



# SOIL HEALTH, TREE HEALTH

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## VEALE GARDENS/WALYU YARTA - (PARK 21) - PART 1

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.

### Summary

A four-year case study in remediating tree decline in Veale Gardens/Walyu Yarta (Park 21), Adelaide Park Lands.

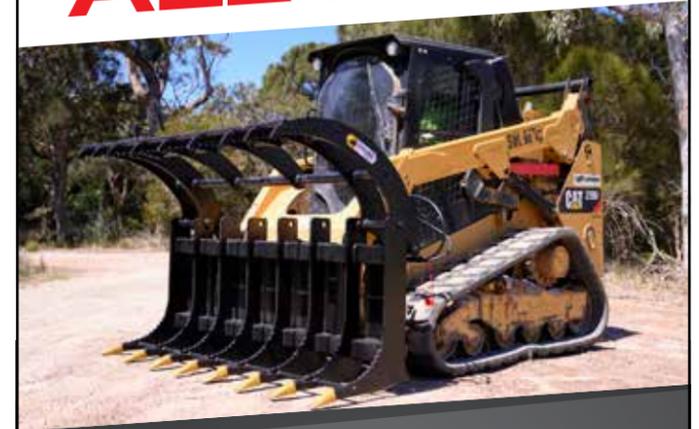
Urban Forestry is currently experiencing unprecedented growth around the globe. By emulating a healthy natural system, urban forestry endeavours to provide multiple benefits including improving human health, increasing ecological sustainability, mitigating storm water and sequestering carbon. However, one of the most important goals of modern Urban Forestry is mitigating the Urban Heat Island Effect (UHIE) through the natural process of transpiration. This cooling effect from evapotranspiration comes from both plants and soil. Healthy plants and soil produce a microclimate that reduces air temperatures day and night during extreme heat conditions. This microclimate productivity is essential to the viability of cities and urbanised areas around the globe. Extreme temperatures and the constraints of urbanisation have a relatively unknown effect on plant and soil health and present an ongoing issue to the effective use and sustainability of urban forests as mitigation tools. The complexities that drive urban forestry's ability to provide sustainable ecosystem functions are currently underdefined and oversimplified.

The current standard approach to define tree health in Arboriculture is based on a Visual Tree Assessment (VTA). This approach uses few objective measures and instead relies on a complex set of observed tree health indicators that vary widely depending on the applicator's education and experience. This



Matthew Daniel, Director of Global Urban Forest Pty Ltd conducted site inspections and soil testing.

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## CASE STUDY

small range of measures does little to define overall tree health and rarely considers below ground factors such as soil health.

This scenario presents a major opportunity to improve the current standards in tree assessment in managing the urban forest. Global Urban Forest (G.U.F) have been investigating and remediating tree decline in urban environments for over a decade. The common denominators of tree decline are extreme weather events and poor soil health. These are interlinked and compounding and often lead to tree decline events. Despite the importance of soil health in tree decline, it is rarely considered nor currently defined in horticulture.

In this case study, soil health is defined as a framework of physical structure, biological activity and soil chemistry. All of which are interrelated,

so increasing soil biological activity can improve soil chemical and physical parameters and vice versa. Measuring all three components provides a detailed understanding to apply evidence-based management practices to improve soil fertility in the Urban Forest.

This study utilised a variety of advanced techniques, methodologies and unique equipment to determine plant and soil health, remediate the issues and capture shifts in critical parameters. This study aimed to draw attention to the importance of soil health, how it is linked intrinsically to plant health and how it drives overall Urban Forest health and function.

In brief the outcomes of the four-year case study were:

- Application of organic amendments increased soil organic matter and increased the availability of macro and micro nutrients including: Nitrogen,

Potassium, Phosphorous, Calcium, etc

- Soil biology can be increased rapidly with the combination of products such as compost, mulch and liquid biological soil amendments such as Actively Aerated Compost Tea
- Soil biological activity could be measured easily and affordably using the Our-Sci Carbon Mineralization Sensor
- The Plant Health Care treatments used in this study reduced soil compaction compared to an untreated control
- Relative chlorophyll content and Visual Tree Assessments both showed tree health increasing over the four years of the case study, but the chlorophyll measurements were more consistent
- Photosynthesis measurements were effective in identifying severe tree stress, but were too complex to be useful as an everyday management tool
- Urban forest soil health can be damaged by long term compounding, extreme heat conditions that leads to tree decline events
- Improving soil health can arrest tree decline if implemented within a key threshold timeline
- The use of recycled water and its impacts on soil health need to be monitored over time

Based on these results it is clear that soil health is crucial to tree health and long-term viability. Therefore, tree health assessments need to be improved to include additional, objective parameters such as relative chlorophyll and soil health indicators. The development of data-driven tree health assessments would provide Urban Forest managers with the tools they need to understand the effects of extreme climate events and management decisions. These tools can further provide managers with the ability to accurately assess the efficacy of remediation methods in urban forestry. This document lays out the process of developing such a data-driven process and provides insights into the lessons learned in the development process.

### Section 1: Introduction

#### 1.1 Statement of the Problem

In 2015, City of Adelaide parks management staff noticed a severe tree decline event affecting a large portion of

Formal Rose Garden - Veale Gardens, Adelaide.



the northwest corner of Veale Gardens/Walyu Yarta (Park 21) Adelaide Park Lands, one of Adelaide's most premier and historic open space parks.

In October 2015, Matthew Daniel, Director of Global Urban Forest Pty Ltd (formerly Director of Tree Preservation Australia), conducted site inspections and soil testing at various sites throughout Adelaide. These investigations uncovered various plant and soil health issues around the Adelaide Park Lands from a variety of stressors (Box 1). Common stressors across the sites were compaction, poor soil nutrition and biological activity, water quality and encroachment of the tree protection zone (Fig. 1, 2). It is common in Urban Forestry that plant and soil health stressors originate from management, environmental conditions and urbanisation impacts. Veale Gardens was an example of this and chosen by the City of Adelaide as a site to investigate advanced management principles.

The Veale Gardens/Walyu Yarta Plant ►

“This study aimed to draw attention to the importance of soil health.”



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**Box 1: Excerpt from initial site investigation Tree Preservation Australia report in 2015**

The Veale Gardens report by TPA reveals several primary manageable factors. Indicators differing in magnitude and impact regarding surveyed trees across the various sites and can reasonably be considered as indicative of wider conditions in their respective areas, and they include:

- a. Severe compaction
- b. Poor and incompatible soil microbiology
- c. Irregular and unbalanced soil nutrient levels
- d. Potentially marginal irrigation water quality
- e. Insufficient drainage considerations for tree roots
- f. Encroachment and imposition of grey infrastructure on tree root zone proximity

Site assessment of many of trees placed them in the 'poor' category with structural issues and a sobering message delivered by the analytical data for soil nutrient and biological levels. These trees will require an intensive level of intervention for extended longevity and resilience to environmental extremes including pest and disease tolerance. Annual repeat recording of soil and tree health data is essential with at least quarterly inspections, to monitor some basic parameters which influence program delivery and timing. External factors will always need to be considered requiring some pre-emptive but most reactionary management. To reduce most of these harsh impacts to soil and tree health, a remediation program is advised for 2016, 2017 and 2018.

Health Care (PHC) Project 2015-2018, was developed as an extensive study into rapid tree decline throughout the park, led by Matthew Daniel. The study was designed to take a holistic approach of measuring multiple tree and soil health factors extensively on an annual basis. Over a four-year period, the response of

**SUMMARY TABLE OF ADELAIDE CITY COUNCIL TREE HEALTH SCOPING ON 22-23 OCT 2015**  
The following table provides an easy reference in comparing identified conditions at each site. (The colour code is Good Acceptable Marginal Poor Extreme)

Site	Rundle Mall	Victoria Drive	Veale Gardens	Rymill Park/Lake	Palmer Gardens
Condition	Good	Good	Poor	Poor	Good
Compaction	Good	Good	Poor	Poor	Good
Soil Microbiology	Poor	Marginal	Poor	Marginal	Marginal
Soil Nutrient Levels	Marginal	Marginal	Poor	Marginal	Poor
Irrigation and water quality	Poor	Marginal	Poor	Marginal	Good
Drainage	Marginal	Poor	Marginal	Marginal	Good
TPZ Encroachment	Marginal	Marginal	Poor	Poor	Good

**Figure 1: Visual indication of data interpretation of various sites from the 2015 investigations. The main issues at Veale Gardens/Waylu Yarta were compaction, soil nutrient and biological levels, water quality and Tree Protection Zone (TPZ) encroachment restricting root to shoot ratio development.**



**Figure 2: Preparation of the Plant Health Care root zone area of a smaller tree in the study.**

**Figure 3: Image of 30 trees of a variety of species, chosen for the PHC project 2015-2018.**



30 trees, each showing signs of decline, to Plant Health Care (PHC) remediation applications were tracked.

To understand tree health holistically and implement remediation methods, it is essential to include measurable tree and soil parameters. This study developed a detailed set of baseline soil and photosynthetic analytics that can be used and applied in practical terms by current Urban Forest management and provide future managers with benchmark data of methodology supported by measurables to better understand Urban Forest productivity. Four years of data

from 2015 up to October 2018 identified the progress of soil remediation works at Veale Gardens/Walyu Yarta (Park 21). The soil analysed by independent laboratories consists of two major categories: soil chemistry (Environmental Analysis Laboratories (EAL) and soil microbiology (Agpath). Soil physical components such as compaction and moisture were measured in the field with specialised equipment. To determine the tree health response a hand-held photosynthesis meter and meta data collection tool called MultispeQ was used [www.photosynq.org/instruments](http://www.photosynq.org/instruments).

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— Millennium Drought Eastern Australia States - 1997 - 2010. SA experienced between 2005 - 2010.  
 — GAP - Glenelg to Adelaide Park Lands Recycled Water Project-Irrigation 2010 - 2017.  
 — GAP - water supply disruption period- Dec - Jan 2018.

**1.2: Impacts of Historic Climate Change and Management at the Research Site**

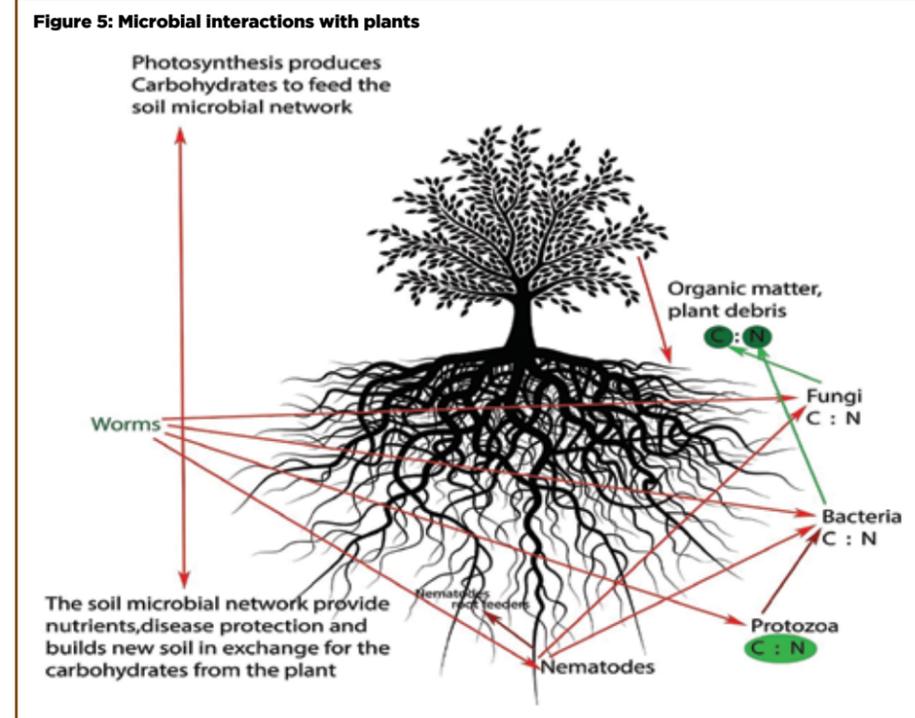
Urban Forest canopy cover takes decades to establish a functional level of essential service. The impacts of extreme weather events on soil health in Urban Forestry are relatively unknown but must not be underestimated. The effect of extreme weather events such as drought on soil health that compounds into tree decline is an ongoing issue to address in Urban Forestry. The effects of extreme weather events on the Veale Gardens/Walyu Yarta study site can be seen in Figure 4. Soil health is more than just moisture content. The complexities of soil must be managed more effectively in Urban Forestry because this fundamental component of growing trees determines how long the natural assets will be viable and productive.

**1.3: A Whole System – Plant and Soil Function**

Plant and soil health must be defined and managed in Urban Forestry. It is not currently defined adequately throughout many industries including the Urban Forest industry. This project aims to assist in providing a practical framework to achieve a better understanding of soil health and define it in functional terms in relation to our urban environment, and then how that relates to providing a measurable essential service from individual trees. To understand this complexity the whole system including photosynthesis, plants and soil needs to be investigated.

**1.4: Defining Soil Health**

Soil Health can be defined “as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals and humans” – (www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/).



**Figure 4: The colour coded composite of aerial photography of the NW corner of Veale Gardens/Walyu Yarta (Park 21) over a period of 50 years. Arrows indicate impacts of drought periods over time and implementation of GAP water. Photos courtesy of Kent Williams.**

**Figure 5: Key components of the whole system: Photosynthesis and energy distribution to soil biology by the plant to develop symbiotic relationship with soil microbiology. These symbiotic relationships between plant and microbes must not be underestimated. Diagram courtesy of Matthew Daniel, Global Urban Forest, 2011.**

**Chemical** – understand total, available and exchangeable nutrient pools in soil in relation to the requirements of supporting plant material.

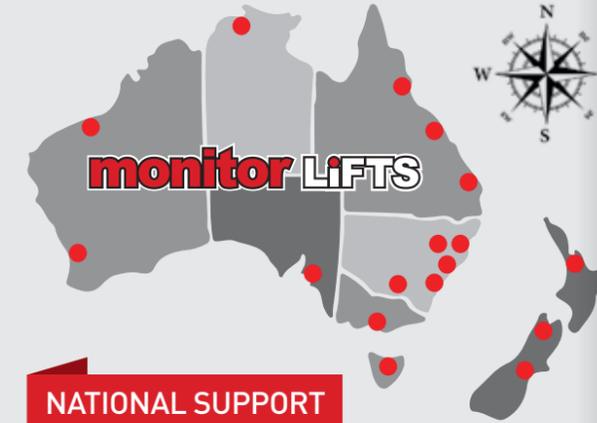
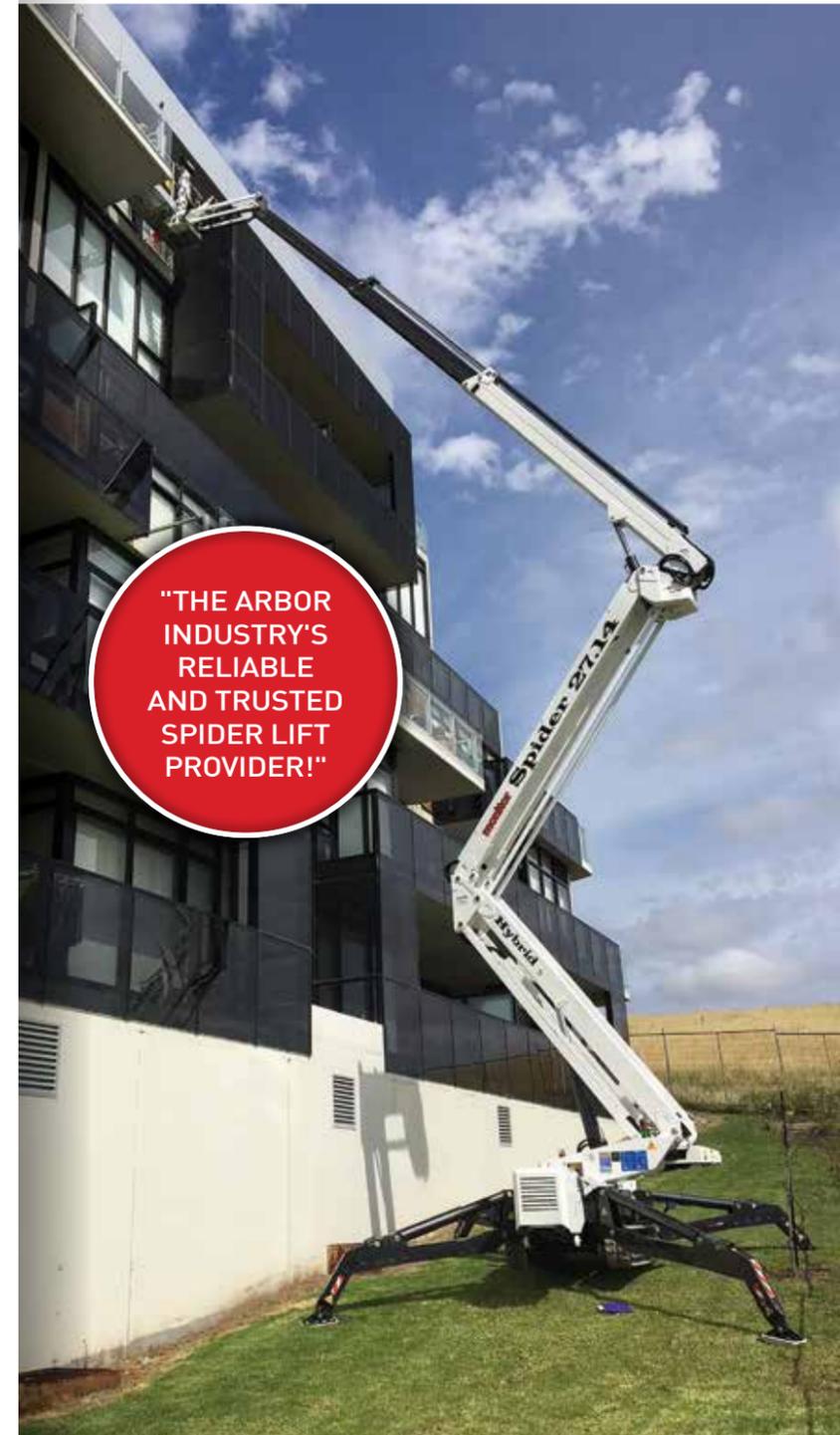
**Physical** – measure and understand physical soil structure and water holding capacity.

**Biological** – understand and measure the soil microbiome, a balanced set of functioning bacteria, fungi, protozoa, nematodes and mycorrhizae that develop symbiotic relationships with plants.

**1.5: Relationship Between Soil Health and Climate Change in Urban Forestry**

Localised extreme weather events caused by climate change, are occurring, being observed on the ground, experienced and documented all over the globe. A common and consistent driving factor associated with these extreme weather events is heat. To mitigate this heat in cities or highly urbanised areas, Urban Forests are being designed, installed

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and developed around the planet. This is a direct response to urbanised areas getting hotter and described as the Urban Heat Island Effect (UHIE). The concept of mitigating UHIE with vegetative growth to reduce the temperature relies on the plant and soil functioning effectively. It is often assumed soil health is a given and water is the only consideration regarding soil health. Water is a key component, essential to soil health and soil health is critical to plant health, although soil health is more than just water availability.

The effects to Soil Health from heat waves and drought, both short and long have a residual sinister potential to cause tree decline years after the extreme event has occurred. The Millennium Drought and SA Government response in transitioning to GAP water to maintain the Adelaide Park Lands is an example of this and investigated in this study. This intensive study of Veale Gardens/Waylu Yarta aims to understand the change in ecosystem function from a plant and soil health perspective. Through a process of:

- Defining soil health
- Measuring the components – developing baselines and monitor changes overtime
- Intervening with PHC focused soil management principles and practices that address chemistry, physical structure and biology
- Develop an understanding of how the soil health adjustment have occurred, and if successful, how to continue proactive management of the improved conditions.

An Urban Forest is a sum of its parts, all plants in both public and private realms make up the Urban Forest as a whole. Canopy cover in an Urban Forest provides a potential capacity to mitigate heat with microclimate production. This microclimate supported and stimulated by evapotranspiration, comes from soil and plants.

A result of drought is reduced plant and soil health. It would be fair to say that most would assume this poor plant and soil health resulting from drought could be visualised as “brown grass and

trees.” If you ask those same people what caused the “browning off” the response is commonly “Lack of water”. The assumption that the reintroduction of water into the system after a drought resolves any risk to environmental decline, is oversimplified and short-sighted.

These types of extreme droughts that trigger a collapse in ecosystem productivity do not exclude the Urban Forest. The Millennium Drought in Australia that developed into the 2000’s and declared over in 2010 is one such drought. In Adelaide, South Australia the Millennium Drought between 2005 and 2010 became the period in which a compounding amount of plant and soil stressors culminated into a tree decline event in Veale Gardens/ Waylu Yarta, although the effects continued years after the drought had finished and soil moisture returned, because soil health had been damaged in the park.

It is important to consider the long term and compounding effects of severe drought to the Urban Forest ecosystem and how that relates to soil health.

### 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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Soil health is more than just moisture content.



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