OAKHURST RISE DEVELOPMENT

SOIL CONSULTATION REPORT

July 2019

Prepared by 59 Degrees AB

CONTENTS & GLOSSARY OF TERMS

CONTENTS

GLOSSARY OF TERMS

Drip Zone – the area defined by the outermost circumference of a tree canopy where water drips from and onto the ground.

Veteran Buffer Zone – the area defined by Natural England as 15x stem diameter.

Tree Buffer Zones – a term used to describe both zones listed above.

Total Biomass – within this report, Total Biomass includes the total biomass of 1st Trophic level organisms including only fungi and bacteria.

Line of best fit – a straight line that best represents the data on a scatter plot.

SOIL CONSULTATION REPORT

1 INTRODUCTION

1.1 59 Degrees AB have been instructed, on behalf of Arboriculturist, Julian Forbes-Laird of FLAC (Forbes-Laird Arboricultural Consultancy), to provide a soil consultation report for the proposed development on land adjacent to Oakhurst Rise, located in Cheltenham. Client William Morrison (Cheltenham Ltd.).

1.2 Following a visit to the site on July 18th 2019, 59 Degrees have been commissioned to produce a report providing details on the Soil Microbiological populations surrounding certain notable trees within the site.

1.3 The proposed development scheme has taken into account various Tree Buffer Zones surrounding trees to be retained as part of the final scheme. This report provides evidence on a microbiological level as to the scope of these zones.

1.4 A glossary of terms is provided at the beginning of the report.

2 SITE VISIT

2.1 As previously mentioned, a visit to the proposed development site was carried out on 18th July 2019, and a site walkover conducted.

2.2 Soil samples were also collected at the location of two trees on site (Tree No. 3018 and Tree No. 3026 on dwg. No. 38-1036.02), both of which are to be retained as part of the final development. The precise methodology of sampling and the results are detailed further in this report and provide evidence to support the current Tree Buffer Zones shown on The Tree Protection Plan provided by FLAC (dwg. No. 38-1036.03).

2.3 Both soils sampled are from Pedunculate Oak (Quercus robur).

Brief Site Description

2.4 The site is approximately 4.3Ha and comprises two separate meadows, separated by a mature hedge/line of trees.

2.5 The site is generally SSW facing and the topography of the site varies by 20 meters over 250 meters (from a height of 125m AOD down to 105m AOD)

2.6 Across the site, the soil seems relatively compacted for this type of environment, which mainly comprises low maintenance meadowland/grassland, a small amount of bramble and scrub with mature hedge/tree defined field boundaries.

2.7 Historically, the treed areas have been left relatively undisturbed. Trees are self organising, self sustaining organisms and have, over the course of their evolution, built in resilience through a myriad of mechanisms. Many of these mechanisms are enhanced through the feeding and establishment of a potent, diverse, and thriving Soil Food Web (SFW) [1].

2.8 To ensure the consistency of sustainability and diversity, differing levels of detail within treed growing systems exist, that are both observable and quantifiable in terms of leaf fall and other above ground carbon debris that then go on to feed the soil dwelling microbes.

2.9 Conversely, in the meadowland, a biannual harvesting of grass using conventional agricultural machinery, that ungulates provide in terms of grazing action, grass trampling and manure, strips the land of valuable biomass. Ungulates are a vital component of a healthy and optimally functioning grassland ecosystem[2]. In this instance, we would expect that the lack of animal interaction within the meadowland has led to a slow demise of the health and productivity of the ecosystem as a whole.

[1] Garbeva, P., Van Veen,J.A., and Van Elsas, J.D., (2004). **Microbial Diversity in Soil.** Annual Review of Phytopathology. ***Vol 42,*** (pgs 243-270).

[2] Rudgers, J.A. et al., (2015). **Long-term ungulate exclusion reduces fungal symbiont prevalence in native grasslands.** Oecologia. ***Vol 181. (pgs.***

3 BACKGROUND INFORMATION

3.1 Without a microbiological portion, soil is just mineral particles and dead organic matter. Microbial communities are needed to extract a steady, but constant flow of nutrients, whilst engineering the soil into a hospitable habitat. Under optimal scenarios, the benefits of a healthy and intact SFW are conferred to both plants and animals by protecting against various forms of pest and disease. The greater the microbiological diversity the, the greater the ecosystem resilience and therefore, the higher the chances of optimal plant health.

3.2 Plants and microbes are intricately linked, with many species forming complex symbiotic relationships that allow each organism to thrive in its environment.

3.3 Woodland soil varies substantially from soil found in grassland and the microbial communities also vary between these ecosystems. Each community is adapted to the environment it lives within and reflects the needs of the plants that grow there.

3.4 For instance, trees preferential uptake of N comes in the form of NH_4^+ (ammonium), which fungi and protozoa readily excrete. This is why, in a mature forest, there is an abundance of fungi, with the fungal communities supressing bacterial populations. Conversely, within grassland ecosystems there is a bacterial dominance. With a lack of fungal biomass to supress populations of Bacteria, NH_4^+ is converted to Nitrate (NO_3^-). Grasses, annuals and other perennials preferentially take up NO_3^-, which bacteria excrete, having converted it from ammonium. By these means, each soil ecosystem becomes tailored, through adaptation and symbiosis, to the needs of the plants it supports.[3]

3.5 Through ecological succession change occurs within the population ratios of fungi and bacteria (and of course other organisms), with this at least partially determining the relative maturity of the ecosystem on a successional scale (with bare soil at 0, and a thriving woodland climax community at 10). Thus, soil microbiological populations reveal the functionality of the soil ecosystem.

3.6 Therefore, when looking at soil samples, a ratio of biomass between fungi and bacteria is calculated (F:B ratio). This tells us how suitable the ecosystem is for the type of vegetation growing there and can help determine whether soil is potentially being influenced by external factors (i.e. soil surrounding a tree that shows a bacterial dominance may be affected by factors occurring in the surrounding environment).

3.7 A grassland ecosystem may require an F:B ratio* of 0.1 - 1[4], whereas, a deciduous woodland environment may require an F:B ratio of anywhere between 5 – 10[4].

***NOTE:** F:B ratios are expressed as a number representing the ratio of fungi, when bacteria are at 1, (i.e. an F:B ratio of 5:1 can simply be represented as 5).

3.8 However, due to the nature of the appeal – the narrow, linear tree lines and the proximity of the grassland to each tree, a more conservative F:B ratio should be expected. It is estimated that in this ecosystem, soils surrounding the Rhizosphere of the tree are likely to have an F:B ratio towards the bottom end of the woodland ecosystem range, i.e. anywhere between 1 and 10 would be considered acceptable.

3.9 The appeal shows a traditional field and hedge/tree layout. Small scale meadows are surrounded by vegetation, comprising large trees, but also shrubs and some scrub. Field boundaries are linear, and areas of trees are narrow and corridor like.

3.10 In general, grassland vegetation extends up to the Drip Zone of the trees, but in some cases extends beyond the Drip Zone, right up to the trunk.

3.11 Bearing in mind the science noted above and the nature of the site, it is likely that the microbiological populations observed within the soil under the trees will not correspond with 'undisturbed' woodland soil microbiological populations. Instead, we would expect soil microbiological populations to be somewhere between what you would expect in grassland and woodland ecosystems.

[3] Elmqvist, T., et al. (2003) **Response diversity, ecosystem change, and resilience.** Frontiers in Ecology and the Environment. ***Vol 1, Issue 9*** (pgs. 488-494).

[4] Ingham, E. R., Oregon State University. https://illinois.edu

4 METHODOLOGY

4.1 This section provides a detailed explanation of the methodology use for sample collection during the site visit.

4.2 During the site visit, the two trees to be sampled were identified, and their Drip Zones measured (details below).

4.3 Using the pre-recorded trunk diameter (provided by FLA), calculations for the the Veteran Tree Buffer zone were obtained. The following calculations were used:

The Distance for the Veteran Tree Buffer (D) = Stem Diameter (S) x 15 (X)

X is a constant (recommended by Natural England) as a guide for maximum protection of the trees.

4.4 Therefore, given the following stem diameter measurements, the distance for the Veteran Tree Buffer zones have been provided in **Table 1** below. The Veteran Tree Buffer Zone is the furthest sample point from the tree stem and another sample point was taken at the Drip Zone.

4.5 A further two sample locations were added within the Drip Zone in order to obtain additional data relating to the microbial populations within this area. All four sample point values have been included below.

Table 1. All sample location figures are given in metres.

	Stem Dia (mm)	1/3 Drip Zone (A)	2/3 Drip Zone (B)	Drip Zone (C)	Veteran Tree Buffer Zone (D)
Tree 3018	1760	3.5	7.0	10.4	25.5*
Tree 3026	1660	3.6	7.2	11.0	24.1*

**To make it easy to measure from the stem itself, half the width of the stem was taken away from D and is shown in the figures above.*

4.6 A total of four soil samples were taken per tree at the measurements provided above, and include:

- Sample Location A; 1/3 of the Drip Zone;
- Sample Location B; 2/3 of the Drip Zone;
- Sample Location C; Drip Zone boundary; and
- Sample Location D; Veteran Tree Buffer.

4.7 A spade was used to cut and extract a small square (a sod) of earth approximately 150x150mm by 200mm deep. This depth was chosen since this is where the majority of root mass would be found. A higher density of microorganisms is prevalent in this area due to the biological communities' dependence on liquid carbon exuded from the root hair. It is this microbe rich zone that directly influences soil health, soil structure, microbe/plant interactions, and consequently the long term health of the plants growing there.

4.8 A photo was taken of each sod. Soil was taken using a soil knife from a variety of depths throughout the sod to gain a variety of spread throughout the soil profile and placed in a standard soil bag.

4.9 Samples were collected between 10am-12am and were analysed as soon as possible on the same day for maximum accuracy.

4.10 Samples were analysed using Bright Field Microscopy with an OMAX compound light microscope.

4.11 Each soil sample was well mixed to integrate all soil and form an even consistency and 1g of soil placed in a small conical flask for further examination.

4.12 Samples were diluted to a 1:5 ratio with water and shaken lightly for 1 minute.

4.13 1 pipette drop of solution was placed on a slide and an 18x18mm cover slip placed on top. One slide was viewed per sample and a total of 20 fields of view were observed per slide.

4.14 Nematodes were counted first using 40x magnification. Then 20 randomly chosen fields of view were observed, counting the fungal strands, protozoa and any other organisms within a calculation table. This table converts these figures into biomass per gram (for fungi and bacteria) and estimated numbers for protozoa.

4.15 All results are provided in full within Appendix 1 and a summary is provided in Section 6 of this report.

4.16 At each sample location, a soil compaction level was recorded using a Penetrometer (Martin Lishman Soil Compaction Tester) and the depth recorded in cm where soil resistance to the penetrometer probe reached 100psi (ca. 690kpa).

5 SOIL MICROBIOLOGICAL RESULTS

5.1 Full Bioassays are presented in Appendix 1 at the end of this report and provide a detailed breakdown of the results.

5.2 The tables (Table 2-4) below present results from the microbiological analysis, and this data has been used, along with statistical analysis (correlation coefficient), in order to determine a suitable standard for Tree Buffer Zones in relation to microbiological populations on site.

5.3 In each instance, an average value has been calculated for the data. The mean average has been used and has been calculated as the sum of all the values (x) divided by the number of values (n).

5.4 The mean values presented form a benchmark at which we can determine whether results presented fall above or below this point.

A Correlation Coefficient (r) value has also been calculated for each set of data in order to check the interdependence of the two variables (x and y, x = the distance away from the tree and y = the F:B ratio, Total Biomass or compaction). A number between +1 and −1 is calculated so as to represent how strongly the data is related.

The following correlation conclusions can be drawn. If the correlation coefficient (r) =

-1 = perfect negative
-1 to -0.5 = strong negative
-0.5 to 0 = weak negative
0 = no correlation
0 to 0.5 = weak positive
0.5 to 1 = strong positive
1 = perfect positive

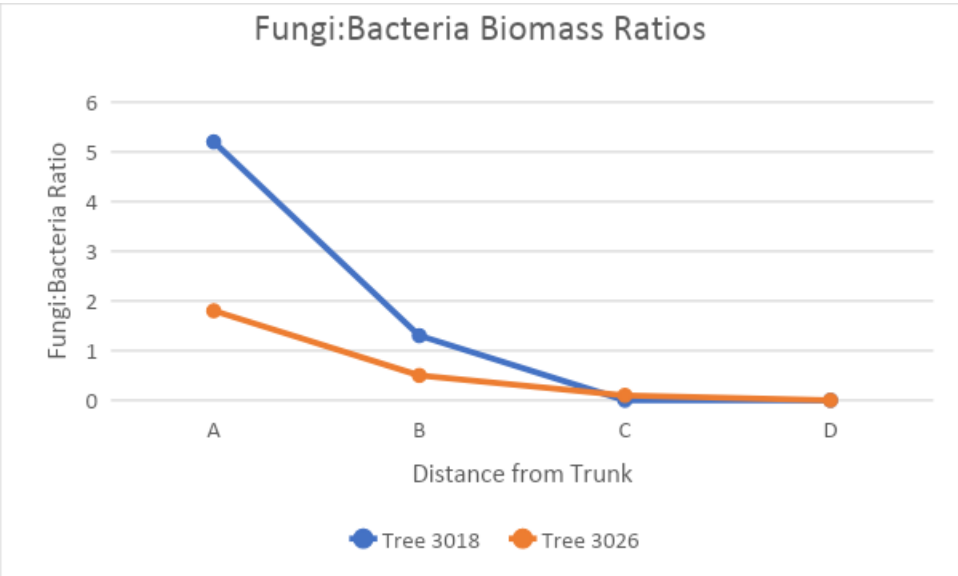
Fungi to Bacteria

5.5 F:B ratios were calculated for each sample location and are presented below.

Table 2. Fungi to bacteria ratios

Fungi to Bacteria Ratio				
	Tree 3018		***Tree 3026***	
Sample Location	Distance (m)	F:B Ratio*	Distance (m)	F:B Ratio
A	3.5	5.2	3.6	1.8
B	7.0	1.3	7.2	0.5
C	10.4	0	11.0	0.1
D	25.5	0	24.1	0
Mean		**1.63**		**0.60**
Correlation Coefficient (r)		**-0.67**		**-0.74**
Combined Correlation Coefficient		**-0.88**		
Correlation Conclusion		**Strong Negative**		

*F:B ratios are expressed as a figure representing the number of fungi, when bacteria are at a value of 1, (i.e. an F:B ratio of 5:1 can simply be represented as 5).



5.6 There is sufficient evidence to conclude that there is a significant linear relationship, of F:B Ratio, between Tree 3018 and Tree 3026. The combined correlation coefficient value of **-0.88** is significantly different from the value of 0, indicating that there is a strong negative correlation between distance and F:B ratio.

5.7 Therefore, the mean can be used as a tool for benchmarking other data.

5.8 The mean for the fungi:bacteria ratios is 1.63 (Tree 3018) and 0.6 (Tree 3026).

5.9 As expected, the F:B ratios were not as high as expected for a 'woodland' ecosystem. However, both sets of data show a linear trend with decreasing F:B ratio the further away from the tree stem.

5.10 Surprisingly, even within the Drip Zone, the F:B ratio dropped off quickly to a figure more accepted in grassland ecosystems. The understorey vegetation included mainly bramble within the Drip Zone of Tree 3018, however for Tree 3026, the vegetation changed from scrub and bramble to grass at about 3.5m. This understorey of vegetation will have an impact on the microbiology present within the soil.

5.11 At sample location B (within the drip zone) of both trees, the F:B ratio falls below that of the calculated mean and well below what is expected for a woodland/ tree environment.

Total Biomass

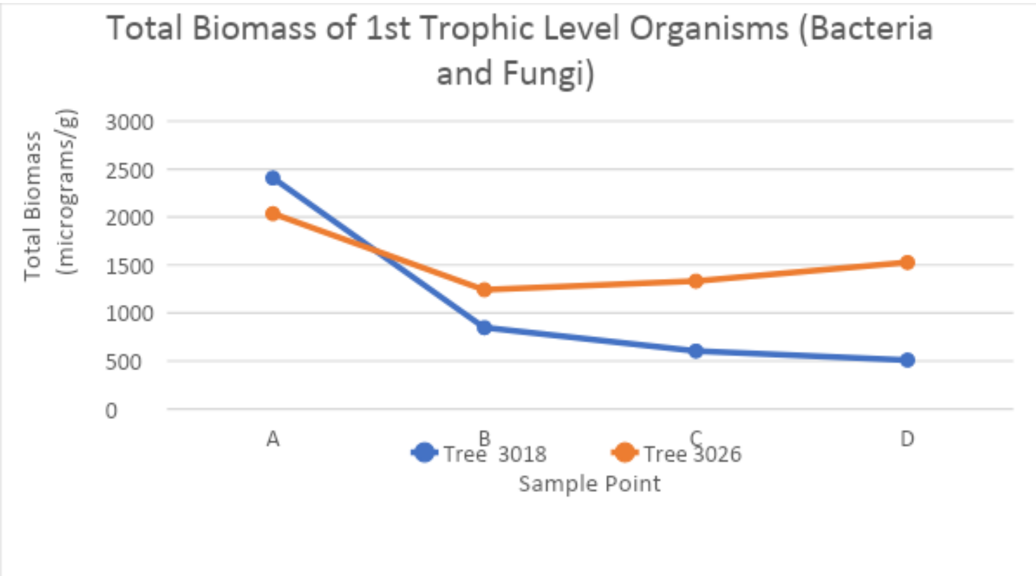
5.12 Total Biomass was calculated as a total between 1st level trophic organisms, including bacteria and fungi. Protozoa were also recorded, but are highly variable in population size due to their reliance on prey (2nd level trophic organisms), and therefore are not a good indicator species.

5.13 **NB:** It is essential to note that where this report makes mention of Total Biomass, it is referring to the above definition rather than the absolute Total Biomass.

5.14 Nematodes were not observed at all and so have not been included in the results. However, it must be noted that nematodes indicate that there is a healthy food web functioning within the soil. A lack of any nematodes indicates that the soil may not have a fully functioning food web currently.

Table 3. Total biomass of 1st Trophic Organisms (bacteria and fungi)

Total Biomass				
	Tree 3018		Tree 3026	
Sample Location	Distance (m)	Biomass (μ/g)	Distance (m)	Biomass (μ/g)
A	3.5	2407	3.6	2035
B	7.0	847	7.2	1242
C	10.4	603	11.0	1332
D	25.5	509	24.1	1526
Mean		**1091.50**		**1533.75**
Correlation Coefficient (r)		**-0.66**		**-0.28**
Combined Correlation Coefficient		**-0.60**		
Correlation Conclusion		**Strong Negative**		



5.15 There is sufficient evidence to conclude that there is a significant linear relationship, of total biomass of first trophic level organisms, between Tree 3018 and Tree 3026. The combined correlation coefficient value of **-0.60** is significantly different from the value of 0, indicating that there is a strong negative correlation between distance and Total Biomass.

5.16 The mean can be used as a tool for benchmarking other data against.

5.17 The mean for the Total Biomass is 1091.50 (Tree 3018) and 1533.75 (Tree 3026).

5.18 For Tree 3018, there is a decrease in Total Biomass as distance from the tree stem increases. Tree 3026 shows an initial drop from point A to B, but then steadily increases to point D. However, the total biomass at Point A is still considerably higher than that of point D.

5.19 At sample location B (within the drip zone) of both trees, the Total Biomass falls below that of the calculated mean.

5.20 These figures imply that the beneficial interactions between soil microbes and tree roots, which leads to a healthier SFW and well structured soil, does not extend out to beyond sample point B at furthest. Typically, biomass is greatest surrounding the Rhizosphere (the area directly surrounding root hairs), due to the plant/microbe interactions, and therefore these results highlight a decline in SFW functionality the further the distance is from the tree stem.

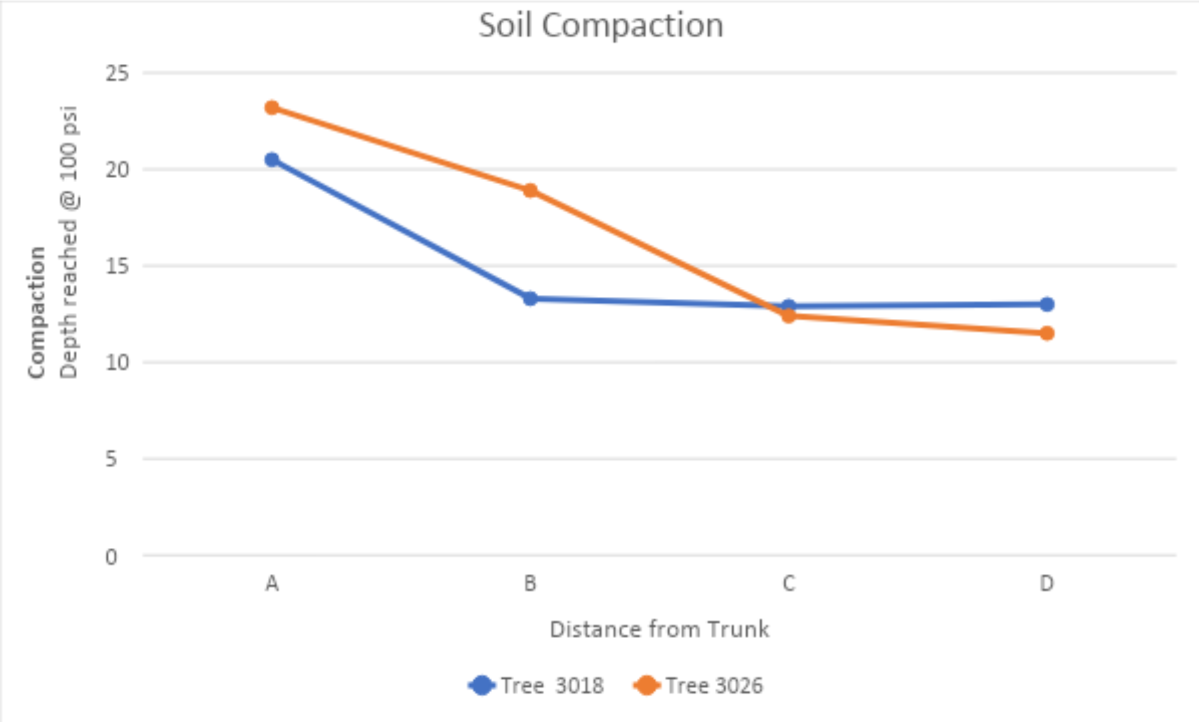
Soil Compaction

5.21 Soil compaction was tested using a Martin Lishman Penetrometer and is recorded at depth at 100psi of pressure.

Table 4. Soil Compaction

Soil Compaction				
	Tree 3018		Tree 3026	
Sample Location	Distance (m)	Depth (cm)*	Distance (m)	Depth (cm)*
A	3.5	20.5	3.6	23.3
B	7.0	13.3	7.2	18.9
C	10.4	12.9	11.0	12.4
D	25.5	16.0	24.1	11.5
Mean		**15.68**		**16.50**
Correlation Coefficient		**-0.20**		**-0.83**
Combined Correlation Coefficient		**-0.69**		
Correlation Conclusion		**Strong Negative**		

**Depth measured at 100psi*



5.22 There is sufficient evidence to conclude that there is a significant linear relationship, of soil compaction, between Tree 3018 and Tree 3026. The combined correlation coefficient value of **-0.69** is significantly different from the value of 0, indicating that there is a strong negative correlation between distance and soil compaction.

5.23 Therefore, the mean can be used as a tool for benchmarking other data against.

5.24 The mean for soil compaction is 15.68 (Tree 3018) and 16.5 (Tree 3026).

5.25 Both trees show a dramatic drop in compaction, between points A to B for Tree 3018, and points A to C for Tree 3026.

5.26 At sample location B (within the drip zone) of Tree 3018, the compaction level falls below that of the calculated mean, however, at Point B Tree 3026 had a compaction value greater than the calculated mean (CMA). Point C value falls below the CMA.

5.27 These figures imply that the beneficial interactions between soil microbes and tree roots, which leads to a healthier SFW and well structured soil, does not extend out to beyond sample point B at furthest. Typically, a healthy SFW provides many benefits to the soil structure, including creating light, friable crumb structure and aerated soil. The increase in compaction in samples further from the tree stem, indicate that the SFW functionality is also declining with distance.

Line of best fit

5.28 For each set of data, a mean was obtained, and a linear line of best fit has been calculated. The line of best fit is a straight line superimposed onto each graph, so that that it best represents the data on the graph.

5.29 The calculated means (y) shown on each table above (Table 2, 3 & 4) have been inserted into their own line of best fit equation to find the value of x (the distance fro the tree).

5.30 From the method above, we are able to find a distance for each set of data, beyond which (i.e. further away from the tree) data is more likely to fall below the average.

5.31 This calculation is intended to provide a baseline distance from the tree, where the values of y are at their averages.

5.32 These values have been averaged again, to show a mean value for the F:B ratio, Total Biomass and soil compaction for each tree. The values are listed below in table 5.

Table 5. Line of best fit averages

Line of Best Fit Averages		
	Tree 3018	***Tree 3026***
Tree Diameter	1.760	1.660
Distance from tree (m)	11.60	11.47
Constant for each tree	6.6	6.9
Average Constant (X)	6.75	

5.33 These indices listed in Table 5. indicate the points (in meters) along the transects where it is expected to find data at the average values (for F:B ratio, Total Biomass & Soil Compaction). Any further out than this from the tree stem and it is likely that values will fall below that of the average.

5.34 Therefore, from a microbiological perspective ONLY (it does not take account of factors such as root protection), this value represents the distance from the tree that may be deemed as a 'safe zone'.

5.35 It must be noted here that changes to the microbiology can occur due to any matter of seemingly insignificant change, and will certainly alter given changes in vegetation cover, compaction, chemical use, ground disturbance, water flow/hydrology etc., and thus these figures act as theoretical values only given that site disturbances are very likely to cause many of these impacts. For this reason, the provision of Veteran Tree Buffer zones that extend well beyond the microbiological 'safe zone' distances can be expected to safeguard soil microorganisms.

5.36 It is advised that the indicated buffer zones provided by FLAC should provide suitable protection to the soil and trees on a microbiological level, particularly given the site's poor current state microbiologically.

6 SUMMARY

6.1 In summary, the results show that the existing microbiological populations, close to the trees, are below what is expected for this type of environment.

6.2 The F:B ratios are significantly poor for this type of habitat and both the F:B ratio and the Total Biomass showed an overall decrease from point A outwards.

6.3 Soil compaction also showed a similar trend.

6.4 Generally, soil seemed compacted over the whole site and a clear increase in compaction was shown with distance from the trees. It is believed that this is due to the lack of periodic ungulate grazing on the land, and is the reason behind the absence of nematode on site.

6.5 Nematodes are indicative of a fully functioning SFW, since they are higher up the food chain, at the 2nd/3rd Trophic levels, and require well aerated soil with good crumb structure. Suggestions have been made in **Section 7**, **Recommendations,** for techniques to improve soil structure and improve the SFW's functionality.

6.6 The Veteran Tree Buffer zone provided by FLAC is generous on a microbiological level, given the results observed in the microbiological soil sampling.

6.7 Ecosystem resilience and integrity refers to empirical scaling relationships that are emergent features of biodiversity. Disturbance through means of mechanical harvesting repeated over decades, have degraded the health of the soil outside of the drip zone to a near hardpan. This is most likely due to a lack of animal interaction and the compounding effects of heavy machinery used in the cutting and harvesting of grass. The soil sods observed during sampling lacked the crumb structure indicative of a soil and plant in a peak state of health. The biological biomass assays support such hypotheses.

6.8 It would be a fair assumption to make that the mycorrhizal associates so valuable to nearly all vascular plants are not present due to the poor soil aggregation since they are instrumental in the building and formation of crumb structure.

6.9 The movement of water through the soil system as a whole must be a vital consideration with the endeavour of retention of valuable specimens within any given ecosystem. However, due to the generous buffer zone and the lack of soil aggregation beyond, it appears highly unlikely the benefits conferred to the specimens beyond the 12x stem diameter root protection area are worth noting.

6.10 The capture zone of rainwater within the indicated buffer zone is more than sufficient to maintain the metabolic processes of the soil ecosystem and the trees they support.

7 RECCOMMENDATIONS

7.1 As mentioned previously, compaction seems to be an issue on site. Given the constrictions that the proposed development places on grazing certain areas on the site retained as grassland, it is advised that other measures be taken in order to reduce compaction and increase microbiological biodiversity.

7.2 It is recommended that mulching the area around the tree stems with good quality, carbon rich compost, up to the drip zone, or where possible given the current understorey layer, will help to increase organic matter within the soil and encourage biological activity, specifically in the formation of humus. This will improve the compaction of these areas. Applications of mulch should be carried out whenever the level drops below about 100mm on the upper surface of soil.

7.3 We would also suggest a root drench for existing trees to increase the species diversity of saprophytes and an inoculation of mycorrhizal spores. Increasing the biological diversity within the soil ecosystem will increase the health and resilience of the plant and will encourage the breakdown of organic matter within the mulch (compost).

7.4 Symptom free does not necessarily mean healthy. We saw first hand the mildew having colonised the leaf surfaces of some of the oak trees nearby. When trees are in the upper spirals of health, the trees can manufacture sufficient lipids through the leaf epidermis to create the “waxy surface” preventing colonisation from such a fungus.

59 Degrees

Soil Biology Specialists

APPENDIX 1: Soil Microbiology Analysis Report

Study Site	OAKHURST RISE CHELTENHAM
Client	WILLIAM MORRISON
Date Issued	19/07/2019
Soil Analyst	Octavia Hopwood
Methodology	Bright field microscope 1 g soil analysed - 20 fields viewed per slide 1 slide per sample Expected ranges are averaged in biomass, and expected ranges correlate to healthy biological ecosystems.

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59 Degrees: *Soil Biology Specialists*

GUIDE: for reading Soil Microbiology Analysis Report

Definition Scale:

	Within Optimal Range*			
Very Low	***Low Optimal***	***Optimal***	***High Optimal***	***Very High***
Very Low	***Low Average***	***Average***	***High Average***	***Very High***

*Results are considered healthy when they are within the Optimal Range (as defined in the scale above), but they can sit at the lower or upper ends. In some cases (as with fungi), it is not necessarily bad if the results do venture into the ***Very High*** range. Where this is the case, a note will be provided.

Bacteria It is expected that between 300 and 2000 µg/g of bacteria are observed in a healthy soil sample. Any results higher or lower than this figure, indicate that there may be imbalances within the SFW.

Protozoa Protozoa numbers are dependent on a range of factors so it is hard to define an optimal level, however, it is important to observe good numbers (>10,000) of a mixture of amoeba and flagellates within the sample (indicative of good Soil Food Web activity), and a lack of large numbers of ciliates (these indicate poor soil conditions).

Fungi It is expected that between 100 and 300 µg/g of fungi are observed in a healthy soil sample. However, due to the woodland type ecosystem, it is expected that a much higher level of fungi should be observed (from 300 to 5000 µg/g). High levels of oomycetes (pathogenic fungi) indicate disease and would not be considered good.

Nematodes Nematodes are indicative of healthy soil, since they are only present in Soil Food Webs that are well balanced and stable, and when soil conditions are suitable. Nematodes prefer soil that is well aerated and has good crumb structure.

Ratios It is expected that, in a wooded/treed ecosystem such as this, a Fungi:Bacteria (F:B) ratio of between 1 and 10 is reached. This would indicate that the soil is fungally dominated which is ideal for trees.

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Biomass Assay

Tree No. 3018

Sample No. 1A
Sample location Within Drip Zone
Distance from trunk centre 3.5m

Date collected 18/07/2019
Date observed 19/07/2019
Compaction (depth @ 100psi) 20.5 cm

Sample description
Moderate organic content, good moisture, woodland smell. Silty texture. Bramble scrub vegetation cover and deadwood at sample location.

	Units	Result	Optimal	Rating
Bacteria				
Total bacteria	µg/g	391	300 - 2000	Low Optimal
Protozoa				
Flagellates	no./g	163,040	> 10, 000	Very High
Amoebae	no./g	20,380	> 10, 000	High Average
Ciliates	no./g	0	0 - 7000	Very Low
Fungi				
Total fungi	µg/g	2016	100 - 300*	Very High
Hyphal diameter	(µm)	5.5	> 2.5	Very High
Oomycetes	µg/g	0	<300	Low
Hyphal diameter	(µm)	0	n/a	n/a
Nematodes				
Total beneficial	no./g	0	10 - 25	Very Low
Total root feeding	no./g	0	0	Excellent
Ratios				
T. fungi/ T. bacteria	n/a	5.2	1 - 10	Optimal

*Although this is an optimal range, higher numbers of fungal hyphae are beneficial (excluding the oomycetes species).

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Analysis

Bacteria

A low optimal amount of bacteria was observed in this sample, meaning that bacteria are at the lower end of the optimal range. A moderate diversity of species was observed, since both cocci and bacillus species were viewed.

Protozoa

A very high amount of flagellates were observed in the sample, and a high average amount of amoeba were observed, which indicates a good level of activity within the soil. No ciliates were observed, which indicates that the sample is not anaerobic or has been anaerobic recently. NOTE: anaerobic soils are not condusive to healthy soil food web ecosystems.

Fungi

A very high amount of fungal hyphae were observed in the sample which is what we would expect to see in this type of ecosystem. No oomycetes (non-beneficial fungal species) were observed within the sample.

Nematodes

No nematodes were observed in the sample. It would be good to see more nematodes in the sample as they are an indicator species of a healthy, functioning soil. No root feeding nematodes were observed which is a positive sign, as they can potentially cause damage and disease to plants.

Ratios

An optimal ratio between fungi and bacteria was calculated for the sample, meaning that the ratio is within the optimal range. This indicates that the soil is dominated by fungi (what you would expect to see within this type of habitat). The result is still at the lower end of what we would like to see, but this may be due to the presence of the grassland habitat in close proximity.

Treatment recommended

Advice

A very good soil sample in general in terms of F:B ratios and protozoa count. A good amount of benefical fungi were observed within the sample, indicating a soil reasonably adapted for a woodland/treed ecosystem. It is presumed that the lack of nematodes is due to the highly compacted nature of the soil across the site. Although nematodes can hep aerate soil, they are fairly fragile creatures and do not fair well within compacted soil. Advice would be to relieve the soil of compaction, by building up the organic content of the soil. Mulching the site surrounding the trees would provide a buffer to the soil environment and would start to encorporate organic matter into the soil. This would help slowly relieve compaction, whilst maintaining and building a healthy soil food web (without the need to mechanically aerate the soil which would disturb the soil food web).

Biomass Assay

Tree No.	3018
Sample No.	1B
Sample location	Within Drip Zone
Distance from trunk centre	7.0m
Date collected	18/07/2019
Date observed	19/07/2019
Compaction (depth @ 100psi)	13.3 cm

Sample description

Moderate organic content, good moisture, woodland smell. Silty texture. Bramble scrub vegetation cover and deadwood at sample location.

	Units	Result	Optimal	Rating
Bacteria				
Total bacteria	µg/g	372	300 - 2000	Low Optimal
Protozoa				
Flagellates	no./g	61,140	> 10, 000	Very High
Amoebae	no./g	0	> 10, 000	Very Low
Ciliates	no./g	0	0 - 7000	Very Low
Fungi				
Total fungi	µg/g	475	100 - 300*	Very High
Hyphal diameter	(µm)	5	> 2.5	Very High
Oomycetes	µg/g	0	<300	Low
Hyphal diameter	(µm)	0	n/a	n/a
Nematodes				
Total beneficial	no./g	0	10 - 25	Very Low
Total root feeding	no./g	0	0	Excellent
Ratios				
T. fungi/ T. bacteria	n/a	1.3	1 - 10	Low Optimal

*Although this is an optimal range, higher numbers of fungal hyphae are beneficial (excluding the oomycetes species).

Analysis

Bacteria

A low optimal amount of bacteria was observed in this sample, meaning that bacteria are at the lower end of the optimal range. A moderate diversity of species was observed, since both cocci and bacillus species were viewed.

Protozoa

A very high amount of flagellates were observed in the sample, but no amoeba were observed, which indicates a moderate level of activity within the soil. It would be good to see more amoeba within the sample as they indicate healthy nutrient cycling. No ciliates were observed, which indicates that the sample is not anaerobic or has been anaerobic recently. NOTE: anaerobic soils are not condusive to healthy soil food web ecosystems.

Fungi

A very high amount of fungal hyphae were observed in the sample which is what we would expect to see in this type of ecosystem. No oomycetes (pathogenic fungal species) were observed within the sample.

Nematodes

No nematodes were observed in the sample. It would be good to see more nematodes in the sample as they are an indicator species of a healthy, functioning soil. No root feeding nematodes were observed which is a positive sign, as they can potentially cause damage and disease to plants.

Ratios

A low optimal ratio between fungi and bacteria was calculated for the sample, meaning that the ratio is at the lower end of the optimal range. This indicates that the soil is dominated by fungi (what you would expect to see within this type of habitat). The result is still at the lower end of what we would like to see however, but this may be due to the presence of the grassland habitat in close proximity.

Treatment recommended

Advice

A very good soil sample in general in terms of F:B ratios and protozoa count. A good amount of benefical fungi were observed within the sample, although the F:B ratio was lower than expected. This could be due to the similarly low populations of both bacteria and fungi. It is presumed that the lack of nematodes is due to the highly compacted nature of the soil across the site. Although nematodes can hep aerate soil, they are fairly fragile creatures and do not fair well within compacted soil. Advice would be to relieve the soil of compaction, by building up the organic content of the soil. Mulching the site surrounding the trees would provide a buffer to the soil environment and would start to encorporate organic matter into the soil. This would help slowly relieve compaction, whilst maintaining and building a healthy soil food web (without the need to mechanically aerate the soil which would disturb the soil food web). Applications of root injections and mycorrhizal spores could be considered, however further soil samples may need to be taken during and after development.

Biomass Assay

Tree No. 3018

Sample No. 1C
Sample location Edge of Drip Zone
Distance from trunk centre 10.6m

Date collected 18/07/2019
Date observed 19/07/2019
Compaction (depth @ 100psi) 12.9 cm

Sample description
Moderate organic content but also high mineral content, good moisture, woodland smell. Silty texture. Grass at sample location.

	Units	Result	Optimal	Rating
Bacteria				
Total bacteria	µg/g	603	300 - 2000	Low Optimal
Protozoa				
Flagellates	no./g	101,900	> 10, 000	Very High
Amoebae	no./g	20,380	> 10, 000	High Average
Ciliates	no./g	0	0 - 7000	Very Low
Fungi				
Total fungi	µg/g	0	100 - 300*	Very Low
Hyphal diameter	(µm)	0	> 2.5	Very Low
Oomycetes	µg/g	0	<300	Low
Hyphal diameter	(µm)	0	n/a	n/a
Nematodes				
Total beneficial	no./g	0	10 - 25	Very Low
Total root feeding	no./g	0	0	Excellent
Ratios				
T. fungi/ T. bacteria	n/a	n/a	1 - 10	n/a

*Although this is an optimal range, higher numbers of fungal hyphae are beneficial (excluding the oomycetes species).

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Analysis

Bacteria

A low optimal amount of bacteria was observed in this sample, meaning that bacteria are at the lower end of the optimal range. A moderate diversity of species was observed, since both cocci and bacillus species were viewed.

Protozoa

A very high amount of flagellates were observed in the sample, and a high average amount of amoeba were observed, which indicates a good level of activity within the soil. No ciliates were observed, which indicates that the sample is not anaerobic or has been anaerobic recently. NOTE: anaerobic soils are not condusive to healthy soil food web ecosystems.

Fungi

No fungi was observed in the sample, indicating that soil conditions are not sufficiently healthy in terms of structure to support fungal populations. No oomycetes (pathogenic fungal species) were observed within the sample which is good.

Nematodes

No nematodes were observed in the sample. It would be good to see more nematodes in the sample as they are an indicator species of a healthy, functioning soil. No root feeding nematodes were observed which is a positive sign, as they can potentially cause damage and disease to plants.

Ratios

No figure could be calculated for F:B ratio since no fungi were observed. This is thus a bacterially dominated soil, which is not ideal for this type of ecosystem. The presence of a grassland type habitat as an understorey at this sample location and the high compaction level may help explain the lack of fungi.

Treatment recommended

Advice

A lack of fungi indicates that conditions at the sample location are far from ideal in terms of soil structuring. Visually a difference was seen between the crumb structure of 1A and 1C, with 1C appearing far more compacted with less air spaces and less organic matter. The compaction issues on site may limit the soil's capacity for good fungal populations. It is presumed that the lack of nematodes is due to the highly compacted nature of the soil across the site. Advice would be to relieve the soil of compaction, by building up the organic content of the soil. Mulching the site surrounding the trees would provide a buffer to the soil environment and would start to encorporate organic matter into the soil. This would help slowly relieve compaction, whilst maintaining and building a healthy soil food web (without the need to mechanically aerate the soil which would disturb the soil food web). Applications of root injections and mycorrhizal spores could be considered, however further soil samples may need to be taken during and after development.

Biomass Assay

Tree No. 3018

Sample No. 1D
Sample location Veteran Tree Buffer
Distance from trunk centre 25.5m

Date collected 18/07/2019
Date observed 19/07/2019
Compaction (depth @ 100psi) 16.0 cm

Sample description
Mainly a high mineral content, good moisture, woodland smell. Silty texture. Grass at sample location.

	Units	Result	Optimal	Rating
Bacteria				
Total bacteria	µg/g	509	300 - 2000	Low Optimal
Protozoa				
Flagellates	no./g	40,760	> 10, 000	Very High
Amoebae	no./g	0	> 10, 000	Very Low
Ciliates	no./g	0	0 - 7000	Very Low
Fungi				
Total fungi	µg/g	0	100 - 300*	Very Low
Hyphal diameter	(µm)	0	> 2.5	Very Low
Oomycetes	µg/g	0	<300	Low
Hyphal diameter	(µm)	0	n/a	n/a
Nematodes				
Total beneficial	no./g	0	10 - 25	Very Low
Total root feeding	no./g	0	0	Excellent
Ratios				
T. fungi/ T. bacteria	n/a	n/a	1 - 10	n/a

*Although this is an optimal range, higher numbers of fungal hyphae are beneficial (excluding the oomycetes species).

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Analysis

Bacteria
A low optimal amount of bacteria was observed in this sample, meaning that bacteria are at the lower end of the optimal range. A low diversity of species was observed, since mainly cocci species were viewed.

Protozoa
A very high amount of flagellates were observed in the sample, but no amoeba were observed, which indicates a moderate level of activity within the soil. It would be good to see more amoeba within the sample as they indicate healthy nutrient cycling. No ciliates were observed, which indicates that the sample is not anaerobic or has been anaerobic recently. NOTE: anaerobic soils are not condusive to healthy soil food web ecosystems.

Fungi
No fungi was observed in the sample, indicating that soil conditions are not sufficiently healthy in terms of structure to support fungal populations. No oomycetes (pathogenic fungal species) were observed within the sample which is good.

Nematodes
No nematodes were observed in the sample. It would be good to see more nematodes in the sample as they are an indicator species of a healthy, functioning soil. No root feeding nematodes were observed which is a positive sign, as they can potentially cause damage and disease to plants.

Ratios
No figure could be calculated for F:B ratio since no fungi were observed. This is thus a bacterially dominated soil, which is not ideal for this type of ecosystem. The presence of a grassland type habitat as an understorey at this sample location and the high compaction level may help explain the lack of fungi.

Treatment recommended

Advice
A lack of fungi indicates that conditions at the sample location are far from ideal in terms of soil structuring. Visually a difference was seen between the crumb structure of 1A and 1D, with 1D appearing far more compacted with less air spaces and less organic matter. The compaction issues on site may limit the soil's capacity for good fungal populations. It is presumed that the lack of nematodes is due to the highly compacted nature of the soil across the site. Advice would be to relieve the soil of compaction, by building up the organic content of the soil. Mulching the site surrounding the trees would provide a buffer to the soil environment and would start to encorporate organic matter into the soil. This would help slowly relieve compaction, whilst maintaining and building a healthy soil food web (without the need to mechanically aerate the soil which would disturb the soil food web). Applications of root injections and mycorrhizal spores could be considered, however further soil samples may need to be taken during and after development.

Biomass Assay

		Tree No.	3026
Sample No.	2A	**Date collected**	18/07/2019
Sample location	Within Drip Zone	**Date observed**	19/07/2019
Distance from trunk centre	3.6 m	**Compaction** (depth @ 100psi)	23.2 cm

Sample description

Moderate organic content, good moisture, woodland smell. Silty texture. A small amount of bramble scrub vegetation cover and deadwood at sample location.

	Units	Result	Optimal	Rating
Bacteria				
Total bacteria	µg/g	734	300 - 2000	Low Optimal
Protozoa				
Flagellates	no./g	61,140	> 10, 000	Very High
Amoebae	no./g	0	> 10, 000	Very Low
Ciliates	no./g	0	0 - 7000	Very Low
Fungi				
Total fungi	µg/g	1301	100 - 300*	Very High
Hyphal diameter	(µm)	7.4	> 2.5	Very High
Oomycetes	µg/g	0	<300	Low
Hyphal diameter	(µm)	0	n/a	n/a
Nematodes				
Total beneficial	no./g	0	10 - 25	Very Low
Total root feeding	no./g	0	0	Excellent
Ratios				
T. fungi/ T. bacteria	n/a	1.8	1 - 10	Low Optimal

*Although this is an optimal range, higher numbers of fungal hyphae are beneficial (excluding the oomycetes species).

Analysis

Bacteria

A low optimal amount of bacteria was observed in this sample, meaning that bacteria are at the lower end of the optimal range. A moderate diversity of species was observed, since both cocci and bacillus species were viewed.

Protozoa

A very high amount of flagellates were observed in the sample, but no amoeba were observed, which indicates a moderate level of activity within the soil. It would be good to see more amoeba within the sample as they indicate healthy nutrient cycling. No ciliates were observed, which indicates that the sample is not anaerobic or has been anaerobic recently. NOTE: anaerobic soils are not condusive to healthy soil food web ecosystems.

Fungi

A very high amount of fungal hyphae were observed in the sample which is what we would expect to see in this type of ecosystem. No oomycetes (pathogenic fungal species) were observed within the sample.

Nematodes

No nematodes were observed in the sample. It would be good to see more nematodes in the sample as they are an indicator species of a healthy, functioning soil. No root feeding nematodes were observed which is a positive sign, as they can potentially cause damage and disease to plants.

Ratios

A low optimal ratio between fungi and bacteria was calculated for the sample, meaning that the ratio is at the lower end of the optimal range. This indicates that the soil is dominated by fungi (what you would expect to see within this type of habitat). The result is still at the lower end of what we would like to see, but this may be due to the presence of the grassland habitat in close proximity.

Treatment recommended

Advice

A very good soil sample in general in terms of F:B ratios and protozoa count. A good amount of benefical fungi were observed within the sample, although the F:B ratio was lower than expected. This could be due to the relatively good bacterial population and a relatively low population of fungi. It is presumed that the lack of nematodes is due to the highly compacted nature of the soil across the site. Although nematodes can hep aerate soil, they are fairly fragile creatures and do not fair well within compacted soil. Advice would be to relieve the soil of compaction, by building up the organic content of the soil. Mulching the site surrounding the trees would provide a buffer to the soil environment and would start to encorporate organic matter into the soil. This would help slowly relieve compaction, whilst maintaining and building a healthy soil food web (without the need to mechanically aerate the soil which would disturb the soil food web).

Biomass Assay

Tree No. 3026

Sample No. 2B
Sample location Within Drip Zone
Distance from trunk centre 7.2m

Date collected 18/07/2019
Date observed 19/07/2019
Compaction (depth @ 100psi) 18.9 cm

Sample description
Moderate organic content, good moisture, woodland smell. Silty texture. Bramble scrub vegetation cover and deadwood at sample location.

	Units	Result	Optimal	Rating
Bacteria				
Total bacteria	µg/g	802	300 - 2000	Optimal
Protozoa				
Flagellates	no./g	40,760	> 10, 000	Very High
Amoebae	no./g	0	> 10, 000	Very Low
Ciliates	no./g	0	0 - 7000	Very Low
Fungi				
Total fungi	µg/g	440	100 - 300*	Very High
Hyphal diameter	(µm)	5	> 2.5	Very High
Oomycetes	µg/g	0	<300	Low
Hyphal diameter	(µm)	0	n/a	n/a
Nematodes				
Total beneficial	no./g	0	10 - 25	Very Low
Total root feeding	no./g	0	0	Excellent
Ratios				
T. fungi/ T. bacteria	n/a	0.55	1 - 10	Very Low

*Although this is an optimal range, higher numbers of fungal hyphae are beneficial (excluding the oomycetes species).

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Analysis

Bacteria

An optimal amount of bacteria was observed in this sample, meaning that bacteria are within the optimal range for this ecosystem. However, a limited diversity of species was observed, since only cocci species were viewed.

Protozoa

A very high amount of flagellates were observed in the sample, but no amoeba were observed, which indicates a moderate level of activity within the soil. It would be good to see more amoeba within the sample as they indicate healthy nutrient cycling. No ciliates were observed, which indicates that the sample is not anaerobic or has been anaerobic recently. NOTE: anaerobic soils are not condusive to healthy soil food web ecosystems.

Fungi

A very high amount of fungal hyphae were observed in the sample which is what we would expect to see in this type of ecosystem, however, compared to the amount of bacteria observed, low F:B ratios are expected. No oomycetes (pathogenic fungal species) were observed within the sample.

Nematodes

No nematodes were observed in the sample. It would be good to see more nematodes in the sample as they are an indicator species of a healthy, functioning soil. No root feeding nematodes were observed which is a positive sign, as they can potentially cause damage and disease to plants.

Ratios

A very low ratio between fungi and bacteria was calculated for the sample, meaning that the ratio is below the optimal range. This indicates that the soil is dominated by bacteria (not what you would expect to see within this type of habitat). The result is at the lower end of what we would like to see, but this may be due to the presence of the grassland habitat in close proximity and compaction levels.

Treatment recommended

Advice

A moderate soil sample in general in terms of F:B ratios and protozoa count. A good amount of benefical fungi were observed within the sample, although the F:B ratio was lower than expected. This could be due to the relatively good bacterial population and a relatively low population of fungi. It is presumed that the lack of nematodes is due to the highly compacted nature of the soil across the site. Although nematodes can hep aerate soil, they are fairly fragile creatures and do not fair well within compacted soil. Advice would be to relieve the soil of compaction, by building up the organic content of the soil. Mulching the site surrounding the trees would provide a buffer to the soil environment and would start to encorporate organic matter into the soil. This would help slowly relieve compaction, whilst maintaining and building a healthy soil food web (without the need to mechanically aerate the soil which would disturb the soil food web). Applications of root injections and mycorrhizal spores could be considered, however further soil samples may need to be taken during and after development.

Biomass Assay

Tree No. 3026

Sample No. 2C
Sample location Edge of Drip Zone
Distance from trunk centre 11 m

Date collected 18/07/2019
Date observed 19/07/2019
Compaction (depth @ 100psi) 12.4 cm

Sample description
Mainly high mineral content, good moisture, woodland smell. Silty texture. Grass at sample location.

	Units	Result	Optimal	Rating
Bacteria				
Total bacteria	µg/g	1213	300 - 2000	Optimal
Protozoa				
Flagellates	no./g	40,760	> 10, 000	Very High
Amoebae	no./g	0	> 10, 000	Very Low
Ciliates	no./g	0	0 - 7000	Very Low
Fungi				
Total fungi	µg/g	119	100 - 300*	Low Optimal
Hyphal diameter	(µm)	5	> 2.5	Very High
Oomycetes	µg/g	0	<300	Low
Hyphal diameter	(µm)	0	n/a	n/a
Nematodes				
Total beneficial	no./g	0	10 - 25	Very Low
Total root feeding	no./g	0	0	Excellent
Ratios				
T. fungi/ T. bacteria	n/a	0.1	1 - 10	Very Low

*Although this is an optimal range, higher numbers of fungal hyphae are beneficial (excluding the oomycetes species).

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Analysis

Bacteria
An optimal amount of bacteria was observed in this sample, meaning that bacteria are within the optimal range. A moderate diversity of species was observed, since both cocci and bacillus species were viewed.

Protozoa
A very high amount of flagellates were observed in the sample, but no amoeba were observed, which indicates a moderate level of activity within the soil. It would be good to see more amoeba within the sample as they indicate healthy nutrient cycling. No ciliates were observed, which indicates that the sample is not anaerobic or has been anaerobic recently. NOTE: anaerobic soils are not condusive to healthy soil food web ecosystems.

Fungi
A low optimal amount of fungi was observed in the sample, indicating that soil conditions are not sufficiently healthy in terms of structure to support good levels of fungal populations. No oomycetes (pathogenic fungal species) were observed within the sample which is good.

Nematodes
No nematodes were observed in the sample. It would be good to see more nematodes in the sample as they are an indicator species of a healthy, functioning soil. No root feeding nematodes were observed which is a positive sign, as they can potentially cause damage and disease to plants.

Ratios
A very low ratio between fungi and bacteria was calculated for the sample, meaning that the ratio is below the optimal range. This indicates that the soil is dominated by bacteria (not what you would expect to see within this type of habitat). The result is at the lower end of what we would like to see, but this may be due to the presence of the grassland habitat in close proximity and compaction levels.

Treatment recommended

Advice
A lack of fungi indicates that conditions at the sample location are far from ideal in terms of soil structuring. Visually a difference was seen between the crumb structure of 2A and 2C, with 2C appearing far more compacted with less air spaces and less organic matter. The compaction issues on site may limit the soil's capacity for good fungal populations. It is presumed that the lack of nematodes is due to the highly compacted nature of the soil across the site. Advice would be to relieve the soil of compaction, by building up the organic content of the soil. Mulching the site surrounding the trees would provide a buffer to the soil environment and would start to encorporate organic matter into the soil. This would help slowly relieve compaction, whilst maintaining and building a healthy soil food web (without the need to mechanically aerate the soil which would disturb the soil food web). Applications of root injections and mycorrhizal spores could be considered, however further soil samples may need to be taken during and after development.

Biomass Assay

Tree No.	3026
Sample No.	2D
Sample location	Veteran Tree Buffer
Distance from trunk centre	24.1 m
Date collected	18/07/2019
Date observed	19/07/2019
Compaction (depth @ 100psi)	11.5 cm

Sample description

Mainly a high mineral content, good moisture, woodland smell. Silty texture. Grass at sample location.

	Units	Result	Optimal	Rating
Bacteria				
Total bacteria	µg/g	1526	300 - 2000	High Optimal
Protozoa				
Flagellates	no./g	81,520	> 10, 000	Very High
Amoebae	no./g	0	> 10, 000	Very Low
Ciliates	no./g	0	0 - 7000	Very Low
Fungi				
Total fungi	µg/g	0	100 - 300*	Very Low
Hyphal diameter	(µm)	0	> 2.5	Very Low
Oomycetes	µg/g	0	<300	Low
Hyphal diameter	(µm)	0	n/a	n/a
Nematodes				
Total beneficial	no./g	0	10 - 25	Very Low
Total root feeding	no./g	0	0	Excellent
Ratios				
T. fungi/ T. bacteria	n/a	n/a	1 - 10	n/a

*Although this is an optimal range, higher numbers of fungal hyphae are beneficial (excluding the oomycetes species).

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Analysis

Bacteria

A high optimal amount of bacteria was observed in this sample, meaning that bacteria are at the higher end of the optimal range. A moderate diversity of species was observed, since both cocci and bacillus species were viewed.

Protozoa

A very high amount of flagellates were observed in the sample, but no amoeba were observed, which indicates a moderate level of activity within the soil. It would be good to see more amoeba within the sample as they indicate healthy nutrient cycling. No ciliates were observed, which indicates that the sample is not anaerobic or has been anaerobic recently. NOTE: anaerobic soils are not condusive to healthy soil food web ecosystems.

Fungi

No fungi was observed in the sample, indicating that soil conditions are not sufficiently healthy in terms of structure to support fungal populations. No oomycetes (pathogenic fungal species) were observed within the sample which is good.

Nematodes

No nematodes were observed in the sample. It would be good to see more nematodes in the sample as they are an indicator species of a healthy, functioning soil. No root feeding nematodes were observed which is a positive sign, as they can potentially cause damage and disease to plants.

Ratios

No figure could be calculated for F:B ratio since no fungi were observed. This is thus a bacterially dominated soil, which is not ideal for this type of ecosystem. The presence of a grassland type habitat as an understorey at this sample location and the high compaction level may help explain the lack of fungi.

Treatment recommended

Advice

A lack of fungi indicates that conditions at the sample location are far from ideal in terms of soil structuring. Visually a difference was seen between the crumb structure of 2A and 2D, with 2D appearing far more compacted with less air spaces and less organic matter. The compaction issues on site may limit the soil's capacity for good fungal populations. It is presumed that the lack of nematodes is due to the highly compacted nature of the soil across the site. Advice would be to relieve the soil of compaction, by building up the organic content of the soil. Mulching the site surrounding the trees would provide a buffer to the soil environment and would start to encorporate organic matter into the soil. This would help slowly relieve compaction, whilst maintaining and building a healthy soil food web (without the need to mechanically aerate the soil which would disturb the soil food web). Applications of root injections and mycorrhizal spores could be considered, however further soil samples may need to be taken during and after development.