The use of vertical mulching and worm technology for long-term soil decompaction

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Stockley Park

One of Europe's most successful business parks located near Heathrow Airport.

Since the early 1980's over 140,000 trees and shrubs have been planted.

However, like all manicured landscapes issues with: nutrient deprivation, drought, water excess, soil compaction, and chemical soil pollution exist.

Stockley Park

Tree decline symptoms

- Poor canopy coverage
- Limited stem extension growth
- Sporadic branch/ stem and leaf die-back
- Stem lesions
- Leaves yellowing/ chlorotic
- Presence of insect/disease pests

Findings of soil nutrient and compaction analysis

Analysis of soil and foliar samples indicate non-optimal growth conditions for the trees.

Soil analysis:

- pH values are too high (7.1-8.9 rather than optimum at ~6.5)
- High levels of salinity (high conductivity values) around London Plane
- Low potassium, nitrogen, calcium and magnesium levels
- High sand/silt soil content
- Very low organic matter

Compaction analysis:

- High soil compaction levels
- Tree planted to deep

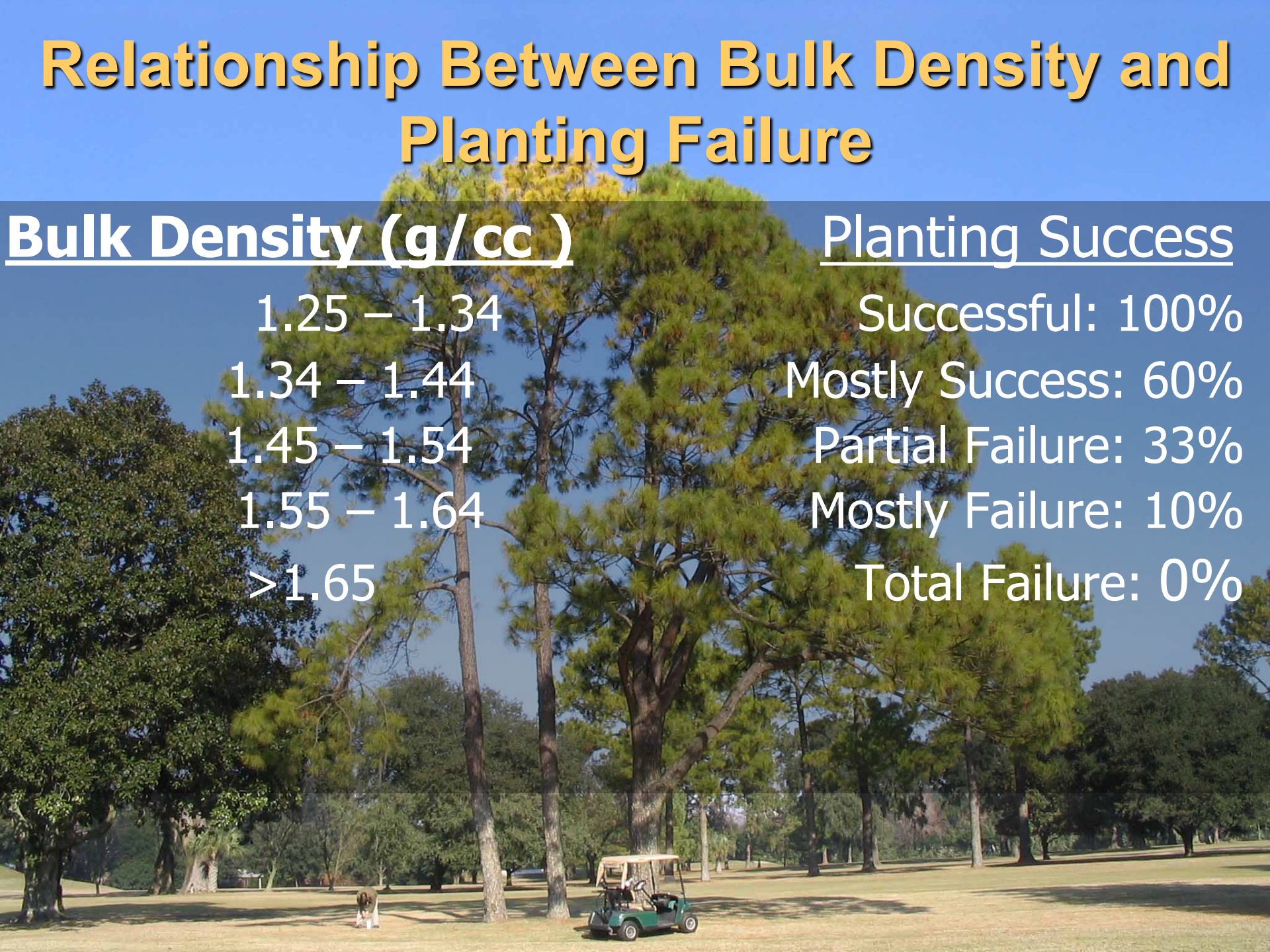
One of the main causes of tree decline – Soil compaction

Perfect trial site: Several different speices of equal size and uniformity

Measuring Soil Compaction

Relationship Between Bulk Density and Planting Failure

Bulk Density (g/cc)	Planting Success
1.25 – 1.34	Successful: 100%
1.34 – 1.44	Mostly Success: 60%
1.45 – 1.54	Partial Failure: 33%
1.55 – 1.64	Mostly Failure: 10%
>1.65	Total Failure: 0%



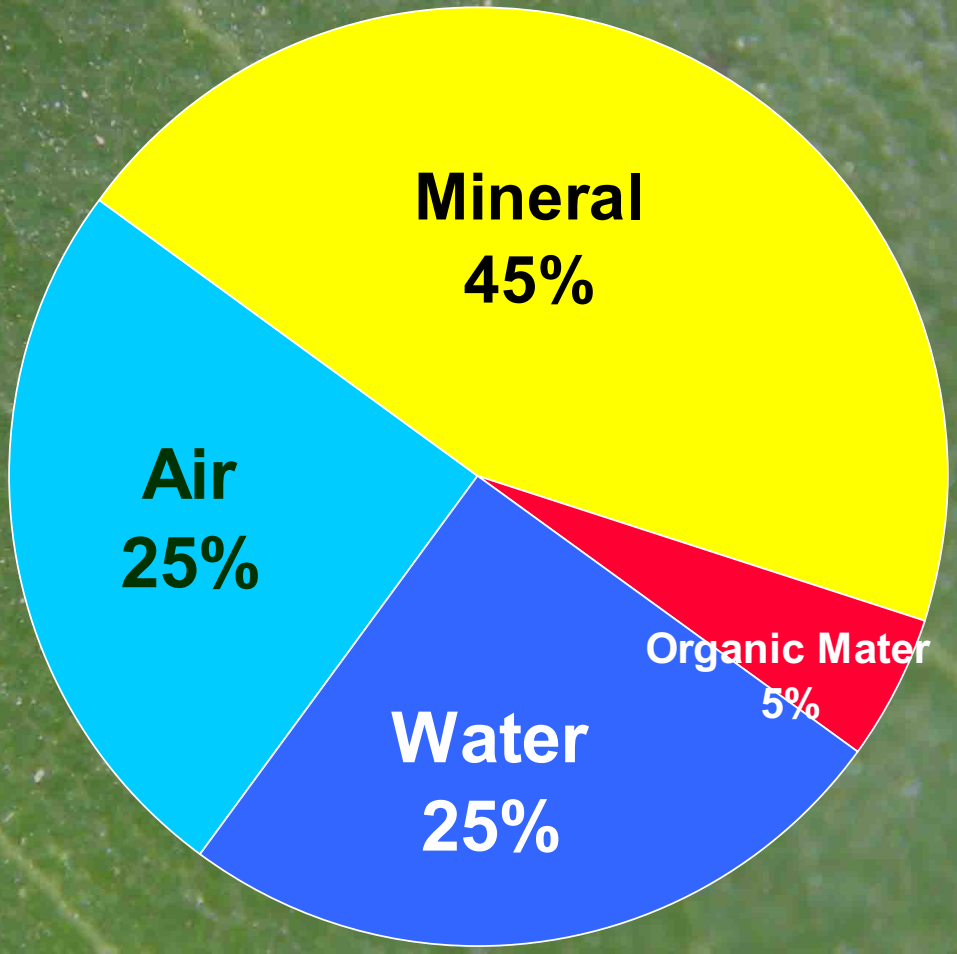
Soil Compaction and Tree Root Growth

- High density soils will reduce root growth
- Limiting root growth will limit plant potential

Soil Components

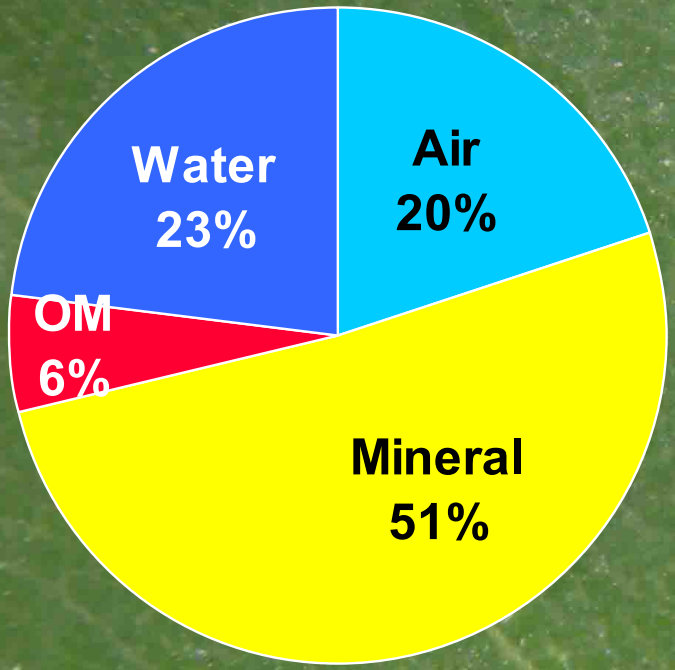
The ideal soil for plant growth

BD=1.33

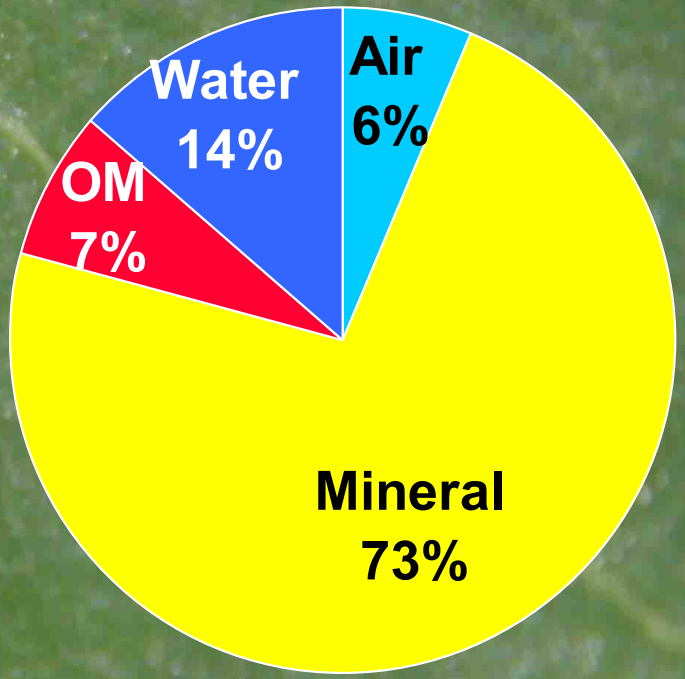


Soil Porosity

Bulk Density = 1.5



Bulk Density = 2




BD = 1.8-2.0
Brick = BD 1.9-2.4

Many systems exist to alleviate soil compaction

http://apexsoilsolutions.com/the-geo-injector/

Vertical Mulching

De-compaction/mulch studies on root growth


Re-Compaction Is A Big Problem
EJ03 OWB
RAMP

What about Soil De-Compaction in Nature

Facts about worms

Earthworms eat leaf mold, decomposing wood particles, dead insects, organic matter. As the materials pass through, their digestive systems they are "broken down". The worm castings they excrete are high in usable nitrogen. When they die their carcasses become part of the organic mix.

Earthworms also loosen compacted soil and improve structure. They aerate the soil as they create tunnels and burrows. As they eat, they carry the materials to new locations before eliminating them. Consequently both organic and inorganic materials are constantly being "churned up" through out the soil. Earthworms can improve soil porosity by as much as 400 percent.

Two types of native Earth Worms used

. *Dendorobaena veneta* and *Lumbricus terrestris*. Each of which operates in different planes in the soil. One in a vertical and one in a horizontal plane providing a mixing action down to 1 metre deep.

Experimental Set-Up

Test and treat 20 trees x 3 species (Maple/Lime/Horse Chestnut):

Trees were subjected to soil core removal (7.5 cm wide, 30 cm deep; at 50 cm spacings under the tree crown dripline. Soil cores removed were disposed of and core holes left behind re-filled with:

Experimental Set-Up

1. Biochar (5%)/John Innes soil (92%) slow release organic fertilizer (3%)/wood chip mulch.
2. Biochar/John Innes soil/slow release organic fertilizer/wood chip mulch/worms (box every 2m)
3. Biochar/John Innes soil/slow release organic fertilizer/clover
4. Biochar/John Innes soil/slow release organic fertilizer/ clover/worms
5. No treatment (control)

NB: Other treatments were evaluated such as mulch alone, mulch + biochar etc. For reasons of clarity data not shown


Before
After


Treated
Untreated

Tree Health Assesment

- Leaf Size & Colour
- Twig Growth
- Twig & Branch
- Dieback
- Pest/Disease
- Infestations
- Root growth
- Soil Biology

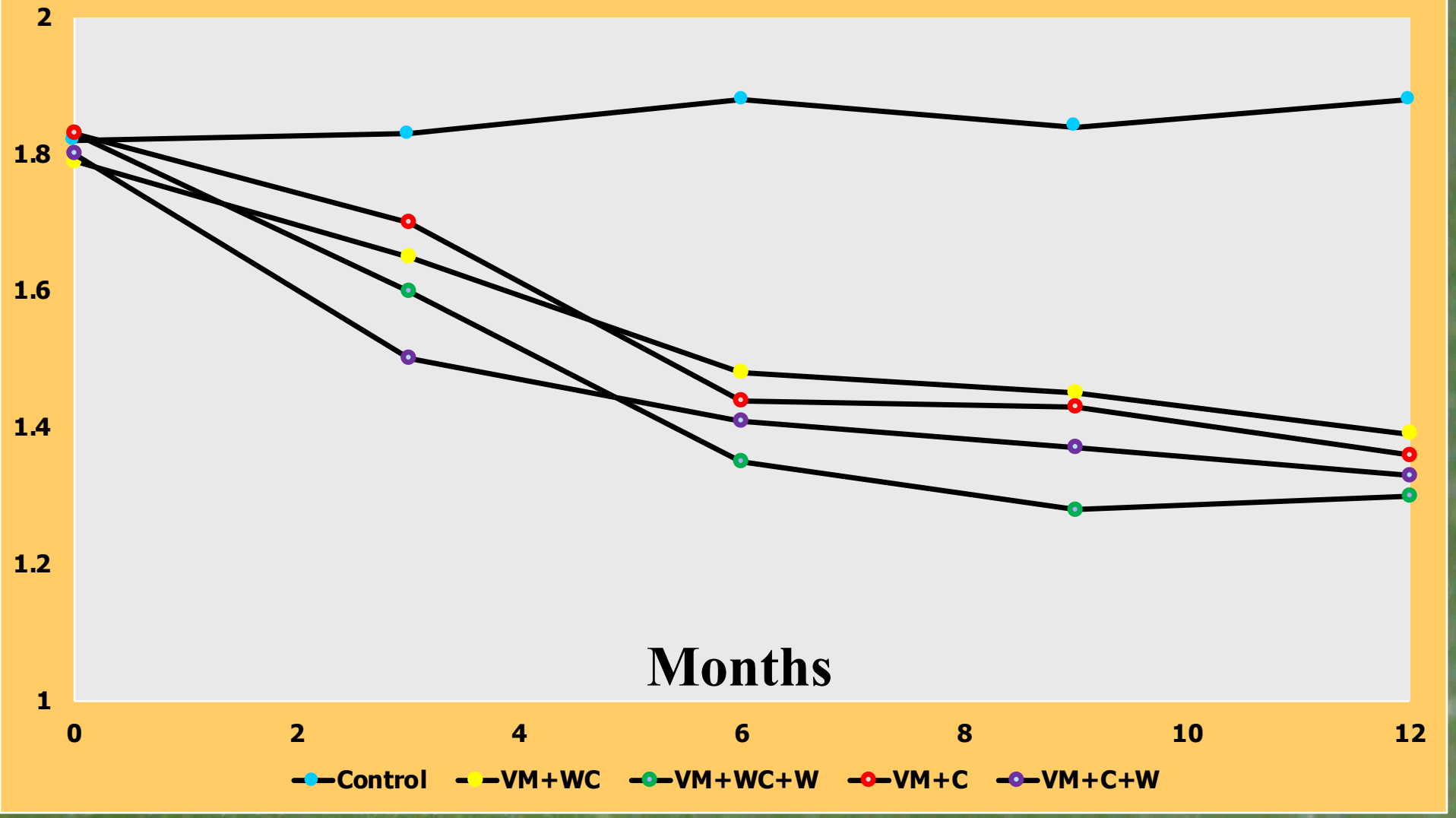
A Picture Paints a 1000 Words

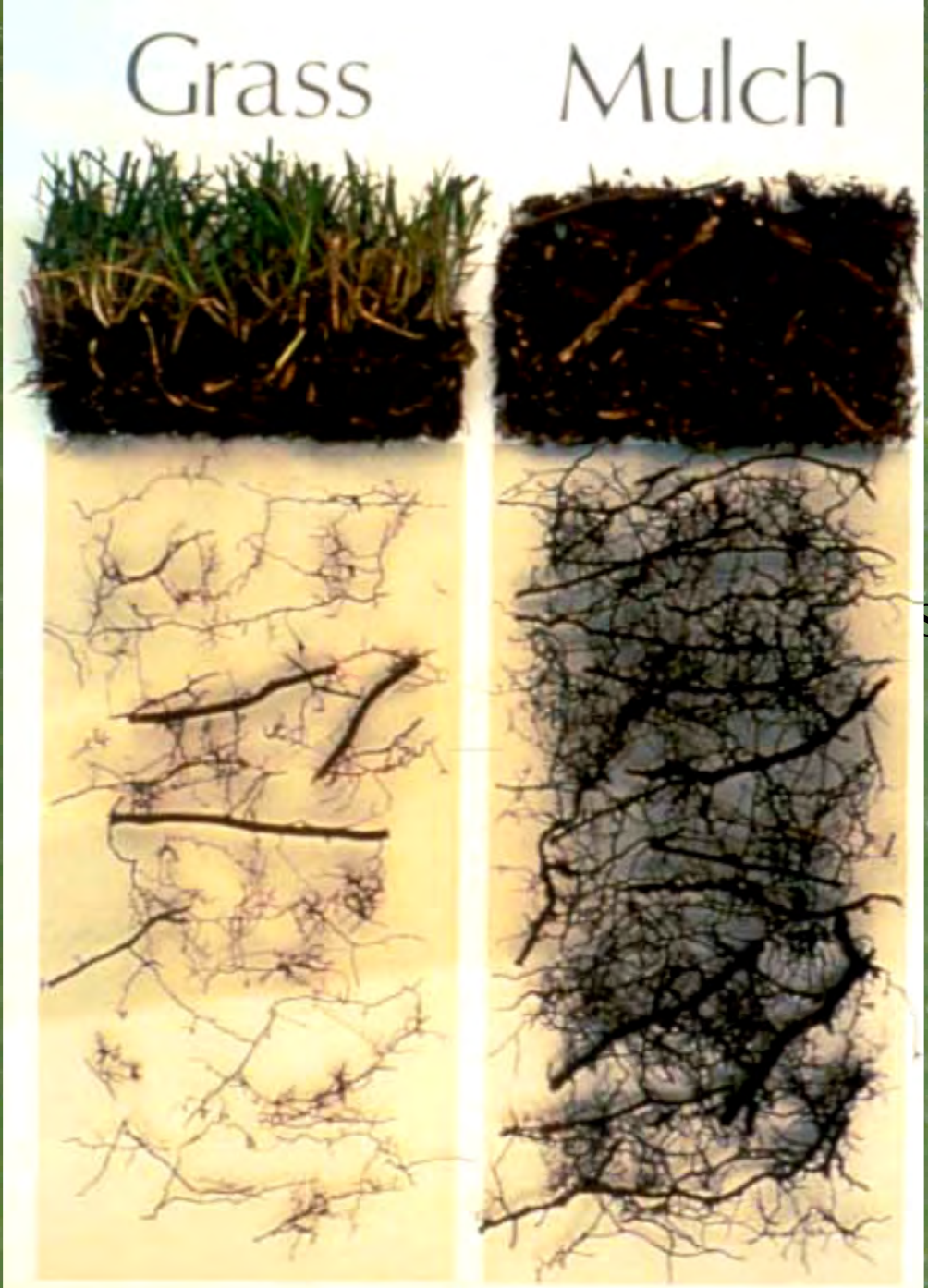
Control Treated


5
LONGWALK
IMG
STUDIOS


What Happens Below Ground
Treated
Untreated
Worms Casts

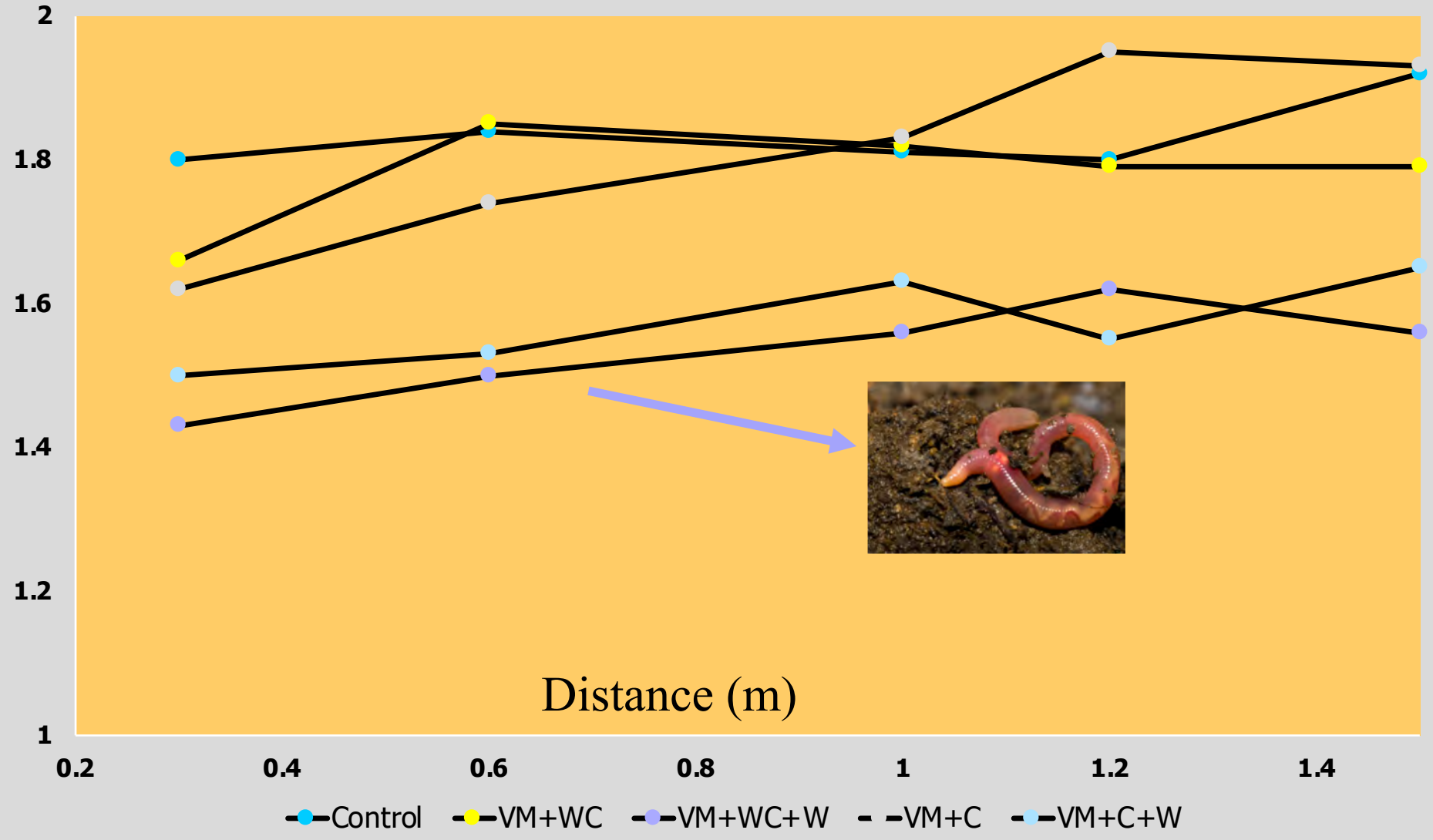
Bulk Density (Under Canopy, Treated Area)





G Watson, Morton Arboretum

Bulk Density Outside Canopy (Untreated Area) At Month 9



Monitoring Soil Respiration

Soil respiration is commonly estimated as the flux of CO2 emitted from the soil surface representing the sum of CO2 produced by root respiration and by heterotrophic decomposition of root exudates, soil organic matter, and plant litter i.e. soil respiration is an indicator of biological activity

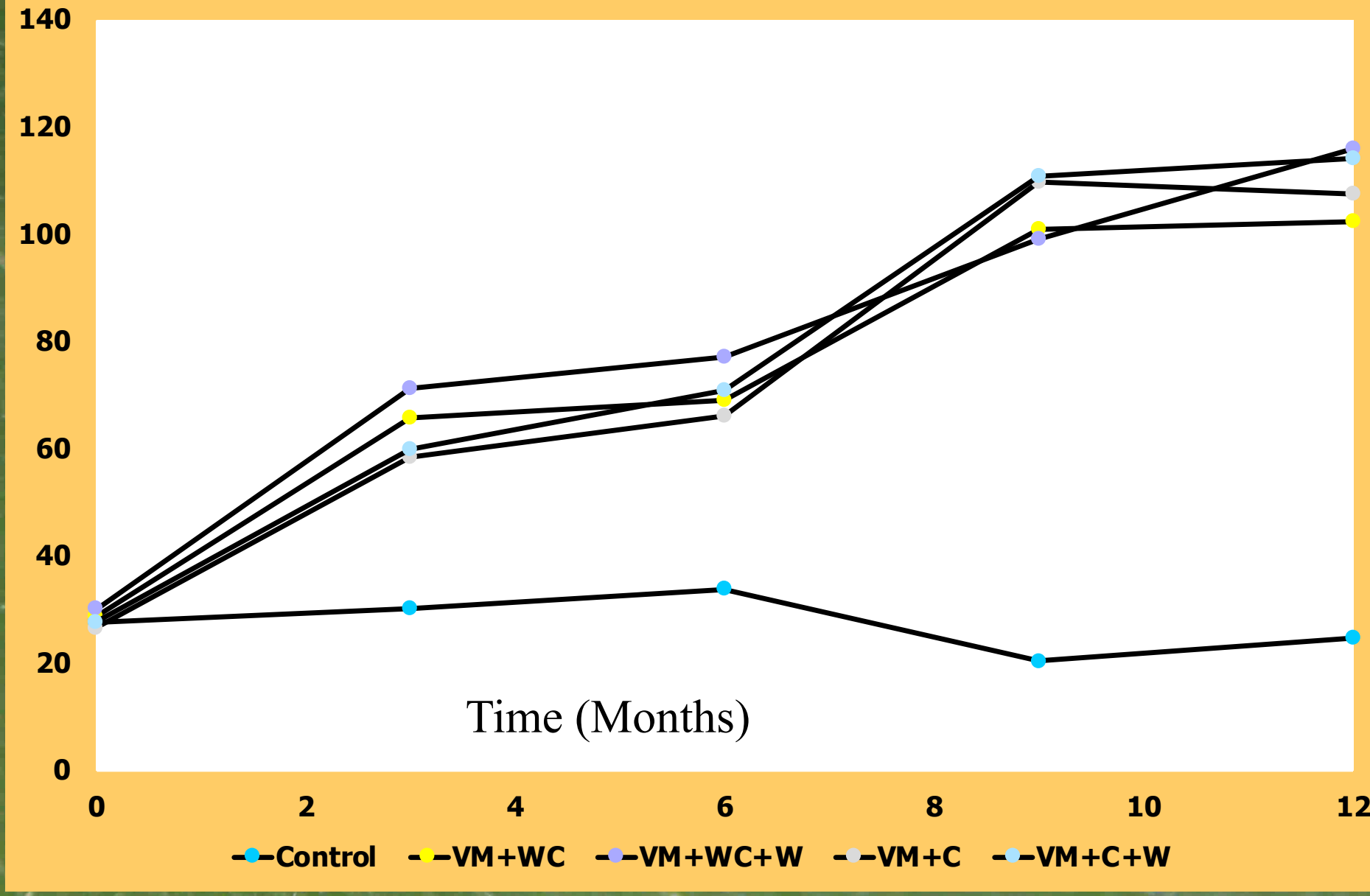
Soil Respiration kilograms/hectare-7.6 centimeters/day = PF x TF x (%CO_2 - 0.035) x 22.91 x H

PF = pressure factor = 1

TF = temperature factor = (soil temperature in Celsius + 273)

H = inside height of ring = 5.08 cm

Soil Respiration (mg CO_2-C/kg soil) Under Canopy



Results

	Soil Respiration (mg CO_2-C/kg soil; Outside of Canopy At Month 6)
	Distance = 1.0m
No treatment (control)	32.3
Vertical Mulching + Wood Chip	37.7
Vertical Mulching + Wood Chip + Worms	60.4
Vertical Mulching + Clover	41.2
Vertical Mulching + Clover + Worms	62.8

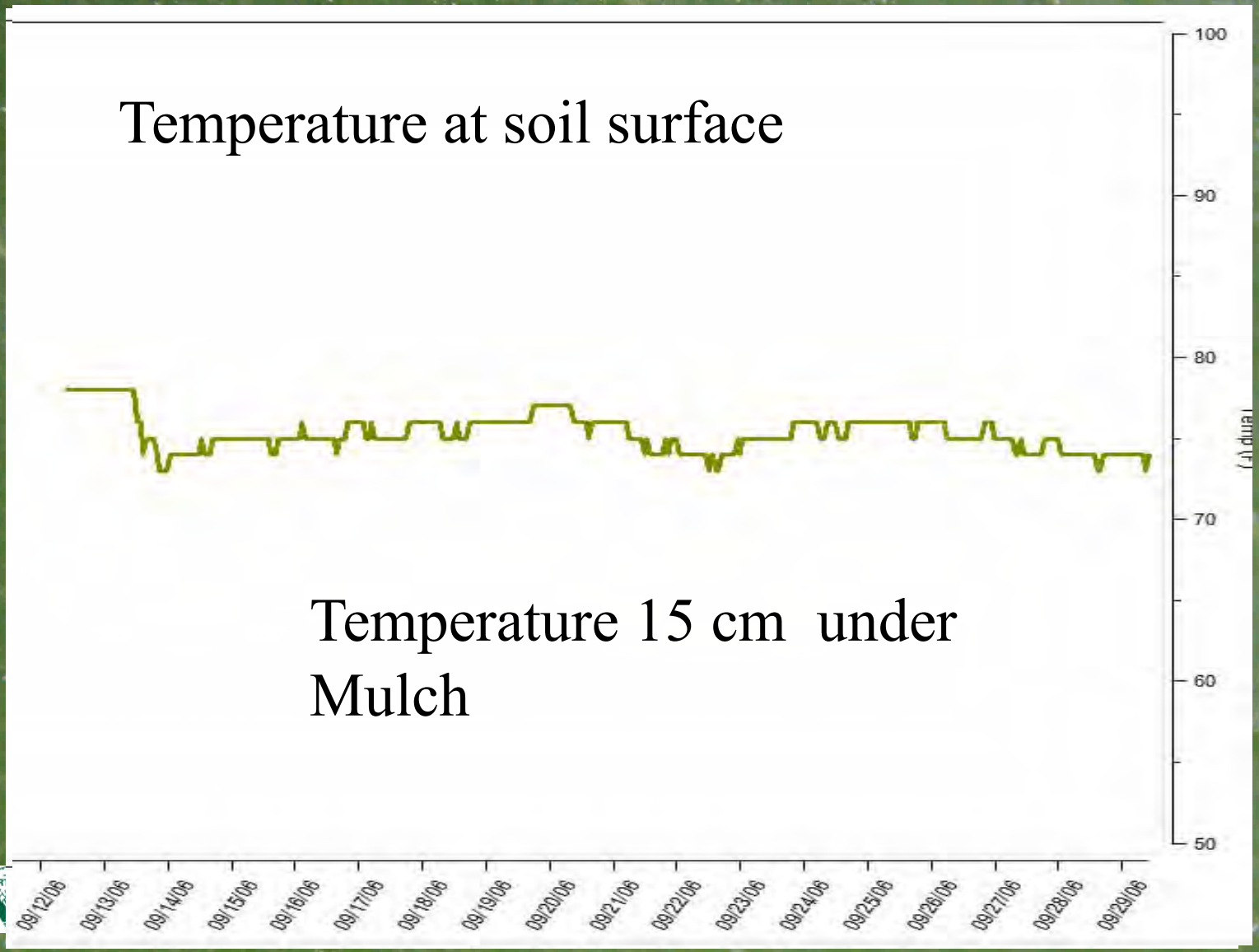
Results of soils outside the canopy (Untreated area)

Similar trends recorded for soil fertility (N:P:K), root growth (g per 100 cm^3 of soil).

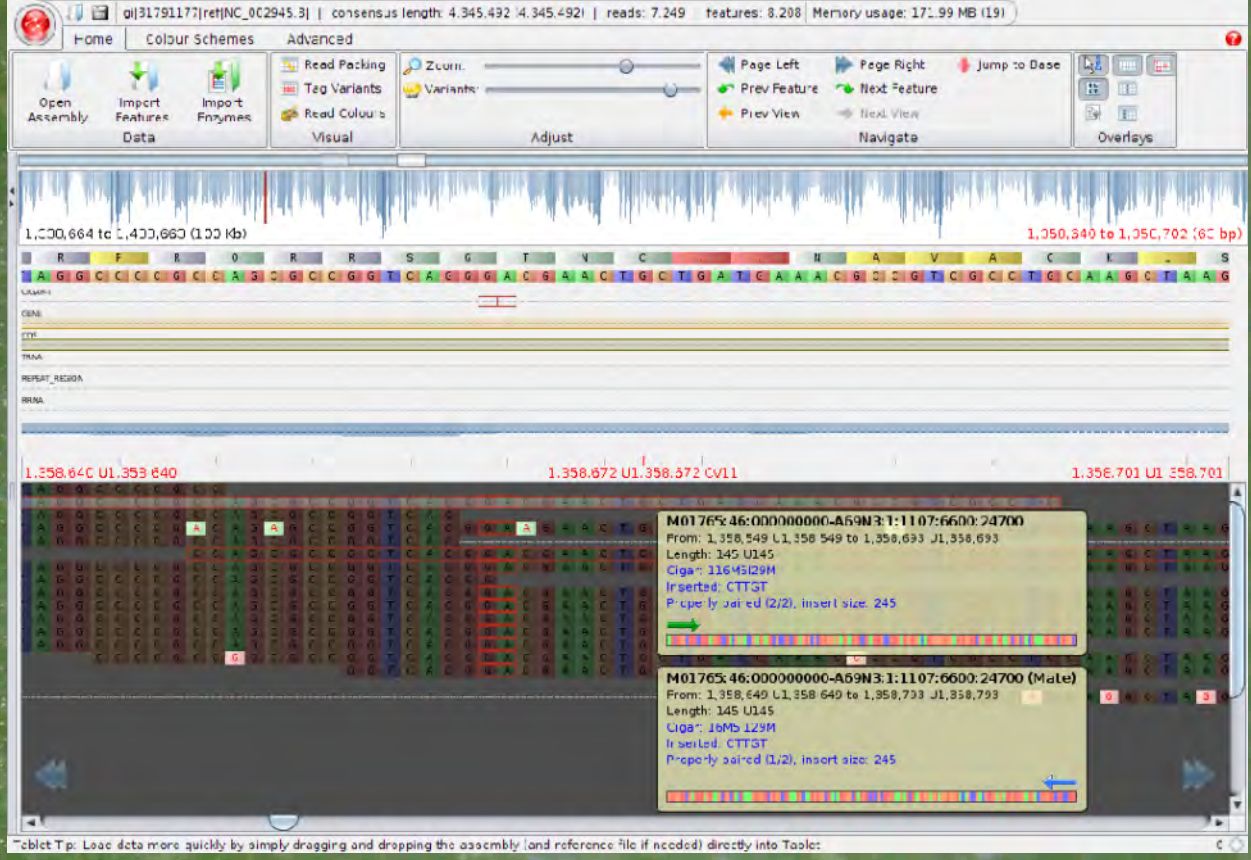
	With Worms	No Worms
Soil Respiration	Up	No Change
Bulk Density	Down	Slight Change
Root Growth	Up	Slight Change
Soil Fertility	Up	No Change
Soil O_2	Up	No Change

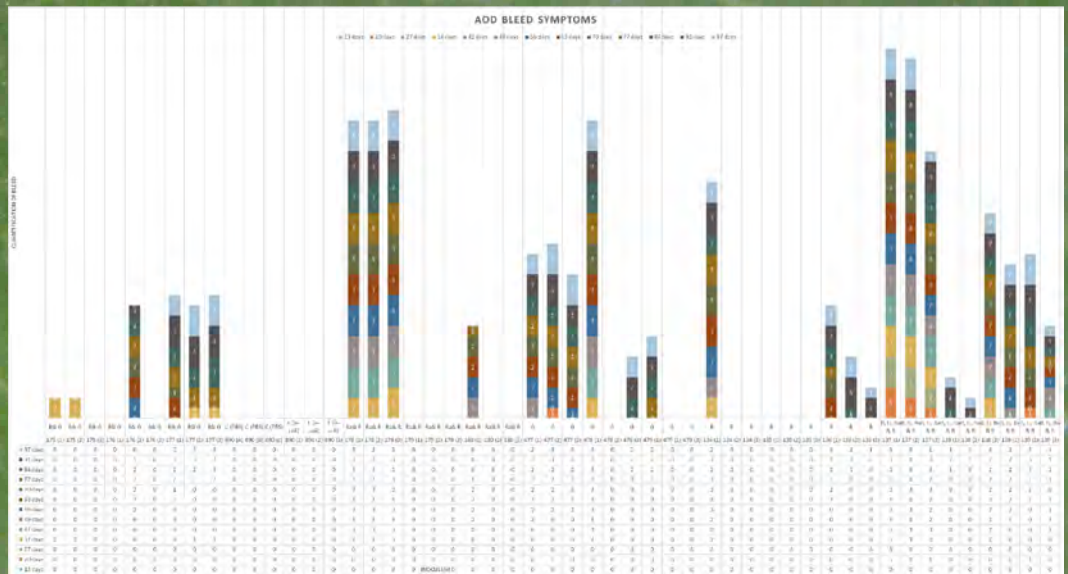
Monitoring Moisture and Temperature

Temperature

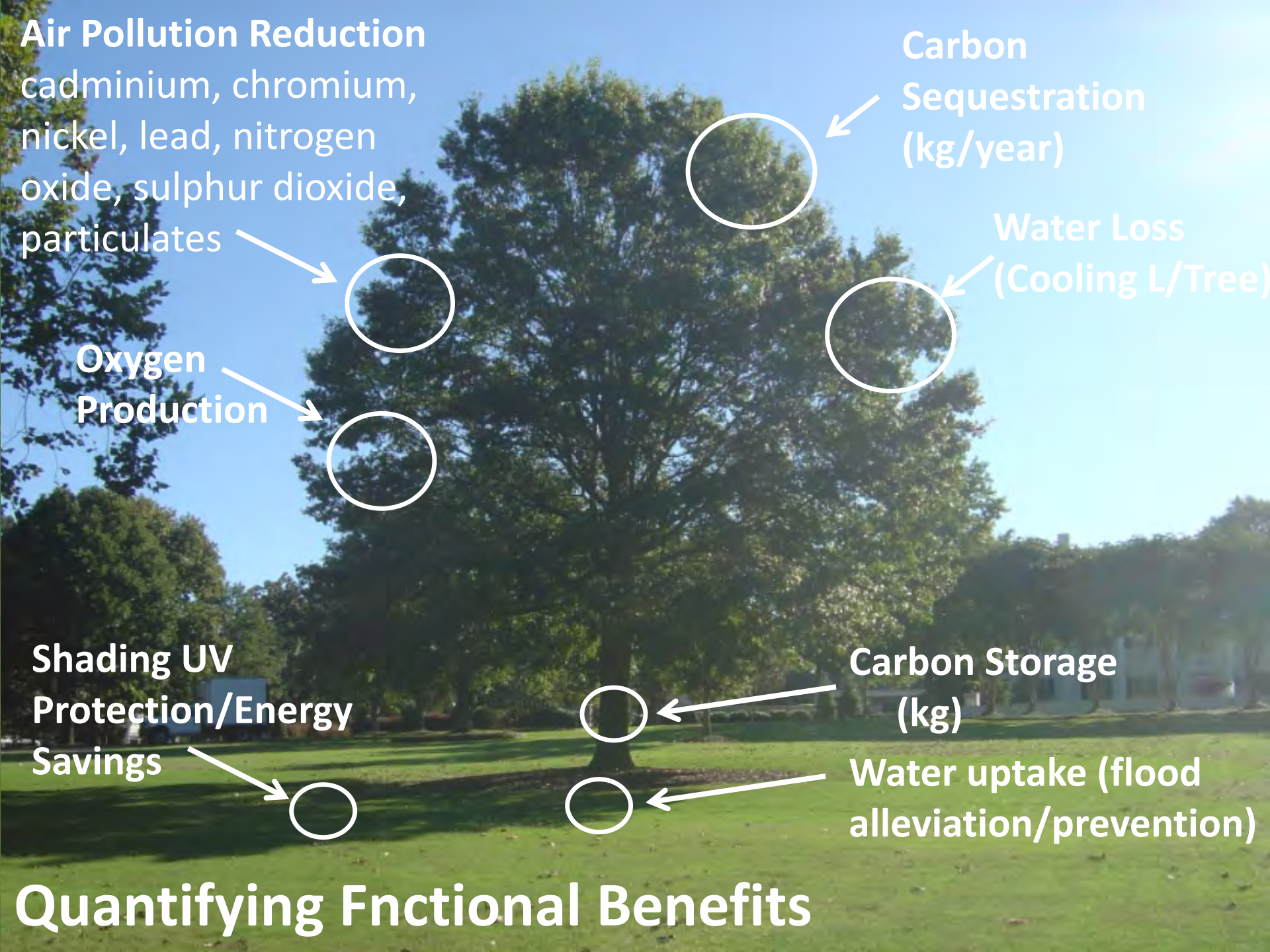


Community DNA Analysis (Future)





So what does this really mean



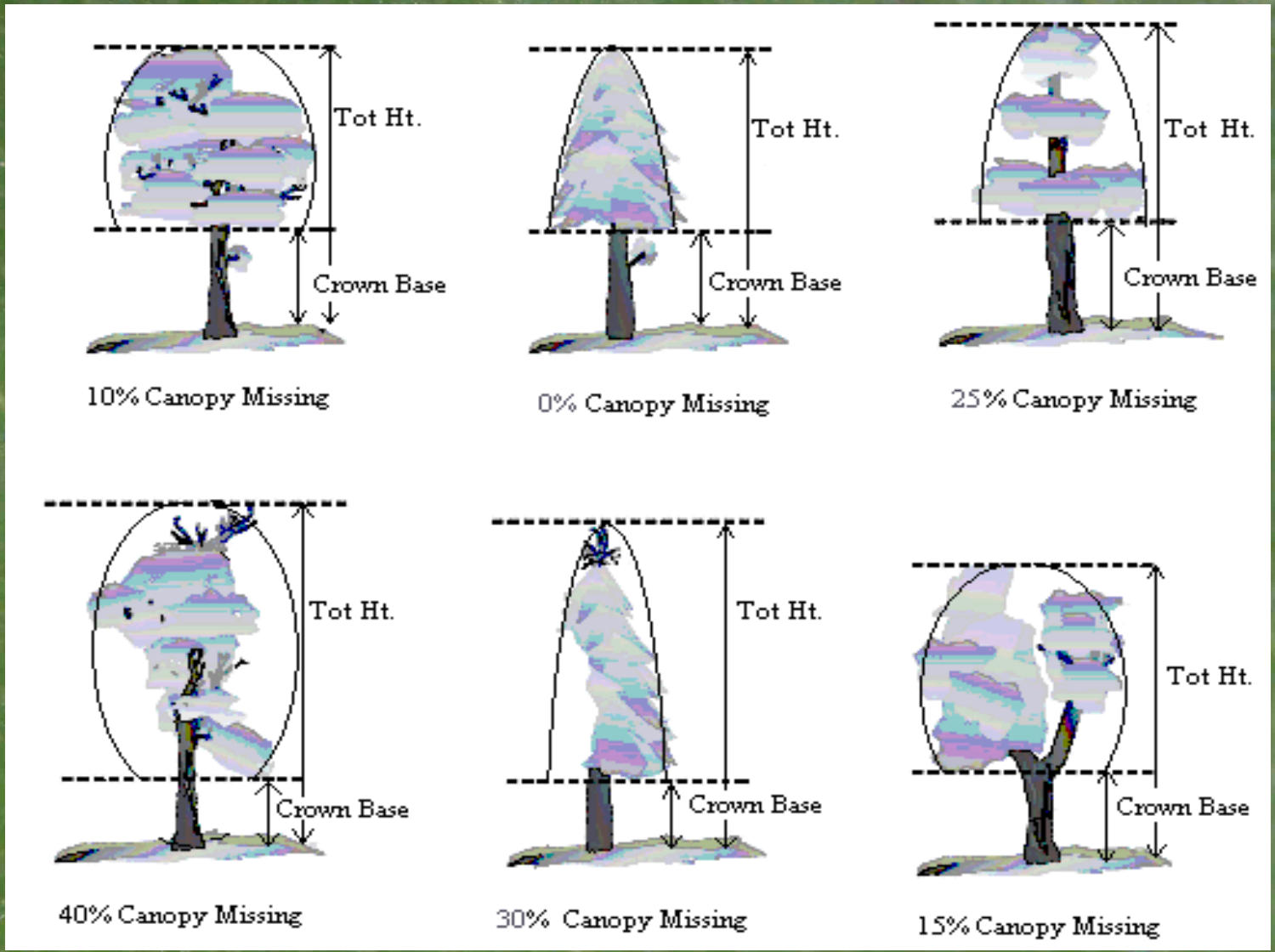
Quantifying Fnctional Benefits

i-Tree

- **Eco** – entire urban forest
- **Streets** – street tree population
- **Hydro** – stream flow & water quality
- **Vue** – tree canopy, planting scenarios, etc.
- **Design** – tree placement assessments
- **Canopy** – estimate land cover types
- **Species** – species selection
- **Storm** – storm damage assessment protocol

Further research is needed into better adapting the US model to UK realities in order to provide more accurate results in the future.

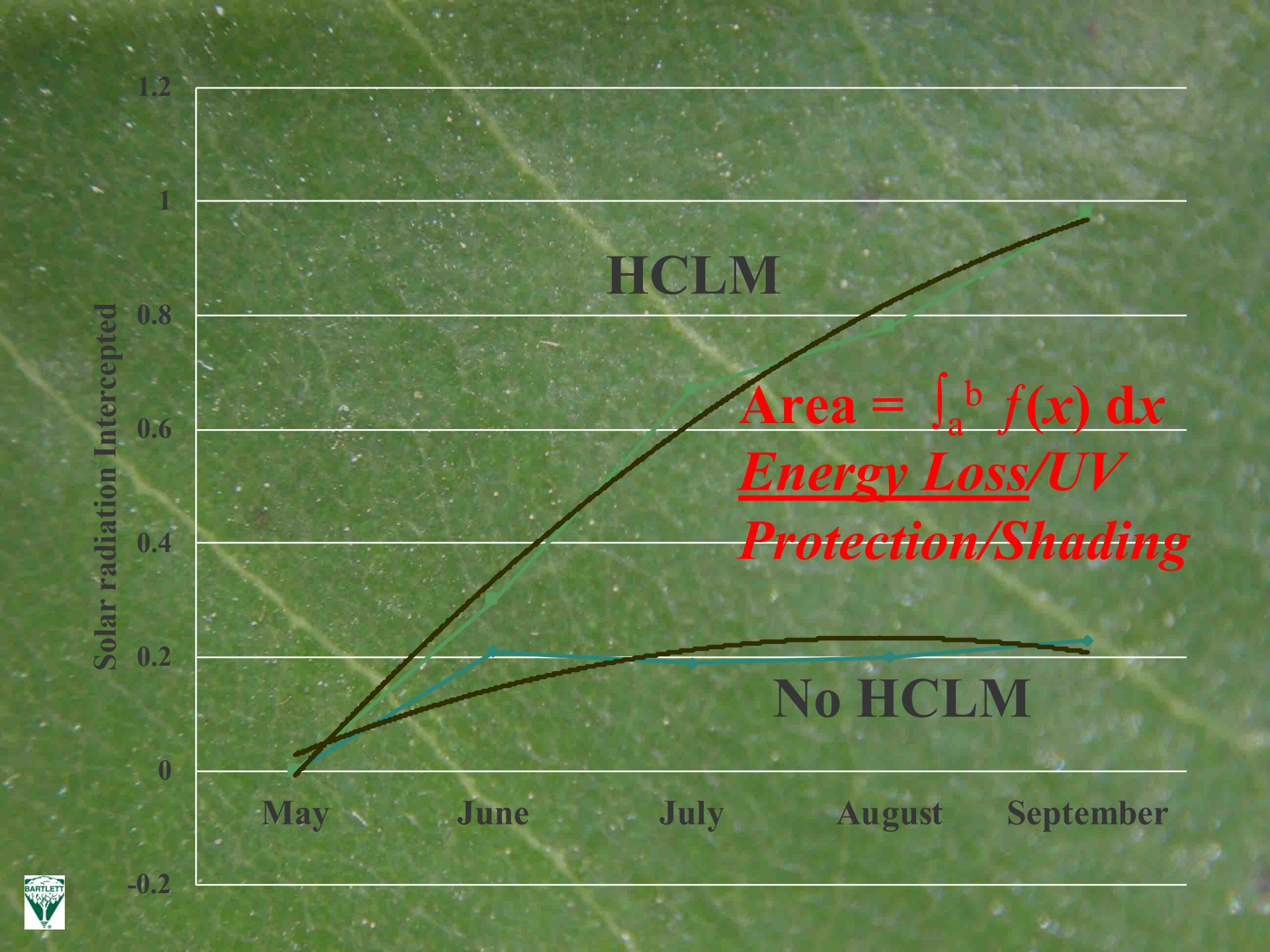
Calculate Tree Canopy Volume (Equations)



Madalena Vaz Monteiro, Kieron J. Doick, Vicki Lawrence & Jeffrey Wilson. (2018) Estimation of leaf area for open-grown urban trees in Great Britain using HemiView. Arboricultural Journal, https://doi.org/10.1080/03071375.2018.1415563

Greater use of digital technology

Measuring light interception (Shading/UV reduction)


1.2
1
0.8
0.6
0.4
0.2
0
-0.2
Solar radiation Intercepted
HCLM
No HCLM
Area = $\int_a^b f(x)\,dx$
Energy Loss/UV Protection/Shading
May
June
July
August
September

Treated Tree = 40% more shade and UV protection. 64% increase in energy production

Treated Tree = 30% more shade and UV protection. 43% increase in energy production

We Assume All Leaves/Canopy is Healthy and Operating at 100% Photosynthetic Efficiency

Arborcheck

- Leaf Colour
- Broadleaf, Conifer, & Benchmarks
- Synonym handling
- 'Reference' species

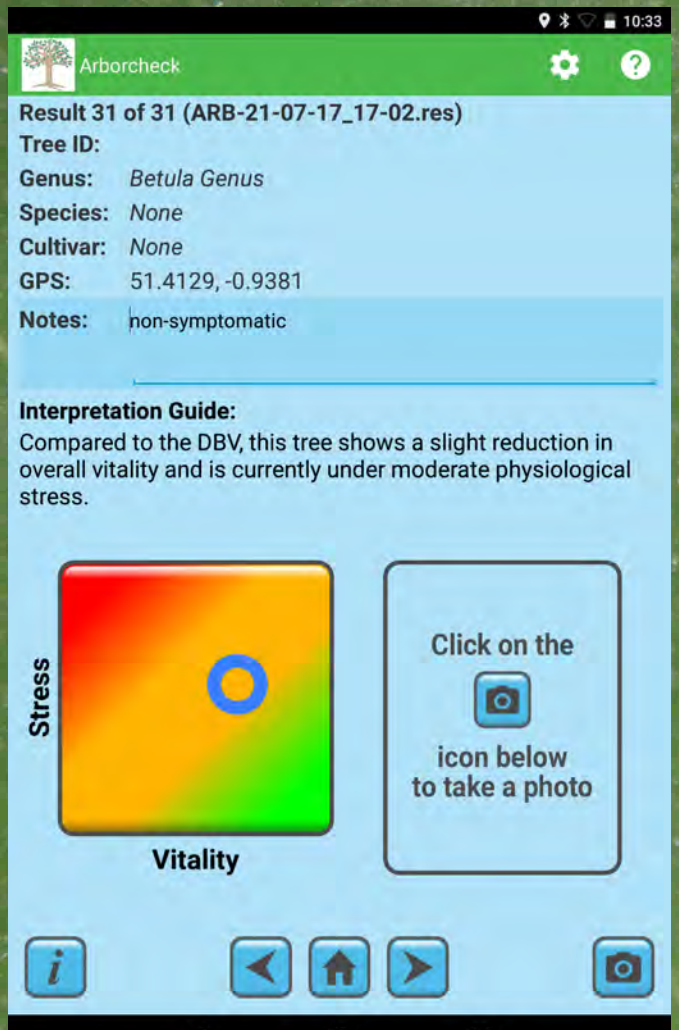
Lead biggest UK data collection: ~400 cultivars

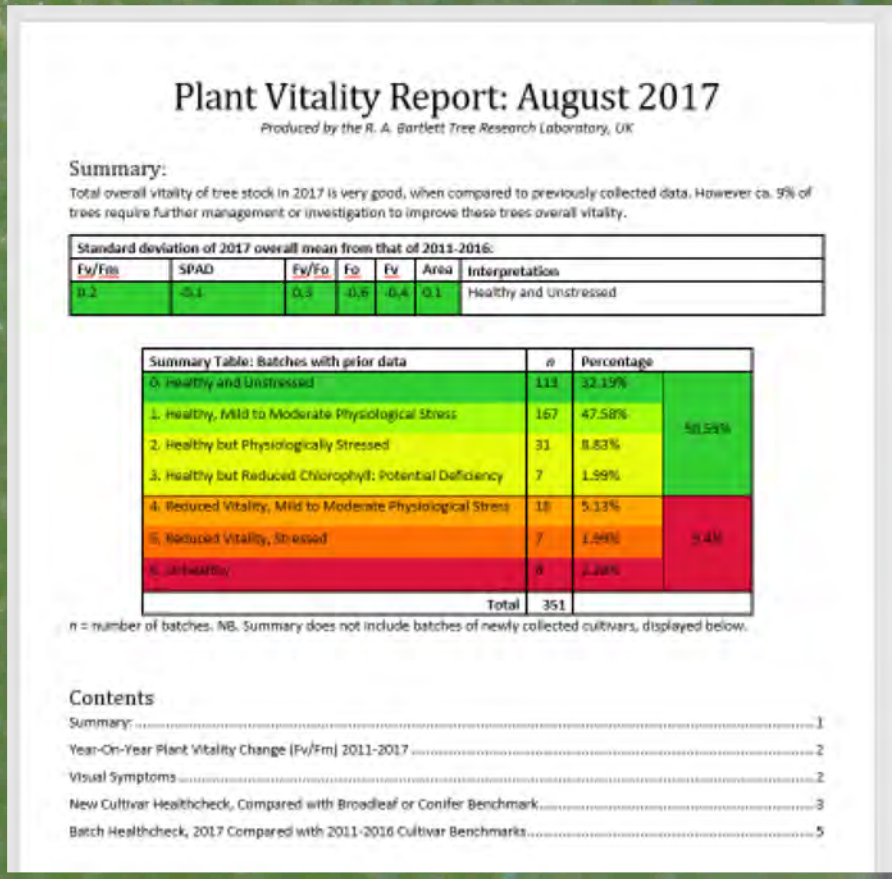
- Protocols developed could be used elsewhere




Automatically generate fluorescence report:

- Automatically label collected data, produce Excel spreadsheet: paste tables into Word.
- monitoring tree stress & vitality on any site over time e.g. inventories.





Plant Vitality Report: August 2017

Produced by the R. A. Bartlett Tree Research Laboratory, UK

Summary:

Total overall vitality of tree stock in 2017 is very good, when compared to previously collected data. However ca. 9% of trees require further management or investigation to improve these trees overall vitality.

Standard deviation of 2017 overall mean from that of 2011-2016:						
Fv/Fm	SPAD	Fv/Fo	Fo	Fv	Area	Interpretation
0.2	-5.1	0.3	-0.6	-0.4	0.1	Healthy and Unstressed

Summary Table: Batches with prior data	n	Percentage	
0. Healthy and Unstressed	113	32.19%	
1. Healthy, Mild to Moderate Physiological Stress	167	47.58%	90.59%
2. Healthy but Physiologically Stressed	31	8.83%	
3. Healthy but Reduced Chlorophyll: Potential Deficiency	7	1.99%	
4. Reduced Vitality, Mild to Moderate Physiological Stress	18	5.13%	
5. Reduced Vitality, Stressed	7	1.99%	9.4%
6. Unhealthy	8	2.28%	
Total	351		

n = number of batches. NB. Summary does not include batches of newly collected cultivars, displayed below.

Contents

CO_2 Sequestration/Oxygen Output

Photograph courtesy of Opti-Science

Infra-Red Gas Analyser

0.4 Kg CO_2 sequestered/2.2kg O_2 produced per year

CO_2 Sequestration/Oxygen Output

Measured values over time on hot and not so hot days

Pollution Removal – Particulate Matter (1-10ug/cm^2 Leaf Area)

Heavy Metal Removal

Heavy Metal (mg/growing season)	
Cadminium	0.2
Chronium	0.4
Zinc	3.9
Lead	12
Nickel	2.3
Copper	8.0

Doick, K.J. et al., (2018) CAVAT (Capital Asset Value for Amenity Trees): valuing amenity trees as public assets. Arboricultural Journal, https://doi.org/10.1080/03071375.2018.1454077

Assigning a monetary value to these changes

Conclusions

All treatments (-/+ worms) significantly enhanced root growth, soil respiration, fertility etc., within the treated area

Only treatments with worms significantly de-compacted soils, enhanced soil fertility, soil respirationy and root growth out-with the treated area.

Effects are manifest above ground in terms of enhanced leaf colour, photosynthetic activity, crown canopy coverage that can be quantified in terms of tree functional benefits i.e. water uptake/cooling, O2 formation, CO_2 sequestration, heavy metal/PM absorption, UV Protection

Thank You