SOIL HEALTH, TREE HEALTH

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VEALE GARDENS/WALYU YARTA - (PARK 21) - PART 2

This case study examines the application of advanced tree management techniques to rehabilitate a population of trees experiencing decline in Urban Forestry. These management techniques focus on enhancing soil health by improving soil physical structure, chemistry and biology. The efficacy of this approach was evaluated using innovative sensing technologies to better understand the links between soil health and tree health and to quantify the productivity of trees in Urban Forestry.

Following up to PART 1 of this Case Study, which ran in *The Australian Arbor Age* February/March 2019 issue, we are taking a further step ahead with this project, focusing on the evaluation of the tree and soil response.

Section 2: Plant Health Care and Evaluating Tree and Soil Response

2.1 Plant Health Care (PHC) Applications

In 2016, a soil remediation plant health care plan was designed for 30 trees in the northwest corner of Veale Gardens/Walyu Yarta. This plan included a mixture of compost, mulch, compost tea and microbial stimulants applied from 2016 - 2018 (Table 1). The first step was to calculate individual Tree Protection Zones (TPZ) and remove grass (sod) from within the treatment areas (Figure 6). One healthy tree, Tree #31, was left untreated and used as a healthy control tree throughout the course of the project.

Figure 6: An example of the individual tree preparation area. The grass was removed, and a layer of compost and mulch applied then liquid amendments applied via drench and soil injection method.

APPLICATION	APPLICATION INPUT	APPLICATION RATES
2016	Compost – AS 4454 2012 - compliant	100mm per tree
2016	Mulch – ACC Green waste - tub grinding	150mm per tree
2017 & 2018	Actively aerated compost tea - AACT - liquid drench and soil probe	Approx. 252,000 litres applied between 30 trees
2017 & 2018	Microbial stimulants	Approx. 336,000 litres applied between 30 trees

Table 1: Soil Remediation PHC – Applications - Total Application volumes – 30 x trees.

Figure 7A: G.U.F - PHC - preparation centre at the Adelaide Nursery. AACT 3 x 1000L mobile brew operation.

Figure 7B: AACT - microbe brewer oxygenating the 1000 L liquid solution to provide conditions for beneficial aerobatic microbes to increase.

Compost Application

100mm of compost material was applied to each designated TPZ. Compost was recommended because it's a good source of plant nutrients and organic carbon, which provides an important food source for soil microorganisms early in the remediation process. Unfortunately, the standards for producing compost (Australian Standard AS 4454 – 2012 Compost, Soil Conditioners and Mulch) do not put an emphasis on quality, such that compost quality varies widely. Increasing the minimum standards for compost to promote material that is fit for soil remediation, meaning it can improve soil biological, chemical and physical status in soil would help improve compost quality.

Mulch Application

150 mm of course green waste mulch material was supplied by the ACC Green waste facility and was applied to each trees unique Tree Protection Zone (TPZ) area.

Actively Aerated Compost Tea (AACT)

AACT is a liquid soil amendment produced with specialised equipment that contains bacteria, fungi, protozoa, nematodes and soluble nutrients sourced from high-quality compost.

Over a 24-hour period the liquid amendment is brewed with food additives to grow bacteria and fungi and aerated with dissolved oxygen to grow the aerobic organisms derived from the compost inoculum. The outcome is a liquid product containing a concentrate of beneficial microorganisms including bacteria, fungi, protozoa and nematodes. Figures 7A, B and C show the processes used by G.U.F. for producing and applying AACT.

Microbial Stimulants

Microbial stimulants are organic liquid amendments that provide a strong food source for soil microbes. The types of products used are for specific microbial ▶

Figure 7C: G.U.F – PHC application Vehicle.

groups and are high quality and laboratory tested for their specific stimulant efficacy. Microbial stimulants consist of products such as:

- Kelp
- Fish Hydrolysate
- Humic Acid
- Molasses

Microbial Inoculums

Microbial inoculums provide dormant spores of species of Mycorrhizae and were applied as part of each batch of AACT, then drenched onto the tree rootzone area covered by compost and mulch.

2.2 Measuring Photosynthesis - Canopy Function Data

The photosynthesis data collected in this study was collected using a sophisticated but inexpensive hand-held photosynthesis meter called the MultispeQ which was connected to the PhotosynQ open data platform (Figure 8A). PhotosynQ is a collaborative online plant research platform, which enables users to create, share and collaborate worldwide to analyse detailed sophisticated environmental scientific information. The PhotosynQ project was developed at Michigan State University in the Kramer Laboratory. The device and platform allow for intensive data collection to unlock nature's secrets and develop a greater understanding of how the natural world functions in its innumerable complexities.

Figure 8A: The PhotosynQ cloud-based open source data collection platform.

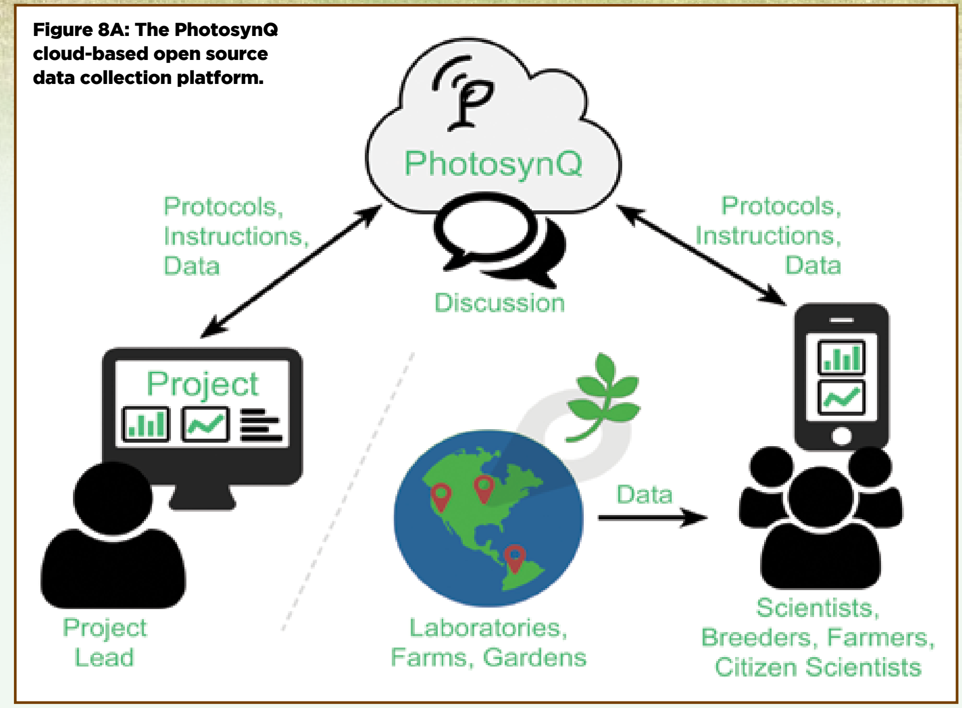

Figure 8B: The MultispeQ V1.0 sensor which links to a mobile phone via a PhotosynQ app.

In 2015, Matthew Daniel of Global Urban Forest Pty Ltd was invited by the PhotosynQ team to beta test the platform and join the Experts Program. This initial small group hailed from diverse fields of science and industry which included agricultural research scientists from Malawi (East Africa), science educators from Ukraine, Great Barrier Reef marine science researchers from Australia and plant scientists from across the USA. ▶

Each member of the initial 'Experts Program' were supplied with a 3D printed MultispeQ prototype to conduct research in their chosen fields and support the development of the MultispeQ version 1.0. Matthew Daniel's focus was the Arboriculture and Urban Forest industry. He developed the Tree Health Calculator 1.0 project to better understand the link between soil health and canopy function.

MultisepQ, photosynthesis data was collected from 2015 - 2018, intensively during the PHC # 1 and # 2 program mobilizations. The primary photosynthesis parameters that were measured with the MultispeQ are as follows:

- **SPAD** – Relative chlorophyll content, measures leaf" greenness"
- **Phi2**[UNBOLD] – Quantum yield of Photosystem II. This measurement is essentially the percentage of incoming light (excited electrons) that go into Photosystem II. Photosystem II is where most light energy is converted into food
- **PhiNPQ** – Estimate of non-photochemical quenching. The amount of incoming light that is regulated away from photosynthetic processes to reduce damage to the plant
- **PhiNO** – Ratio of incoming light that is lost via non-regulated processes. PhiNO is the combination of several unregulated processes whose by-products can inhibit photosynthesis or be harmful to the plant
- **LEF** – Linear Electron Flux. The total flow of electrons from antennae complexes (were light is captured) into Photosystem II, taking the leaf absorptivity into account. Calculated as LEF = Phi2 x PAR x 0.42

2.3: Measuring Soil Compaction and Moisture Content

Soil compaction was measured using a penetrometer (Figure 9A). Penetrometers measure the force of pushing a spike into the soil and then note the depth at which the pressure is recorded. For example, 600 psi @ 5cm would indicate high soil compaction at a shallow depth that would restrict healthy tree root growth.

Soil moisture was measured using a moisture probe that provides moisture content as volumetric water content percentage (Figure 9B). Moisture was recorded at three depths - 10 cm, 20cm, 40cm.

Figure 9A: Measuring soil physical status: using a penetrometer to determine soil compaction.

Figure 9B: Measuring soil moisture with a moisture probe.

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2.4: Laboratory Analysis of Soil Samples
Soil samples were collected from a subset of eight trees every year starting in 2015. Soil samples were collected from each tree in 2016, 2017 and 2018 to determine the shift in soil chemistry and allow for adjustments in the PHC program applications. These samples were then sent to Environmental Analysis Laboratories, Southern Cross University, Lismore NSW for analysis.

The chemistry assessments conducted were to understand three essential components of soil nutrients:

1. Total Nutrients
2. Available Nutrients
3. Exchangeable Nutrients

2.5: Measuring Soil Respiration
Soil respiration was measured for a subset of eight trees using a Carbon Mineralization Sensor developed by Dr. Dan TerAvest of Our Sci, LLC, a start-up from Michigan, USA. This method adds water to an air-dry soil sample and measures the resulting "burst" of CO2 after 24 hours by using a syringe to push air over a pass-through CO2 sensor. This methodology can be easily conducted by Urban Forest tree survey professionals in soil health investigations and can assist in the specification of input materials such as composts and mulches.

Disclaimer
Note: Any soil analysis or observation taken and recorded in this report will only ever capture the status of the soil and vegetation on that day. It must be emphasized that changes of sometimes considerable magnitude can be expected in response to normal seasonal and extreme weather responses and some management actions. This means that outcomes as anticipated with the available evidence collated may be unpredictable, so regular recording of the soil and vegetation using a Soil Health Card or VSA and VTA or TREE HEALTH CALCULATOR 1.0 is essential, with the taking of photos always encouraged to record a history of change. G.U.F warrants that the methods adopted in its programs are largely a practical application of many years of experience in Plant Health Care together with scientifically verified management directives and measures through numerous sensors which are continually improved as new research findings come to hand.

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