mg/kg to 160mg/kg), Magnesium % of ECEC (28% to 25%), Potassium % of ECEC (2.2% to 1.1%), the calcium magnesium ratio (0.64 to 0.37) and manganese content were higher under the plants that between them, whilst only the exchangeable sodium (913mg/kg to 1247mg/kg), and sodium - ESP % (50% to 64%) were higher between the plants in the 2021 data set.
    - In marked contrast within the 10-30cm samples (theoretically less impacted by surface activity and plant growth), (a) the EC (0.91dS/m to 1.40dS/m), aluminium % (0.23% to 0.16%), and the calcium magnesium ratio (0.45 to 0.26) were higher under the plants than between and (b) the soluble magnesium (172mg/kg to 229mg/kg), sulfur (61mg/kg to 95mg/kg), exchangeable magnesium (174mg/kg to 271mg/kg), exchangeable sodium (863mg/kg to

1245mg/kg), ECEC (6.5cmol/kg to 9.5cmol/kg), and Sodium – ESP% (65% to 70%) were higher between the plants compared to under them.

- For the under plant subset, the 0-10cm depth, the EC (1.3dS/m to 06dS/m), exchangeable magnesium (313mg/kg to 220mg/kg), exchangeable sodium (1290mg/kg to 670mg/kg), and the ECEC (10.3cmol/kg to 6.1cmol/kg) were all higher within the scarified area, whilst only the Potassium % of ECEC (1.7% to 2.7%) was higher within the non-scarified area. The higher exchangeable sodium (1105mg/kg to 755mg/kg) and the ECEC (7.7cmol/kg to 5.3cmol/kg) in the scarified compared to non-scarified area was replicated in the 10-30cm with pH additionally showing a higher value (7.7 to 7.0). Only the aluminium % of ECEC was higher at the 10-30cm depth in the non-scarified area.
- Within the between plant subset, less significant differences were identified. In the 0-10cm depth, exchangeable sodium (1523mg/kg to 1074mg/kg), and the ECEC (10.1cmol/kg to 7.5cmol/kg) were the only two properties of significantly higher content in the scarified area. No properties were noted with a higher content in the non-scarified area. In the 10-30cm depth, soluble calcium (114mg/kg to 81mg/kg), exchangeable calcium (144mg/kg to 106mg/kg), and silicon content (22mg/kg to 16mg/kg) were higher in the scarified area; and as per the 0-10cm data set, only the aluminium % (0.19% to 0.31%) was higher in the non-scarified.

- It was evident that:
  - there was a steeper rise in EC, the ECEC and the exchangeable sodium of the soil sampled from 2020 to 2021 within the scarified area as compared to the non-scarified.
  - the rise for total nitrogen, manganese, boron, silicon, and soluble calcium was more consistent between the two areas.
  - in contrast, the soluble phosphorus, exchangeable potassium and exchangeable aluminium displayed a greater increase within the non-scarified / control plot.
- Whilst the EC, exchangeable sodium and ECEC was higher in soil sampled from between the plants to under them, the change in these values from 2020 to 2021 was a consistent significant rise for both locations. The total nitrogen, boron and silicon contents of the soils sampled under the plants was higher than that found between in 2020 and both demonstrated a consistent rise across the areas.
- In the comparison of the individual year, scarification and relative plant location samples, pH, the carbon nitrogen ratio, and the plant available phosphorus was identified as having decreased for all sets between 2020 and 2021. In contrast, the total

nitrogen, manganese, boron, and silicon demonstrated an increase for all sets between 2020 and 2021.

- It is noted that whilst the ECEC (reflected in the exchangeable sodium content) demonstrated a rise from 2020 to 2021 within both the under and between locations of the scarified area, whilst the non-scarified remained relatively consistent.
- A salinity focused review determined that:
  - Within the 2021 sampling regime there was a statistically significant difference identified between the EC of the scarified and non-scarified soil samples taken from the shallow depth soil under plants (1.30dS/m and 0.59dS/m respectively). Additionally both in the 0-10cm depth and the 10-30cm depth, there was a significantly higher EC identified between the plants as opposed to under them (0.59dS/m to 1.05dS/m and 0.75dS/m to 1.40dS/m respectively). It was also noted that between the 2020 and 2021 sampling, there was an overall increase in the EC for the total data set and for the scarified data set (0.79dS/m to 1.03dS/m and 0.78dS/m to 1.4dS/m respectively. The non-scarified area identified negligible changes. All results, irrespective of depth, plant proximity or scarification indicated elevated salinity compared to the laboratory recommended guideline of 0.200 dS/m for clay or 0.100 dS/m for loamy/sand. No depth differential nor outliers were identified for the EC either in the scarified or non-scarified soils.
  - In conjunction with a high EC, an exchangeable sodium % (ESP) in excess of 5% indicates a potential salt issue (EAL Laboratory guideline). The sodium content review across the Wild Harvest Site demonstrated lower salinity under plants, in the non-scarified area and within the shallower soils consistently.
  - Unlike the EC data where the total and scarified data sets were noted, (i) the exchangeable sodium identified the total data and the scarified under plant data to have a significant increase from 2020 to 2021 (867 to 1080mg/kg and 743 to 1289 mg/kg respectively) and (ii) the exchangeable sodium % as a portion of the total ECEC identified the scarified data, the between plant data and the scarified between plant data to have increased between 2020 and 2021 (53 to 60%, 56 to 64% and 56 to 65% respectively).
  - All results, irrespective of depth, plant proximity or scarification indicated elevated salinity compared to the laboratory recommended guideline of 23.5mg/kg and 3.3% dS/m sandy soils).
  - A graphical examination of sodium at depth demonstrates a higher content was identified in the exchangeable sodium as a percentage (ESP) of the ECEC for all areas and plant proximities

    - From 2020 to 2021, unlike the EC, the ESP had all the 10-30cm depth samples recording a greater mean exchangeable sodium content. The non-scarified under plant sample set had the most differential in both 2020 and 2021. All the sample sets had a higher 2021 content than that identified in 2020 for the 0-10cm samples. This was also the case for the 10-30cm scarified data sets, however for the non-scarified, the under plant sample content dropped slightly, while the between plant sample set mean was approximately equal for the 2020 to 2021 comparison.
- Soil biological responses
    - Overall the Wild Harvest Site has observed stable results from the inclusion of saltbush. Over the sampling time period. Whilst there were no increases in alpha diversity, the background diversity was relatively high to begin with. Scarification had no detectable influence, and cannot be seen as detrimental to the soil biology (as assessed through soil bacteria) and its function
    - Increases in Actinobacteria in 2020, followed by decreases in 2021 due to scarification is likely due to the initial soil disturbance event, followed by stabilization, with a very common distribution of major phyla at the 0 to 10cm soil profile. Interestingly theses dynamic responses in the deeper soil profile had less of an impact by 2021 from either scarification or sample location.
    - Carbon and nitrogen cycling potential did increase over time, and is indicative of a healthy sol able to functionally provide carbon and nitrogen cycling process, these responses were more prominent in the upper soil profile and was not impacted by scarification. Importantly, the potential for all fractions of carbon was observed in both soil profiles and represents a high capacity for carbon cycling to occur at all levels from labile to recalcitrant. By 2021 only the smallest of differences in nitrogen cycling potential was observed in the non-scarified areas by sample location, with no changes in the scarified area being observed. This may be due to such high background nitrogen cycling capacity of the soil, and indeed the full spectrum of nitrogen cycling genes is a positive measure of soil biology ability to function in agriculture.

5.6. Plantation Site to Wild Harvest Site Comparison (2021)

A general comparison of the differences between 2020 and 2021 findings within two very different project locations and saline tolerant plant management strategies was conducted.

  - The Plantation Site had a reduction in electrical conductivity (EC) from 2019 to 2021 (263% to 243%), but was always well below than that within the Wild Harvest Site which increased from 2020 (783%-795%) to 2021 (822%-1397%).
  - The Plantation Site had a reduction in total carbon and total nitrogen from 2019 to 2021 (123% to 80% and 71% to 58% respectively), but both were well above than that within the Wild Harvest Site (carbon consistent 2020 and 2021 - 47-51%; nitrogen increased from 2020 - 22-24% to 2021 - 34-36%).

- Total Nitrogen - the Plantation Site decreased from 2019 to 2021 (71% to 58%), but was well above than that within the Wild Harvest Site which increased from 2020 (22-24%) to 2021 (34-36%).
  -
  - The Plantation Site also had a reduction in the effective cation exchange capacity (ECEC) from 2019 to 2021 (92% to 72%), but was always well below than that within the Wild Harvest Site which had a dominant increase in the scarified area from 2020 (214%) to 2021 (309%) with the non-scarified remaining the similar on average.
  - From a mineralogy perspective only manganese was higher in the Plantation Site compared to the Wild Harvest Site, whereas the Wild Harvest Site was higher for iron, magnesium, phosphorus, potassium, and sodium in different forms.

5.7. Additional Project Findings (2021)

- The two water production wells (Production Bore (Valley) 1 (PB1), Production Bore (Hill) 2 (PB2)) were installed adjacent to the Plantation Site in February 2020. The EC data identifies that the Production Bore 1 EC was 9.0dS/m, ~14% that of sea water and classified as within the drinking tolerance for sheep (7.5-14.9 dS/m, livestock can adapt without loss of production), but at the cusp of salinity for salt tolerant crops (8.1 dS/m) (Ref: Measuring salinity - Science notes Land series L137, Queensland Government publications (publications.qld.gov.au)). Production Bore 2 had an EC of 1.34dS/m, ~15% that of Production Bore 1, and ~2.4% if sea water, rendering it more of a brackish water EC. This analysis was conducted in March 2021. The soil samples extracted during the drilling of Production Bore 2 identified that the (a) pH generally was increasing with depth from 5.67 at 2 metres depth to 9.2 at 66 meters (b) electrical conductivity (EC) had a moderately consistent decreasing trend from 0.46 dS/m at 2 metres depth to 9.2dS/m at 66 meters (c) there was no consistent trend for the mineralogy analysis and (d) the effective cation exchange capacity (ECEC) decreased from 4.5cmol/kg at 2metres down the 2cmol/kg at 6metres and then rose steadily to 3.2cmol/kg at 54 metres
- Three shallow water table observation wells were drilled - within and adjacent to the Plantation Site and also within the Wild Harvest Site – and water depth, EC, and pH were recorded throughout 2021.
  - The observation well surface water depth within the Plantation Site dropped until late May and then rose for consistently until November when the first decline in water level was observed in the lead up to summer.
  - In contrast, the well adjacent to the Plantation Site water level rose from the start of the sampling in February until September with only a slight elevation in the July sample. Again the November analysis revealed a large drop in level back to the May/June recorded values.
  - The Wild Harvest Site water level results are more consistent across the duration of sampling with no trend up or down observed.
  - Both the Plantation Site observation wells identified a general trend of reducing EC throughout the majority of 2021 with an increase commencing towards the end of the year reflecting the reducing water level / dilution. The observation well within the Plantation Site had a significantly higher EC than that of the well adjacent to this area. The Wild Harvest Site observation well water had a greater EC recorded than for the Plantation Site well and did not reveal a consistent trend over the duration of sampling.

        - The significant elevation in water level from July to October was accompanied by significant drop in pH. This may be a result of the unusual season where the influx of water has brought more acidity from adjacent structures or anaerobic biological activities may have led to acidification in surface soils. This would need to be confirmed in a subsequent year of testing as the degree of change was surprising. Over the course of the records, the Plantation area has a greater degree of variation in pH than that observed within the Wild Harvest Site.
    - Saltbush plant tissue samples were taken in August 2021 two years after planting. It is noted that many of the plants were just starting to struggle with water logging at the time of sampling. Whilst this data was only one timestamp and not accompanied by harvest data, the indicative assessment relative to a CSIRO standard provides some insight regarding the salt removal by these plants. Salinity within the Wheatbelt Region is typically associated with sodium chloride.
        - The sodium content of the leaves had a mean of 6.23% (range 4.90% in Plot 1 to 6.99% in plot 4) and a consistently increasing trend from west to east across the Plantation Site. These values could be considered slightly below the comparative study (Norman et al., 2004). This has been observed in parallel to a west to east trend noted in the consistency of statistically significant results in Plots 1 and 2 which suggested the more western end of the Plantation Site had a greater propensity to recover and build ecosystems following a disturbance.
        - The Chloride content mean was 64,588mg/kg (6.46%) (range of 4.87% in Plot 1 to 7.33% within Plot 3), however there was not a consistent trend across the Plantation Site. These values were substantially lower than the comparative study (Norman et al., 2004).
        - Other cations were considered within the salt removal. Namely calcium (mean 0.63%, comparative - 0.73 to 0.85%, Norman et al., 2004), magnesium (mean 0.73%, comparative - (0.77-1.17%, Norman et al., 2004) and potassium (mean 2.36% - 2.66 to 3.83%, Norman et al., 2004) which were all lower than the respective ions of the comparative study.
    - Soil coverage was photographically assessed and analysed using histogram analysis within Adobe Photoshop®.
        - The mean coverage for the Plantation Site increased from 70% in 2020 (Plot 4 had a significantly higher soil coverage than Plots 2 and 3) to 87% in 2021 (no significant difference identified between plots). Plots 1, 2 and 3 had a statistically significant increase in coverage between 2020 and 2021. It is noted that the coverage was estimated at 0% at the completion of the Plantation Site preparation and 10-20% at the completion of the initial planting.

    - In 2020, the Non-Scarified plots in the Wild Harvest Site had greater coverage than the scarified (76% and 64% for Non-Scar Plot 1 and 2 respectively, and 70% for the total compared to 24% for the Scarified). After a year's growth, the soil coverage within the scarified versus individual non-scarified plots were no longer significantly different, however the combined non-scarified areas combined did demonstrate a higher coverage (78% versus 64%).
    - Between the sampling regimes of 2020 and 2021, the Scarified area increased in coverage (24% to 64%), the Non-Scarified Control Area 2 increased in coverage (64% to 77%), the combined Non-Scarified Control Area data increased in coverage (70% to 78%) and the overall Wild Harvest Site coverage increased (56% to 74%). The significance of the increase within only one of the control areas suggests that some (i.e. the Non-Scarified Control Area 2 had a significant increase), but not all (i.e. the Non-Scarified Control Area 1 had no significant change) of the improvement in coverage could be attributed to the different weather experienced within the growing season of 2021.
    - In the comparison of the 2021 data, the Plantation Site had a higher plant coverage than that identified in the Wild Harvest Site (87% compared to 74% respectively).
    - It is noted that the examination of coverage does not take into account the quality/longevity/height of coverage which must also be considered in the defining of environmental benefit and habitat/micro-climate creation.
    - It is also noted that when a comparison was made between the 2019 and 2021 data within the Plantation Site, the Total Carbon %, never regained the 2019 content highlighting the importance on soil coverage and minimal tilling to protect soil carbon and soil ecology for the development of saline impacted soils as well as highlighting the rate at which these systems recover when considering a timeframe for analysis of potential long term ecological benefits.
- Plant height was also recorded during the soil sampling regime of 2020 and 2021
    - The mean tree height for the Plantation Site increased from 76cm in 2020 to 124cm in 2021. There was no significant difference identified between the plots for either year, however from 2020 to 2021, Plots 1, 3 and 4 as well as the total Plantation Site had an increase in height. This was not surprising over that period, however it indicates that even with harvesting occurring at various times in between the two sampling regimes, a generally larger vertical habitat was evident in 2021 than in previous years. With both a greater soil coverage and tree height, the increase in habitat available which was visually evident has been reinforced through an objective analysis.

- Not surprisingly, in the 2020 analysis (4 months post scarification), the plant heights recorded for the Non-Scarified areas were approximately double that identified within the limited number of plants in the Scarified area (51cm and 25cm height respectively). A similar relative presentation was recorded for 2021 (63cm Combined Non-Scar relative to the 28cm height for the Scarified areas).
- From 2020 to 2021, the height data of both the Scarified Area plants and the combined Non-Scarified Area plants had both increased by approximately 12cm. It is noted that this was not a reflection on the potential harvest material from this area and so cannot be defined as a positive or negative reflection on the financial aspect of scarification, only the ecological impact.
- From an overall plant height data perspective, the Plantation Site had more than double the mean plant height when compared to the total Wild Harvest Site assessment across the two years, and 2021 demonstrated an 80% increase from the combined Plantation Site and Wild Harvest Site plant height of 2020.
- Within the second year, soil sampling and photographs for the Plantation Site were captured in August, after which point it is understood that a significant death of plants was noted due to water logging of the soils and a subsequent trim of all plants was conducted to promote regrowth where possible. Therefore the photographs and comments made apply only to that timestamp. The relative degree of environmental benefit through habitat creation is obviously negated by hard trimming or limited by harvesting. The project had potentially conflicting interests within this space of profitable enterprise and habitat / ecological system creation.
- Similarly whilst habitat creation can be commented on within the Wild Harvest Site without the imposition of harvesting (no harvest was undertaken for the duration of the trial), it is noted that the total area, with the exception of the smaller control plots, was scarified about 6 months into the trial. This process was soil scarification rather than plant scarification, removing the majority of plants from the scarified area would have significantly set back the habitat potential of the area early in the trial.
- Whilst the comparison has been made outlining the under plant versus between plant relationships for the scarified and non-scarified data, it is critical to note that for the scarified area there were approximately 5-10% (smaller) trees than those (larger) trees present within the non-scarified area. Hence the comments regarding an overall limitation in the positive nature of the under plant benefits within the Scarified area.

5.8. Project Objectives Addressed

The outcome of this study has highlighted the conflicting interest within the short term of a saltbush regenerative program coupled with a saltbush harvesting program on ecological systems.

It was apparent that the detrimental impact on the soil itself as a result of the preparation of the Plantation Site (broad area tilling and full landscape exposure rather than rehabilitation typical individual plant holes) had not been recovered by the conclusion of the trial where soil health is measured in terms of soil carbon. When considering the salinity indicators, the EC and sodium content of the 2021 analysed soils both under and between the plants was approximately equivalent to the 2019.

In the longer term however it is anticipated that salinity indicators will reduce and, should light harvesting be continued, the soil carbon and available mineral content as well as the above ground coverage and vertical habitat creation will increase. In turn this increase will provide ecological and environmental benefits potentially in excess of what was present prior to the project (note: pre-project measurements were not taken). However it is noted that in the Plantation Site where water logging due to unusually consistent heavy winter rains hampered the growth of the plants in 2021 and where heavy pruning was implemented, this benefit was significantly set back.

In the Plantation Site by 2021 there were increases in bacterial species richness for samples collected directly under the saltbush plants which is a positive outcome. This represents an increased biodiversity, and a greater functional capacity of the soil can be inferred. Increases in major Phyla of Actinobacteria, Firmicutes, and Proteobacteria represent major groups of bacteria involved in carbon and nitrogen cycling processes. This was evidenced with a high functional capacity through the predicted carbon and nitrogen cycling potential analysed through PICRUSt. The key take home message is that across the Plantation Site, there was a positive impact on the soil biology between 2020 and 2021, evident in the enhance bacterial diversity underneath the plants, as well increased carbon and nitrogen cycling capacity and this effect was duplicated at both soil depths. It is noted that no pre-impact DNA data is available.

Within the Wild Harvest Site the trial of scarification to enhance bush food plant growth demonstrated that, again in the short term and under the weather conditions of the project period, the ecological cost was significant with exposed soil subject to weathering and micro climate / habitat removal. This impact was marked by an overall increase in the 2020 to the 2021 samples for EC for the total data set which was dominated by the change in the scarified data set (0.79dS/m to 1.03dS/m and 0.78dS/m to 1.4dS/m respectively). The effective cation exchange capacity (ECEC, reflected in the exchangeable sodium content) as a salinity indicator also demonstrated a rise from 2020 to 2021 within both the under and between locations of the scarified area, whilst the non-scarified remained relatively consistent. The sodium content as a percentage (ESP) of the ECEC was lowest under plants, in the non-scarified soils and within the 0-10cm depth. With the larger area scarified and with the majority of plants within this area removed, the average salinity within the Wild Harvest Site has been significantly increased and the habitat markedly depleted within the short to medium term.

With respect to the DNA analysis, dynamic results of alpha and beta diversity for the Wild Harvest Site, and these data showed great variation between and within the sampling time periods. However, there was a clear outcome of scarification by 2021 having no detrimental impact to the soil bacterial community over the time frame of this trial. All changes to higher order phylum relative abundance appeared to be only minor changes from the impact of scarification, and this was reflected in the carbon and nitrogen cycling capacity to be relatively minor, and may be due to the carbon and nitrogen cycling genes being detected in relatively high proportions within the soil bacterial community. Overall, the key message is that the management practice of scarification can be continued with no detriment to the soil biological health as assessed by the bacterial community as quantified through DNA sequencing and subsequent analysis of functional genes pertaining to carbon and nitrogen cycling potential.

Unfortunately ground water sampling was only available for 2021 and therefore the long term impact of activities without the seasonal fluctuation could not be determined. This single year's data is presented as a high rainfall year example for comparison purposes in the future.

By the conclusion of the trial the total carbon within the Plantation Site had been generally re-established following the degradation incurred in the preparation for planting process. Future carbon behaviour is anticipated to continue this increasing trajectory, should the impact of the water logging within 2021 not be too severe. Salt Bush harvesting, excluding the incident of compaction as a risk of increased traffic within the area, should serve to promote soil carbon through regular shedding of root systems as the plant foliage is reduced and the promotion of new root systems during regrowth. Soil coverage within the Plantation Site bodes well for the preservation and growth of the soil flora and fauna community, further increasing both the carbon and the system's resilience to extreme events impacting plant and soil health.

Within the Wild Harvest Site, the under plant total carbon was higher than the between plant for the shallow soil depth in the non-scarified area in 2020, highlighting the benefit of root systems in promoting and protecting soil flora and fauna (represented by carbon measurement). This indicates that the plant coverage was developing and protecting carbon stores pre-scarification. For the 2021 samples, where no significant statistical difference was determined between the scarified and non-scarified samples, it suggests that with coverage the system is recovering. However it is noted that for the non-scarified area, a higher carbon content was identified under the plants compared to between in 2021 suggesting that the more plants that are available in the long term, the higher the system’s total carbon. The scarified area had minimal plants compared to the non-scarified area due to the scarification process. The elevated bush layer as opposed to the current, fine leaved ground cover / individual tiny plants is anticipated to take many years to return to pre-scarification levels.

The 2021 total nitrogen within the Plantation Site demonstrated a similar trend to the carbon, with the 2021 data sets all higher than those from 2020 and approaching the 2019 original levels. Such information highlights the importance of minimum tillage and keeping soil coverage in place to minimize the impact of topsoil (and its ecosystem’s) exposure to temperature swings, wind and sunlight.

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7. APPENDIX 1: Soil Sampling Tabulated Summary

7.1. Soil Sampling Tabulated Summary

Plantation Sampling 2019	**Treatment Sampling A**	EC, pH OM, TC, TN Nutrient Content	2 of 5 samples per plot (2), 4 plots (8), and two depths per sample (16)	A - 8 shallow samples and 8 deep samples Intensive analysis - EAL - Agricultural - Albrecht/Reams (RA-PACK-001) *	20 shallow samples and 8 deep samples total (<u>baseline plantation sample set</u>)
	Treatment Sampling B		3 of 5 samples per plot (3), 4 plots (12), and one depth per sample (12)	B - 12 shallow samples Reduced analysis - EAL - Agricultural - Standard A-1 (RA-PACK-004)**	
	Treatment Sampling A+B	BD	5 samples per plot (5), 4 plots (20), and two depths per sample (40)	A + B - 20 shallow samples and 20 deep samples - Bulk Density Analysis	20 shallow samples and 20 deep samples total (<u>baseline plantation sample set</u>)
Plantation Sampling 2020 - July - Aug 2020	**Treatment Sampling A**	Under plants EC, pH OM, TC, TN Nutrient Content Bulk Density	1 sample per plot/transect (1), under plants (1), 4 plots/transects (4), two depths 0-10 and 10-30cm (8 samples).	A - 4 shallow samples and 4 deep samples for under plants Intensive analysis - EAL - Agricultural - Albrecht/Reams (RA-PACK-001)*	12 shallow samples and 8 deep samples in total for under plant
	Treatment Sampling B		2 samples per plot/transect (2), under plants (2), 4 plots/transects (8), one depth 0-10cm (8 samples).	B - 8 shallow samples for under plants Reduced analysis - EAL - Agricultural - Standard A-1 (RA-PACK-004)**	
	Treatment Sampling A (duplicate samples)		1 sample per plot/transect (1), under plants (1), 4 plots/transects (4), two depths 0-10 and 10-30cm (8 samples).	A - 4 shallow samples and 4 deep duplicate samples for under plants BD analysis - EAL - Total Dry Weight (SS-PREP-017)	4 shallow samples and 4 deep samples in total for under plant
	Control A	Between Plantation Rows EC, pH OM, TC, TN Nutrient Content Bulk Density	1 sample per plot/transect (1), between plantation rows (1), 4 plots/transects (4), two depths 0-10 and 10-30cm (8 samples).	A - 4 shallow samples and 4 deep samples for between plants Intensive analysis - EAL - Agricultural - Albrecht/Reams (RA-PACK-001)*	12 shallow samples and 4 deep samples in total for between plantation rows
	Control B		2 samples per plot/transect (2), between plantation rows (2), 4 plots/transects (8), one depth 0-10cm (8 samples).	B - 8 shallow samples for between plants Reduced analysis - EAL - Agricultural - Standard A-1 (RA-PACK-004)**	
	Control A (duplicate samples)		1 sample per plot/transect (1), between plantation rows (1), 4 plots/transects (4), two depths 0-10 and 10-30cm (8 samples).	A - 4 shallow samples and 4 deep samples for between plants BD analysis - EAL - Total Dry Weight (SS-PREP-017)	4 shallow samples and 4 deep samples in total for between plant
	Treatment Sampling A	Under Plants DNA	1 sample per plot/transect (1), under plants (1), 4 plots/transects (4), two depths 0-10 and 10-30cm (8 samples).	A - 4 shallow samples and 4 deep samples for under plants (DNA)***	12 shallow samples and 4 deep samples in total for under plants (<u>baseline plantation sample set</u>)
	Treatment Sampling B		2 samples per plot/transect (2), under plants (2), 4 plots/transects (8), one depth 0-10cm (8 samples).	B - 8 shallow samples for under plants (DNA)***	
	Control A	Between Plantation Rows DNA	1 sample per plot/transect (1), between plantation rows (1), 4 plots/transects (4), two depths 0-10 and 10-30cm (8 samples).	A - 4 shallow samples and 4 deep samples for between plants (DNA)***	12 shallow samples and 4 deep samples in total for between plants (<u>baseline plantation sample set</u>)
	Control B		2 samples per plot/transect (2), between plantation rows (2), 4 plots/transects (8), one depth 0-10cm (8 samples).	A - 8 shallow samples for between plants (DNA)***	

Plantation Sampling 2021 - July - Aug 2021	**Treatment Sampling A**	Under plants EC, pH OM, TC, TN Nutrient Content Bulk Density	1 sample per plot/transect (1), under plants (1), 4 plots/transects (4), two depths 0-10 and 10-30cm (8 samples).	A - 4 shallow samples and 4 deep samples for under plants Intensive analysis - EAL - Agricultural - Albrecht/Reams (RA-PACK-001)*	12 shallow samples and 8 deep samples in total for under plant
	Treatment Sampling B		2 samples per plot/transect (2), under plants (2), 4 plots/transects (8), one depth 0-10cm (8 samples).	B - 8 shallow samples for under plants Reduced analysis - EAL - Agricultural - Standard A-1 (RA-PACK-004)**	
	Treatment Sampling A (duplicate samples)		1 sample per plot/transect (1), under plants (1), 4 plots/transects (4), two depths 0-10 and 10-30cm (8 samples).	A - 4 shallow samples and 4 deep duplicate samples for under plants BD analysis - EAL - Total Dry Weight (SS-PREP-017)	4 shallow samples and 4 deep samples in total for under plant
	Control A	Between Plantation Rows EC, pH OM, TC, TN Nutrient Content Bulk Density	1 sample per plot/transect (1), between plantation rows (1), 4 plots/transects (4), two depths 0-10 and 10-30cm (8 samples).	A - 4 shallow samples and 4 deep samples for between plants Intensive analysis - EAL - Agricultural - Albrecht/Reams (RA-PACK-001)*	12 shallow samples and 4 deep samples in total for between plantation rows
	Control B		2 samples per plot/transect (2), between plantation rows (2), 4 plots/transects (8), one depth 0-10cm (8 samples).	B - 8 shallow samples for between plants Reduced analysis - EAL - Agricultural - Standard A-1 (RA-PACK-004)**	
	Control A (duplicate samples)		1 sample per plot/transect (1), between plantation rows (1), 4 plots/transects (4), two depths 0-10 and 10-30cm (8 samples).	A - 4 shallow samples and 4 deep samples for between plants BD analysis - EAL - Total Dry Weight (SS-PREP-017)	4 shallow samples and 4 deep samples in total for between plant
	Treatment Sampling A	Under Plants DNA	1 samples per plot/transect (1), under plants (1), 4 plots/transects (4), two depths 0-10 and 10-30cm (8 samples).	A - 4 shallow samples and 4 deep samples for under plants (DNA)***	12 shallow samples and 4 deep samples in total for under plants
	Treatment Sampling B		2 samples per plot/transect (2), under plants (2), 4 plots/transects (8), one depth 0-10cm (8 samples).	B - 8 shallow samples for under plants (DNA)***	
	Control A	Between Plantation Rows DNA	1 samples per plot/transect (1), between plantation rows (1), 4 plots/transects (4), two depths 0-10 and 10-30cm (8 samples).	A - 4 shallow samples and 4 deep samples for between plants (DNA)***	12 shallow samples and 4 deep samples in total for between plants
	Control B		2 samples per plot/transect (2), between plantation rows (2), 4 plots/transects (8), one depth 0-10cm (8 samples).	A - 8 shallow samples for between plants (DNA)***	

NOTES:

***RA-PACK-001 -** Includes pH and EC (1:5 water); Available Calcium, Magnesium, Potassium, Ammonium, Nitrate, Phosphate, Sulfur; Exchangeable Sodium, Potassium, Calcium, Magnesium, Hydrogen, Aluminium, Cation Exchange Capacity; Bray I and II, Phosphorus; Colwell Phosphorus; Available Micronutrients Zinc, Manganese, Iron, Copper, Boron, ilicon; Total Carbon (TC), Total Nitrogen (TN), Organic Matter, TC/TN Ratio; Basic Colour, Basic Texture.

****RA-PACK-004 -** Includes pH and EC (1:5 water); Exchangeable Sodium, Potassium, Calcium, Magnesium, Hydrogen, Aluminium, Cation Exchange Capacity; Bray I Phosphorus; Total Carbon (TC), Total Nitrogen (TN), Organic Matter; Basic Colour, Basic Texture.

*****DNA -** Soil bacterial community analyses using molecular DNA techniques now provide more quantitative and informative analysis of microbial communities than traditional laboratory techniques.

Wild Harvest Sampling 2020 - July - Sep 2020	**Treatment Sampling A**	Treatment - scarified EC, pH OM, TC, TN Nutrient Content Bulk Density	5 samples per plot/transect combined (1), under versus between plants (2), 4 plots/ transects (8), two depths 0-10 and 10-30cm (16 samples)	A - 8 shallow composite samples and 8 deep composite samples (4 under and 4 between) Intensive analysis - EAL - Agricultural - Albrecht/Reams (RA-PACK-001)*	10 shallow composite samples (5) and 4 deep composite (5) samples for each plant proximity (baseline wild harvest sample set)
	Treatment Sampling B		5 samples per plot/transect combined (1), under versus between plants (2), 6 plots/ transects (12), one depth 0-10cm (12 samples)	B - 12 shallow composite samples (6 under and 6 between) Reduced analysis - EAL - Agricultural - Standard A-1 (RA-PACK-004)**	
	Treatment Sampling A (Duplicate Samples)		5 samples per plot/transect combined (1), under versus between plants (2), 4 plots/ transects (8), two depths 0-10 and 10-30cm (16 samples)	A - 8 shallow composite samples and 8 deep composite samples (4 under and 4 between) BD analysis - EAL - Total Dry Weight (SS-PREP-017)	8 shallow composite samples (4x2) and 8 deep composite (4x2) samples for each plant proximity (baseline wild harvest sample set)
	Control A	Control - no scarification EC, pH OM, TC, TN Nutrient Content Bulk Density	5 samples per plot/transect combined (1), under versus between plants (2), 4 plots/ transects (8), two depths 0-10 and 10-30cm (16 samples)	A - 8 shallow composite samples and 8 deep composite samples (4 under and 4 between) Intensive analysis - EAL - Agricultural - Albrecht/Reams (RA-PACK-001)*	10 shallow composite samples (5) and 4 deep samples composite (5) for each plant proximity (baseline wild harvest sample set)
	Control B		5 samples per plot/transect combined (1), under versus between plants (2), 6 plots/ transects (12), one depth 0-10cm (12 samples)	B - 12 shallow composite samples (6 under and 6 between) Reduced analysis - EAL - Agricultural - Standard A-1 (RA-PACK-004)**	
	Control A (Duplicate Samples)		5 samples per plot/transect combined (1), under versus between plants (2), 4 plots/ transects (8), two depths 0-10 and 10-30cm (16 samples)	A - 8 shallow composite samples and 8 deep composite samples (4 under and 4 between) BD analysis - EAL - Total Dry Weight (SS-PREP-017)	8 shallow composite samples (4x2) and 8 deep composite (4x2) samples for each plant proximity (baseline wild harvest sample set)
	Treatment Sampling A	DNA	5 samples per plot/transect combined (1), under versus between plants (2), 4 plots/ transects (8), two depths 0-10 and 10-30cm (16 samples)	A - 5 samples combined into 1 average per plot, 4 plots, 0-10 and 10-30cm (DNA)***	10 shallow composite samples (5) and 4 deep composite (5) samples for each plant proximity (baseline wild harvest sample set)
	Treatment Sampling B		5 samples per plot/transect combined (1), under versus between plants (2), 6 plots/ transects (12), one depth 0-10cm (12 samples)	B - 5 samples combined into 1 average per plot, 6 plots, 0-10 cm (DNA)***	
	Control A	DNA	5 samples per plot/transect combined (1), under versus between plants (2), 4 plots/ transects (8), two depths 0-10 and 10-30cm (16 samples)	A - 5 samples combined into 1 average per plot, 4 plots, 0-10 and 10-30cm (DNA)***	10 shallow composite samples (5) and 4 deep samples composite (5) for each plant proximity (baseline wild harvest sample set)
	Control B		5 samples per plot/transect combined (1), under versus between plants (2), 6 plots/ transects (12), one depth 0-10cm (12 samples)	B - 5 samples combined into 1 average per plot, 6 plots, 0-10 cm (DNA)***	

Wild Harvest Sampling 2021 - July - Sep 2021	**Treatment Sampling A**	Treatment - scarified EC, pH OM, TC, TN Nutrient Content Bulk Density	5 samples per plot/transect combined (1), under versus between plants (2), 4 plots/ transects (8), two depths 0-10 and 10-30cm (16 samples)	A - 4 equi-spaced combined transects, 0-10cm and 10-30cm, under plant and between plants Intensive analysis - EAL - Agricultural - Albrecht/Reams (RA-PACK-001)*	10 shallow composite samples (5) and 4 deep composite (5) samples for each plant proximity
	Treatment Sampling B		5 samples per plot/transect combined (1), under versus between plants (2), 6 plots/ transects (12), one depth 0-10cm (12 samples)	B - 6 equi-spaced combined transects, 0-10cm, under plant and between plants Reduced analysis - EAL - Agricultural - Standard A-1 (RA-PACK-004)**	
	Treatment Sampling A (Duplicate Samples)		5 samples per plot/transect combined (1), under versus between plants (2), 4 plots/ transects (8), two depths 0-10 and 10-30cm (16 samples)	A - 8 shallow composite samples and 8 deep composite samples (4 under and 4 between) BD analysis - EAL - Total Dry Weight (SS-PREP-017)	8 shallow composite samples (4x2) and 8 deep composite (4x2) samples for each plant proximity
	Control A	Control - no scarification EC, pH OM, TC, TN Nutrient Content Bulk Density	5 samples per plot/transect combined (1), under versus between plants (2), 4 plots/ transects (8), two depths 0-10 and 10-30cm (16 samples)	A - 4 equi-spaced combined transects, 0-10cm and 10-30cm, under plant and between plants Intensive analysis - EAL - Agricultural - Albrecht/Reams (RA-PACK-001)*	10 shallow composite samples (5) and 4 deep samples composite (5) for each plant proximity
	Control B		5 samples per plot/transect combined (1), under versus between plants (2), 6 plots/ transects (12), one depth 0-10cm (12 samples)	A - 6 equi-spaced combined transects, 0-10cm, under plant and between plants Reduced analysis - EAL - Agricultural - Standard A-1 (RA-PACK-004)**	
	Control A (Duplicate Samples)		5 samples per plot/transect combined (1), under versus between plants (2), 4 plots/ transects (8), two depths 0-10 and 10-30cm (16 samples)	A - 8 shallow composite samples and 8 deep composite samples (4 under and 4 between) BD analysis - EAL - Total Dry Weight (SS-PREP-017)	8 shallow composite samples (4x2) and 8 deep composite (4x2) samples for each plant proximity
	Treatment Sampling A	DNA	5 samples per plot/transect combined (1), under versus between plants (2), 4 plots/ transects (8), two depths 0-10 and 10-30cm (16 samples)	A - 5 samples combined into 1 average per plot, 4 plots, 0-10 and 10-30cm (DNA)***	10 shallow composite samples (5) and 4 deep composite (5) samples for each plant proximity
	Treatment Sampling B		5 samples per plot/transect combined (1), under versus between plants (2), 6 plots/ transects (12), one depth 0-10cm (12 samples)	B - 5 samples combined into 1 average per plot, 6 plots, 0-10 cm (DNA)***	
	Control A	DNA	5 samples per plot/transect combined (1), under versus between plants (2), 4 plots/ transects (8), two depths 0-10 and 10-30cm (16 samples)	A - 5 samples combined into 1 average per plot, 4 plots, 0-10 and 10-30cm (DNA)***	10 shallow composite samples (5) and 4 deep samples composite (5) for each plant proximity
	Control B		5 samples per plot/transect combined (1), under versus between plants (2), 6 plots/ transects (12), one depth 0-10cm (12 samples)	B - 5 samples combined into 1 average per plot, 6 plots, 0-10 cm (DNA)***	

NOTES:

***RA-PACK-001 -** Includes pH and EC (1:5 water); Available Calcium, Magnesium, Potassium, Ammonium, Nitrate, Phosphate, Sulfur; Exchangeable Sodium, Potassium, Calcium, Magnesium, Hydrogen, Aluminium, Cation Exchange Capacity; Bray I and II, Phosphorus; Colwell Phosphorus; Available Micronutrients Zinc, Manganese, Iron, Copper, Boron, ilicon; Total Carbon (TC), Total Nitrogen (TN), Organic Matter, TC/TN Ratio; Basic Colour, Basic Texture.

****RA-PACK-004 -** Includes pH and EC (1:5 water); Exchangeable Sodium, Potassium, Calcium, Magnesium, Hydrogen, Aluminium, Cation Exchange Capacity; Bray I Phosphorus; Total Carbon (TC), Total Nitrogen (TN), Organic Matter; Basic Colour, Basic Texture.

*****DNA -** Soil bacterial community analyses using molecular DNA techniques now provide more quantitative and informative analysis of microbial communities than traditional laboratory techniques.

8. APPENDIX 2: Plantation Site Baseline Sample Analysis 2019

8.1. Plot Comparison Summary

Full outlier and differential analysis of the data contributing to the below tables can be provided on request.

Table APP2.1: Summary of Means, Difference between Plantation Site Plot results for 0-10cm and Difference between all results of 0-10cm compared to 10-30cm – pH, EC, Total C, Total N, C/N Ratio and CEC

Soil Property	pH	EC	Total C	Total N	C/N Ratio	Effective Cation Exchange Capacity
Units		dS/m	%	%		cmol+/kg
	(1:5 Water)	(1:5 Water)	(LECO Trumac Analyser)			(Sum of Ca, Mg, K, Na, Al, H)
Mean Plot1	5.57	0.26	1.89	0.12	15.86	5.43
Mean Plot2	5.99	0.53	2.93	0.21	14.40	10.07
Mean Plot3	6.20	0.20	2.76	0.15	18.39	6.24
Mean Plot4	5.93	0.57	2.22	0.14	16.33	8.44
Overall mean	5.92	0.39	2.45	0.15	16.25	7.55
Number of Outliers	1	2	0	2	1	1
Differences in Mean Total	1:2, 1:3	Nil	1:2	1:2	2:4	1:2, 1:4, 2:3
Differences in Mean Total (Outliers removed)	1:3 only	Nil	N/A	Nil	2:3, 2:4	1:2, 1:4, 2:3
Mean 0-10cm	6.03	0.20	2.50	0.17	14.63	6.64
Mean 10-30cm	6.64	0.15	0.61	0.04	17.53	4.47
Number of Outliers	1 total set	1 total set	2 total set 1 10-30cm	2 10-30cm	1 total set	Nil
Difference in Mean Total	Yes	No	Yes	Yes	No	No
Differences in Mean Total (Outliers removed)	Yes	No	Yes	Yes	No	N/A
Comments		> 0.86 salt tolerant plants only				
EAL Indicative Guidelines (L = Loam)	Clay L: 6.50 **L: 6.30** L Sand : 6.30	0.15 **0.12** 0.10	>2.6 **>2.0** >1.4	>0.25 **>0.20** >0.15	10–12 **10–12** 10–12	14.3 **7.80** 3.30

Key points:

- Moderately to low pH
- Moderately high EC
- Plot 2 was often different other plots.
- Moderately low C
- Low N content relative to C. Plot 2 has high nitrogen outliers (see Appendix 2).
- High C/N ratios suggest a depletion of organic nitrogen
- Moderate ECEC mean, but with significant range.
- pH was higher and the Total C and N lower with greater depth (i.e. 0-10cm Vs 10-30cm)

Table APP2.2: Summary of Means, Difference between Plantation Site Plot results for 0-10cm and Difference between all results of 0-10cm compared to 10-30cm – Soluble, Exchangeable and Base Saturation Calcium and Magnesium

Soil Property	Soluble Calcium*	Exchangeable Calcium	Base Saturation of Calcium	Soluble Magnesium*	Exchangeable Magnesium	Base Saturation of Magnesium
Units	mg/kg	mg/kg	%	mg/kg	mg/kg	%
Mean Plot1	343.10	638.74	59.70	104.88	123.53	18.60
Mean Plot2	539.61	1008.84	50.89	155.89	238.62	19.75
Mean Plot3	213.69	566.54	45.98	148.76	235.68	31.11
Mean Plot4	333.53	596.45	36.65	269.26	322.34	31.48
Overall mean	357.48	702.64	48.31	169.70	230.04	25.23
Number of Outliers		1	1		0	0
Differences in Mean Total		1:2, 2:3, 2:4	1:4, 2:4		1:2, 1:4	1:3, 1:4, 2:3, 2:4
Differences in Mean Total (Outliers removed)		2:3, 2:4	1:4, 2:4		N/A	N/A
Mean 0-10cm	357.48	700.22	52.41	169.70	216.40	27.19
Mean 10-30cm	260.62	410.81	42.07	146.52	170.83	33.91
Number of Outliers	Nil	Nil	Nil	1 total set 1 0-10cm	1 total set	Nil
Difference in Mean Total	No	No	No	No	No	No
Differences in Mean Total (Outliers removed)	N/A	N/A	N/A	No	No	N/A
Comments	*only two samples per plot at two depths			*only two samples per plot at two depths		
EAL Indicative Guidelines (L = Loam)	Clay L: 750 **L: 375** L Sand : 175	2150 **1000** 375	75.7 **65.6** 57.4	105 **60** 25	200 **145** 75.0	11.9 **15.7** 18.1

Key points:

- Generally low calcium
- Plot 2 – higher/recommended Exchangeable Calcium compared to all other plots (multiple samples within plot had this higher value)
- Plot 4 – lower Base Saturation calcium compared to all other plots (multiple samples within plot had this higher value)
- Generally high Mg.
- Plot 1 – lowest for Mg across the board,
- Neither Ca nor Mg demonstrated differences with depth (i.e. 0-10cm Vs 10-30cm)

Table APP2.3: Summary of Means, Difference between Plantation Site Plot results for 0-10cm and Difference between all results of 0-10cm compared to 10-30cm – Soluble, Exchangeable and Base Saturation Potassium and Sources of Nitrogen.

Soil Property	Soluble Potassium*	Exchangeable Potassium	Base Saturation of Potassium	Nitrate Nitrogen*	Ammonium Nitrogen*
Units	mg/kg	mg/kg	%	mg/kg	mg/kg
Mean Plot1	71.91	96.37	2.77	3.36	9.87
Mean Plot2	63.02	91.46	2.10	4.51	15.58
Mean Plot3	N/A	73.10	2.23	2.91	11.10
Mean Plot4	56.66	72.05	1.97	13.98	12.38
Overall mean	63.86	82.75	2.27	6.19	12.23
Number of Outliers		1	1		
Differences in Mean Total		Nil*	No		
Differences in Mean Total (Outliers removed)		N/A*	No		
Mean 0-10cm	63.86	99.71	2.81	6.19	12.23
Mean 10-30cm	61.18	107.02	2.01	1.78	2.22
Number of Outliers		Nil	1 total set 1 0-10cm	1 total set 1 0-10cm	Nil
Difference in Mean Total		No	No	No	Yes
Differences in Mean Total (Outliers removed)		N/A*	No	Yes	N/A
Comments	*only two samples per plot *11 of 16 values combined for two depths registering as <50mg/kg present	* where <50 is substituted as =50, so limited insight		*only two samples per plot at two depths	*only two samples per plot at two depths
EAL Indicative Guidelines (L = Loam)	Clay L: 75 **L: 60** L Sand : 50	190 **150** 100	3.50 **5.25** 9.10	12.5 **10.0** 10.0	18.0 **15.0** 12.0

Key points:

- Significant number of <50mg/kg results within the soluble potassium depth comparison
- Very low exchangeable and base saturation potassium with no difference between the plot means nor the depth means for these two soil characteristics.
- Nitrate Nitrogen – extreme outlier within plot 4 – Plot 1: 3.85, 2.87, Plot 2: 3.71, 5.31, Plot 3: 2.84, 2.98, Plot 4: 6.71, 21.3 (no repeat of the high value in the 10-30cm sample) – Otherwise considered very low contribution to total N.
- Ammonium Nitrogen – good to moderately low in content. Significant decrease in 10-30cm.

Table APP2.4: Summary of Means, Difference between Plot results for 0-10cm and Difference between all results of 0-10cm compared to 10-30cm – Soluble and Extractable Phosphorus, plus Exchangeable Sodium.

Soil Property	Soluble Phosphorus*,**	Phosphorus (Bray 1)	Phosphorus (Bray 2)*	Phosphorus (Colwell)*	Exchangeable Sodium	Exchangeable Sodium Percent - ESP
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%
Mean Plot1	2.32	12.10	21.39	16.73	222.46	16.91
Mean Plot2	2.40	8.87	22.04	21.81	638.90	26.31
Mean Plot3	3.21	24.06	55.95	41.66	293.16	19.53
Mean Plot4	3.37	16.58	29.12	20.99	590.84	28.75
Overall mean	2.83	15.40	32.12	25.30	436.34	22.87
Number of Outliers		2			1	0
Differences in Mean Total		1:3, 2:3, 2:4			No	No
Differences in Mean Total (Outliers removed)		1:3, 2:3, 2:4			No	N/A
Mean 0-10cm	2.83	14.85	32.12	25.30	249.32	16.17
Mean 10-30cm	1.26	4.55	7.21	11.85	204.86	21.19
Number of Outliers	1 0-10cm	1 total set 1 0-10cm 1 10-30cm	1 total set 1 0-10cm 1 10-30cm	1 total set 1 0-10cm 1 10-30cm	Nil	Nil
Difference in Mean Total		Yes	Yes	No	No	Yes
Differences in Mean Total (Outliers removed)		Yes	Yes	Yes	N/A	N/A
Comments	*only two samples per plot **5 of 8 10-30cm values <1mg/kg		*only two samples per plot at two depths	*only two samples per plot at two depths	Very high	Very High
EAL Indicative Guidelines (L = Loam)	Clay L: 12 **L: 10** L Sand : 5	30 **24** 20	60 **48** 40	50 **45** 35	59.8 **50.6** 25.3	1.80 **2.89** 3.30

Key points:

- Significant number of <1mg/kg in the 10-30cm results for the soluble phosphorus therefore depth differential not valuable.
- Bray 1 – two high outliers increasing Plot 3 mean, however removal does not impact mean difference. Difference in mean identified for low Plot 2 and high Plot 3. Moderately low content. Significant difference in depth means.
- Bray 2 and Colwell reflect same Plot 3 high, overall low P content, and significant depth differences in mean.
- Exchangeable Sodium – single high outlier within Plot 2 and two high values within Plot 4, however lowest value still ~ double guideline.
- ESP – No outliers and no difference in plot means. Difference in depth mean with higher content at depth. Overall reinforcement of very high Na content of soil relative to guidelines.

Table APP2.5: Summary of Means, Difference between Plot results for 0-10cm and Difference between all results of 0-10cm compared to 10-30cm –Exchangeable and Base Saturation Aluminium and Hydrogen, plus Mg/Ca Ratio and Sulfur.

Soil Property	Exchangeable Aluminium	Base Saturation of Aluminium	Exchangeable Hydrogen*,**	Base Saturation of Hydrogen	Ca/Mg Ratio	Sulfur*
Units	mg/kg	%	cmol+/kg	%		mg/kg
Mean Plot1	5.29	1.08	0.05	0.95	3.30	26.51
Mean Plot2	3.89	0.46	0.07	0.50	2.60	34.21
Mean Plot3	3.72	0.64	0.03	0.50	1.60	15.40
Mean Plot4	4.25	0.66	0.04	0.49	1.18	34.46
Overall mean	4.29	0.71	0.05	0.61	2.17	27.64
Number of Outliers	0	1	1	0	1	
Differences in Mean Total	No	1:2, 1:3	No	No	1:3, 1:4, 2:4	
Differences in Mean Total (Outliers removed)	N/A	1:2, 1:3, 1:4, 2:4	No	N/A	1:3	
Mean 0-10cm	0.54	0.54	0.06	0.88	2.19	27.64
Mean 10-30cm	0.45	0.45	0.02	0.37	1.47	21.65
Number of Outliers	1 total set 1 0-10cm 1 10-30cm	1 total set 1 0-10cm 1 10-30cm	Nil	1 total set 1 10-30cm	Nil	1 0-10cm 1 10-30cm
Difference in Mean Total	Yes	No		No	No	No
Differences in Mean Total (Outliers removed)	Yes	No		Yes	N/A	Yes
Comments			*5 of 8 10-30cm values <1mg/kg **All mg/kg values <1 mg/kg, so Cmol/kg substituted			*only two samples per plot at two depth
EAL Indicative Guidelines (L = Loam)	Clay L: 45.0 **L: 32.4** L Sand : 13.5	7.10 **10.5** 12.1	0.50 **0.4 cmol+/kg** 0.20	7.10 **10.5** 12.1	6.35 **4.17** 3.17	8.0 **8.0** 7.0

Key points:

- Exchangeable Al – no outliers, no difference in means between plots, difference in means between sample depths. Consistent high outlier in depth comparison in Plot 1. Single <1 mg/kg results within Plot 3 10-30cm depth. Low Exchangeable Al.
- Base Sat Al – single high outlier in Plot4, difference in means between plots, but not between depths. Very low Base Saturation Al.
- Exchangeable H – majority of values <1 mg/kg, therefore Cmol+/kg has been used for comparison. Single high outlier in Plot 2, four <0.01cmol/kg. Five of the eight subsurface samples <0.01cmol/kg, therefore depth comparison was not valuable. Very low H.
- Base Sat H – diverse results leading to no identified outliers nor difference in plot means for 0-10cm depth. All values indicate very low H. Five of the eight subsurface samples 0% and with a high outlier also present, the depth comparison was not valuable. Very low H.

- Ca/Mg Ratio – Single high outlier with no impact on difference of mean present between plots. Low Ca and high Mg has led to low ratio results. Ratio higher in 0-10cm over 10-30cm.
- Sulfur – Low outlier for 0-10cm Plot 3 and high outlier for 10-30cm Plot 1. Once removed, there was a discernable difference between surface and subsurface samples. Very high sulfur ~3 times indicative guidelines.

Table APP2.6: Summary of Means, Difference between all results of 0-10cm compared to 10-30cm –Available Micro Nutrients – Zinc, Manganese, Iron, Copper, Boron and Silicon.

Soil Property	Available Micro Nutrient - Zinc*	Available Micro Nutrient - Manganese*	Available Micro Nutrient - Iron*	Available Micro Nutrient - Copper*,**	Available Micro Nutrient - Boron*	Available Micro Nutrient - Silicon*
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Mean Plot1	1.11	5.11	226.12	0.22	0.85	22.78
Mean Plot2	1.83	8.99	244.47	0.53	1.54	35.47
Mean Plot3	0.76	2.50	115.45	0.12	0.77	16.06
Mean Plot4	1.16	4.31	134.28	0.25	1.33	26.92
Overall mean	1.22	5.23	180.08	0.28	1.12	25.30
Number of Outliers						
Differences in Mean Total						
Differences in Mean Total (Outliers removed)						
Mean 0-10cm	1.22	5.23	180.08	0.28	1.12	25.30
Mean 10-30cm	N/A	1.40	31.41	0.23	0.91	15.64
Number of Outliers	Nil	1 total set 1 10-30cm	1 total set	Nil	Nil	1 total set
Difference in Mean Total	N/A	Yes	Yes	No	No	Yes
Differences in Mean Total (Outliers removed)	N/A	Yes	Yes	N/A	N/A	Yes
Comments	*only two samples per plot at two depths ** 8 of 8 samples 10-30cm values	*only two samples per plot at two depths	*only two samples per plot at two depths	*only two samples per plot at two depths ** 4 of 8 samples 10-30cm values	*only two samples per plot at two depths	*only two samples per plot at two depths
EAL Indicative Guidelines (L = Loam)	Clay L: 5.00 **L: 4.00** L Sand : 3.00	22.0 **18.0** 15.0	22.0 **18.0** 15.0	2.00 **1.60** 1.20	1.70 **1.40** 1.00	45.0 **40.0** 35.0

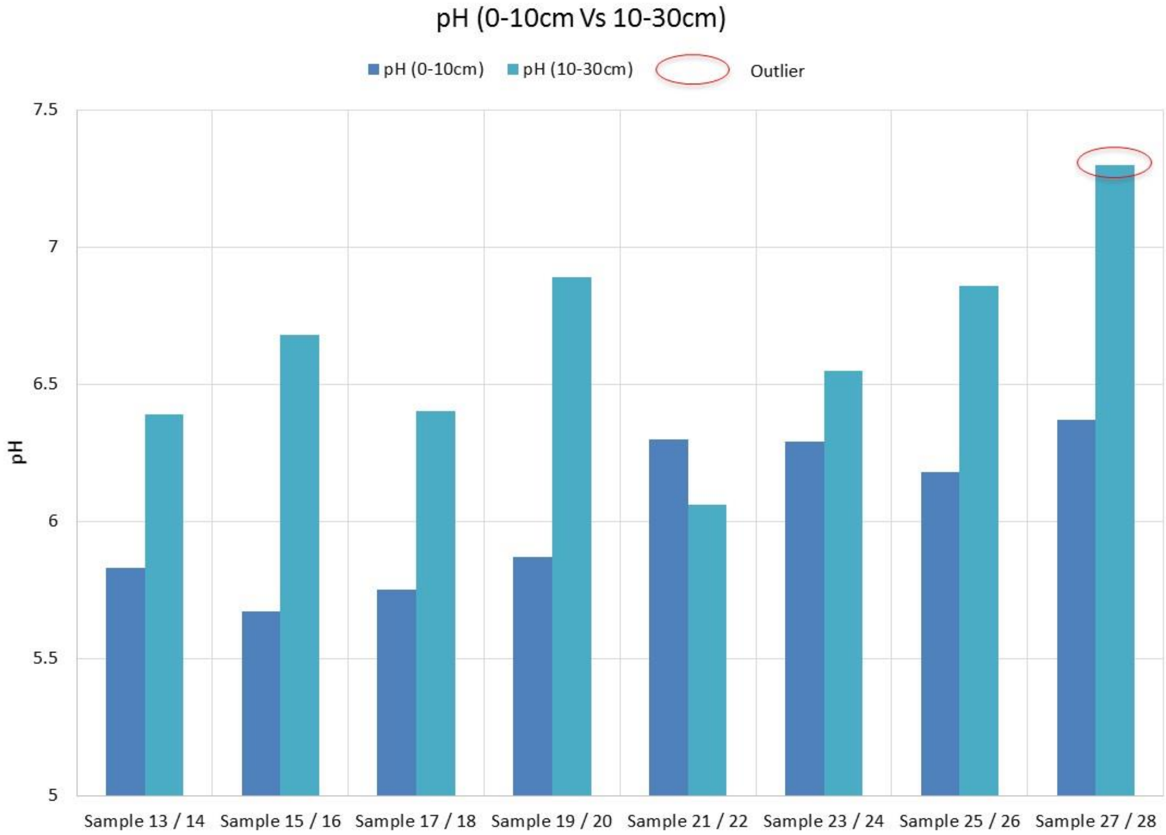
Key points:

- Zn – No outliers 0-10cm. All 10-30cm samples contain <0.05mg/kg. Low Zn content.
- Mn – No outliers 0-10cm. Single high outlier 10-30cm. Depth difference in mean with significantly less present in subsurface. Low Mn content.
- Fe –Single high outlier combined 0-10cm and 10-30cm. Depth difference in mean with significantly less present in subsurface. High Fe content. (*Note: check sampling equipment*)
- Cu – No outliers. Four of eight 10-30cm samples contain <0.1mg/kg. No depth difference in mean. Low Cu content.
- B – No outliers. No depth difference in mean. Moderately low Boron content.
- Si –Single high outlier combined 0-10cm and 10-30cm. Depth difference in mean with significantly less present in subsurface. Moderately low Si content.

8.2. Detailed Additional 2019 Plantation Data

8.2.1. 2019 Plantation Soil pH

"Soil pH - A water pH > 6.5 or CaCl2 pH > 5.5 indicates no major problem… Soils with pH < 4.5 often have high exchangeable hydrogen and aluminium (…with high % hydrogen and aluminium base saturation)." (EAL Laboratories, 2020)



Note: Plot 1 = Sample 13 (0-10cm) / 14 (10-30cm) and Sample 15 (0-10cm) / 16 (10-30cm)
Plot 2 = Sample 17 (0-10cm) / 18 (10-30cm) and Sample 19 (0-10cm) / 20 (10-30cm)
Plot 3 = Sample 21 (0-10cm) / 22 (10-30cm) and Sample 23 (0-10cm) / 24 (10-30cm)
Plot 4 = Sample 25 (0-10cm) / 26 (10-30cm) and Sample 27 (0-10cm) / 28 (10-30cm)

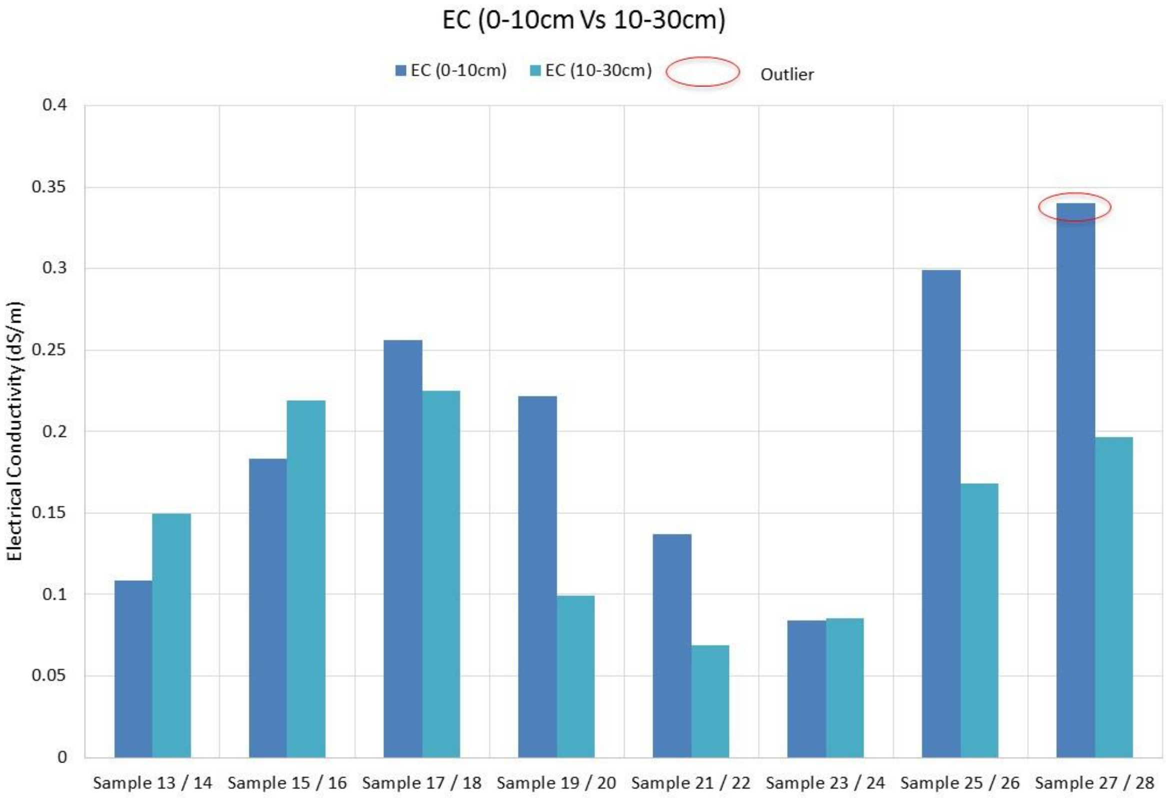
Mean Differential 0.609
No outliers from individual sets, however 7.3 sits as outlier to combined sets.

Interesting that 0-10cm higher pH plot has less extreme subsurface pH

*Note that other property testing has established that the Sample 21/22 was a true reading albeit inverse to other locations.

8.2.2. 2019 Plantation Soil EC (1:5 water)

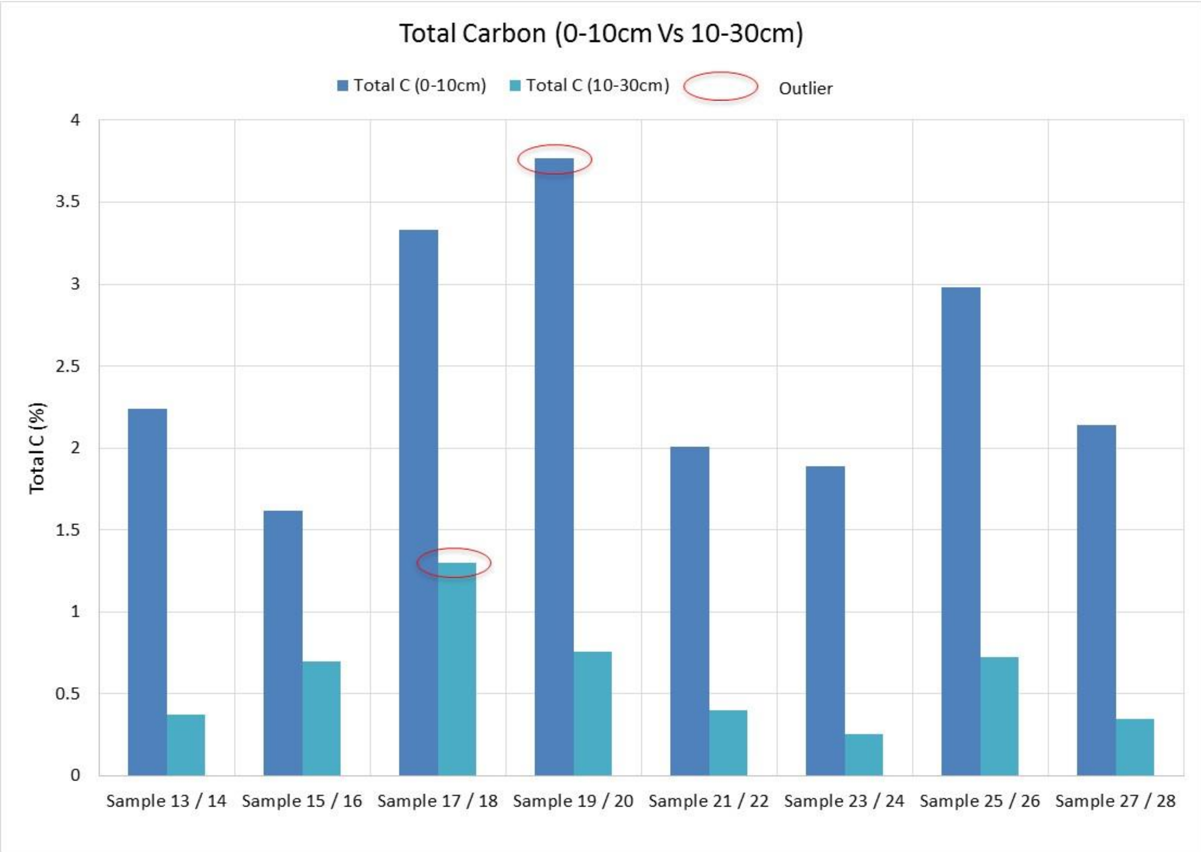
"Soil Salinity - An electrical conductivity (EC) greater than the texture guidelines… may indicate a salinity issue. If the Exchangeable Sodium Percentage (ESP) or % Exchangeable Sodium is > 5% you may have a salt issue. High EC (1:5 water) soils can have elevated chloride concentrations." (EAL Laboratories, 2020)



Note: Plot 1 = Sample 13 (0-10cm) / 14 (10-30cm) and Sample 15 (0-10cm) / 16 (10-30cm)
Plot 2 = Sample 17 (0-10cm) / 18 (10-30cm) and Sample 19 (0-10cm) / 20 (10-30cm)
Plot 3 = Sample 21 (0-10cm) / 22 (10-30cm) and Sample 23 (0-10cm) / 24 (10-30cm)
Plot 4 = Sample 25 (0-10cm) / 26 (10-30cm) and Sample 27 (0-10cm) / 28 (10-30cm)

Mean Differential 0.052
No outliers from individual sets, however 0.34 sits as outlier to combined sets.
Interesting that 0-10cm mixed values relative in EC (1:5 water) to 10-30cm

8.2.3. 2019 Planation Soil Total Carbon

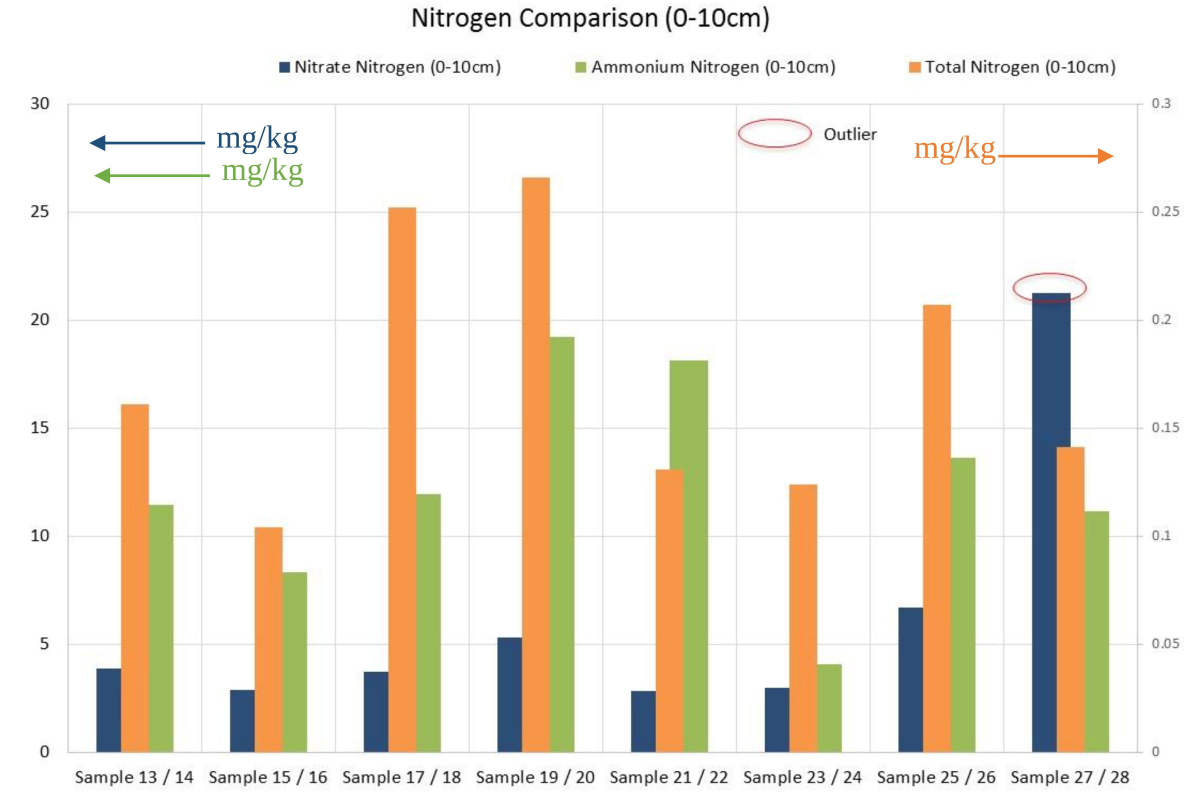


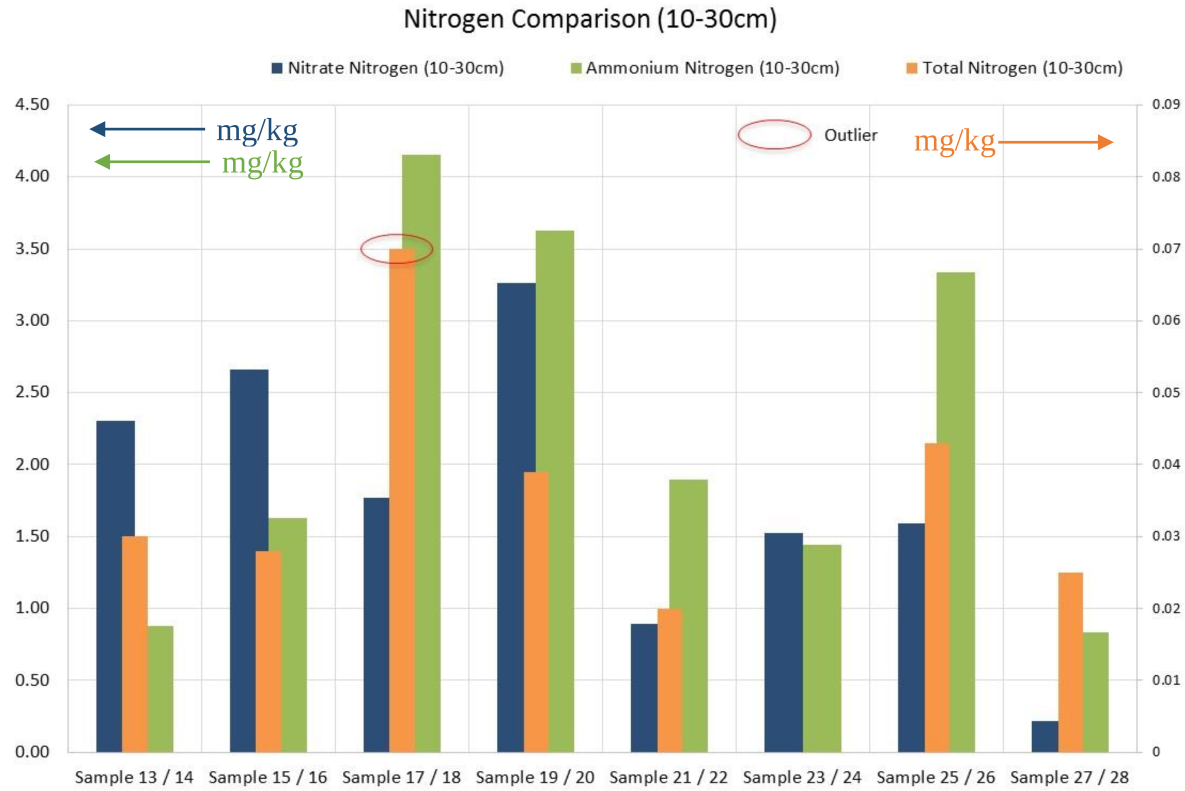
Note: Plot 1 = Sample 13 (0-10cm) / 14 (10-30cm) and Sample 15 (0-10cm) / 16 (10-30cm)
Plot 2 = Sample 17 (0-10cm) / 18 (10-30cm) and Sample 19 (0-10cm) / 20 (10-30cm)
Plot 3 = Sample 21 (0-10cm) / 22 (10-30cm) and Sample 23 (0-10cm) / 24 (10-30cm)
Plot 4 = Sample 25 (0-10cm) / 26 (10-30cm) and Sample 27 (0-10cm) / 28 (10-30cm)

Mean Differential 1.89
One outlier 3.8 from combined sets and 1.3 sits as an outlier for the 10-30cm data set.
Note that 0-10cm higher C plot and less than half subsurface
Note Ratio Surface/Subsurface: 0.24 i.e. 1/4 (With outliers removed).
Concluded investigation of potentially incorrectly labelled Sample 21/22 bags - carbon in 10-30cm depth range highly unlikely to have 5x carbon in 0-10cm range.
Removal of outliers from analysis reduced the P(T<=t) two-tail for the differences in the means.

8.2.4. 2019 Planation Soil Nitrogen

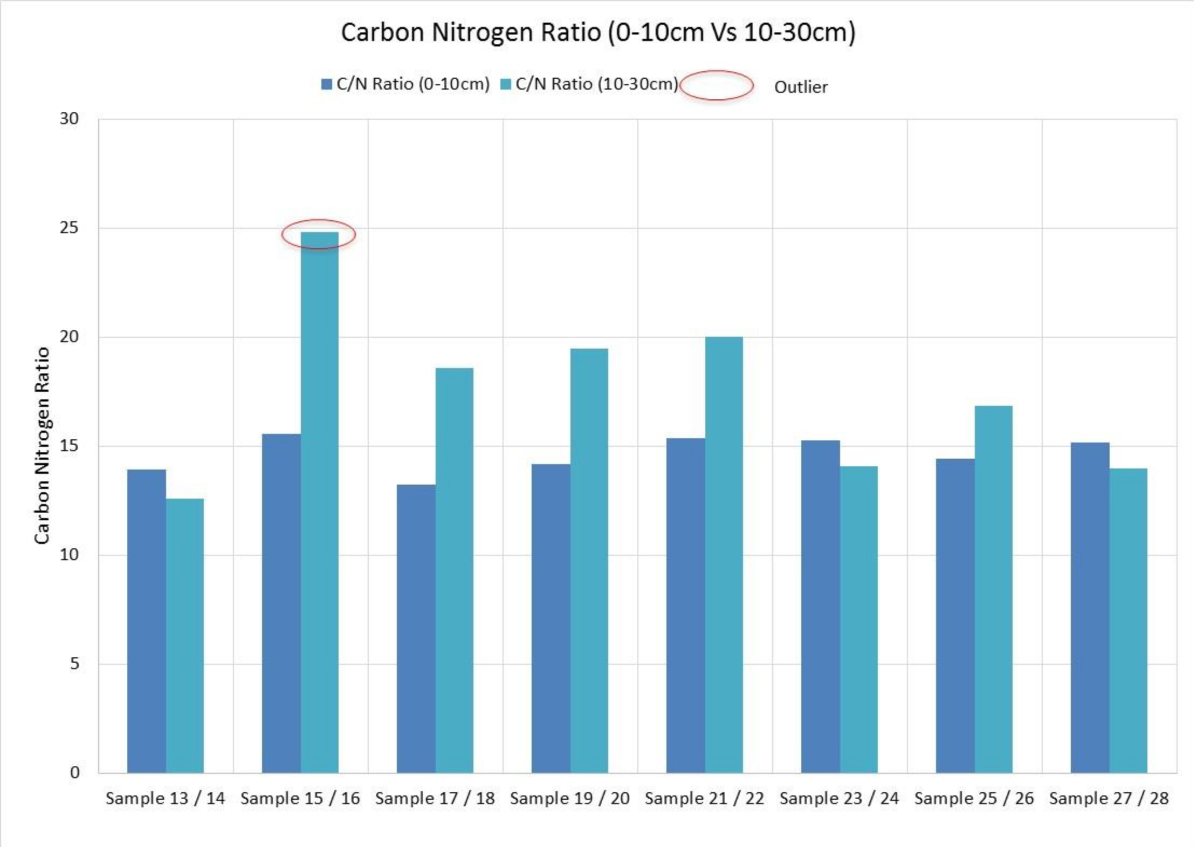
Nitrogen Comparison:





8.2.5. 2019 Plantation Soil Carbon/Nitrogen Ratio

"The Carbon/Nitrogen ratio should be between 10 and 12. Higher values suggest a depletion in organic nitrogen." (EAL Laboratories, 2020)

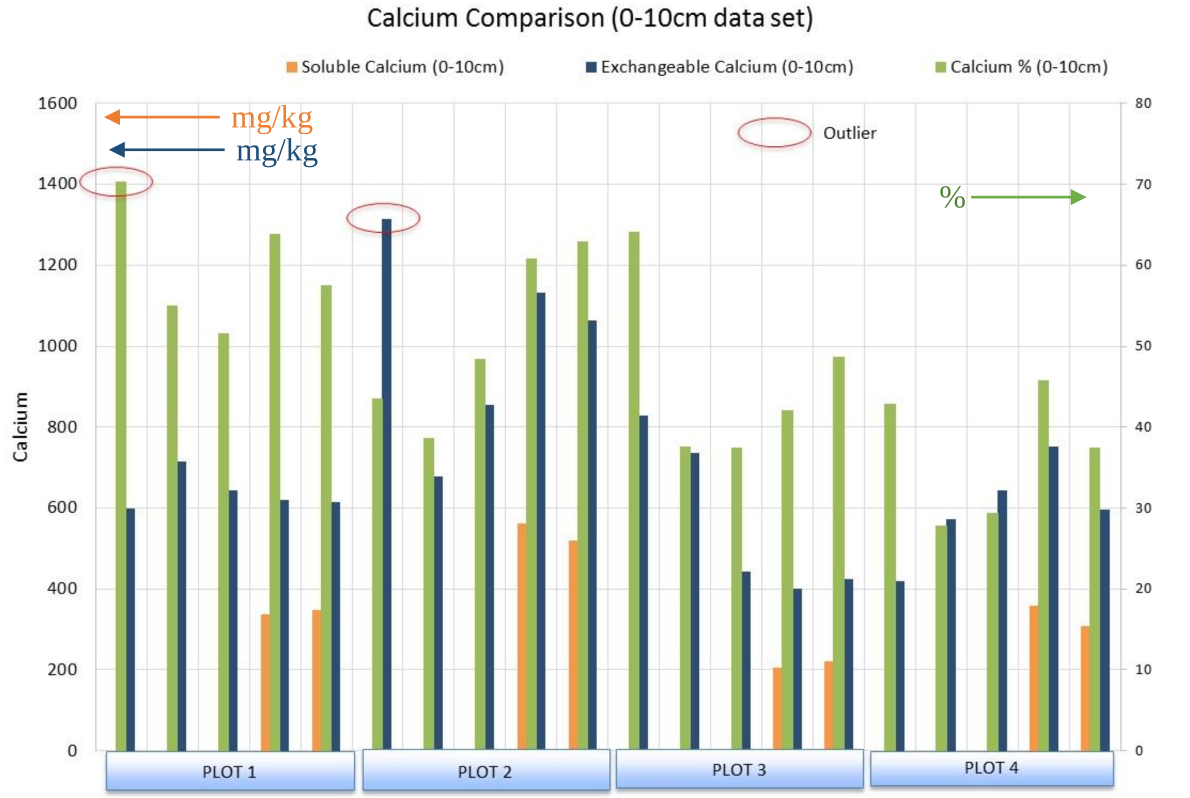


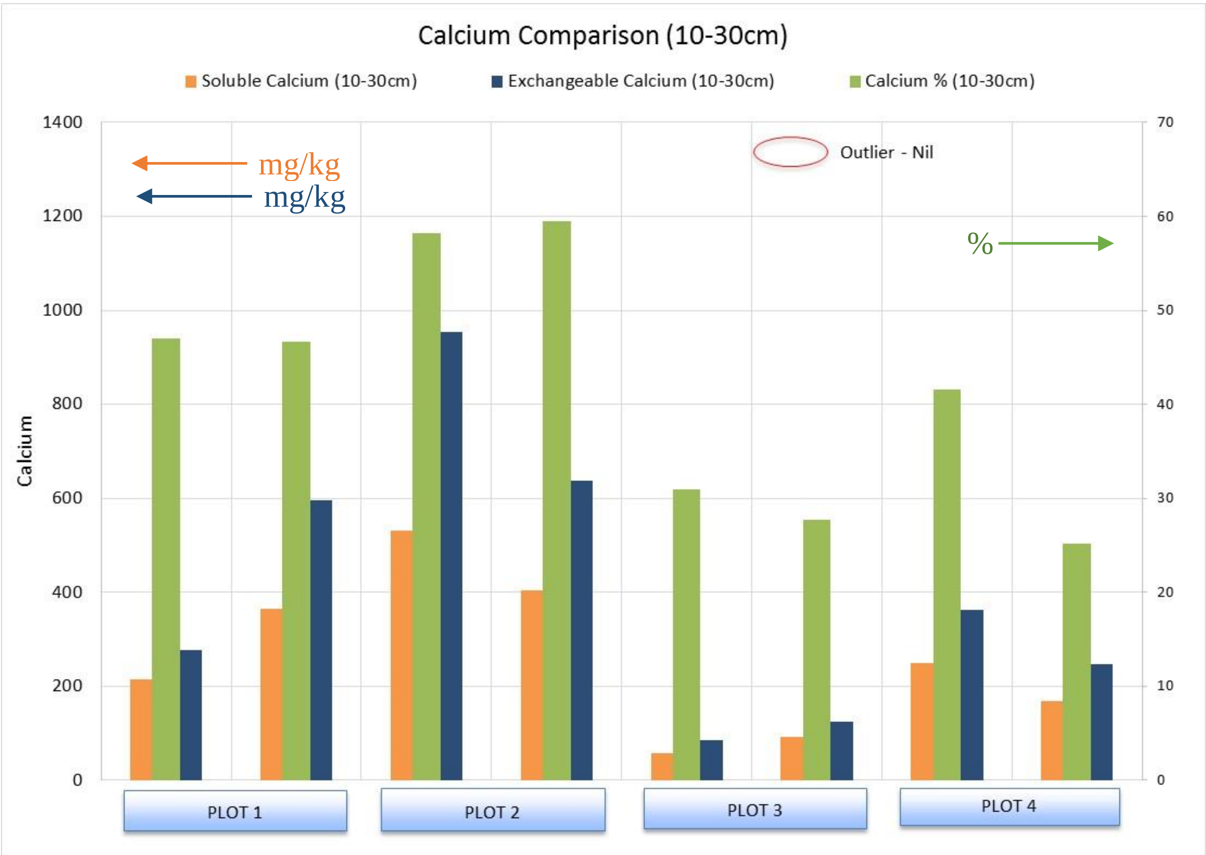
Note: Plot 1 = Sample 13 (0-10cm) / 14 (10-30cm) and Sample 15 (0-10cm) / 16 (10-30cm)
Plot 2 = Sample 17 (0-10cm) / 18 (10-30cm) and Sample 19 (0-10cm) / 20 (10-30cm)
Plot 3 = Sample 21 (0-10cm) / 22 (10-30cm) and Sample 23 (0-10cm) / 24 (10-30cm)
Plot 4 = Sample 25 (0-10cm) / 26 (10-30cm) and Sample 27 (0-10cm) / 28 (10-30cm)

Mean Differential 2.905
No outliers from individual sets, however 24.8 sits as outlier to combined sets.
Interesting that 0-10cm mixed values relative in the C/N ratio of the 10-30cm

8.2.6. 2019 Plantation Soil Calcium Content

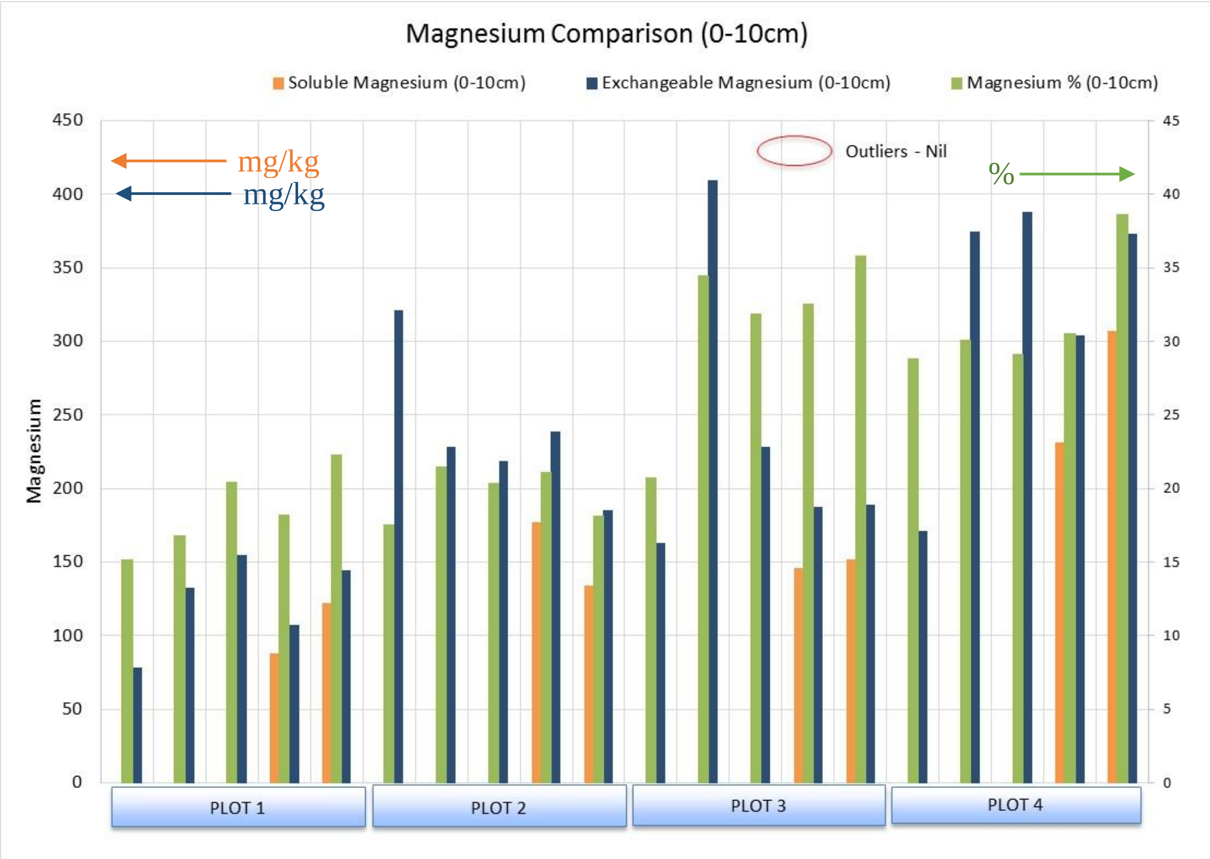
Ca COMPARISON

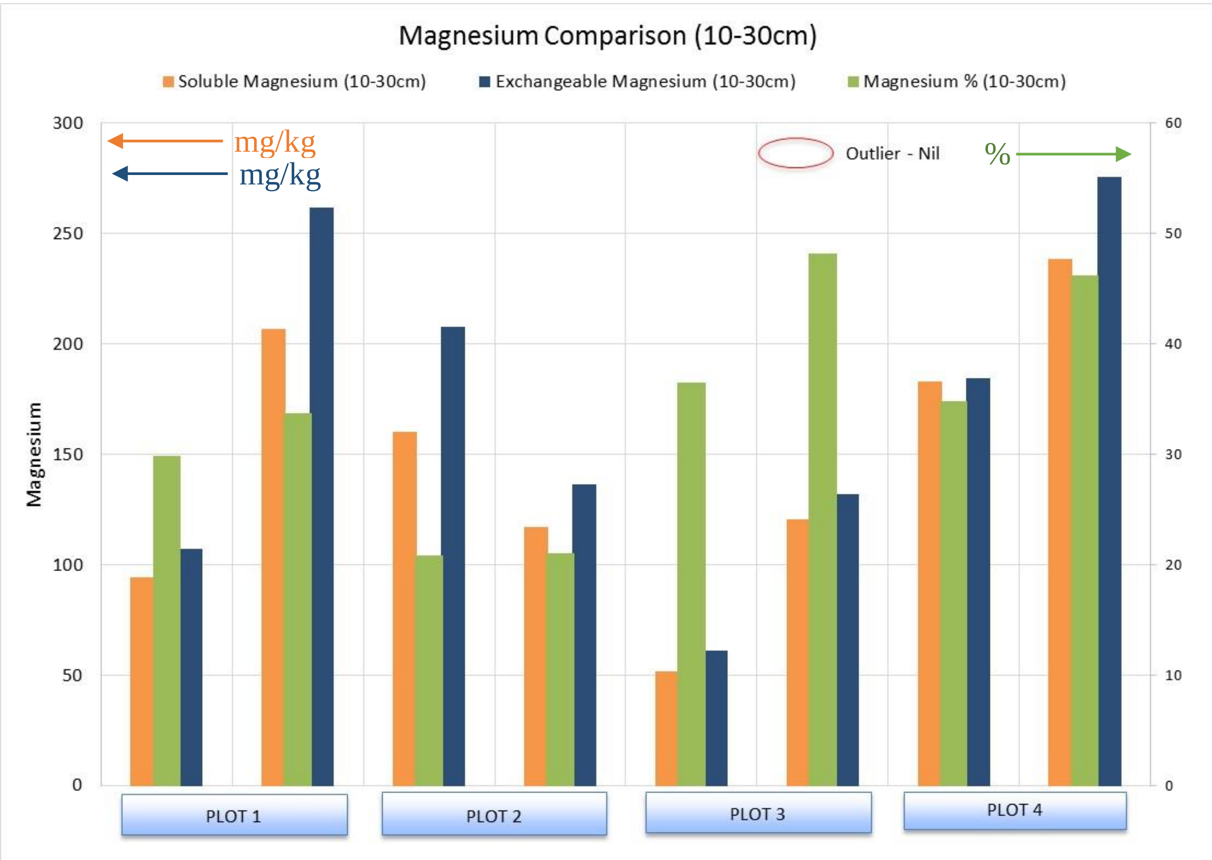




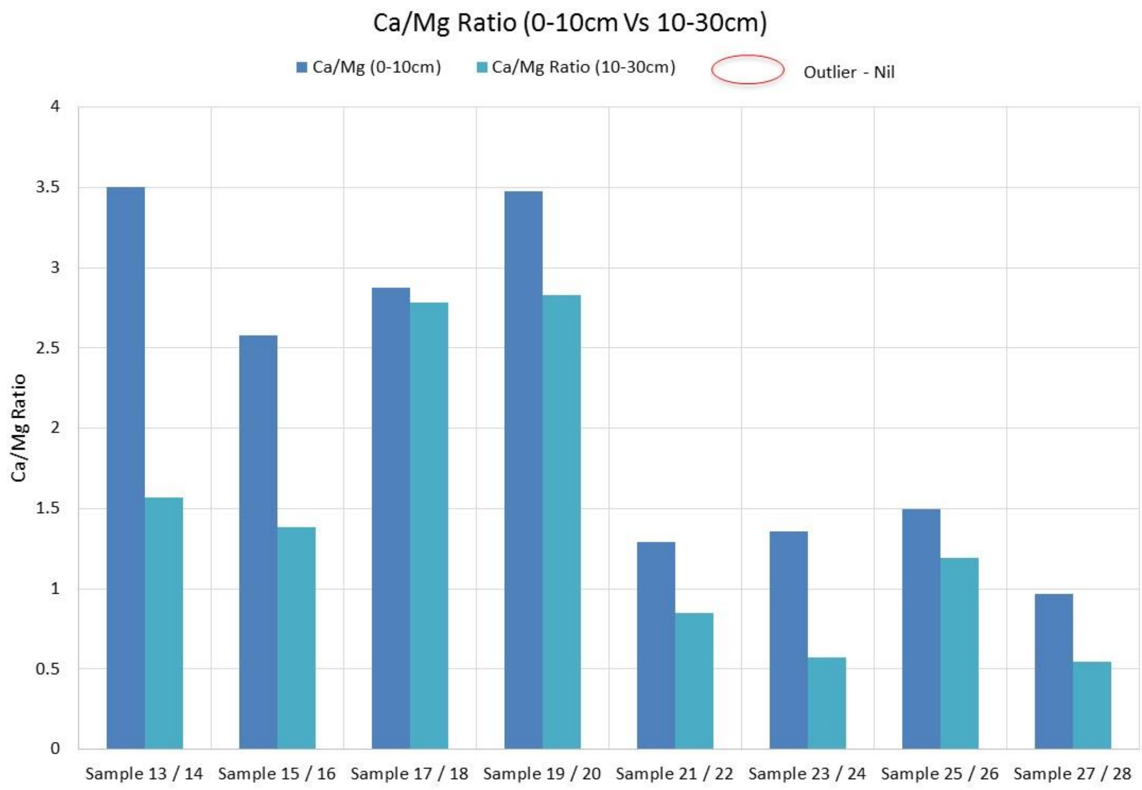
8.2.7. 2019 Plantation Soil Magnesium Content

Mg COMPARISON



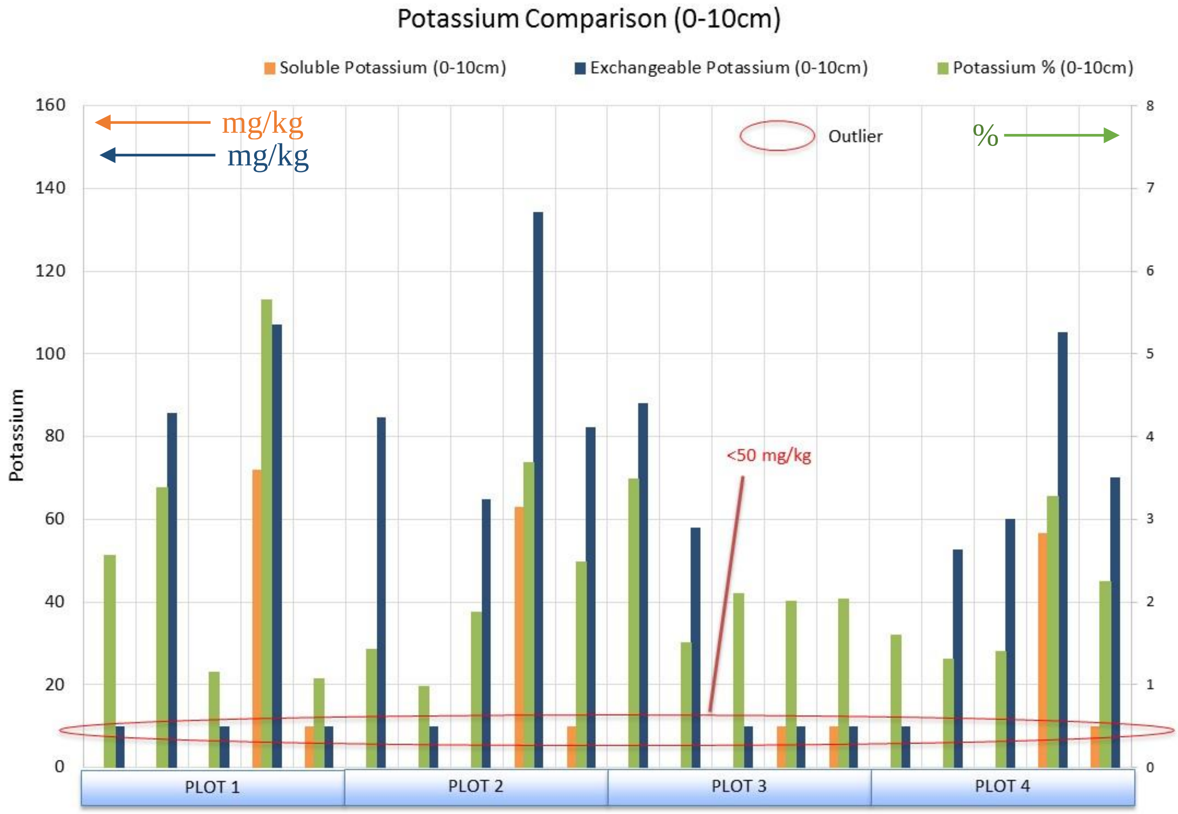


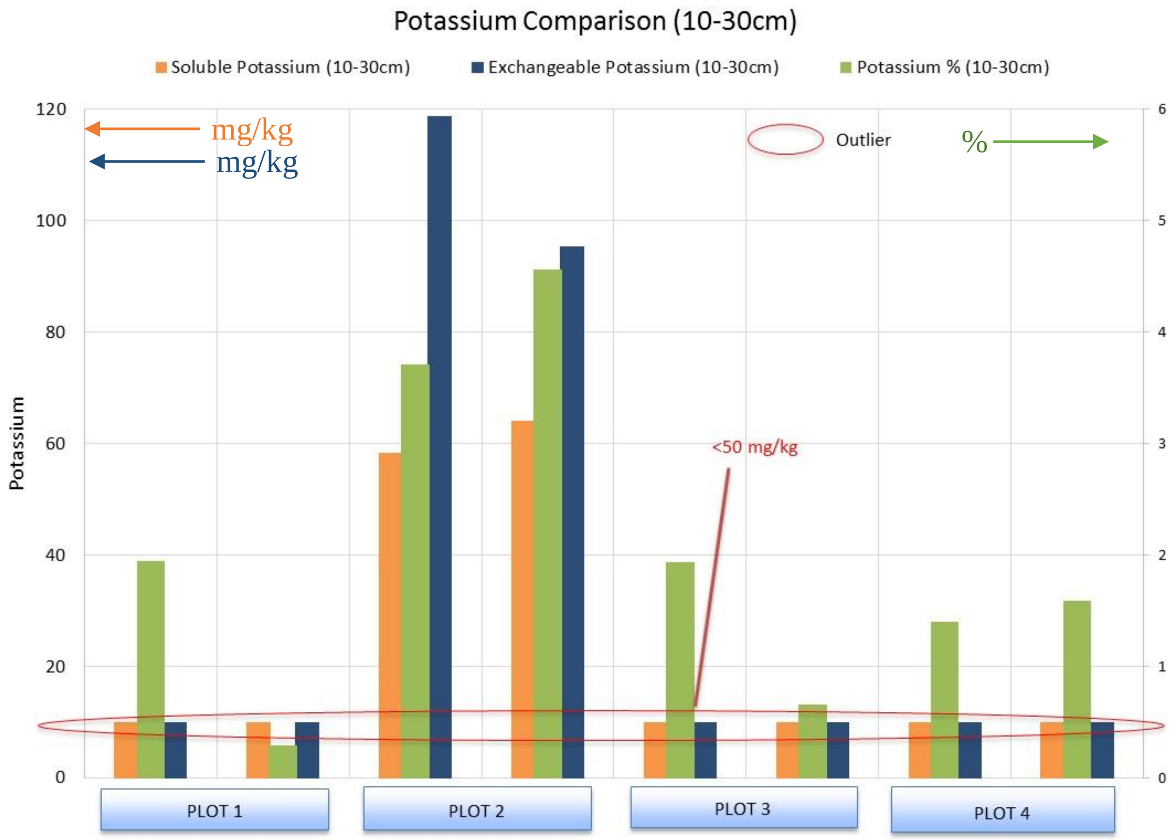
8.2.8. 2019 Plantation Soil Calcium/Magnesium Ratio



8.2.9. 2019 Plantation Soil Potassium Content

K COMPARISON

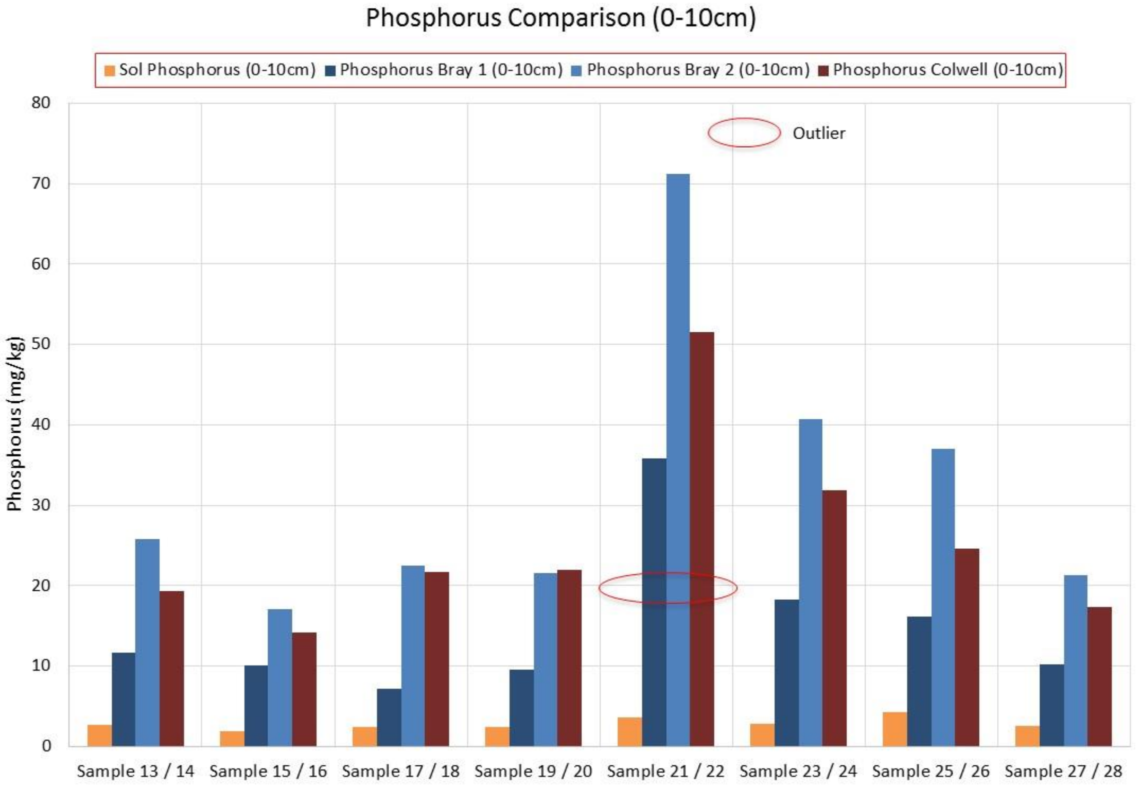




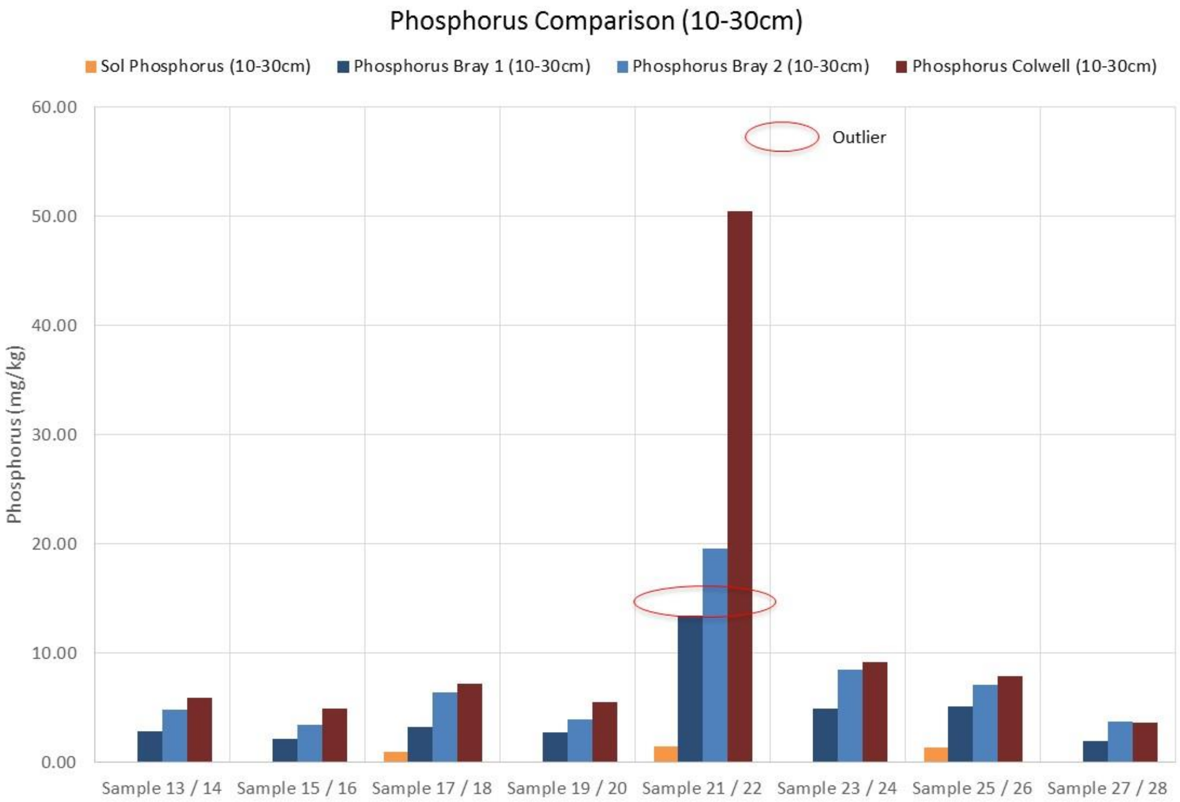
Note: <50gm/kg put in graph as 10mg/kg so data was visible.

8.2.10. 2019 Plantation Soil Phosphorus Content

P Comparison



Note: Plot 1 = Sample 13 (0-10cm) / 14 (10-30cm) and Sample 15 (0-10cm) / 16 (10-30cm)
Plot 2 = Sample 17 (0-10cm) / 18 (10-30cm) and Sample 19 (0-10cm) / 20 (10-30cm)
Plot 3 = Sample 21 (0-10cm) / 22 (10-30cm) and Sample 23 (0-10cm) / 24 (10-30cm)
Plot 4 = Sample 25 (0-10cm) / 26 (10-30cm) and Sample 27 (0-10cm) / 28 (10-30cm)



8.3. Laboratory Indicative Guidelines

*All 2020 soil samples defined as "brownish loam" and 2021 samples were "brownish Loam" or "brownish sandy soil". Therefore guidelines are quoted for Loam or Loamy Sand depending on the year and location.

			Heavy Soil	Medium Soil	Light Soil	Sandy Soil
		Sample ID:				
		Crop:				
		Client:	Clay	Clay Loam	Loam	Loamy Sand
Parameter		**Method reference**	**Indicative guidelines - refer to Notes 6 and 8**			
Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	1150	750	375	175
Soluble Magnesium (mg/kg)			160	105	60.0	25.0
Soluble Potassium (mg/kg)			113	75.0	60.0	50.0
Soluble Phosphorus (mg/kg)			15.0	12.0	10.0	5.00
Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	45 [note 8]	30 [note 8]	24 [note 8]	20 [note 8]
		**Rayment & Lyons 2011 - 9B2 (Colwell)	80.0	50.0	45.0	35.0
		**Inhouse S3A (Bray 2)	90 [note 8]	60 [note 8]	48 [note 8]	40 [note 8]
Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	15.0	12.5	10.0	10.0
Ammonium Nitrogen (mg/kg N)			20.0	18.0	15.0	12.0
Sulfur (mg/kg S)			10.0	8.00	8.00	7.00
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.50	6.50	6.30	6.30
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.200	0.150	0.120	0.100
Estimated Organic Matter (%OM)		**Calculation: Total Carbon x 1.75	> 5.5	>4 .5	> 3.5	> 2.5
Exchangeable Calcium	(cmol$_+$/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	15.6	10.8	5.00	1.90
	(kg/ha)		7000	4816	2240	840
	(mg/kg)		3125	2150	1000	375
Exchangeable Magnesium	(cmol$_+$/kg)		2.40	1.70	1.20	0.600
	(kg/ha)		650	448	325	168
	(mg/kg)		290	200	145	75.0
Exchangeable Potassium	(cmol$_+$/kg)		0.600	0.500	0.400	0.300
	(kg/ha)		526	426	336	224
	(mg/kg)		235	190	150	100
Exchangeable Sodium	(cmol$_+$/kg)		0.300	0.260	0.220	0.110
	(kg/ha)		155	134	113	56.7
	(mg/kg)		69.0	59.8	50.6	25.3
Exchangeable Aluminium	(cmol$_+$/kg)	**Inhouse S37 (KCl)	0.60	0.50	0.40	0.20
	(kg/ha)		121	101	72.6	30.2
	(mg/kg)		54.0	45.0	32.4	13.5
Exchangeable Hydrogen	(cmol$_+$/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.60	0.50	0.40	0.20
	(kg/ha)		13.4	11.2	8.06	3.36
	(mg/kg)		6.00	5.00	3.60	1.50
Effective Cation Exchange Capacity (ECEC) (cmol$_+$/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol$_+$/kg)	20.10	14.30	7.80	3.30

		Heavy Soil	Medium Soil	Light Soil	Sandy Soil
	Sample ID:				
	Crop:				
	Client:	Clay	Clay Loam	Loam	Loamy Sand
Parameter	**Method reference**	**Indicative guidelines - refer to Notes 6 and 8**			
Calcium (%)	**Base Saturation Calculations - Cation cmol$_+$/kg / ECEC x 100	77.6	75.7	65.6	57.4
Magnesium (%)		11.9	11.9	15.7	18.1
Potassium (%)		3.00	3.50	5.25	9.10
Sodium - ESP (%)		1.50	1.80	2.89	3.30
Aluminium (%)		6.00	7.10	10.5	12.1
Hydrogen (%)					
Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol$_+$/kg)	6.50	6.35	4.17	3.17
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	6.00	5.00	4.00	3.00
Manganese (mg/kg)		25.0	22.0	18.0	15.0
Iron (mg/kg)		25.0	22.0	18.0	15.0
Copper (mg/kg)		2.40	2.00	1.60	1.20
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	2.00	1.70	1.40	1.00
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	50.0	45.0	40.0	35.0
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	> 3.1	> 2.6	> 2.0	> 1.4
Total Nitrogen (%)		> 0.30	> 0.25	> 0.20	> 0.15
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	10–12	10–12	10–12	10–12
Basic Texture	**Inhouse S65	..	..	..	..
Basic Colour		..	..	..	..
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	..	..	..	..

8.4. Macro and Micro Nutrient Importance and Function

Macronutrients:

(Life Sciences Vol I, Ahuja, M, 2006) – The following is quoted from the book as it provides the best summary:

1. **"Nitrogen (N)** is a major component of proteins, hormones, chlorophyll, vitamins and enzymes essential for plant life. Nitrogen metabolism is a major factor in stem and leaf growth (vegetative growth). Too much can delay flowering and fruiting. Deficiencies can reduce yields, cause yellowing of the leaves, and stunt growth.
2. **Phosphorus (P)** is necessary for seed germination, photosynthesis, protein formation and almost all aspects of growth and metabolism in plants. It is essential for flower and fruit formation. Low pH (<4) results in phosphate being chemically locked up in organic soils. Deficiency symptoms are purple stems and leaves; maturity and growth are retarded. Yields of fruit and flowers are poor. Premature drop of fruits and flowers may often occur. Phosphorus must be applied close to the plant's roots in order for the plant to utilise it.
3. **Potassium (K)** is necessary for formation of sugars, starches, carbohydrates, protein synthesis and cell division in roots and other parts of the plant. It helps to adjust water balance, improves stem rigidity and cold hardiness enhances flavour and colour on fruit and vegetable crops, increases the oil content of fruits and is important for leafy crops. Deficiencies result in low yields, mottled, spotted or curled leaves, scorched or burned look to leaves.
4. **Sulfur (S)** is a structural component of amino acids, proteins, vitamins and enzymes and is essential to produce chlorophyll. It imparts flavour to many vegetables. Deficiencies show as light green leaves. Sulfur is readily lost by leaching from soils and should be applied with a nutrient formula.
5. **Magnesium (Mg)** is a critical structural component of the chlorophyll molecule and is necessary for functioning of plant enzymes to produce carbohydrates, sugars and fats. It is used for fruit and nut formation and essential for germination of seeds. Deficient plants appear chlorotic, show yellowing between veins of older leaves; leaves may droop.
6. **Calcium (Ca)** activates enzymes, is a structural component of cell walls, influences water movement in cells and is necessary for cell growth and division. Some plants must have calcium to take up nitrogen and other minerals. Calcium is easily leached. Deficiency causes stunting of new growth in stems, flowers and roots. Symptoms range from distorted new growth to black spots on leaves and fruit. Yellow leaf margins may also appear."

Micronutrients (trace elements):

(Life Sciences Vol I, Ahuja, M, 2006).

The micronutrients (also called trace elements) are defined as either essential or beneficial. Essential is defined as a nutrient without which a plant is unable to complete its lifecycle in the absence of the mineral, the function of the element is not replaceable by another mineral element and the element must be directly involved in the plant's metabolism. Beneficial mineral elements are those that can compensate for the toxic effects of other elements or can replace a mineral nutrient in function not directly related to plant metabolism. Omission of the beneficial elements for a plant will result is the suboptimal performance of the plant. Having said that, a beneficial element for one plant may be essential for another, so the definition should not be taken as the recipe for all plants.

The following is quoted from the referenced book *(Life Sciences Vol I, Ahuja, M, 2006)* but with italic-ed comments to include information from elsewhere in the book:

1. **"Iron (Fe)** is necessary for many enzyme functions and as a catalyst for the synthesis of chlorophyll. It is essential for the young growing parts of plants. Deficiencies are pale leaf colour of young leaves followed by yellowing of leaves and large veins. Iron is lost by leaching and is held in the lower portions of the soil structure. High pH (alkaline) conditions render iron unavailable to plants." ***Essential***
2. **"Manganese (Mn)** is involved in enzyme activity for photosynthesis, respiration, and nitrogen metabolism. Deficiency in young leaves may show as a network of green veins on a light green background similar to an iron deficiency. In the advanced stages, the light green parts become white, and leaves are shed. Brownish, black, or greyish spots may appear next to the veins. In neutral or alkaline soils plants often show deficiency symptoms. In highly acid soils (low pH), manganese may be available to the extent that it results in toxicity." ***Essential***
3. **"Boron (B)** is necessary for cell wall formation, membrane integrity, calcium uptake and may aid in the translocation of sugars. Boron affects at least 16 functions in plants, including flowering, pollen germination, fruiting, cell division, water relationships and the movement of hormones. Boron must be available throughout the life of the plant. It is not translocated and is easily leached from soils. Deficiencies kill terminal buds leaving a rosette effect on the plant. Leaves are thick, curled and brittle. Fruits, tubers and roots are discoloured, cracked and flecked with brown spots." ***Essential****.*
4. **"Zinc (Zn)** is a component of enzymes or a functional co-factor of a large number of enzymes, including auxins (plant growth hormones). It is essential to carbohydrate metabolism, protein synthesis and intermodal elongation (stem growth). Deficient plants have mottled leaves with irregular chlorotic areas. Zinc deficiency leads to iron deficiency, causing similar symptoms. Deficiency occurs on eroded soils and is least available at a pH

range of 5.5 – 7.0. Lowering the pH can render zinc more available to the point of toxicity.” ***Essential***

5. **“Copper (Cu)** is concentrated in roots of plants and plays a part in nitrogen metabolism. It is a component of several enzymes and may be part of the enzyme systems that use carbohydrates and proteins. Deficiencies cause die back of the shoot tips, and terminal leaves develop brown spots. Copper is bound tightly in organic matter and may be deficient in highly organic soils. It is not readily lost from soil, but may often be unavailable. Too much copper can cause toxicity.” ***Essential***

6. **“Molybdenum (Mo)** is a structural component of the enzyme that reduces nitrates to ammonia. Without it, the synthesis of proteins is blocked and plant growth ceases. Root nodule (nitrogen fixing) bacteria also require it (*Exciting topic for the future*). Seeds may not form completely, and nitrogen deficiency may occur if plants are lacking molybdenum. Deficiency signs are pale green leaves with rolled or cupped margins.” ***Essential***

7. **“Chlorine (Cl)** is involved in osmosis (movement of water or solutes in cells), the ionic balance necessary for plants to take up mineral elements and in photosynthesis. Deficiency symptoms include wilting, stubby roots, chlorosis (yellowing) and bronzing. Odours in some plants may be decreased. Chloride, the ionic form of chlorine used by plants, is usually found in soluble forms and is lost by leaching.” ***Essential***

8. **“Nickel (Ni)** is required for the enzyme urease to break down urea to liberate the nitrogen into a useable form for plants. Nickel is required for iron absorption. Seeds need nickel in order to germinate. If nickel is deficient plants may fail to produce viable seeds.” ***Essential***

9. **“Sodium (Na)** is involved in osmotic (water movement) and ionic balance in plants.” ***Essential***

10. **“Cobalt (Co)** is required for nitrogen fixation in legumes and in root nodules of non-legumes. The demand for cobalt is much higher for nitrogen fixation than for ammonium nutrition. Deficient levels could result in nitrogen deficiency symptoms.” ***Beneficial***

11. **“Silicon (Si)** is a component of cell walls. Plants with supplies of soluble silicon produce stronger, tougher cell walls making them a mechanical barrier to piercing and sucking insects. This significantly enhances plant heat and drought tolerance. Silicon may be deposited by the plants at the site of infection by fungus to combat the penetration of the cell walls by the attacking fungus. Improved leaf erectness, stem strength and prevention (or depression) of iron and manganese toxicity have all been noted as effects from silicon.” ***Beneficial***

In addition to these, Selenium should also be considered as an important element and is deficient in WA soils.

9. APPENDIX 3: 2020 and 2021 Plantation Site Soil Sampling Analysis Details

9.1. 2020 Under Vs Between Detailed Analysis:

From the total parameters list, the following parameters met the minimum 3 out of 4 criteria for acceptance of a trend with criteria comments included:

- Phosphorus – Bray 1 (plant available phosphorus)– Between always higher than under
- Ammonium Nitrogen - Between always higher than under
- pH – Plots 1,2, and 4, under higher than between
- Electrical conductivity (1:5 water) – All plots under higher than between
- Exchangeable Nutrients
  - Exchangeable Magnesium - Plots 1, 2, and 4, under higher than between
  - Exchangeable Potassium - Plots 1, 2, and 4, under higher than between
  - Exchangeable Sodium - Plots 1, 2, and 4, under higher than between
  - Exchangeable Aluminium - Plots 1, 2, and 3, between higher than under
- Effective Cation Exchange Capacity - Plots 1, 2, and 4, under higher than between, Plot 3 has as equal.
- Total % Nutrients
  - Magnesium % - Plots 1, 3, and 4, between higher than under
  - Potassium % - Plots 1, 2, and 4, under higher than between
  - Sodium ESP % - Plots 1, 2, and 3, under higher than between, Plot 4 has as equal.
  - Aluminium % - All plots between higher than under
- Micro-nutrients
  - Zinc - Plots 2, 3, and 4, between higher than under
  - Iron - Plots 1, 2, and 4, between higher than under
  - Copper - Plots 2, 3, and 4, between higher than under
  - Boron – All plots under was higher than between
  - Silicon - Plots 1, 2, and 4, under higher than between. Plot 3 has as equal.
- Total Carbon % - All plots between higher than under
- Carbon Nitrogen Ratio - Plots 1, 2, and 3, between higher than under

From the total parameters list, an outlier analysis (> or < 2 standard deviations) was conducted to determine if more significant differentials were apparent.

- Electrical conductivity (1:5 water) – All plots under higher than between changed to Plots 2, 3, and 4 under higher than between - high outlier of plot 1 under removed.

- Exchangeable Nutrients
    - Exchangeable Magnesium – Remained as per total data set with plot 1 between high outlier removed.
    - Exchangeable Potassium – Remained as per total data set with plot 1 under high outlier removed.
    - Exchangeable Sodium – All plots under higher than between changed to Plots 2, 3, and 4 under higher than between - high outlier of plot 1 and 2 under removed.
    - Exchangeable Aluminium - Plots 1, 2, and 3, between higher than under changed to all plots between higher than under with removal of plot 4 under high outlier removed.
- Total Nutrient %
    - Magnesium % - Remained as per total data set with plot 1 under low outlier removed.
    - Sodium ESP % - Plots 1, 2, and 3, between higher than under changed to only plots 1 and 2 higher and plot 4 remaining equal –criteria no longer met.
    - Aluminium % - Remained as per total data set with plot 1 under and between high outlier removed.
- Calcium/Magnesium Ratio – removal of high outlier for plot 1 under lead to criteria now being met – Plot 1, 2, and 3 between higher than under.
    -
- Carbon % - Remained as per total data set with plot 4 under high outlier removed.
- Carbon Nitrogen Ratio – Trend reversed from total data set. Plots 1, 2, and 3, between higher than under changed to Plots 1, 3 and 4 under higher than between with removal of under low outlier from plot 1 and high between outlier from plot 3.

Full outlier and differential analysis of the data contributing to the below tables has been presented in the supplementary document "2020 Additional Data Summary Report" and can be provided on request.

Table 9.1.1: Total Data Set and Under Versus Between of Total Data differentials 2019-2020

Location	Outliers Removed	Significant Data	Analysis							
			pH	**Electrical Conductivity (dS/m)**	**Total Carbon (%)**	**Total Nitrogen (%)**	**Phosphorus (mg/kg P, Bray 1)**	**Sulfur (mg/kg S)**	**Exchangeable Calcium**	**Exchangeable Aluminium**
		Average 2019	5.925		2.452	0.153		27.64	703	4.286
Total Data	No	Average 2020	6.516		1.322	0.083		60.69	405	1.192
		P(T<=t) two-tail	2.52E-03		2.81E-05	6.32E-05		7.94E-03	1.04E-03	1.14E-07
		Average 2019	5.962	0.316	2.452	0.142	2.826	27.64	670	4.286
Total Data	Yes	Average 2020	6.516	0.575	1.254	0.072	1.515	67.68	349	1.066
		P(T<=t) two-tail	3.89E-03	4.23E-02	1.22E-05	1.68E-06	1.86E-02	1.02E-04	2.05E-06	1.19E-07
		Average 2019	5.925		2.452	0.153				4.286
Under	No	Average 2020 (under)	6.738		1.130	0.073				1.089
		P(T<=t) two-tail	6.84E-03		1.80E-04	3.62E-04				1.33E-07
		Average 2019			2.452	0.153		27.64	703	4.286
Between	No	Average 2020 (between)			1.514	0.093		65.29	361	1.296
		P(T<=t) two-tail			3.86E-03	5.94E-03		7.87E-04	5.34E-05	4.31E-07

Location	Outliers Removed	Significant Data	Analysis						
			Calcium (%)	**Sodium - ESP (%)**	**Aluminium (%)**	**Hydrogen (%)**	**Calcium/ Magnesium Ratio**	**Manganese (mg/kg)**	**Chloride Estimate (equiv. mg/kg)**
		Average 2019	48.31	22.87	0.709	0.608	2.170	5.227	
Total Data	No	Average 2020	30.51	38.52	0.184	0.132	1.118	1.553	
		P(T<=t) two-tail	1.53E-04	2.34E-04	2.11E-05	5.60E-04	8.62E-04	5.68E-03	
		Average 2019	47.14	22.87	0.654	0.608	2.040		202
Total Data	Yes	Average 2020	32.15	35.53	0.135	0.058	0.993		368
		P(T<=t) two-tail	2.78E-05	1.68E-04	2.46E-06	6.32E-05	1.44E-04		4.23E-02
		Average 2019	48.31	22.87	0.709	0.608	2.170	5.227	
Under	No	Average 2020 (under)	28.28	41.48	0.128	0.078	1.075	1.479	
		P(T<=t) two-tail	1.23E-02	1.75E-02	4.33E-06	1.81E-04	1.58E-02	6.53E-02	
		Average 2019	48.31	22.87	0.709	0.608	2.170	5.227	
Between	No	Average 2020 (between)	32.74	35.57	0.240	0.186	1.161	1.627	
		P(T<=t) two-tail	1.67E-04	1.08E-03	5.68E-03	2.97E-02	8.52E-04	5.96E-03	

Table 9.1.2: Plot Comparison differentials 2019-2020

Plot	Significant Data	Analysis										
		pH	**Total Carbon (%)**	**Total Nitrogen (%)**	**Phosphorus (mg/kg P, Bray 1)**	**Exchangeable Calcium**	**Calcium (%)**	**Magnesium (%)**	**Sodium - ESP (%)**	**Aluminium (%)**	**Hydrogen (%)**	**Calcium/ Magnesium Ratio**
1	Average 2019		1.890	0.120		639	59.70			1.076	0.946	3.303
	Average 2020		0.828	0.056		296	31.67			0.286	0.324	1.426
	P(T<=t) two-tail		8.38E-03	3.87E-03		4.37E-03	3.29E-02			9.66E-03	4.44E-02	4.91E-02
2	Average 2019		2.934	0.206		1009	50.89	19.75		0.458		2.600
	Average 2020		1.389	0.091		418	25.16	26.44		0.135		0.962
	P(T<=t) two-tail		3.18E-02	3.05E-02		4.67E-03	2.03E-02	1.91E-03		6.06E-03		4.14E-03
3	Average 2019	6.204	2.762	0.149		567			19.53	0.643		
	Average 2020	6.563	1.269	0.072		297			33.62	0.181		
	P(T<=t) two-tail	3.84E-03	1.71E-02	3.28E-03		3.48E-02			4.46E-02	6.62E-03		
4	Average 2019				24.06							
	Average 2020				51.82							
	P(T<=t) two-tail				1.54E-03							

Table 9.1.3: Plot Specific Averages – Under Relative to Between, graphically assessed utilizing a 3 of 4 consistent trend criteria.

Data Group	Plot Averages Trend (Under Vs Between)	
Significant Data	**Total Set (Higher)**	**Outlier Removed**
pH	Y (Under)	N/A
Electrical Conductivity (dS/m)	Y (Under)	Y (Under)
Total Carbon (%)	Y (Between)	Y (Between)
Total Nitrogen (%)		
Carbon/ Nitrogen Ratio	Y (Between)	Y (Under)
Soluble Calcium (mg/kg)		
Soluble Magnesium (mg/kg)		
Soluble Potassium (mg/kg)		
Soluble Phosphorus (mg/kg)		
Phosphorus (mg/kg P, Bray 1)	Y (Between)	N/A
Phosphorus (mg/kg P, Colwell)		
Phosphorus (mg/kg P, Bray 2)		
Nitrate Nitrogen (mg/kg N)		
Ammonium Nitrogen (mg/kg N)	Y (Between)	N/A
Sulfur		
Exchangeable Calcium (mg/kg)		
Exchangeable Magnesium (mg/kg)	Y (Under)	Y (Under)
Exchangeable Potassium (mg/kg)	Y (Under)	Y (Under)
Exchangeable Sodium (mg/kg)	Y (Under)	Y (Under)
Exchangeable Aluminium (mg/kg)	Y (Between)	Y (Between)
Exchangeable Hydrogen (mg/kg)		
Effective Cation Exchange Capacity	Y (Under)	N/A
Calcium (%)		
Magnesium (%)	Y (Between)	Y (Between)
Potassium (%)	Y (Under)	N/A
Sodium - ESP (%)	Y (Under)	
Aluminium (%)	Y (Between)	Y (Between)
Hydrogen (%)		
Calcium/ Magnesium Ratio		Y (Between)
Zinc (mg/kg)	Y (Between)	N/A
Manganese (mg/kg)		
Iron (mg/kg)	Y (Between)	N/A
Copper (mg/kg)	Y (Between)	N/A
Boron (mg/kg)	Y (Under)	N/A
Silicon (mg/kg)	Y (Under)	N/A
Chloride Estimate (equiv. mg/kg)		

Full graphical assessment has been presented in the supplementary document "2020 Additional Data Summary Report" and can be provided on request.

9.2. 2021 Under Vs Between Detailed Analysis:

From the total parameters list, the following parameters met the criteria for acceptance of a trend with criteria comments included:

- pH:
    - Total data set – Plot 2 has a higher pH than Plots 1 and 4
    - Under plant data set – Plot 2 has a higher pH than Plots 3 and 4
    - Between plant data set – Plot 1 has a lower pH than the other three plots.
    - There was no significant difference in the comparison of the Under Vs the Between within the plots.
    - Under plants has a more neutral pH than between plants (mean 6.7 Vs 6.3) for the combined plot data sets.
    - No significant difference with depth for total, under or between grouped data.
- Electrical Conductivity (EC):
    - Total data set – Plot 2 has a higher EC than other three plots (with high outlier removed from Plot 1, this plot has lowest EC of all plots)
    - Between plant data set – Plot 2 has a higher EC than other three plots
    - Under plant data set – nothing significant
    - Under plants has a higher EC in the 0-10cm than between plants (mean 0.34 Vs 0.25 dS/m) for the combined plot data set.
    - Under plants has a higher EC in the 0-10cm than the 10-30cm depth (mean 0.34 Vs 0.24 dS/m)
    - Note that the Chloride Estimate was the EC*640
- Total Carbon (TC):
    - Total data set – Plot 1 has a lower TC than other three plots (no change with low outlier removed)
    - Plot 2 has a higher TC under plants versus in between (1.91% Vs 1.40%)
    - Between plant data set – Plot 1 has a lower TC than other three plots; Plot 2 has a lower TC than Plot 4. Suggesting an increasing TC between the plants moving west to east across the plots.
    - Under plant data set – Plot 2 has a higher TC than Plot 3.
    - Combined plot under versus between plant data sets had no significant differences.
    - Total, under and between data sets all had higher TC in the 0-10cm depth range compared to the 10-30cm.

- Total Nitrogen (TN):
    - Plot 2 has a higher TN under plants versus in between (0.14% Vs 0.10%)
    - Total data set – Plot 1 has a lower TN than plots 2 and 4. Plot 3 has a lower TN than plots 4.
    - Between plant data set – Plot 1 has a lower TN than plots 2 and 4. Plot 2 has a lower TN than plots 4. Again suggesting an increasing TN between the plants moving west to east across the plots.
    - Under plant data set – Plot 2 has a higher TN than Plot 3. Plot 4 has a higher TN than Plot 3.
    - Combined plot under versus between plant data sets had no significant differences.
    - Total, under and between data sets all had higher TN in the 0-10cm depth range compared to the 10-30cm.

- Carbon Nitrogen (CN) Ratio:
    - Total data set – Plot 1 has a lower CN ratio than plots 2 and 3. Plot 3 has a higher CN Ratio than plot 2 with the raw data. Plot 3 has higher CN ratio than all other plots.
    - Between plant data set –Plot 3 greater than Plot 1 for the between plant CN ratio.
    - Under plant data set – Plot 3 has a higher CN ratio than Plots 2 and 4.
    - Combined plot under versus between plant data sets had no significant differences.
    - Total, under and between data sets all had higher CN ratios in the 0-10cm depth range compared to the 10-30cm.

- Effective Cation Exchange Capacity (CEC)
    - Total data set –Plot 1 has lower CEC than all other plots.
    - Between plant data set – Plot 1 has a lower CEC than plot 2.
    - Under plant data set – As per between plants, Plot 1 has a lower CEC than plot 2.
    - Combined plot under versus between plant data sets had no significant differences.
    - Total, Under and Between data sets all had higher CEC in the 0-10cm depth range compared to the 10-30cm.
- Calcium (Ca)
    - Soluble Ca
        - Plot 4 exhibited the highest soluble Ca for the under plant (10-30cm depth) and for both depths between the plants.
        - No significant difference was identified under versus between plants and between depths.
    - Exchangeable Ca
        - Plot 2 has a higher exchangeable Ca under plants versus in between (700mg/kg Vs 548mg/kg)
        - Total data set – Plot 1 has a lower exchangeable Ca than plots 2 and 4. Plot 3 has a lower exchangeable Ca than plot 2.
        - Between plant data set – Plot 1 has a lower exchangeable Ca than plot 2.
        - Under plant data set – Plot 2 has a higher exchangeable Ca than plot 1 and 3.
        - Combined plot under versus between plant data sets had no significant differences.
        - Total, under and between data sets all had higher exchangeable Ca in the 0-10cm depth range compared to the 10-30cm.
    - Percentage Ca of CEC
        - Plot 4 has a lower % Ca under plants versus in between (41% Vs 47%)
        - Total data set – had no significant differences between the plots.
        - Between plant data set – Plot 2 has a lower % Ca than plot 4.
        - Under plant data set – Plot 3 has a lower % Ca than plot 1 and 2.
        - Combined plot under versus between plant data sets had no significant differences.
        - Total, between and under plant data sets all had higher % Ca in the 0-10cm depth range compared to the 10-30cm.
        -
- Magnesium (Mg)
    - Soluble Mg - As per Ca

        - Plot 4 exhibited the highest soluble Mg for the under plant (10-30cm depth) and for both depths between the plants.
        - No significant difference was identified under versus between plants and between depths.
    - Exchangeable Mg
        - Plot 1 has a higher exchangeable Mg under plants versus in between (156mg/kg Vs 101mg/kg)
        - Total data set – Plot 1 has a lower exchangeable Mg than all other plots.
        - Between plant data set – Plot 1 has a lower exchangeable Mg than all other plots.
        - Under plant data set – Plot 1 has a lower exchangeable Mg than all other plots.
        - Combined plot under versus between plant data sets had no significant differences.
        - Total under and between data sets all had higher exchangeable Mg in the 0-10cm depth
    - Percentage Mg of CEC
        - Total data set – Plot 3 has a higher % Mg than all other plots.
        - Between plant data set – Plot 3 has a higher % Mg than plot 1.
        - Under plant data set – Plot 3 has a higher % Mg than plot 2.
        - Combined plot under versus between plant data sets had no significant differences.
        - No significant difference for Mg for the 0-10cm depth range compared to the 10-30cm.
- Ca/Mg Ratio
    - Plot 4 has a higher Ca/Mg Ratio under plants versus in between (1.64% Vs 1.29%)
    - Total data set – Plot 3 has a lower Ca/Mg Ratio than all other plots.
    - Between plant data set – No differences identified.
    - Under plant data set – Plot 2 has a higher Ca/Mg Ratio than Plot 3.
    - Combined plot under versus between plant data sets had no significant differences.
    - Total and between data sets all had higher Ca/Mg Ratio in the 0-10cm depth range compared to the 10-30cm.

- Potassium (K)
    - Soluble K
        - No significant difference was identified under versus between plants 0-10cm depth.
        - Analysis not possible for 10-30cm depth due to level being below measurable depth for all except one sample.
    - Exchangeable K
        - Note: 16 of 24 samples had same value result suggesting at low measurable level within calculation for 0-10cm depth. 6 of the 8 non-minimum values were in the under plant subset, with 2 in Plot 1, 3 in Plot 2 and 1 in Plot 4. 7 of 8 samples in 10-30cm depths samples, with the only non-minimum value being in plot 2.
    - Percentage K of CEC
        - Plot 4 has a higher % K under plants versus in between (2.3% Vs 1.6%)
        - Total data set – Plot 1 has a higher % K than Plot 4.

        - Between plant data set – Plot 4 has a lower % K than Plots 1 and 3. Plot 1 has a higher % K to Plot 3.
        - Under plant data set – Plot 2 has a higher % K than plot 3.
        - Combined plot under versus between plant data sets had no significant differences.
        - Only the under plant data set had a high % K for the 0-10cm depth range compared to the 10-30cm.
- Sodium (Na)
    - Exchangeable Na
        - Total data set – Plot 1 has a lower exchangeable Na than plots 2 and 4. Plot 2 has a higher exchangeable Na than plots 3 and 4.
        - Between plant data set – Plot 2 has a higher exchangeable Na than plots 1 and 3.
        - Under plant data set – No difference between the plots was identified for the under plant data set.
        - Combined plot under versus between plant data sets had no significant differences.
        - The between plant data set had higher exchangeable Na in the 0-10cm depth range compared to the 10-30cm. The total data set had a significantly higher content in the 0-10cm depth.

    - Percentage Na of CEC
        - Total data set – The only relationship is plot 2 being greater than plot 4.
        - Between plant data set – Plot 2 has a higher % Na than all other plots.
        - Under plant data set – had no significant differences.
        - Combined plot under versus between plant data sets had no significant differences.
        - Total, under and between plant data sets all had a significant difference for Na for depth with the 0-10cm depth range being approximately 2/3 of the content in the 10-30cm.

- Phosphorus (P)
    - Soluble P -
        - Plot 3 exhibited the highest soluble P for the 0-10cm depth in both under and between plant samples.
        - No significant difference was identified under versus between plants and between depths.
    - Bray 1 P
        - Total data set – Plot 3 has a higher Bray 1 P than Plots 1, 2 and 4 (>2 x the average). Plot 4 has a higher Bray 1 P than Plot 2.
        - Between plant data set – As per the total data set.
        - Under plant data set – Plot 3 has a higher Bray 1 P than Plots 1 and 2 (>2 x the average).
        - Combined plot under versus between plant data sets had no significant differences.
        - Total, under and between data sets all had higher Bray 1 P in the 0-10cm depth range compared to the 10-30cm.

- Aluminium (Al)
        - No statistically significant difference between any data sets for exchangeable Al – within plot, between plots, under versus between plants nor different depth.
        - Total data set – Plot 1 has a higher %Al than Plot 2.
        - Total data set has a lower %Al in the 0-10cm depth range compared to the 10-30cm.

- Hydrogen (H) - Exchangeable and % H
    - Note: 13 of 24 samples had same value result suggesting at low measurable level within calculation for 0-10cm depth, with 1 plot only having a single value. 7 of the 8 10-30cm samples were of the same <1 mg.kg level. Thus only the under versus between for the 0-1cm combined data sets were examined with no statistical difference identified.
- Zinc (Zn)
    - Only the 0-10cm data sets from Under and Between the samples have > two non-minimum values. There was no significant difference between this data.
- Manganese (Mn) –
    - For the 0-10cm and 10-30cm depths - the under plant data set has a lower Mn compared to the between plant data set (4.20 to 8.82mg/kg and 0.65 to 1.28mg/kg respectively).
    - For the under plant samples there was no significant finding.
    - For the between plant samples, the 0-10cm depth has a higher Mn compared to the 10-30cm depth (8.82 to 1.28mg/kg).

- Iron (Fe) –
    - For the between plant samples, the 0-10cm depth has a higher Fe compared to the 10-30cm depth (202 to 28.7mg/kg). These samples reflect the highest compared to the lowest value sets.
- Copper (Cu) –
    - For the 0-10cm depth - the under plant data set has a lower Cu compared to the between plant data set (0.40 to 0.71mg/kg).
    - For the under plant samples the 0-10cm depth has a higher Cu compared to the 10-30cm depth (0.40 to 0.18mg/kg).
    - For the between plant samples, the 0-10cm depth has a higher Mn compared to the 10-30cm depth (0.71 to 0.25mg/kg).
- Boron (B) –
    - For the under plant samples the 0-10cm depth has a higher B compared to the 10-30cm depth (1.29 to 0.57mg/kg).
- Silicon (Si) –
    - No significant relationships detected

Table APP 9.2.1(a): 2021 Data Summary of Means, Difference between Plantation Site Plot results for 0-10cm and Difference between all results of 0-10cm compared to 10-30cm – pH, EC, Total C, Total N, C/N Ratio and CEC for 2021

Soil Property 2021	pH	EC	Total C	Total N	C/N Ratio	Effective Cation Exchange Capacity
Units		dS/m	%	%		cmol+/kg
	(1:5 Water)	(1:5 Water)	(LECO Trumac Analyser)			(Sum of Ca, Mg, K, Na, Al, H)
Mean Plot 1 0-10cm	6.11	0.19	1.13	0.08	12.03	3.81
Mean Plot 2 0-10cm	6.90	0.41	1.66	0.12	13.55	7.48
Mean Plot 3 0-10cm	6.51	0.43	1.61	0.11	15.02	5.65
Mean Plot 4 0-10cm	6.46	0.27	1.91	0.14	13.57	6.16
Overall mean 0-10cm	6.49	0.29	1.60	0.12	13.62	5.65
Number of Outliers	0 within plots 1 within 0-10cm total	1 within plot 1 1 within 0-10cm total	1 within plot 1 1 within 0-10cm total	0 within plots 1 within 0-10cm total	1 within plot 3 1 within 0-10cm total	1 within plot 1 1 within 0-10cm total
Differences in Mean - Plots 0-10cm	2 > 1 and 4	2>all others	1<all others Plot 2: under>between	1<2and4, 3<4 Plot 2: under>between	1<2, 3>all others	1<all other plots
Mean 0-10cm	6.49	0.29	1.60	0.12	13.62	5.65
Mean 10-30cm	6.67	0.31	0.39	0.05	7.89	2.66
Number of Outliers	0 in 0-10cm 1 in 10-30cm	1 in 0-10cm 1 in 10-30cm	1 in 0-10cm 0 in 10-30cm	1 in 0-10cm 0 in 10-30cm	1 in 0-10cm 0 in 10-30cm	1 in 0-10cm 1 in 10-30cm
Difference in Mean at depth - U, B, and T	Total: None Under Plant: None Between Plant: None	Total: None Under Plant: 0-10cm>10-30cm Between Plant: None	Total, Under and Between: 0-10cm > 10-30cm	Total, Under and Between: 0-10cm > 10-30cm	Total, Under and Between: 0-10cm > 10-30cm	Total, Under and Between: 0-10cm > 10-30cm
Under 0-10cm	6.67	0.34	1.64	0.12	13.62	5.81
Between 0-10cm	6.32	0.24	1.55	0.11	13.61	5.51
Number of Outliers	1 under	1 between	1 under	1 under	1 under	1 under
Difference in Mean at 0-10cm - All Plots	Total: Under > Between 0-10cm depth: Under: 2 > 3 and 4	Total: Under > Between 0-10cm depth: Under: None	Total: None 0-10cm depth: Under: 2>3	Total: None 0-10cm depth: Under: 2>3, 4>3	Total: None 0-10cm depth: Under: 3>2 and 4	Total: None 0-10cm depth: Under: 1<2
Comments	o Under plants has a more neutral pH than between plants (mean 6.7 Vs 6.3) for the combined plot data sets.	> 0.86 salt tolerant plants only	Increasing trend from west to east.	Increasing trend from west to east.		
EAL Indicative Guidelines (L = Loam)	Clay L: 6.50 **L: 6.30** L Sand : 6.30	0.15 **0.12** 0.10	>2.6 **>2.0** >1.4	>0.25 **>0.20** >0.15	10–12 **10–12** 10–12	14.3 **7.80** 3.30

Table APP 9.2.1(b): 2021 Data Summary of Means, Difference between Plantation Site Plot results for 0-10cm and Difference between all results of 0-10cm compared to 10-30cm – pH, EC, Total C, Total N, C/N Ratio and CEC for 2021

Soil Property 2021	Soluble Calcium*	Exchangeable Calcium	Base Saturation of Calcium	Soluble Magnesium*	Exchangeable Magnesium	Base Saturation of Magnesium
Units	mg/kg	mg/kg	%	mg/kg	mg/kg	%
Mean Plot1	267	360	43.3	119	128	25.35
Mean Plot2	368	624	41.7	206	244	28.32
Mean Plot3	240	434	39.7	178	221	33.60
Mean Plot4	380	547	44.0	216	226	30.24
Overall mean	314	491	43.5	180	213	29.86
Number of Outliers	None	None	0 within plots 1 within 0-10cm total	None	1 within plot 2 1 within 0-10cm total	0 within plots 1 within 0-10cm total
Differences in Mean - Plots 0-10cm	Plot 4: highest under plant 0-10cm and between plants for both depths	1<2and4, 3<2 'Plot 2: under>between for both depths	Nil interplot Plot 4: under>between	Plot 4: highest under plant 10-30cm and between plants for both depths	1<all other, Plot 1: under>between	3>all other plots
Mean 0-10cm	314	491	52.4	180	213	29.86
Mean 10-30cm	141	185	42.1	86.1	97.5	30.39
Number of Outliers	Nil	0 in 0-10cm 1 in 10-30cm	1 in 0-10cm 0 in 10-30cm	0 in 0-10cm 1 in 10-30cm	1 in 0-10cm 1 in 10-30cm	Nil
Difference in Mean at depth - U, B, and T	None	Total, Under and Between: 0-10cm > 10-30cm	Total, Under and Between: 0-10cm > 10-30cm	None	Total, Under and Between: 0-10cm > 10-30cm	None
Under 0-10cm	310	510	41.6	185	225	30.53
Between 0-10cm	317	472	43.5	175	190	28.23
Number of Outliers	None	None	1 between	None	None	None
Difference in Mean at 0-10cm - All Plots Inter Plot	None	Total: None 0-10cm depth: Under: 2>1and3 Between: 1<2	Total: None 0-10cm depth: Under: 3<1and2 Between: 2<4	None	Total: None 0-10cm depth: Under: 1<all other Between: 1<all other	Total: None 0-10cm depth: Under: 3>2 Between: 3>1
Comments	*only two samples per plot at two depths			*only two samples per plot at two depths		
EAL Indicative Guidelines (L = Loam)	Clay L: 750 **L: 375** L Sand : 175	2150 **1000** 375	75.7 **65.6** 57.4	105 **60** 25	200 **145** 75.0	11.9 **15.7** 18.1

Table APP 9.2.1(c): 2021 Data Summary of Means, Difference between Plantation Site Plot results for 0-10cm and Difference between all results of 0-10cm compared to 10-30cm – pH, EC, Total C, Total N, C/N Ratio and CEC for 2021

Soil Property	**Base Saturation of Potassium**	**Phosphorus (Bray 1)**	**Exchangeable Sodium**	Exchangeable Sodium Percent - ESP	**Base Saturation of Aluminium**
Units	**%**	**mg/kg**	**mg/kg**	%	**%**
Mean Plot1	2.66	13.2	219	22.9	0.72
Mean Plot2	2.10	12.3	442	25.2	0.29
Mean Plot3	1.97	42.2	291	23.3	0.28
Mean Plot4	1.94	19.2	307	21.6	0.38
Overall mean	2.19	20.1	303	23.3	0.41
Number of Outliers	1 within plot 3 0 within 0-10cm total	1 within plot 2 1 within 0-10cm total	0 within plots 1 within 0-10cm total	1 within plot 2 0 within 0-10cm total	1 within plot 3 1 within 0-10cm total
Differences in Mean - Plots 0-10cm	1>4, Plot 4: under>between	3>all other plots, 4>2	1<2and4, 2>all other plots	2>4	1>2
Mean 0-10cm	2.19	20.1	303	23.3	0.41
Mean 10-30cm	2.00	3.76	186.7	32.1	1.04
Number of Outliers	Nil	1 in 0-10cm 1 in 10-30cm	1 in 0-10cm 1 in 10-30cm	Nil	1 in 0-10cm
Difference in Mean at depth - U, B, and T	Under plant: 0-10cm > 10-30cm	Total, Under and Between: 0-10cm > 10-30cm	Total and Between: 0-10cm > 10-30cm,	Total, Under and Between: 0-10cm > 10-30cm	Total 0-10cm < 10-30cm
Under 0-10cm	2.33	18.5	316	24.0	0.31
Between 0-10cm	2.05	19.5	290	22.7	0.48
Number of Outliers	Nil	Nil	1 under	Nil	1 under and 1 between
Difference in Mean at 0-10cm - All Plots Inter Plot	Total: None 0-10cm depth: Under: 2>3 Between: 4<1and3, 1>3	Total: None 0-10cm depth: Under: 3>1and2 Between: '3>all other plots, 4>2	Total: None 0-10cm depth: Under: None Between: '2>1and3	Total: None 0-10cm depth: Under: None Between: 2>all other plots	None
Comments			Very high	Very High	
EAL Indicative Guidelines (L = Loam)	3.50 **5.25** 9.10	30 **24** 20	59.8 **50.6** 25.3	1.80 **2.89** 3.30	7.10 **10.5** 12.1

Table 9.2.1d: Plantation Site Total Data Set and Under Versus Between of Total Data differentials 2019-2021

Location	Significant Data	Analysis - 2021									
		pH	**Electrical Conductivity**	**Total Carbon (%)**	**Total Nitrogen (%)**	**Phosphorus (mg/kg P,**	**Sulfur (mg/kg S)**	**Exchangeable Calcium**	**Exchangeable Potassium**	**Exchangeable Sodium**	**Exchangeable Aluminium**
	Average 2019	5.96	0.316	2.45	0.142		30.5	670			4.29
Total Data	Average 2020	6.43	0.575	1.32	0.077		67.7	349			1.13
	P(T<=t) two-tail	3.06E-03	4.23E-02	2.81E-05	9.61E-06		7.70E-04	2.05E-06			1.90E-07
	Average 2019	5.96		2.45	0.142	13.4		670	63.1		4.29
Total Data	Average 2021	6.49		1.60	0.117	20.1		491	48.3		2.01
	P(T<=t) two-tail	5.50E-06		8.40E-05	1.47E-02	2.54E-02		1.51E-03	1.41E-02		2.06E-05
	Average 2020		0.575		0.077		67.7	349		656	1.13
Total Data	Average 2021		0.291		0.117		30.4	491		303	2.01
	P(T<=t) two-tail		2.06E-02		6.17E-04		8.60E-04	2.87E-03		3.59E-02	2.12E-04
	Average 2019	5.96		2.45				670			4.29
Under	Average 2020 (under)	6.59		1.64				510			1.62
	P(T<=t) two-tail	1.12E-05		1.73E-04				2.18E-02			2.35E-06
	Average 2020 (under)			1.13	0.073			336			1.09
Under	Average 2021 (under)			1.64	0.121			510			1.62
	P(T<=t) two-tail			2.76E-02	2.20E-03			1.15E-02			3.68E-02
	Average 2019	5.96		2.45	0.142			670	63.1		4.29
Between	Average 2020 (between)	6.39		1.55	0.113			472	45.1		2.36
	P(T<=t) two-tail	1.26E-03		8.71E-04	3.21E-02			6.70E-03	3.44E-03		5.00E-04
	Average 2020 (under)				0.081		65.3			467	1.18
Between	Average 2021 (under)				0.113		24.0			290	2.36
	P(T<=t) two-tail				4.54E-02		1.02E-02			4.96E-02	2.31E-03

Table 9.2.1e: Plantation Site Total Data Set and Under Versus Between of Total Data differentials 2019-2021

Location	Significant Data	Analysis - 2021								
		Cation Exchange	**Calcium (%)**	**Magnesium (%)**	**Sodium - ESP (%)**	**Aluminium (%)**	**Hydrogen (%)**	**Zinc (mg/kg)**	**Manganese (mg/kg)**	**Copper (mg/kg)**
	Average 2019		48.3		22.9	0.654	0.608		5.23	
Total Data	Average 2020		30.3		34.6	0.146	0.084		1.55	
	P(T<=t) two-tail		4.13E-05		4.91E-04	3.43E-06	1.20E-04		5.68E-03	
	Average 2019	7.15		25.23		0.654		1.217		0.280
Total Data	Average 2021	5.65		29.86		0.411		0.678		0.557
	P(T<=t) two-tail	1.43E-02		9.69E-03		9.88E-03		1.61E-02		1.42E-02
	Average 2020		30.3		34.6	0.146	0.084		1.55	0.345
Total Data	Average 2021		42.5		23.3	0.411	1.645		6.18	0.557
	P(T<=t) two-tail		6.62E-07		8.59E-05	3.73E-05	5.08E-03		2.11E-03	3.55E-02
	Average 2019	7.15	48.3	25.23		0.654		1.217		
Under	Average 2020 (under)	5.81	41.6	30.53		0.349		0.592		
	P(T<=t) two-tail	3.21E-02	2.99E-02	2.44E-02		3.00E-03		6.05E-03		
	Average 2020 (under)		27.1			0.128	0.078			
Under	Average 2021 (under)		41.6			0.349	1.196			
	P(T<=t) two-tail		5.71E-04			4.89E-03	3.28E-02			
	Average 2019	7.15								0.280
Between	Average 2020 (between)	5.51								0.711
	P(T<=t) two-tail	3.36E-02								3.15E-03
	Average 2020 (under)		32.7		35.6	0.166			1.63	0.362
Between	Average 2021 (under)		43.5		22.7	0.479			7.82	0.711
	P(T<=t) two-tail		1.18E-04		7.84E-04	4.94E-03			7.88E-03	2.70E-02

10.APPENDIX 4: Wild Harvest Site

10.1. 2020 Baseline Wild Harvest Site Soil Sampling Analysis Details

Full outlier and differential analysis of the data contributing to the below tables has been presented in the supplementary document "2020 Additional Data Summary Report" and can be provided on request.

Table 10.1.1: Wild Harvest Total Site Comparison – Scarified to Non-Scarified

Location	Outliers Removed	Significant Data	Analysis								
			Soluble Calcium (mg/kg)	**Phosphorus (mg/kg P, Bray 1)**	**Phosphorus (mg/kg P, Colwell)**	**Nitrate Nitrogen (mg/kg N)**	**Exchangeable Potassium (mg/kg)**	**Calcium (%)**	**Calcium/ Magnesium Ratio**	**Copper (mg/kg)**	**Boron (mg/kg)**
		Average SC	158.5	10.21	9.347		72.99				
Total Data SC Vs NS	No	Average NS	115.0	7.251	6.736		50.52				
		P(T<=t) two-tail	9.38E-03	0.029	0.035		0.023				
		Average SC	150.8				61.53				
Total Data SC Vs NS	Yes	Average NS	115.0				50.52				
		P(T<=t) two-tail	0.017				0.042				
		Average SC		12.47		4.064				0.177	1.200
0-10cm SC v NS	No	Average NS		8.905		2.185				0.122	0.690
		P(T<=t) two-tail		0.014		0.050				0.017	0.019
		Average SC		10.79						0.177	1.200
0-10cm SC v NS	Yes	Average NS		8.371						0.122	0.690
		P(T<=t) two-tail		0.021						0.017	0.019
		Average SC			7.336			11.87	0.468		
10-30cm SC v NS	No	Average NS			4.948			6.758	0.263		
		P(T<=t) two-tail			0.048			0.039	0.038		
		Average SC			7.336			11.87	0.468		
10-30cm SC v NS	Yes*	Average NS			4.948			6.758	0.263		
		P(T<=t) two-tail			0.048			0.039	0.038		

Note:
SC Scarified
NS Non-Scarified / Control Scarification
YES* No Outliers for data sets

Table 10.1.2: Scarified Area Comparison –

Location	Outliers Removed	Significant Data	Analysis							
			Total Carbon (%)	Carbon/ Nitrogen Ratio	Soluble Calcium (mg/kg)	Phosphorus (mg/kg P, Bray 1)	Phosphorus (mg/kg P, Colwell)	Phosphorus (mg/kg P, Bray 2)	Ammonium Nitrogen (mg/kg N)	Sodium - ESP (%)
		Average under			202.5		14.34	15.96		
SC 0-10cm U v B comp	No	Average between			118.7		8.372	8.918		
		P(T<=t) two-tail			0.019		0.034	0.020		
		Average under			202.5		14.3	16.0		
SC 0-10cm U v B comp	Yes*	Average between			118.7		8.4	8.9		
		P(T<=t) two-tail			0.019		0.034	0.020		
		Average 0-10cm				13.52		15.96		
SC 0-10cm v 10-30cm U comp	No	Average 10-30cm				6.505		8.375		
		P(T<=t) two-tail				1.91E-03		0.013		
		Average 0-10cm				12.31		14.27	4.296	
SC 0-10cm v 10-30cm U comp	Yes	Average 10-30cm				6.505		8.375	1.750	
		P(T<=t) two-tail				9.40E-03		0.014	0.024	
		Average 0-10cm	0.646	20.43		11.42		8.918		
SC 0-10cm v 10-30cm B comp**	No	Average 10-30cm	0.284	11.25		2.604		3.673		
		P(T<=t) two-tail	8.97E-04	7.50E-03		7.11E-04		0.011		
		Average 0-10cm	0.646	20.43		9.076		8.918		56.48
SC 0-10cm v 10-30cm B comp**	Yes	Average 10-30cm	0.284	13.85		2.604		3.673		65.57
		P(T<=t) two-tail	8.97E-04	1.98E-03		3.39E-03		0.011		0.023
		Average under		22.23		6.505	9.291	8.375		
SC 10-30cm U v B comp	No	Average between		11.25		2.604	5.382	3.673		
		P(T<=t) two-tail		2.09E-03		6.86E-03	0.039	0.013		
		Average under		22.23		6.505	9.291	8.375		
SC 10-30cm U v B comp	Yes	Average between		13.85		2.604	5.382	3.673		
		P(T<=t) two-tail		0.013		6.86E-03	0.039	0.013		

Note:

SC	Scarified
NS	Non-Scarified / Control Scarification
Yes*	for data sets where sign diff occurred
**	Some samples assumed contaminated due to damage of sampling equipment

Table 10.1.3 (a): Non-Scarified Area Comparison –

Location	Outliers Removed	Significant Data	Analysis									
			Electrical Conductivity (dS/m)	**Total Carbon (%)**	**Total Nitrogen (%)**	**Carbon/ Nitrogen Ratio**	**Soluble Calcium (mg/kg)**	**Soluble Magnesium (mg/kg)**	**Phosphorus (mg/kg P, Bray 1)**	**Phosphorus (mg/kg P, Colwell)**	**Phosphorus (mg/kg P, Bray 2)**	**Sulfur (mg/kg S)**
		Average under		0.923	0.044						12.92	
NS 0-10cm U v B comp	No	Average between		0.502	0.024						9.283	
		P(T<=t) two-tail		1.00E-03	5.07E-04						0.041	
		Average under		0.872	0.044		121.9				12.92	
NS 0-10cm U v B comp	Yes	Average between		0.502	0.024		97.03				9.283	
		P(T<=t) two-tail		1.77E-03	5.07E-04		0.045				0.041	
		Average 0-10cm		0.923	0.044				9.35		12.92	
NS 0-10cm v 10-30cm U comp	No	Average 10-30cm		0.414	0.022				3.941		5.465	
		P(T<=t) two-tail		4.01E-03	5.69E-03				1.45E-03		9.01E-04	
		Average 0-10cm		0.923	0.044		121.9		8.27	8.33	12.92	
NS 0-10cm v 10-30cm U comp	Yes	Average 10-30cm		0.414	0.022		95.83		3.941	6.052	5.465	
		P(T<=t) two-tail		4.01E-03	5.69E-03		0.040		1.02E-03	8.18E-03	9.01E-04	
		Average 0-10cm	1.026			20.53	97.03	208.7	8.46	7.77	9.283	56.29
NS 0-10cm v 10-30cm B comp**	No	Average 10-30cm	2.205			13.81	129.6	374.2	2.287	3.844	3.600	169.4
		P(T<=t) two-tail	3.07E-04			1.39E-03	8.13E-03	7.57E-04	5.68E-07	1.53E-03	0.012	2.98E-04
		Average 0-10cm	1.026			19.74	97.03	208.7	8.46	7.77	9.28	56.29
NS 0-10cm v 10-30cm B comp**	Yes	Average 10-30cm	1.975			13.81	129.6	374.2	2.29	3.84	3.60	169.4
		P(T<=t) two-tail	1.11E-04			1.86E-04	8.13E-03	7.57E-04	5.68E-07	1.53E-03	0.012	2.98E-04
		Average under	1.020			17.78	95.83	214.9	3.941	6.052		82.87
NS 10-30cm U v B comp	No	Average between	2.205			13.81	129.6	374.2	2.287	3.844		169.4
		P(T<=t) two-tail	0.013			0.034	7.20E-03	3.75E-03	0.028	4.06E-03		0.017
		Average under	1.020			17.778	95.825	214.9	3.941	6.052		82.87
NS 10-30cm U v B comp	Yes*	Average between	2.205			13.807	129.625	374.2	2.287	3.844		169.4
		P(T<=t) two-tail	0.013			0.034	7.20E-03	3.75E-03	0.028	4.06E-03		0.017

Note:

Note:	SC	Scarified
	NS	Non-Scarified / Control Scarification
	Yes*	No Outliers for data sets where sign diff occurred
	**	Some samples assumed contaminated due to damage of sampling equipment

Table 10.1.3 (b): Non-Scarified Area Comparison –

Location	Outliers Removed	Significant Data	Analysis										
			Exchangeable Calcium (mg/kg)	**Exchangeable Magnesium (mg/kg)**	**Exchangeable Sodium (mg/kg)**	**Effective Cation Exchange Capacity (ECEC) (cmol+/kg)**	**Calcium (%)**	**Magnesium (%)**	**Potassium (%)**	**Sodium - ESP (%)**	**Aluminium (%)**	**Calcium/ Magnesium Ratio**	**Chloride Estimate (equiv. mg/kg)**
		Average under					20.00	31.83	2.42	45.63			
NS 0-10cm U v B comp	No	Average between					12.18	27.13	1.196	59.36			
		P(T<=t) two-tail					0.018	4.02E-03	0.019	4.21E-03			
		Average under					18.33	31.20	2.08	47.64			
NS 0-10cm U v B comp	Yes	Average between					12.18	27.13	1.196	59.36			
		P(T<=t) two-tail					0.032	7.92E-03	0.011	8.06E-03			
		Average 0-10cm	260.4				20.00	31.83		45.63		0.626	
NS 0-10cm v 10-30cm U comp	No	Average 10-30cm	109.7				8.215	26.55		63.56		0.305	
		P(T<=t) two-tail	1.04E-03				0.011	0.031		4.84E-03		0.017	
		Average 0-10cm	239.6				18.33	31.83		45.63		0.573	
NS 0-10cm v 10-30cm U comp	Yes	Average 10-30cm	109.7				8.215	26.55		63.56		0.305	
		P(T<=t) two-tail	1.42E-03				6.74E-03	0.031		4.84E-03		8.41E-03	
		Average 0-10cm			1054	7.698	12.18			59.36	0.146	0.443	57.80
NS 0-10cm v 10-30cm B comp**	No	Average 10-30cm			2446	15.17	5.301			69.94	0.041	0.221	154.4
		P(T<=t) two-tail			1.24E-05	6.55E-04	4.82E-03			6.33E-03	1.71E-03	7.90E-03	4.06E-05
		Average 0-10cm			1054	7.698	12.177			59.36	0.128	0.443	57.80
NS 0-10cm v 10-30cm B comp**	Yes	Average 10-30cm			2288	15.17	5.30			69.94	0.041	0.221	154.4
		P(T<=t) two-tail			7.98E-03	6.55E-04	4.82E-03			6.33E-03	8.68E-04	7.90E-03	4.06E-05
		Average under	109.7	231.4	1072						0.087		652.7
NS 10-30cm U v B comp	No	Average between	158.2	437.6	2446						0.041		1411
		P(T<=t) two-tail	0.022	4.52E-03	2.48E-03						0.022		0.013
		Average under	109.7	231.4	1072						0.087		652.7
NS 10-30cm U v B comp	Yes*	Average between	158.2	437.6	2446						0.041		1411
		P(T<=t) two-tail	0.022	4.52E-03	2.48E-03						0.022		0.013

Note:

SC	Scarified
NS	Non-Scarified / Control Scarification
Yes*	No Outliers for data sets where sign diff occurred
**	Some samples assumed contaminated due to damage of sampling equipment

Table 10.1.4: Scarified and Non-Scarified Under Versus Between Comparison –

Data Group	Scarified Averages Trend (0-10 to 10-30cm)		Non-Scarified Averages Trend (0-10 to 10-30cm)	
Significant Data	Under Plant (Higher)	Between Plant (Higher)	Under Plant (Higher)	Between Plant (Higher)
pH	Y (10-30cm)			
Electrical Conductivity (dS/m)		Y (10-30cm)	Y (10-30cm)	Y (10-30cm)
Total Carbon (%)	Y (0-10cm)	Y (0-10cm)	Y (0-10cm)	Y (0-10cm)
Total Nitrogen (%)	Y (0-10cm)		Y (0-10cm)	
Carbon/ Nitrogen Ratio	Y (10-30cm)	Y (0-10cm)		Y (0-10cm)
Soluble Calcium (mg/kg)			Y (0-10cm)	Y (10-30cm)
Soluble Magnesium (mg/kg)		Y (10-30cm)		Y (10-30cm)
Soluble Potassium (mg/kg)				
Soluble Phosphorus (mg/kg)				
Phosphorus (mg/kg P, Bray 1)	Y (0-10cm)	Y (0-10cm)	Y (0-10cm)	Y (0-10cm)
Phosphorus (mg/kg P, Colwell)	Y (0-10cm)	Y (0-10cm)	Y (0-10cm)	Y (0-10cm)
Phosphorus (mg/kg P, Bray 2)	Y (0-10cm)	Y (0-10cm)	Y (0-10cm)	Y (0-10cm)
Nitrate Nitrogen (mg/kg N)	Y (0-10cm)			
Ammonium Nitrogen (mg/kg N)				
Sulfur		Y (10-30cm)		Y (10-30cm)
Exchangeable Calcium (mg/kg)			Y (0-10cm)	Y (10-30cm)
Exchangeable Magnesium (mg/kg)		Y (10-30cm)		Y (10-30cm)
Exchangeable Potassium (mg/kg)				
Exchangeable Sodium (mg/kg)		Y (10-30cm)	Y (10-30cm)	Y (10-30cm)
Exchangeable Aluminium (mg/kg)				
Exchangeable Hydrogen (mg/kg)				
Effective Cation Exchange Capacity		Y (10-30cm)	Y (10-30cm)	Y (10-30cm)
Calcium (%)		Y (0-10cm)	Y (0-10cm)	Y (0-10cm)
Magnesium (%)	Y (0-10cm)	Y (0-10cm)	Y (0-10cm)	Y (0-10cm)
Potassium (%)			Y (0-10cm)	
Sodium - ESP (%)		Y (10-30cm)	Y (10-30cm)	Y (10-30cm)
Aluminium (%)		Y (0-10cm)		Y (0-10cm)
Hydrogen (%)				
Calcium/ Magnesium Ratio		Y (0-10cm)	Y (0-10cm)	Y (0-10cm)
Zinc (mg/kg)				
Manganese (mg/kg)				
Iron (mg/kg)	Y (0-10cm)			
Copper (mg/kg)				
Boron (mg/kg)		Y (10-30cm)		Y (10-30cm)
Silicon (mg/kg)	Y (0-10cm)			
Chloride Estimate (equiv. mg/kg)		Y (10-30cm)	Y (10-30cm)	Y (10-30cm)

10.2. 2021 Under Vs Between Wild Harvest Site Detailed Analysis:

From the total parameters list, the following parameters met the criteria for acceptance of a trend with criteria comments included:

- pH:
  - Scarified area - the 0-10cm depth had a lower/more acidic pH than the 10-30cm (7.3 to 7.7)
  - Under plants at the 10-30cm depth, the Scarified area had a higher/more neutral pH than the Non Scarified (7.6 to 7.1)

- Electrical Conductivity (EC):
  - Non-Scarified area – the under plant samples had a lower EC than the between plant samples for both 0-10cm and 0-30cm (0.59 to 1.05 dS/m and 0.75 to 1.40 dS/m)
  - Combined Scarified and Non Scarified area samples – within the 10 to 30cm samples the under plant samples had a lower EC than those taken from between plants (1.40 to 0.91 dS/m).
  - Under plants at the 0-10cm depth, the Non-Scarified area had a lower EC than the Scarified (1.30 to 0.59 dS/m)

- Total Carbon (TC):
  - Scarified area – in the 0-10cm depth, TC was higher in the under plant samples than in those taken from between in the raw data (0.89% to 0.59%). (Became less significant with removal of outlier).
  - Non- Scarified area – in the 0-10cm depth, TC was higher in the under plant samples than in those taken from between (0.79% to 0.52%).
  - In both the Scarified and Non-Scarified samples, the 0-10cm depth samples had a higher TC than for the 10-30cm depth (0.69% to 0.38% and 0.66% to 0.34% respectively)
  - Combined Scarified and Non Scarified area samples – within the 0 to 10cm samples the under plant samples had a higher TC than those taken from between plants. (0.79% to 0.56%)

- Total Nitrogen (TN):
  - Note that the only 10-30cm sample set with more than half its values >0.02 (the minimum measurable level) was the Non-Scarified Under Plant sample.
  - Non- Scarified area – in the 0-10cm depth versus the under sample only 10-30cm depth, TN was higher in the 0-10cm depth (0.051% to 0.022%).

- Carbon Nitrogen (CN) Ratio:
  - No significant result.

- Effective Cation Exchange Capacity (CEC)
  - Non-Scarified area – in both the 0-10cm and 10-30cm depth sample sets, the CEC was higher in the between the plant samples than in those taken from under (6.05 cmol+/kg to 7.51 cmol+/kg and 5.29 cmol+/kg to 8.93 cmol+/kg respectively).

  - Between plant data set – in the 0-10cm depth sample set, the CEC was higher in the Scarified sample set than the Non-Scarified set (10.1 cmol+/kg to 7.51 cmol+/kg respectively).
  - Under plant data set – in both the 0-10cm and 10-30cm depth sample sets, the CEC was higher in the Scarified sample set than the Non-Scarified set (10.3 cmol+/kg to 6.05 cmol+/kg and 7.75 cmol+/kg to 5.29 cmol+/kg respectively).
  - 10-30cm depth data set – the CEC was higher in the between the plant samples than in those taken from under (9.49 to 6.52 cmol+/kg).

    Available nutrients – reflect soil biology….

- Calcium (Ca)
  - Soluble Ca
    - Between Plant Samples – in the 10-30cm depth, the scarified samples had higher Sol Ca than within the non-scarified (114mg/kg to 81.4 mg/kg).
    - Non-Scarified Samples – in the 0-10cm depth, the under plant samples had a higher Sol Ca than the between plant sample set (203 mg/kg to 90.7 mg/kg).
    - Non-Scarified Samples – in the combined under and between data, the 0-10cm depth samples had a higher Sol Ca than the 10-30cm data set (147 mg/kg to 80.9 mg/kg).
    - 0-10cm Data Set –the under plant soluble Ca was almost double that of the between plant data set (197 mg/kg to 99.1 mg/kg).

  - Exchangeable Ca
    - 0-10cm Depth – For both the Scarified and Non-Scarified areas, the under plant area had a higher Exchangeable Ca compared to the between plant samples (315mg/kg to 177mg/kg and 229mg/kg to 141mg/kg respectively)
    - Between Plant Samples – for the 10-30cm Depth the Scarified samples had a higher Exchangeable Ca compared to the Non-Scarified areas between the plants (144mg/kg to 106mg/kg)
    - Scarified Area – The 0-10cm depth total data set had a higher Exchangeable Ca compared to the 10-30cm depth (242 mg/kg to 141mg/kg)
    - 0-10cm – The total 0-10cm data set had a higher Exchangeable Ca under plants compared to between them (270 mg/kg to 160 mg/kg)
  - Percentage Ca of CEC
    - 0-10cm Depth – For both the Scarified and Non-Scarified areas, the under plant area had a higher Ca% compared to the between plant samples (17.2% to 8.54% and 19.4% to 9.32% respectively)
    - 10-30cm Depth – For the Non-Scarified area, the under plant area had a higher Ca% compared to the between plant samples (10.7% to 5.92%)
    - Scarified Area – The 0-10cm depth total data set had a higher Ca% compared to the 10-30cm depth (13.0% to 8.21%)
    - 0-10cm – The total 0-10cm data set had almost double the Ca% under plants compared to between them (18.4% to 9.30%)

- Magnesium (Mg)
  - Soluble Mg -

        - 10-30cm – The total 10-30cm data set had a higher Soluble Mg under plants compared to between them (229 mg/kg to 172mg/kg)
    - Exchangeable Mg
        - Under Plants – within the 0-10cm Depth – the Scarified area had a higher Exchangeable Mg compared to the Non-Scarified area (313mg/kg to 220mg/kg).
        - Non-Scarified Area – The 0-10cm depth total data set had a higher Exchangeable Mg compared to the 10-30cm depth (229 mg/kg to 187mg/kg)
        - 10-30cm – The total 10-30cm data set had a higher Exchangeable Mg between plants compared to under them (174 mg/kg to 271 mg/kg)
    - Percentage Mg of CEC
        - Non-Scarified Area – The 0-10cm depth under plant data set had a higher Mg % compared to the between plant samples (29.9mg/kg to 25.3mg/kg)
        - Non-Scarified Area – The 0-10cm depth total data set had a higher Mg % compared to the 10-30cm depth (28.4 mg/kg to 24.2mg/kg)
        - 0-10cm – The total 0-10cm data set had a higher Mg % under plants compared to between them (28.0% to 25.1%)

- Ca/Mg Ratio
    - 0-10cm Depth – For both the Scarified and Non-Scarified areas, the under plant area had a higher Ca/Mg Ratio% compared to the between plant samples (0.62 to 0.35 and 0.66% to 0.36% respectively)
    - Non-Scarified Area – The 0-10cm depth total data set had a higher Ca/Mg Ratio compared to the 10-30cm depth (0.51 to 0.34)
    - Combined Scarified and Non Scarified area samples – within the 0 to 10cm samples and 10-30cm samples, the under plant samples had a higher Ca/Mg ratio than those taken from between plants. (0.64 to 0.37 and 0.45 to 0.26 respectively)

- Potassium (K)
    - Soluble K
        - Scarified Samples – statistical analysis was conducted on the scarified data comparison of the under versus between data for the 0-10cm depth, and for the total scarified data set for the 0-10cm versus 10-30cm without significant results.
        - Analysis not possible for any other data sets due to level being below measurable depth (<25mg/kg) for ≥ half the 4 available data points in each set. However the comment was that none of the Non-Scarified data sets nor the Scarified between plant 10-30cm data set had more than half of the values ≥ 25mg/kg.
    - Exchangeable K
        - Under Plant Samples– statistical analysis was conducted on the comparison of the under plant data from the scarified and non-scarified data sets without significant results.
        - Analysis not possible for any other data sets due to level being below measurable depth (<50mg/kg) for ≥ half the 10 available data points in each set. However the comment was that none of the between plant, nor the 10-30cm data sets, had more than half of the values ≥ 50mg/kg.
    - Percentage K of CEC

        - Under Plant - For the 0-10cm depth, the Scarified area had a higher K% compared to the Non-Scarified area (2.67% to 1.66%)
        - Non-Scarified Area – The 0-10cm depth under plant samples had a higher K% compared to the between samples (2.67% to 0.91%)
        - 0-10cm – The total 0-10cm data set had double the K% under plants compared to between them (2.17% to 1.07%)
- Sodium (Na)
    - Exchangeable Na
        - Under Plant Samples – for the 0-10cm and the 10-30cm depth, the Scarified samples had a higher Exchangeable Na compared to the Non-Scarified areas under the plants (1289mg/kg to 669mg/kg and 1105mg/kg to 755mg/kg)
        - Non-Scarified Area – The 0-10cm depth and 10-30cm depth data sets both had higher Exchangeable Na between the plants than under them (1074mg/kg to 669mg/kg and 1432mg/kg to 755mg/kg)
        - Between Plant Samples – for the 0-10cm Depth, the Scarified samples had a higher Exchangeable Na compared to the Non-Scarified areas between the plants (1523mg/kg to 1074mg/kg)
        - 0-10cm Depth – For the combined Scarified and Non-Scarified areas, the between plant area had a higher Exchangeable Na compared to the under plant samples (1247mg/kg to 913mg/kg and 1245mg/kg to 863mg/kg respectively)
        - A good sign for plant salt extraction and not scarifying
    - Percentage Na of CEC
        - 0-10cm Depth – For both the Scarified and Non-Scarified areas, the under plant area had a lower Na% compared to the between plant samples (52.2% to 64.5% and 49.0% to 63.7% respectively)
        - 10-30cm Depth – For the Non-Scarified area, the under plant area had a lower Na% compared to the between plant samples (62.1% to 69.9%)
        - Depth Comparison– For both the Scarified and Non-Scarified areas, the 0-10cm depth had a higher Na% compared to the 10-30cm depth (59.6% to 68.1% and 55.8% to 66.0% respectively)
        - Depth Comparison– For both the Scarified and Non-Scarified areas, the under plant sample set had a lower Na% compared to the between plant sample set (49.9% to 64.1% and 65.0% to 70.3% respectively)

- Phosphorus (P)
    - Soluble P -
        - Under plants - Scarified to Non Scarified for the 0-10cm depth, Under versus Between for the Non Scarified for 0-10cm depth, and the under versus between for the total 0-10cm depth samples were appropriate for statistical analysis without significant results.
        - Analysis not possible for any other data sets due to level being below measurable depth (<1mg/kg) for ≥ half the 4 available data points in each set. However the comment was that none of the 10-30cm data sets had more than half of the values ≥ 1mg/kg.
    - Bray 1 P

        - For both the Scarified and Non-Scarified data sets, the 0-10cm data set had a higher P than the 10-30cm data set. (11.2mg/kg to 5.04mg/kg and 7.72mg/kg to 4.41mg/kg respectively)

- Aluminium (Al)
        - Note: limited values were designated as <1% - all 8 were in the 0-10cm depth samples (40 total samples, max of 3 in the 10 between plant, non-scarified, 0-10cm sample set)
    - Exchangeable Al
        - No statistically significant difference between any data sets for exchangeable Al – within plot, between plots, under versus between plants nor different depth.
    - Percentage Al of CEC
        - 10-30cm depth – Both the under plant sample and the between plant sample sets have a lower Al% in the Scarified than the Non-Scarified data sets (0.19% to 0.31% and 0.14% to 0.18%).
        - Non-Scarified Data Set – in the 10-30cm depth, the under plant data set has a higher Al% compared to the between plant data set (0.31% to 0.18%)
        - 10-30cm depth – in the combined Scarified and Non-Scarified data sets, the under plant data set has a higher Al% compared to the between plant data set (0.23% to 0.16%)

- Hydrogen (H) –
    - No available data for analysis – only single non-zero value
- Sulfur (S) –
    - Non-Scarified – Both the 0-10cm depth and the 10-30cm depth the under plant sample set has less S than the between sample set (33.4 to 56.4mg/kg and 46.4 to 93.1mg/kg respectively).
    - 10-30cm depth - in the combined Scarified and Non-Scarified data sets, the under plant data set has a lower S compared to the between plant data set (61.3 to 95.5mg/kg).
- Manganese (Mn) –
    - 0-10cm depth - in the combined Scarified and Non-Scarified data sets, the under plant data set has a higher Mn compared to the between plant data set (2.11 to 1.25mg/kg).
- Iron (Fe) –
    - A single sample indicated some sampling probe material contamination – 10-30cm, between plant sample within the scarified area. No significant differences identified.
- Copper (Cu) –
    - Note: Limited data sets were available without >half the values below the minimum analyzable value <0.1mg/kg – Only the Scarified 0-10cm and 10-30cm for under plants, and the Scarified 0-10cm between plants had more than two data points.
    - No significant differences identified.
- Boron (B) –
    - Non-Scarified – For the 0-10cm depth the under plant sample set has more B than the between sample set (1.40 to 0.81mg/kg). No other significant differences identified.
- Silicon (Si) –

- 10-30cm – For the between plant samples, the Scarified data set has a higher Si than the Non-Scarified (22.4mg/kg to 16.2mg/kg).
- Non-Scarified – For the 0-10cm depth, the under plant sample set has higher Si than the between sample set (36.7mg/kg to 23.6mg/kg).
- Non-Scarified – The 0-10cm depth has a higher Si content than the 10-30cm depth. (30.1 to 16.5mg/kg).
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Table APP 10.2.1(a): 2021 Summary of Means, Difference between Wild Harvest Site Plot results for 0-10cm and Difference between all results of 0-10cm compared to 10-30cm –for 2021

Soil Property 2021	pH	EC	Total C	Total N	C/N Ratio	Effective Cation Exchange Capacity
Units		dS/m	%	%		cmol+/kg
	(1:5 Water)	(1:5 Water)	(LECO Trumac Analyser)			(Sum of Ca, Mg, K, Na, Al, H)
Under SC 0-10cm	7.28	1.29	0.80	0.060	16.65	10.33
Between SC 0-10cm	7.30	1.50	0.59	0.047	14.53	10.08
Under NS 0-10cm	7.15	0.59	0.79	0.057	14.70	6.05
Between NS 0-10cm	7.16	1.05	0.52	0.045	14.53	7.59
Overall mean 0-10cm	7.22	1.11	0.65	0.052	15.23	8.49
Number of Outliers	1 within 0-10cm SC Under	Nil	1 within 0-10cm SC Under 1 within 0-10cm NS Between	Nil	Nil	Nil
Differences in Mean - U Vs B, SC Vs NS, 0-10cm	Nil 0-10cm	SC>NS Under 0-10cm	Nil 0-10cm	Nil 0-10cm	Nil 0-10cm	SC>NS Under 0-10cm SC>NS Between 0-10cm SC>NS Under 10-30cm
Under SC 10-30cm	7.66	1.07	0.41	NA	18.54	7.75
Between SC 10-30cm	7.72	1.40	0.36	NA	17.02	10.05
Under NS 10-30cm	7.05	0.75	0.40	0.022	17.29	5.29
Between NS 10-30cm	6.94	1.40	0.29	NA	16.05	8.93
Overall mean 10-30cm	7.34	1.16	0.36	NA	17.23	8.00
Number of Outliers	Nil	Nil	Nil	Nil	Nil	Nil
Differences in Mean - U Vs B, SC Vs NS, 10-30cm	SC>NS 10-30cm Under	U<B NS 0-10cm U<B NS 10-30cm	U>B NS 0-10cm	Nil 10-30cm	Nil 10-30cm	U<B NS 0-10cm U<B NS 10-30cm
Mean SC 0-10cm	7.29	1.40	0.69	0.053	15.59	10.21
Mean SC 10-30cm	7.69	1.24	0.38	NA	17.78	8.90
Mean NS 0-10cm	7.15	0.82	0.66	0.051	14.86	6.78
Mean NS 10-30cm	7.00	1.07	0.34	NA	16.67	7.11
Number of Outliers	Nil	Nil	1 within 0-10cm SC Under 1 within 0-10cm NS Between	Nil	Nil	Nil
Difference in Mean at depth - U, B, and T	0-10<10-30cm SC	Nil depth differential	0-10>10-30cm SC 0-10>10-30cm NS	Nil depth differential	Nil depth differential	Nil depth differential
Under SC+NS 0-10cm	7.21	0.92	0.85	0.060	15.67	8.19
Between SC+NS 0-10cm	7.19	1.27	0.60	0.046	14.78	8.79
Under SC+NS 10-30cm	7.36	0.91	0.40	NA	17.92	6.52
Between SC+NS 10-30cm	7.33	1.40	0.33	NA	16.54	9.49
Number of Outliers	1 within 0-10cm SC Under 1 within 0-10cm SC Between	Nil	Nil	Nil	Nil	Nil
Difference in Mean Under Versus Between	Nil U vs B differential	U>B for SC+NS and 10-30cm	U>B for SC+NS and 0-10cm	Nil U vs B differential	Nil U vs B differential	U>B for SC+NS and 10-30cm
Comments				Multiple <minimum analysable value limited analysis.		
EAL Indicative Guidelines (L = Loam)	Clay L: 6.50 **L: 6.30** L Sand : 6.30	0.15 **0.12** 0.10	>2.6 **>2.0** >1.4	>0.25 **>0.20** >0.15	10–12 **10–12** 10–12	14.3 **7.80** 3.30

Table APP 10.2.1(b): 2021 Summary of Means, Difference between Wild Harvest Site Plot results for 0-10cm and Difference between all results of 0-10cm compared to 10-30cm –for 2021

Soil Property 2021 Units	**Soluble Calcium***	**Exchangeable Calcium**	**Base Saturation of Calcium**	**Soluble Magnesium***	**Exchangeable Magnesium**	**Base Saturation of Magnesium**
	mg/kg	**mg/kg**	**%**	**mg/kg**	**mg/kg**	**%**
Under SC 0-10cm	411	315	17.2	243	313	26.22
Between SC 0-10cm	152	177	8.5	262	296	24.00
Under NS 0-10cm	203	229	19.4	188	220	29.88
Between NS 0-10cm	91	141	9.3	198	237	25.31
Overall mean 0-10cm	147	217	14.1	223	256	27.01
Number of Outliers	Nil	1 within 0-10cm SC Under 1 within 0-10cm NS Between	1 within 0-10cm SC Under 1 within 0-10cm NS Between	Nil	Nil	1 within 0-10cm SC Between 1 within 0-10cm NS Between
Differences in Mean - U Vs B, SC Vs NS, 0-10cm	Nil 0-10cm	U>B SC 0-10cm U>B NS 0-10cm	U>B SC 0-10cm U>B NS 0-10cm	Nil 0-10cm	SC>NS Under 0-10cm	U>B NS 0-10cm
Under SC 10-30cm	132	179	11.4	200	232	24.33
Between SC 10-30cm	114	144	7.4	238	289	23.35
Under NS 10-30cm	93	111	10.7	168	163	25.24
Between NS 10-30cm	81	106	5.9	220	253	23.18
Overall mean 10-30cm	105	124	8.3	189	216	23.27
Number of Outliers	Nil	Nil	1 within 10-30cm SC Under	Nil	Nil	Nil
Differences in Mean - U Vs B, SC Vs NS, 10-30cm	SC>NS Between 10-30cm 'U>B NS 0-10cm	SC>NS Between 10-30cm	U>B NS 10-30cm	Nil 10-30cm	Nil 10-30cm	Nil 10-30cm
Mean SC 0-10cm	168	242	13.0	252	304	25.54
Mean SC 10-30cm	123	141	8.2	219.0	260	22.20
Mean NS 0-10cm	147	193	15.0	193	229	28.00
Mean NS 10-30cm	87	109	8.3	180.9	187	24.21
Number of Outliers	1 within 0-10cm SC Under 1 within 0-10cm NS Between	1 within 0-10cm SC Under 1 within 10-30cm SC Under 1 within 0-10cm NS Between	1 within 0-10cm SC Under 1 within 0-10cm NS Between 1 within 10-30cm SC Between	1 within 0-10cm SC Under 1 within 10-30cm SC Under	1 within 0-10cm SC Under 1 within 0-10cm SC Between 1 within 10-30cm SC Under	1 within 0-10cm SC Under 1 within 0-10cm NS Between 1 within 10-30cm SC Under
Difference in Mean at depth - U, B, and T	0-10>10-30cm NSC	0-10>10-30cm SC 0-10>10-30cm NSC	0-10>10-30cm SC 0-10>10-30cm NSC	Nil depth differential	0-10>10-30cm NSC	0-10>10-30cm NSC
Under SC+NS 0-10cm	197	270	18.4	195	256	28.61
Between SC+NS 0-10cm	99	160	9.3	230	259	25.07
Under SC+NS 10-30cm	113	123	11.1	172	174	23.27
Between SC+NS 10-30cm	98	125	6.2	229	271	18.29
Number of Outliers	1 within 0-10cm SC Under	1 within 0-10cm SC Under 1 within 10-30cm SC Under	1 within 0-10cm SC Under 1 within 10-30cm SC Under	1 within 10-30cm NS Between	1 within 10-30cm NS Between	1 within 10-30cm SC Under
Difference in Mean Under Versus Between	U>B for SC+NS 0-10cm	U>B for SC+NS and 0-10cm	U>B for SC+NS and 0-10cm U>B for SC+NS and 10-30cm	U>B for SC+NS and 10-30cm	U<B for SC+NS and 10-30cm	U>B for SC+NS and 0-10cm
Comments	*only four samples per set			*only four samples per set		
EAL Indicative Guidelines (L = Loam)	Clay L: 750 **L: 375** L Sand : 175	2150 **1000** 375	75.7 **65.6** 57.4	105 **60** 25	200 **145** 75.0	11.9 **15.7** 18.1

Table APP 10.2.1(c): 2021 Summary of Means, Difference between Wild Harvest Site Plot results for 0-10cm and Difference between all results of 0-10cm compared to 10-30cm –for 2021

Soil Property 2021 Units	Base Saturation of Potassium	Phosphorus (Bray 1)	Exchangeable Sodium	Exchangeable Sodium Percent - ESP	Exchangeable Aluminium	Base Saturation of Aluminium
	%	mg/kg	mg/kg	%	mg/kg	%
Under SC 0-10cm	1.66	11.2	1298	52.2	1.38	0.17
Between SC 0-10cm	1.09	8.9	1523	64.5	1.11	0.14
Under NS 0-10cm	2.67	6.9	669	49.0	2.69	0.40
Between NS 0-10cm	0.91	8.5	1115	61.9	1.20	0.18
Overall mean 0-10cm	1.63	9.4	1139	57.7	1.28	0.23
Number of Outliers	1 within 0-10cm NS Between	1 within 0-10cm SC Under 1 within 0-10cm SC Between 1 within 0-10cm NS Under	Nil	1 within 0-10cm NS Under	1 within 0-10cm SC Between 1 within 0-10cm NS Between	1 within 0-10cm NS Under 1 within 0-10cm NS Between
Differences in Mean - U Vs B, SC Vs NS, 0-10cm	SC<NS Under 0-10cm 'U>B NS 10-30cm	Nil 0-10cm	SC>NS Under 0-10cm 'SC>NS Between 0-10cm U<B NS 0-10cm	U<B SC 0-10cm U<B NS 0-10cm	Nil 0-10cm	Nil 0-10cm
Under SC 10-30cm	1.59	8.6	1105	62.5	1.33	0.19
Between SC 10-30cm	1.45	4.1	1560	67.7	1.25	0.14
Under NS 10-30cm	1.62	4.5	755	62.1	1.45	0.31
Between NS 10-30cm	0.79	4.3	1432	69.9	1.44	0.18
Overall mean 10-30cm	1.36	4.7	1149	67.0	1.34	0.18
Number of Outliers	Nil	Nil	Nil	1 within plot 2 0 within 0-10cm total	Nil	Nil
Differences in Mean - U Vs B, SC Vs NS, 10-30cm	U>B NS 10-30cm	Nil 10-30cm	SC>NS Under 10-30cm U<B NS 10-30cm	U>B NS 10-30cm	Nil 10-30cm	SC<NS Under 10-30cm SC<NS Between 10-30cm U>B NS 10-30cm
Mean SC 0-10cm	1.37	11.16	1406	59.6	1.22	0.15
Mean SC 10-30cm	1.52	5.04	1213.4	68.1	1.29	0.17
Mean NS 0-10cm	1.88	7.72	872	55.8	1.69	0.31
Mean NS 10-30cm	1.20	4.41	1093.5	66.0	1.44	0.22
Number of Outliers	1 within 0-10cm SC Under	1 within 0-10cm SC Between 1 within 10-30cm SC Under 1 within 10-30cm NS Under	1 within10-30cm SC between	1 within10-30cm SC Under 1 within 0-10cm NS Under	1 within 0-10cm SC Under 2 within 0-10cm NS Under	1 within 0-10cm NS Under 1 within 0-10cm NS Between 1 within 10-30cm NS Under
Difference in Mean at depth - U, B, and T	Nil depth differential	0-10>10-30cm SC 0-10>10-30cm NS	Nil depth differential	0-10<10-30cm SC 0-10<10-30cm NS	Nil depth differential	Nil depth differential
Under SC+NS 0-10cm	2.17	10.2	845	49.9	1.55	0.28
Between SC+NS 0-10cm	1.07	8.71	1247	64.1	1.17	0.17
Under SC+NS 10-30cm	1.38	5.24	930	65.0	1.39	0.23
Between SC+NS 10-30cm	0.86	4.24	1400	70.3	1.34	0.16
Number of Outliers	1 within 0-10cm NSC Between 1 within 10-30cm SC Under 1 within 10-30cm SC Between	1 within 0-10cm NS Between 1 within 0-10cm SC Between 1 within 10-30cm SC Under	1 within 10-30cm SC Between	1 within 0-10cm NSC Between 1 within 10-30cm SC Under 1 within 10-30cm SC Between	2 within 0-10cm NS Under 1 within 0-10cm NS Between	1 within 0-10cm NS Under 1 within 0-10cm NS Between 1 within 10-30cm NS Under
Difference in Mean Under Versus Between	U>B for SC+NS and 0-10cm	Nil	U<B for SC+NS and 0-10cm U<B for SC+NS and 10-30cm	U<B for SC+NS and 0-10cm U<B for SC+NS and 10-30cm	Nil	U<B for SC+NS and 0-10cm U<B for SC+NS and 10-30cm
Comments			Very high	Very High		
EAL Indicative Guidelines (L = Loam)	3.50 **5.25** 9.10	30 **24** 20	59.8 **50.6** 25.3	1.80 **2.89** 3.30	7.10 **10.5** 12.1	7.10 **10.5** 12.1

Table APP 10.2.1(d): 2021 Summary of Means, Difference between Wild Harvest Site Plot results for 0-10cm and Difference between all results of 0-10cm compared to 10-30cm –for 2021

Soil Property	Ca/Mg Ratio	Available Micro Nutrient - Manganese*	Available Micro Nutrient - Iron*	Available Micro Nutrient - Boron*	Available Micro Nutrient - Silicon*
Units		mg/kg	mg/kg	mg/kg	mg/kg
Under SC 0-10cm	0.62	2.24	57.5	1.35	29.6
Between SC 0-10cm	0.35	1.38	40.8	1.66	26.3
Under NS 0-10cm	0.66	1.99	45.5	1.40	36.7
Between NS 0-10cm	0.36	1.13	46.9	0.81	23.6
Overall mean 0-10cm	0.48	1.68	39.5	1.31	27.9
Number of Outliers	1 within 0-10cm SC Under 1 within 0-10cm SC Between 1 within 0-10cm NS Between	Nil	1 within 10-30cm SC Between	Nil	Nil
Differences in Mean - U Vs B, SC Vs NS, 0-10cm	U>B SC 0-10cm 'U>B NS 0-10cm	Nil 0-10cm	Nil 0-10cm	U>B SC 0-10cm	U>B NS 0-10cm
Under SC 10-30cm	0.46	1.36	35.1	1.32	19.7
Between SC 10-30cm	0.33	3.04	16.0	1.35	20.9
Under NS 10-30cm	0.43	1.13	56.0	0.84	16.9
Between NS 10-30cm	0.26	0.75	38.0	0.96	16.2
Overall mean 10-30cm	0.37	1.46	33.7	1.06	18.7
Number of Outliers	Nil	Nil	Nil	Nil	Nil
Differences in Mean - U Vs B, SC Vs NS, 10-30cm	Nil 10-30cm	Nil 10-30cm	Nil 10-30cm	Nil 10-30cm	SC>NS Between 10-30cm
Mean SC 0-10cm	0.47	1.81	37.5	1.50	25.3
Mean SC 10-30cm	0.40	2.20	26.9	1.33	21.0
Mean NS 0-10cm	0.51	1.56	46.2	1.11	30.1
Mean NS 10-30cm	0.34	0.82	50.0	0.78	16.0
Number of Outliers	1 within 0-10cm SC Under 1 within 0-10cm NS Under	Nil	1 within 0-10cm SC Under 1 within 10-30cm SC Between	1 within 10-30cm SC Bewteen 1 within 10-30cm NS Between	1 within 0-10cm SC Under
Difference in Mean at depth - U, B, and T	0-10>10-30cm NS	Nil depth differential	Nil depth differential	Nil depth differential	0-10>10-30cm NS
Under SC+NS 0-10cm	0.64	2.11	40.2	1.47	33.1
Between SC+NS 0-10cm	0.39	1.25	43.8	1.24	24.9
Under SC+NS 10-30cm	0.45	1.04	35.0	0.89	17.0
Between SC+NS 10-30cm	0.26	0.83	28.6	1.13	19.3
Number of Outliers	1 within 0-10cm SC Under 1 within 10-30cm SC Between	1 within 10-30cm SC Under 1 within 10-30cm SC Between	1 within 0-10cm SC Under 1 within 10-30cm NS Under 1 within 10-30cm SC Between	1 within 0-10cm SC Under 1 within 10-30cm SC Under 1 within 10-30cm SC Between	1 within 10-30cm SC Under
Difference in Mean Under Versus Between	U>B for SC+NS and 10-30cm	U>B for SC+NS and 0-10cm	Nil	Nil	Nil
Comments		*only four samples per set	*only four samples per set	*only four samples per set	*only four samples per set
EAL Indicative Guidelines (L = Loam)	6.35 **4.17** 3.17	22.0 **18.0** 15.0	22.0 **18.0** 15.0	1.70 **1.40** 1.00	45.0 **40.0** 35.0

Table APP 10.2.2(a): Summary of Means, Difference between Wild Harvest Site Properties for 2021

Location	Significant Data	Analysis									
		pH	Electrical Conductivity	Total Carbon (%)	Total Nitrogen (%)	Soluble Calcium (mg/kg)	Soluble Magnesium	Phosphorus (mg/kg	Sulfur (mg/kg S)	Exchangeable Calcium	Exchangeable Magnesi
	Average U			0.788		197.0				269.8	
0-10cm Total U v B	Average B			0.557		99.1				159.8	
	P(T<=t) two-tail			5.13E-04		3.97E-03				2.09E-04	
	Average U						172		61.3		174
10-30cm Total U v B	Average B						229		95.5		271
	P(T<=t) two-tail						7.51E-03		2.29E-02		1.54E-02
	Average SC		1.30								313
0-10cm Under SC v NS	Average NS		0.59								220
	P(T<=t) two-tail		2.33E-02								8.29E-03
	Average SC										
0-10cm Between SC v NS	Average NS										
	P(T<=t) two-tail										
	Average SC	7.66									
10-30cm Under SC v NS	Average NS	7.05									
	P(T<=t) two-tail	4.71E-02									
	Average SC					114.1				143.7	
10-30cm Between SC v NS	Average NS					81.4				105.8	
	P(T<=t) two-tail					2.48E-02				3.89E-02	
	Average 0-10	7.29		0.685				11.2		242.5	
SC 0-10cm v 10-30cm Total	Average 10-30	7.69		0.385				5.04		141.3	
	P(T<=t) two-tail	2.07E-02		5.93E-03				1.25E-03		1.98E-03	
	Average 0-10			0.659	0.051	146.678		7.72		193.2	229
NS 0-10cm v 10-30cm Total	Average 10-30			0.345	0.022	80.854		4.41		108.6	187
	P(T<=t) two-tail			2.93E-04	4.11E-06	3.05E-02		5.05E-04		2.65E-05	4.01E-02
	Average SC									315	
SC 0-10cm U v B comp	Average NS									177	
	P(T<=t) two-tail									1.06E-02	
	Average U		0.593	0.787		202.6			33.4	229	
NS 0-10cm U v B comp	Average B		1.052	0.517		90.74			56.4	141	
	P(T<=t) two-tail		7.68E-04	8.38E-04		3.97E-03			1.83E-02	6.04E-04	
	Average U		0.750						46.4		
NS 10-30cm U v B comp	Average B		1.399						93.1		
	P(T<=t) two-tail		0.004						6.63E-03		

Table APP 10.2.2(b): Summary of Means, Difference between Wild Harvest Site Properties for 2021

Location	Significant Data	Analysis										
		Exchangeable Sodium	Effective Cation Exchang	Calcium (%)	Magnesium (%)	Potassium (%)	Sodium - ESP (%)	Aluminium (%)	Calcium/ Magnesium Ratio	Manganese (mg/kg)	Boron (mg/kg)	Silicon (mg/kg)
	Average U	913			28.05	2.166	49.9		0.643	2.11		
0-10cm Total U v B	Average B	1247			25.07	1.073	64.1		0.366	1.25		
	P(T<=t) two-tail	3.47E-02			2.90E-02	3.68E-04	2.49E-06		1.35E-05	3.09E-02		
	Average U	863	6.517				65.0	0.230	0.446			
10-30cm Total U v B	Average B	1245	9.489				70.3	0.161	0.263			
	P(T<=t) two-tail	2.38E-02	6.18E-03				2.65E-02	1.99E-02	4.11E-03			
	Average SC	1289	10.331			1.663						
0-10cm Under SC v NS	Average NS	669	6.052			2.668						
	P(T<=t) two-tail	1.42E-02	4.61E-03			3.56E-02						
	Average SC	1523	10.082									
0-10cm Between SC v NS	Average NS	1074	7.507									
	P(T<=t) two-tail	4.88E-02	4.52E-02									
	Average SC	1105	7.749					0.192				
10-30cm Under SC v NS	Average NS	755	5.286					0.314				
	P(T<=t) two-tail	4.70E-02	9.79E-03					2.91E-02				
	Average SC							0.140				22.4
10-30cm Between SC v NS	Average NS							0.183				16.2
	P(T<=t) two-tail							1.90E-02				4.79E-02
	Average 0-10			13.04			59.6					
SC 0-10cm v 10-30cm Total	Average 10-30			8.22			68.1					
	P(T<=t) two-tail			1.57E-02			1.11E-02					
	Average 0-10			15.03	28.40		55.8		0.509			30.1
NS 0-10cm v 10-30cm Total	Average 10-30			8.32	24.21		66.0		0.344			16.5
	P(T<=t) two-tail			1.15E-03	4.52E-03		1.26E-03		4.05E-02			5.27E-03
	Average SC			17.23			52.2		0.622			
SC 0-10cm U v B comp	Average NS			8.54			64.5		0.351			
	P(T<=t) two-tail			5.86E-03			1.03E-02		3.13E-03			
	Average U	669	6.052	19.40	29.88	2.67	49.0		0.661		1.404	36.7
NS 0-10cm U v B comp	Average B	1074	7.507	9.32	25.31	0.914	63.7		0.362		0.808	23.6
	P(T<=t) two-tail	3.06E-04	8.23E-03	2.67E-04	2.68E-03	1.08E-03	1.22E-05		1.72E-03		2.06E-02	4.44E-02
	Average U	755	5.286	10.716			62.1	0.314				
NS 10-30cm U v B comp	Average B	1432	8.929	5.918			69.9	0.183				
	P(T<=t) two-tail	4.51E-03	1.27E-02	2.79E-02			1.87E-02	1.76E-02				

Note:	SC	Scarified
	NS	Non-Scarified / Control Scarification
	U	Under
	B	Between

11.APPENDIX 5: Trial Photographic Representation

Plantation Site 2019 – August 2021

Wild Harvest Site – October 2021

12.APPENDIX 6: Production Bore Data

Table 13.1: Full Analysis Data for Production Bore Water

Analyser		CSBP	CSBP	Handheld Greenhouse
Name		PB1 (Valley)	PB2 (Hillside)	PB1 (Valley)
Date		21/02/20	21/02/20	4/3/2021
Ammonium Nitrogen	**mg/L**	< 0.10	< 0.10	
Nitrate Nitrogen	**mg/L**	< 0.10	< 0.10	
Boron	**mg/L**	0.40	0.13	
Sodium	**mg/L**	1660.00	224.00	
Magnesium	**mg/L**	241.00	24.32	
Phosphorous	**mg/L**	< 0.05	0.16	
Sulfur	**mg/L**	95.27	11.30	
Chloride	**mg/L**	3097.50	352.75	
Potassium	**mg/L**	15.37	3.45	
Calcium	**mg/L**	61.02	13.65	
Manganese	**mg/L**	1.31	< 0.05	
Iron	**mg/L**	< 0.05	< 0.05	
Copper	**mg/L**	< 0.05	< 0.05	
Zinc	**mg/L**	0.09	< 0.05	
Conductivity	**dS/m**	9.030	1.340	7.9
pH		6.8	7.1	

Soil Sample data:

Production Bore 1 (Valley) Soil Deposits

Sample Number	Sample Depth (m)	Sample Colour (informal)	Analysis
1	2	Orange	Full
2	4	Cream/Orange	pH/EC
3	6	Cream/White	Full
9	18	White	pH/EC
12	24	White	Full
14	28	Cream/Orange	pH/EC
15	30	Light Grey/Fawn	-
16	32	Fawn	-
17	34	Cream/Orange	pH/EC
18	36	Light Grey/Fawn	-
19	38	Light Grey/Fawn	-
21	42	Light Grey	pH/EC
24	48	Light Grey	-
27	54	Light Grey	Full
31	62	Light Grey	-
33	66	Light Grey/Fawn	pH/EC

Table 13.2: Full Analysis Data for Production Bore Extracted Soils

(Courtesy of EAL (Environmental Analysis Laboratory) Southern Cross University)

		Sample ID:	PB2-S1	PB2-S2	PB2-S3	PB2-S9	PB2-S12	PB2-S14	PB2-S17	PB2-S21	PB2-S27	PB2-S33	*Sandy Soil*
		Depth:	2 metres	4 metres	6 metres	18 metres	24 metres	28 metres	34 metres	42 metres	54 metres	66 metres	*Loamy Sand*
Parameter		Method reference	K4381/1	K4381/2	K4381/3	K4381/4	K4381/5	K4381/6	K4381/7	K4381/8	K4381/9	K4381/10	Indicative guidelines - refer
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	5.67	6.06	6.32	5.87	6.65	7.32	8.16	9.47	9.28	9.20	*6.3*
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.459	0.436	0.025	0.296	0.198	0.128	0.098	0.066	0.175	0.168	*0.100*
Exchangeable Calcium	($cmol_+$/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	0.74	..	0.08	..	0.11	..	..	..	2.0	..	*1.9*
	(kg/ha)		333	..	35	..	50	..	..	..	901	..	*840*
	(mg/kg)		149	..	16	..	22	..	..	..	402	..	*375*
Exchangeable Magnesium	($cmol_+$/kg)		1.6	..	1.4	..	1.1	..	..	..	0.23	..	*0.60*
	(kg/ha)		443	..	368	..	306	..	..	..	64	..	*168*
	(mg/kg)		198	..	164	..	136	..	..	..	28	..	*75*
Exchangeable Potassium	($cmol_+$/kg)		0.23	..	<0.12	..	<0.12	..	..	..	0.21	..	*0.30*
	(kg/ha)		202	..	<112	..	<112	..	..	..	183	..	*224*
	(mg/kg)		90	..	<50	..	<50	..	..	..	82	..	*100*
Exchangeable Sodium	($cmol_+$/kg)		1.9	..	0.50	..	1.1	..	..	..	0.68	..	*0.11*
	(kg/ha)		969	..	255	..	554	..	..	..	350	..	*57*
	(mg/kg)		433	..	114	..	247	..	..	..	156	..	*25*
Effective Cation Exchange Capacity (ECEC) ($cmol_+$/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H ($cmol_+$/kg)	4.5	..	2.0	..	2.4	..	..	..	3.1	..	*3.3*
Calcium (%)		**Base Saturation Calculations - Cation $cmol_+$/kg / ECEC x 100	17	..	4.0	..	4.7	..	..	..	64	..	*57.4*
Magnesium (%)			36	..	69	..	47	..	..	..	7.5	..	*18.1*
Potassium (%)			5.2	..	1.4	..	2.3	..	..	..	6.7	..	*9.1*
Sodium - ESP (%)			42	..	25	..	45	..	..	..	22	..	*3.3*
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium ($cmol_+$/kg)	0.46	..	0.06	..	0.10	..	..	..	8.6	..	*3.2*
Soil Texture		**AS1547-2012 (Based on Northcote 1979)	Sandy Loam	..	Sandy Clay Loam	..	Sandy Clay Loam	..	..	..	Loamy Sand	..	*..*

(See Notes over the page)

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
   Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 $cmol_+$/kg = 230 mg/kg Sodium, 390 mg/kg Potassium,
    122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
14. Analysis conducted between sample arrival date and reporting date.
15. This report is not to be reproduced except in full. Results only relate to the item tested.
16. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer scu.edu.au/eal).
17. This report was issued on 12/03/2021.

Quality Checked: Kris Saville
Agricultural Co-Ordinator