Beyond the Great Debate: Assessing Post Installation Manufactured Soils Performance

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WHY ARE WE HERE?

Previous panels and discussions have raised significant unanswered questions.

We recognize that there is a lack of data after a project's substantial completion.

We want to look beyond visual assessments and anecdotes.

We want to be better equipped to make design, implementation, and management decisions.

LEARNING OBJECTIVES

Learn to make informed soil design decisions based on post-construction performance assessments of a range of soil types and conditions

Review objective post-occupancy testing of CU, Sand-Based, and traditional blended soils

Understand how structural, chemical, and biological metrics have evolved in soils in place up to 45 years and how they relate to tree growth rates and tree performance

Learn best practice techniques for post-installation management of manufactured soils

OUR TEAM

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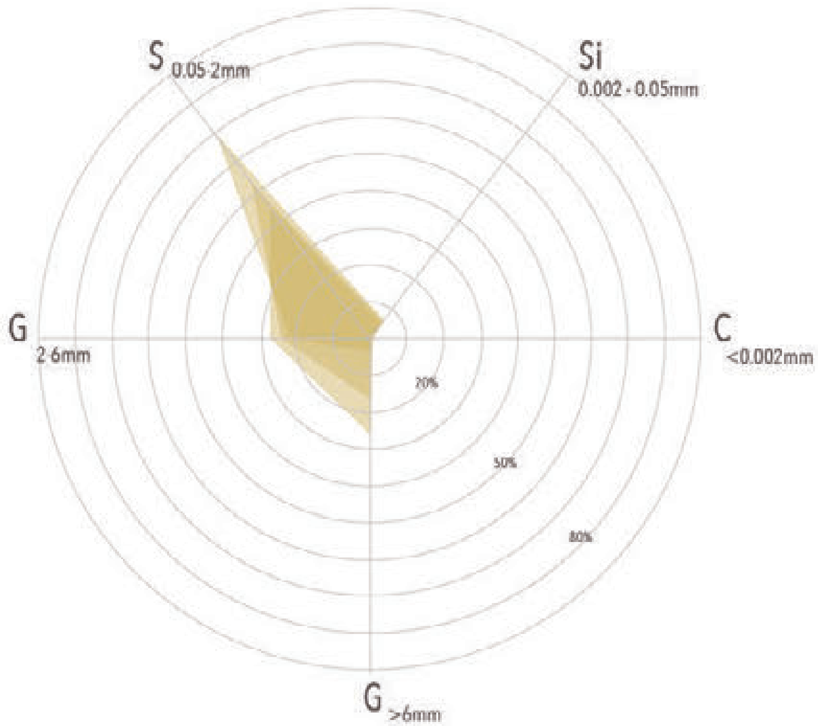
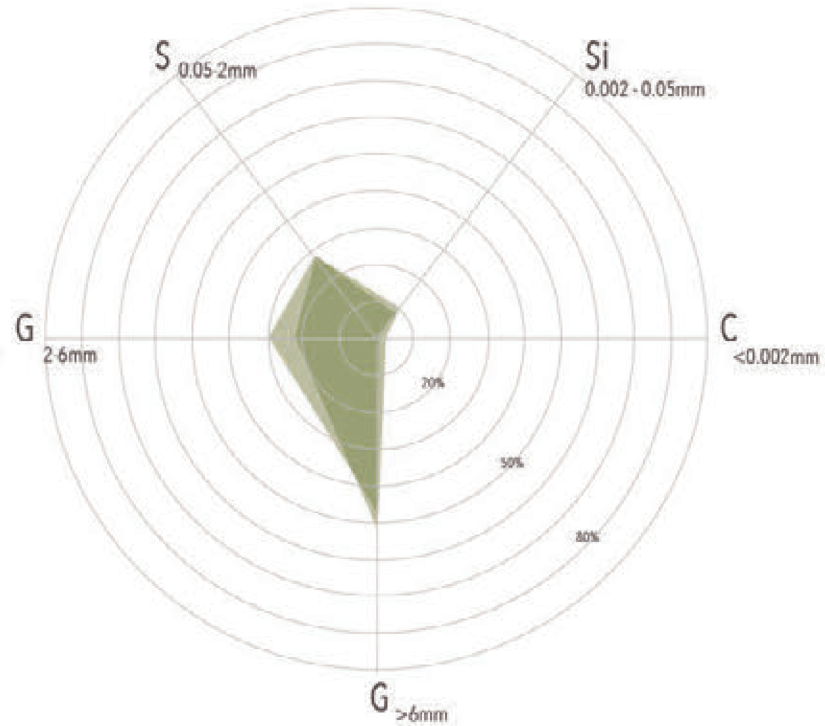
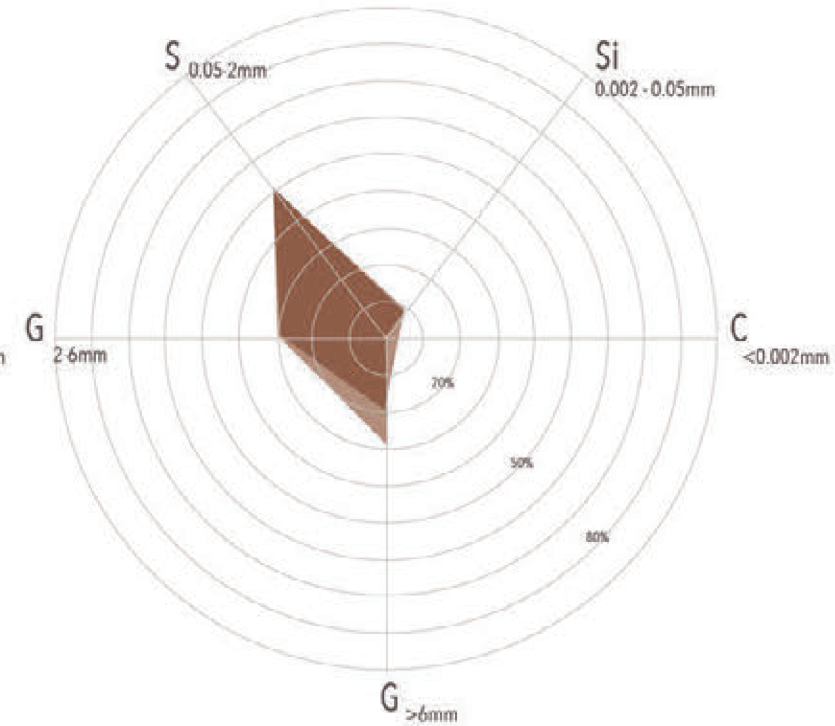
SOIL TYPES



Sand Based



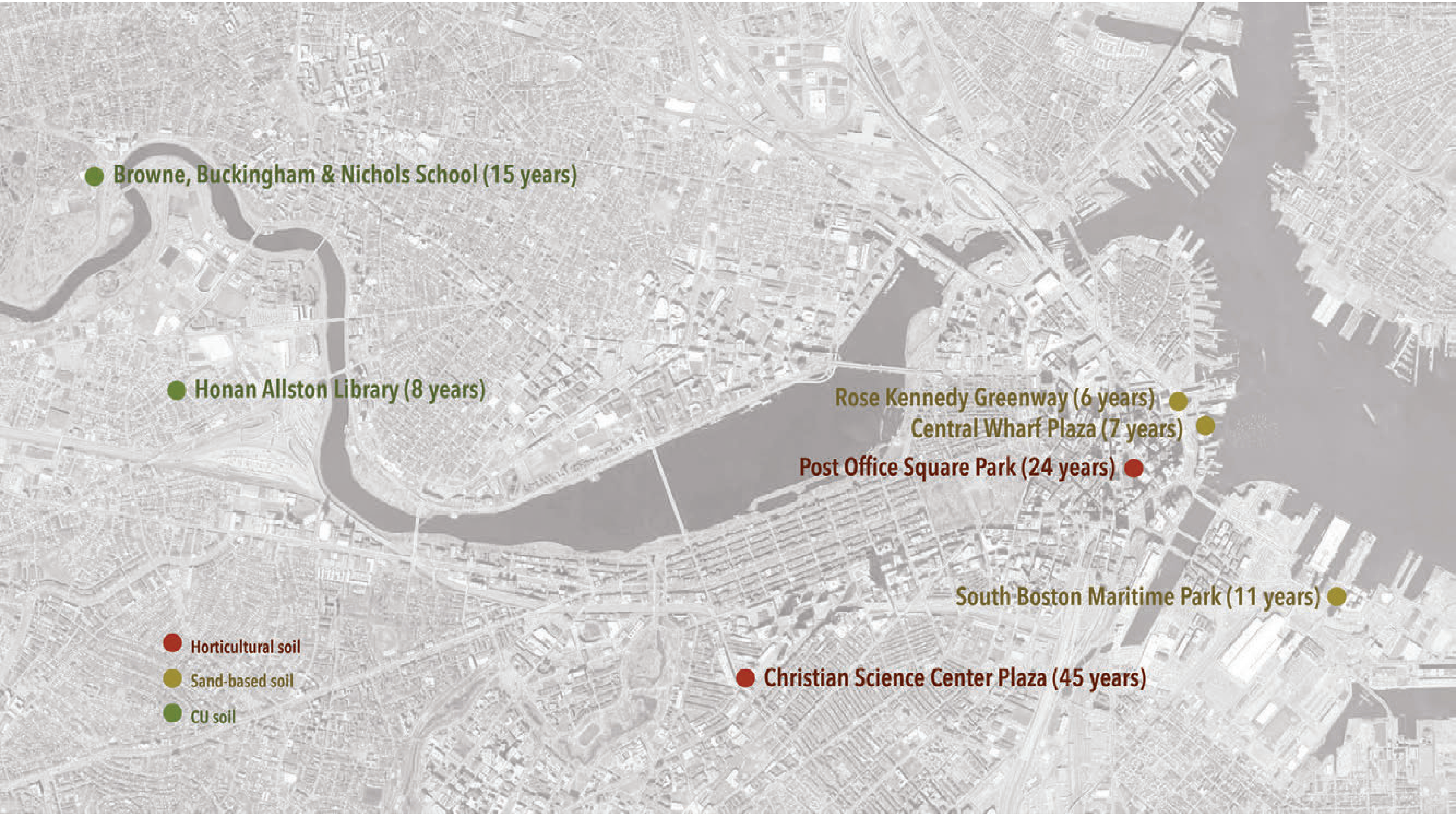
Cornell University



Horticultural Soil

Large Gravel = G >6 mm (%)
Small Gravel = G 6-2 mm (%)
Sand = S 2-0.05 mm (%)
Silt = Si 0.05-0.002 mm (%)
Clay = C <0.002 mm (%)

THE SITES



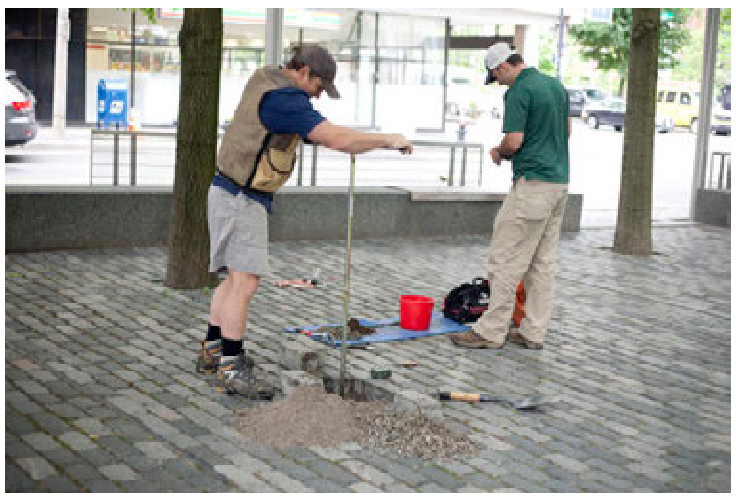
Browne, Buckingham & Nichols School (15 years)
Honan Allston Library (8 years)
Rose Kennedy Greenway (6 years)
Central Wharf Plaza (7 years)
Post Office Square Park (24 years)
South Boston Maritime Park (11 years)
Christian Science Center Plaza (45 years)
Horticultural soil
Sand-based soil
CU soil

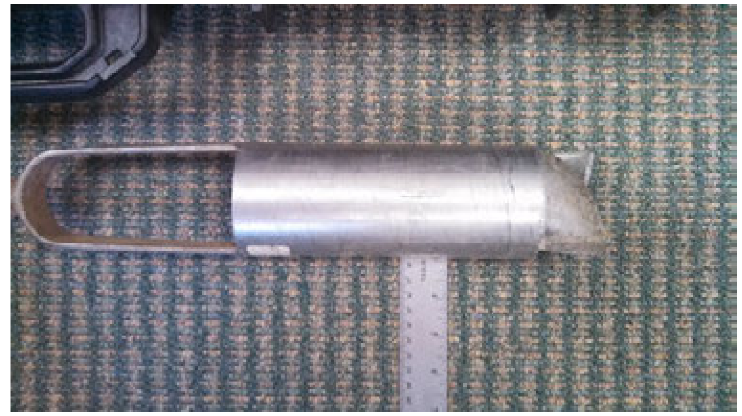
THE SITES

Boston Convention Center

Spaulding Hospital

THE SOILS





THE TREES

TREE CONDITION	0	1	2	3
Condition	(dead) >½ of the crown dead and sloughing bark	(poor) <½ of crown dead, severely stunted	(fair) reduced growth, chlorosis, minor dieback	(good) no stress and high growth rates

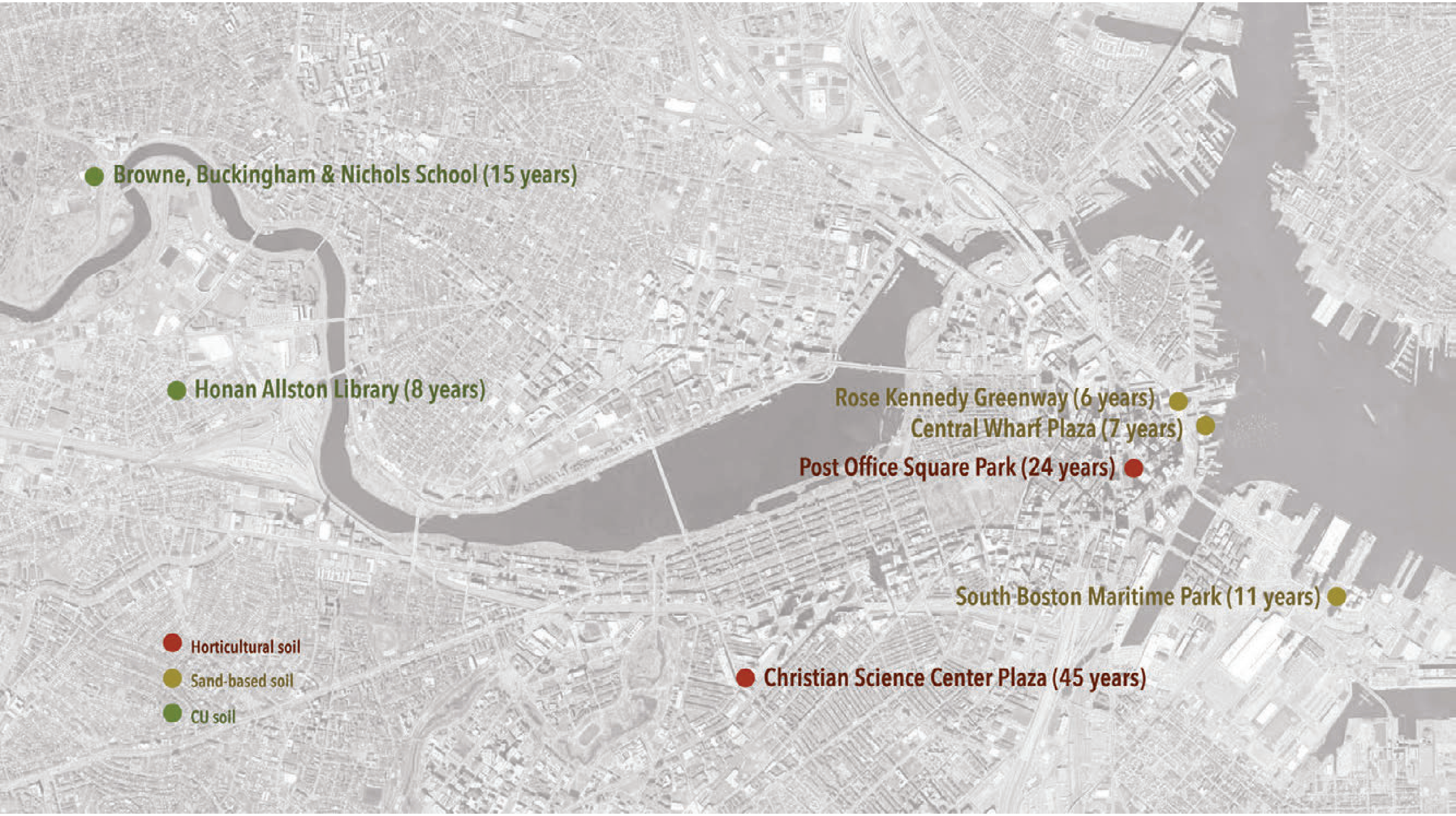
TREE CONDITION INDEX	0	1	2	3
TCI-Crown	>50% dieback	25-50% dieback	minor stress, reduced growth, chlorosis	no signs of stress and relatively high growth
TCI-Stem	cavities, large cracks, extensive decay, fungi	decay, cambial damage, many structural defects	mostly solid with few structural defects	solid throughout with good structure
TCI-Root	no root flares, no taper, girdling roots, fungi	no root flares, but taper evident	visible root flares that are appear unbalanced	visible root flares that appear balanced

URBAN TREE HEALTH*	0	1	2	3	4	5
Ratio	No live crown	1-20%	21-40%	41-60%	61-80%	81-100%
Opacity	No live crown	1-20%	21-40%	41-60%	61-80%	81-100%
Vitality	No live crown	1-20%	21-40%	41-60%	61-80%	81-100%
Growth	No live crown	<5 cm	5-10 cm	10-15 cm	15-20 cm	>20 cm
Quality	No live crown	1-20%	21-40%	41-60%	61-80%	81-100%

BOND, JERRY. 2012. URBAN TREE HEALTH. A PRACTICAL AND PRECISE ESTIMATION METHOD

THE DATABASE

THE SITES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Horticultural soil
Sand-based soil
CU soil

CHRISTIAN SCIENCE CENTER HORTICULTURAL SOIL

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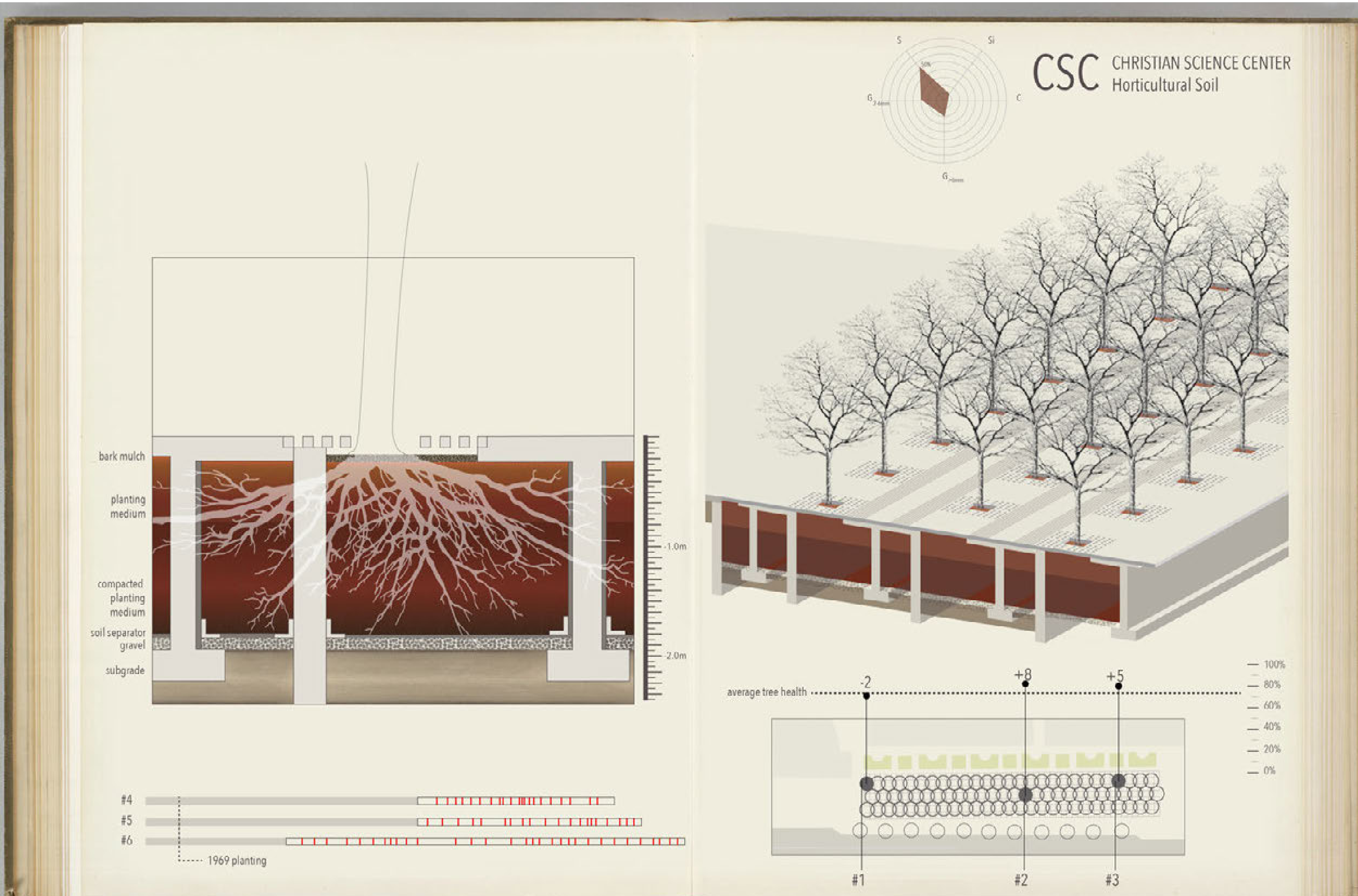
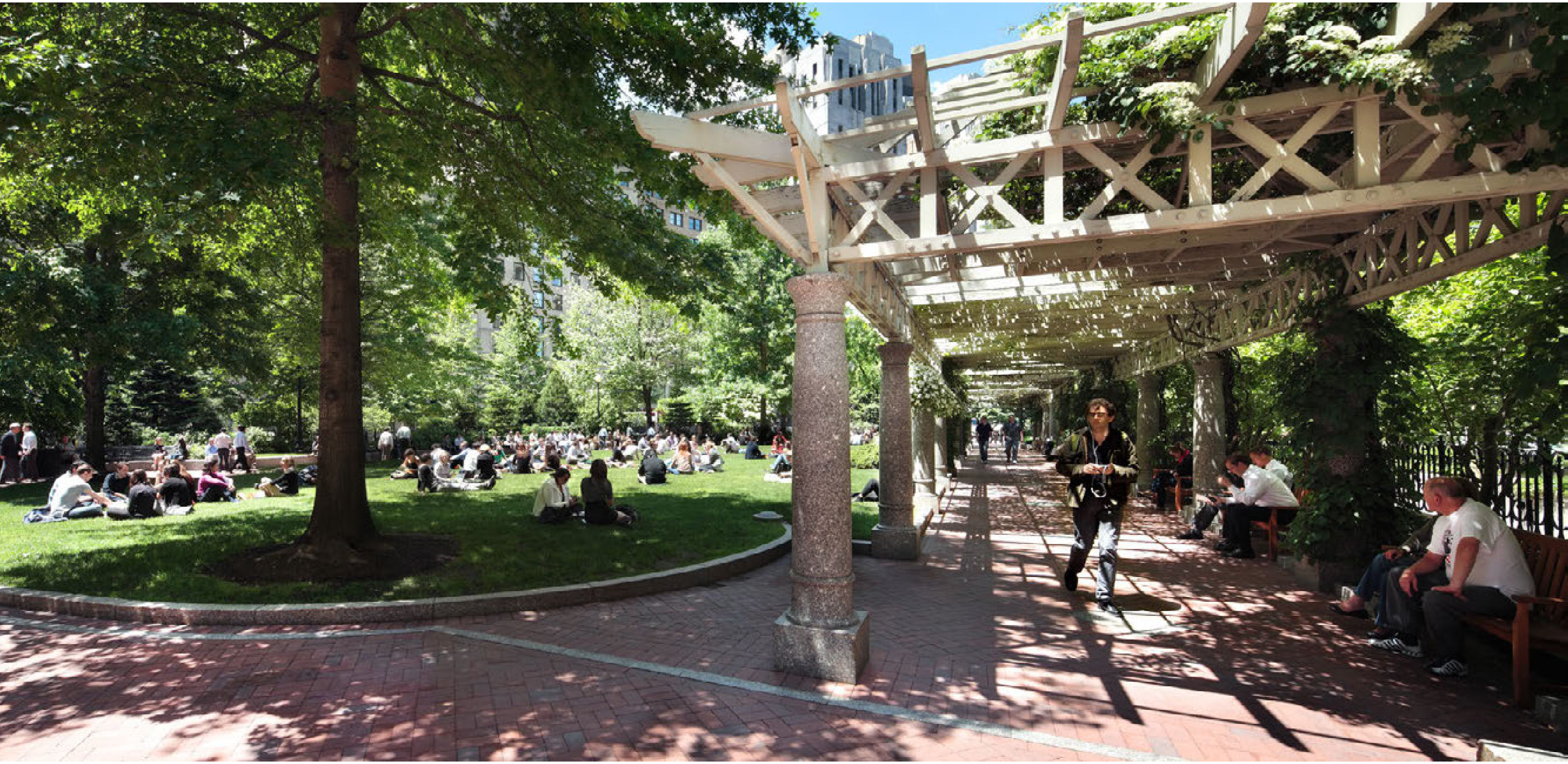
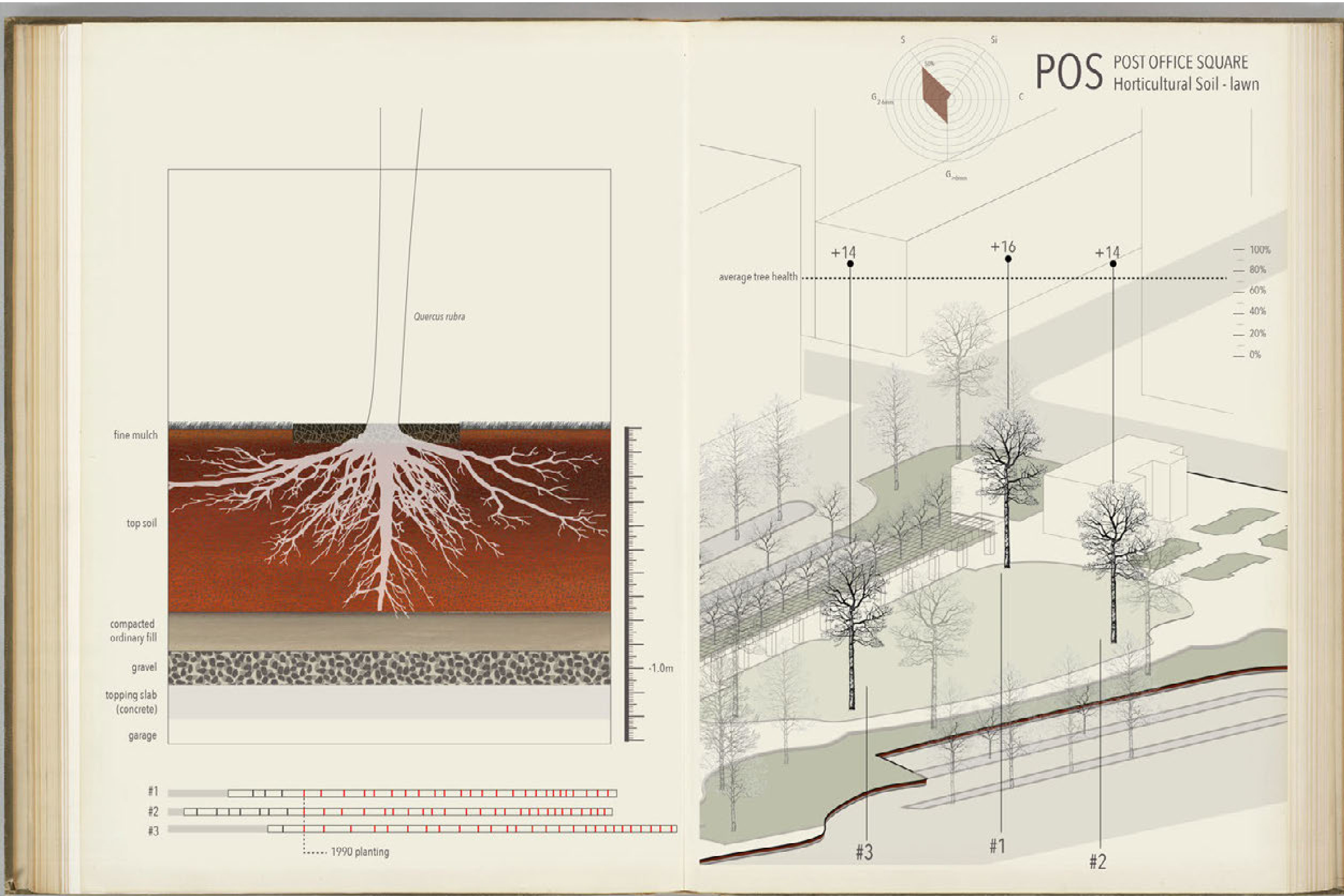


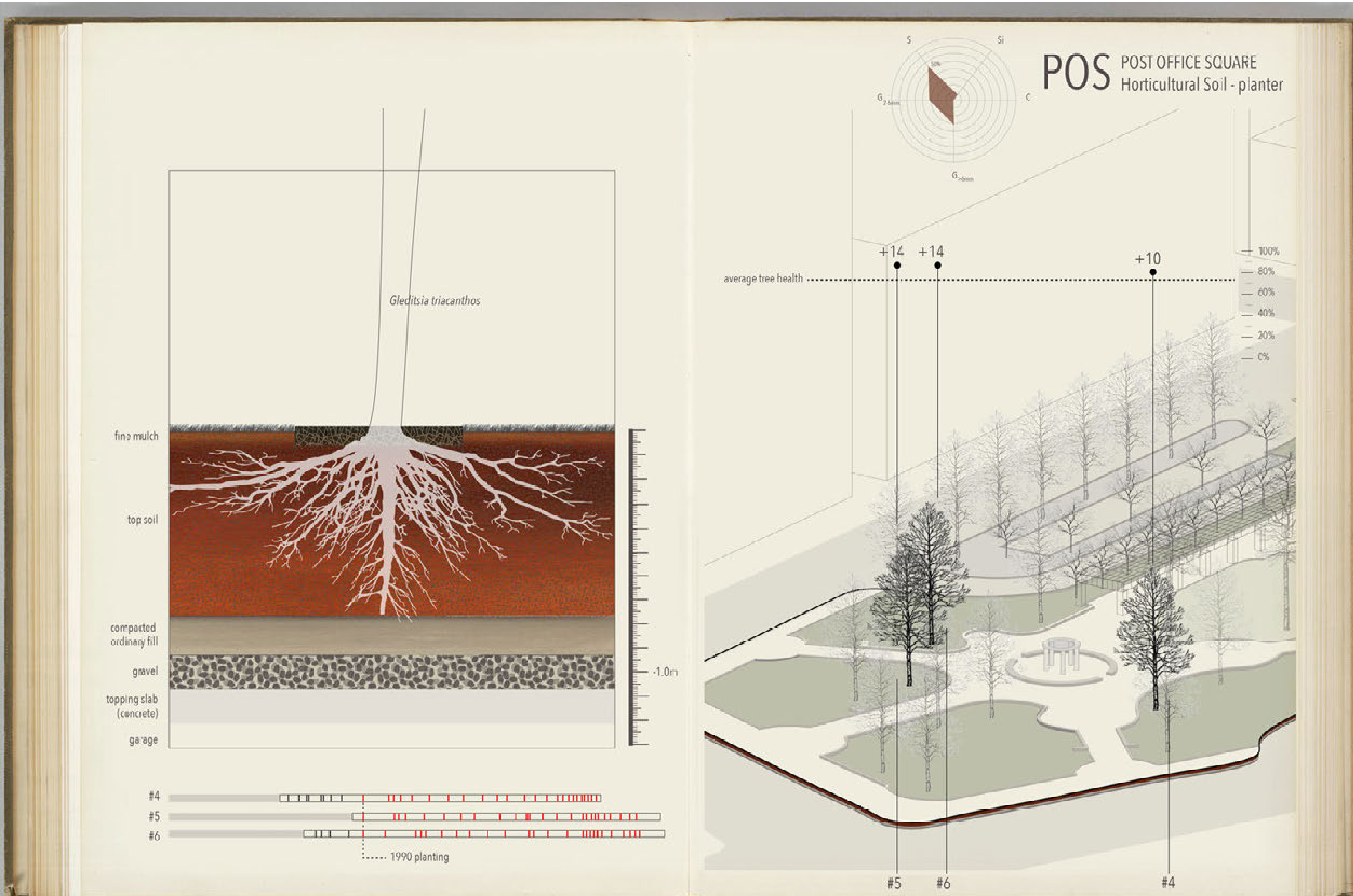
POST OFFICE SQUARE HORTICULTURAL SOIL



POST OFFICE SQUARE
HORTICULTURAL SOIL

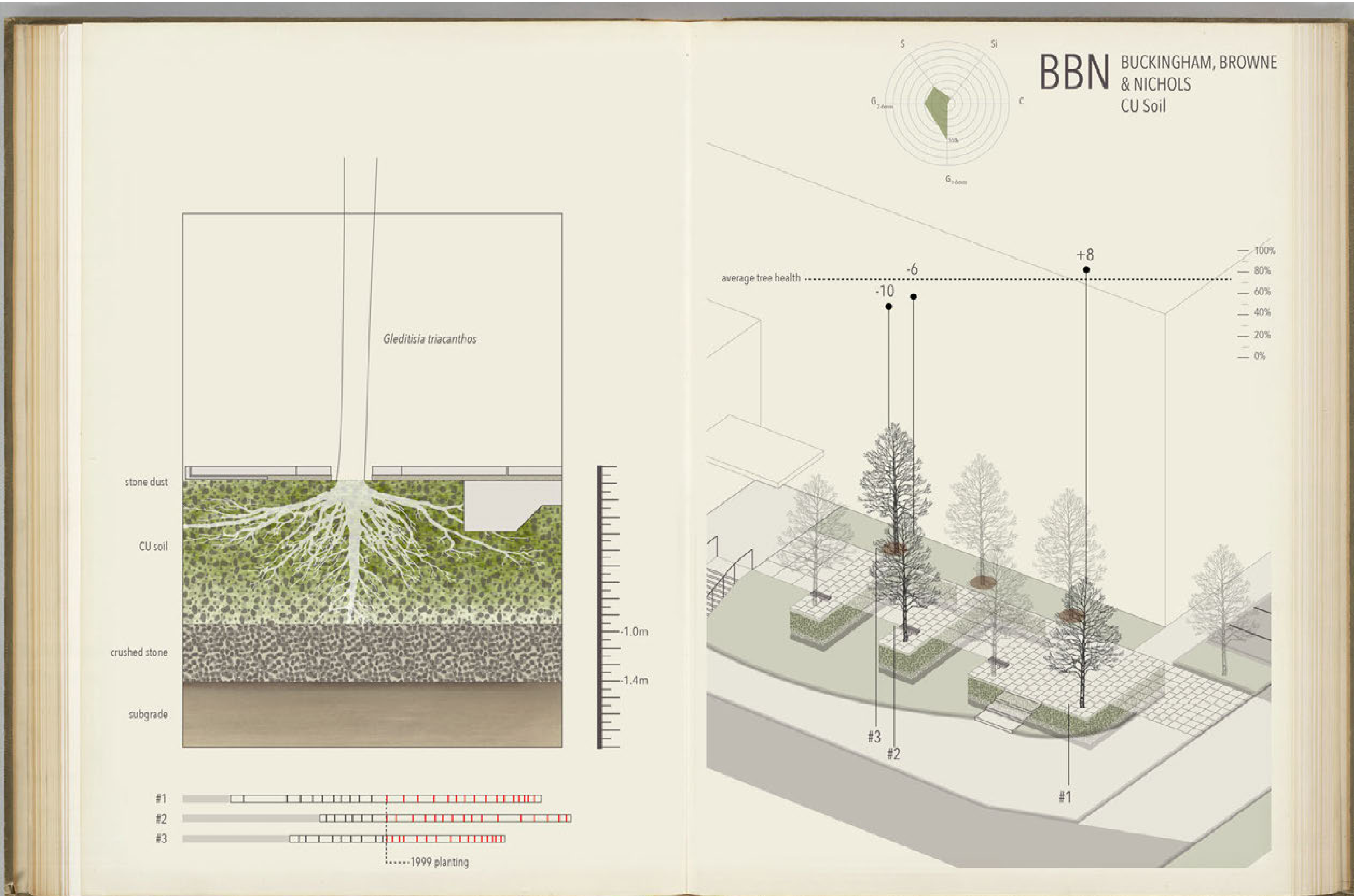


POST OFFICE SQUARE
HORTICULTURAL SOIL



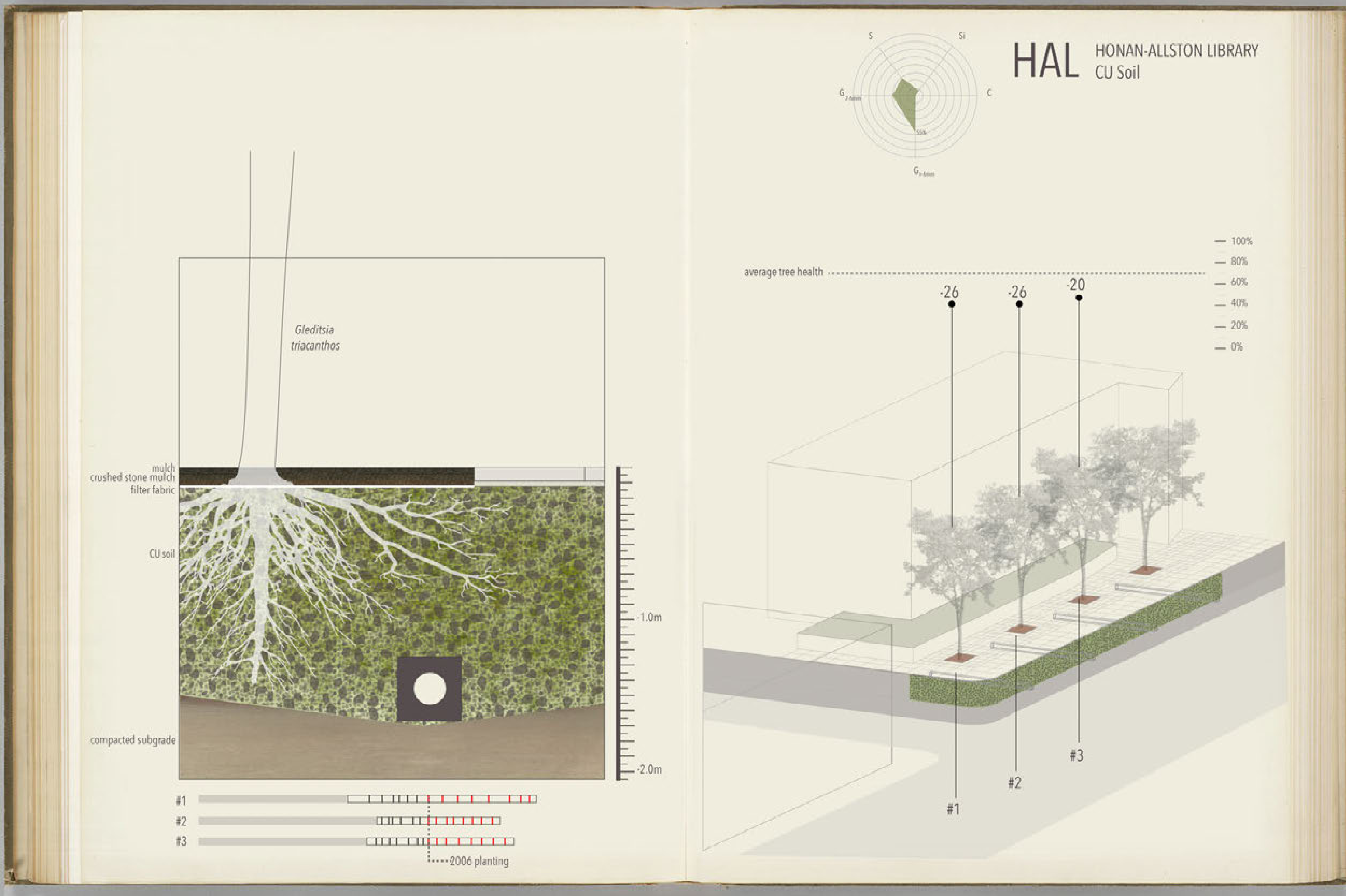
BUCKINGHAM BROWN, NICHOLS
CORNELL UNIVERSITY SOILS

BUCKINGHAM BROWN, NICHOLS
CORNELL UNIVERSITY SOILS



HONAN ALLSTON LIBRARY
CORNELL UNIVERSITY SOILS

HONAN ALLSTON LIBRARY
CORNELL UNIVERSITY SOILS



SOUTH BOSTON MARITIME PARK
SAND BASED SOILS

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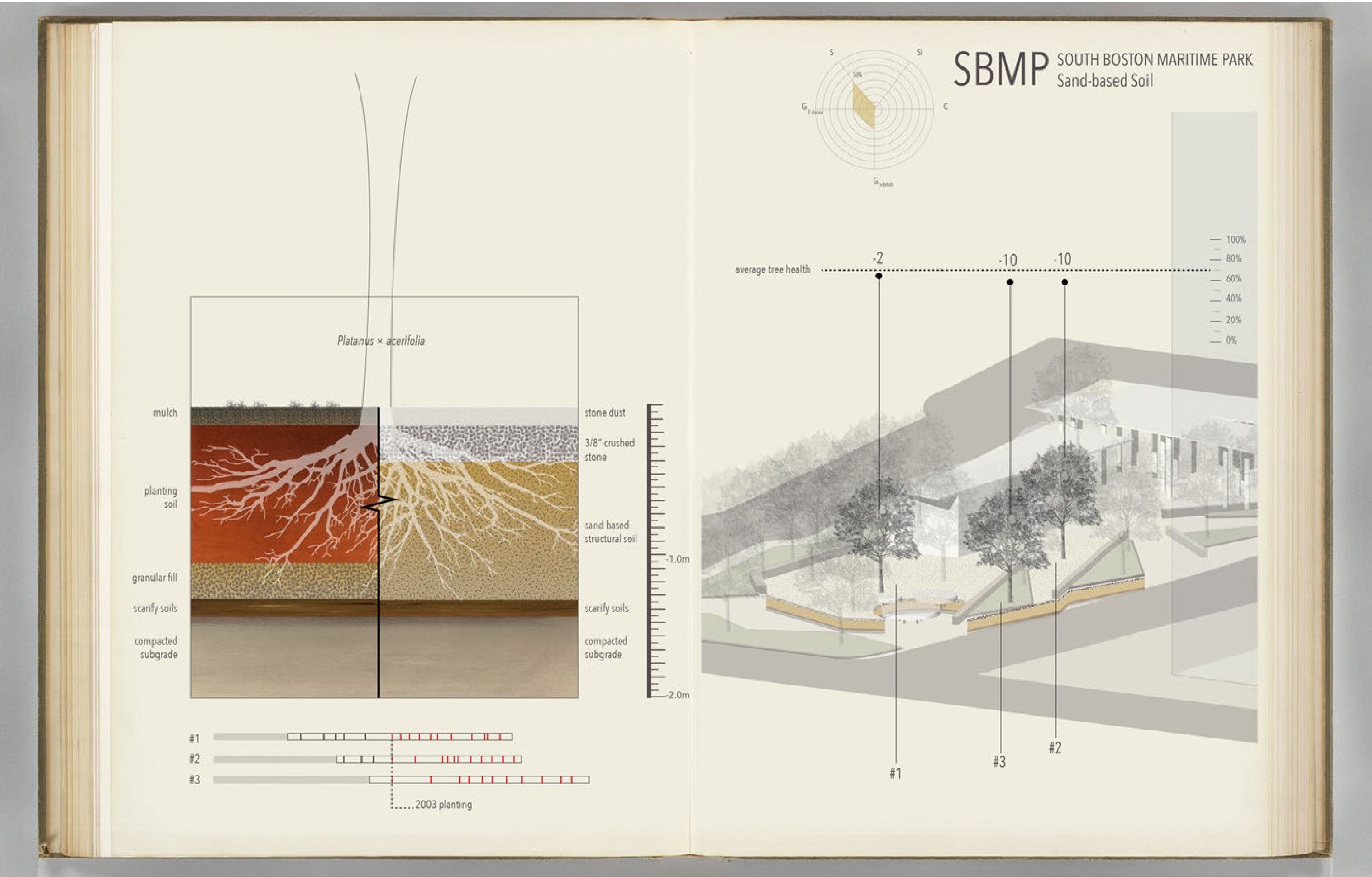
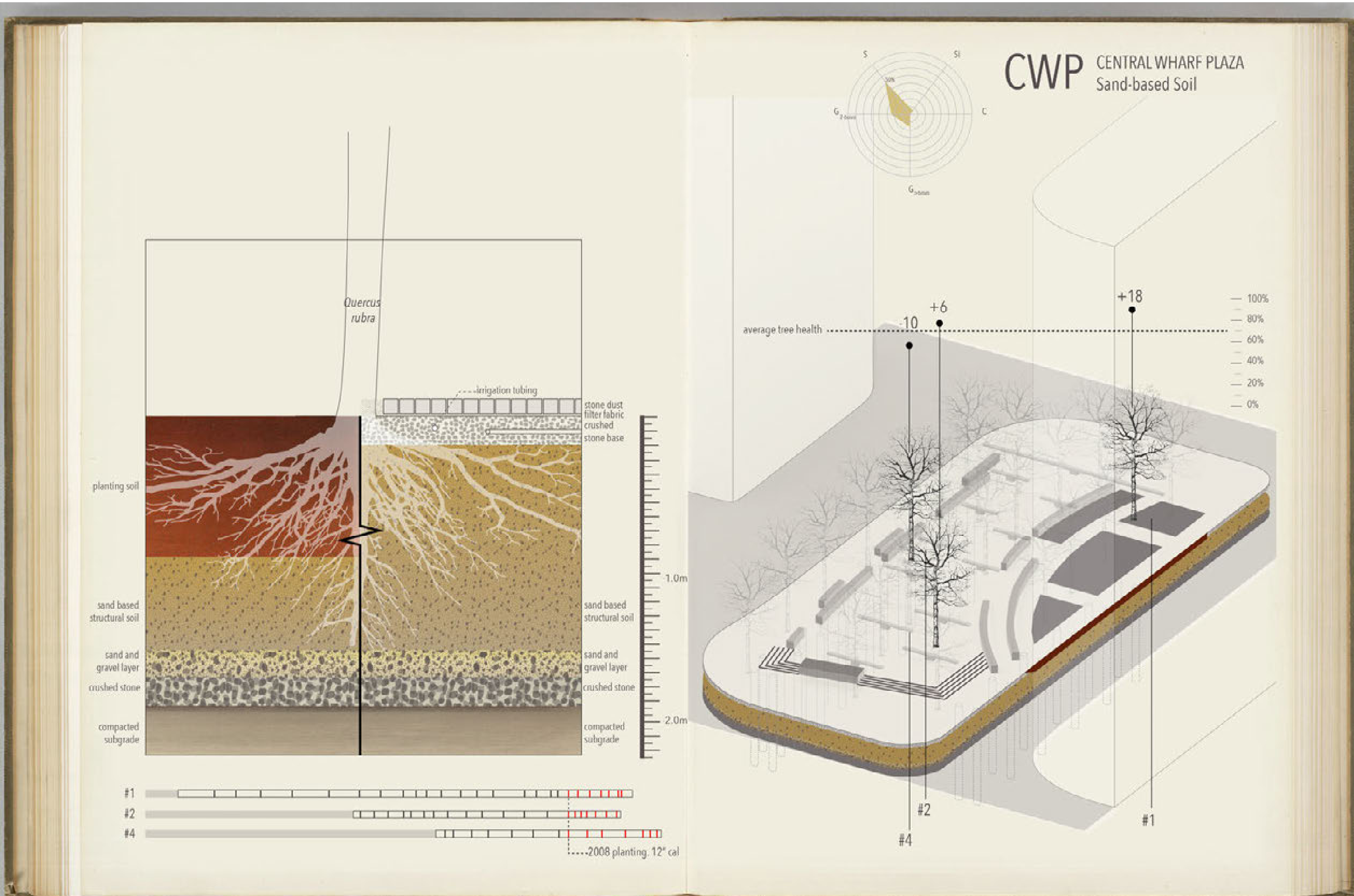
SAND BASED SOILS



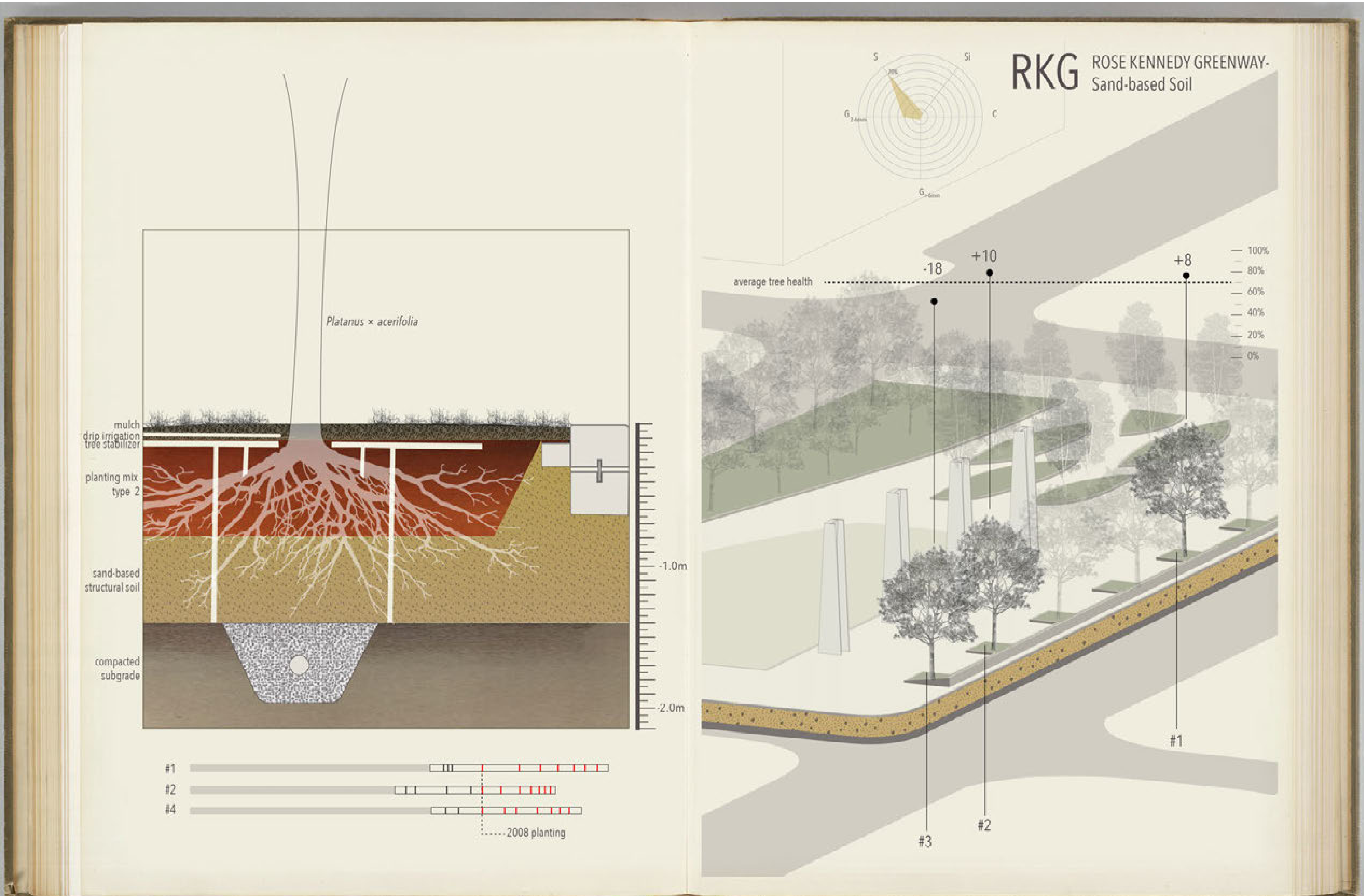
CENTRAL WHARF PLAZA
SAND BASED SOILS

CENTRAL WHARF PLAZA
SAND BASED SOILS

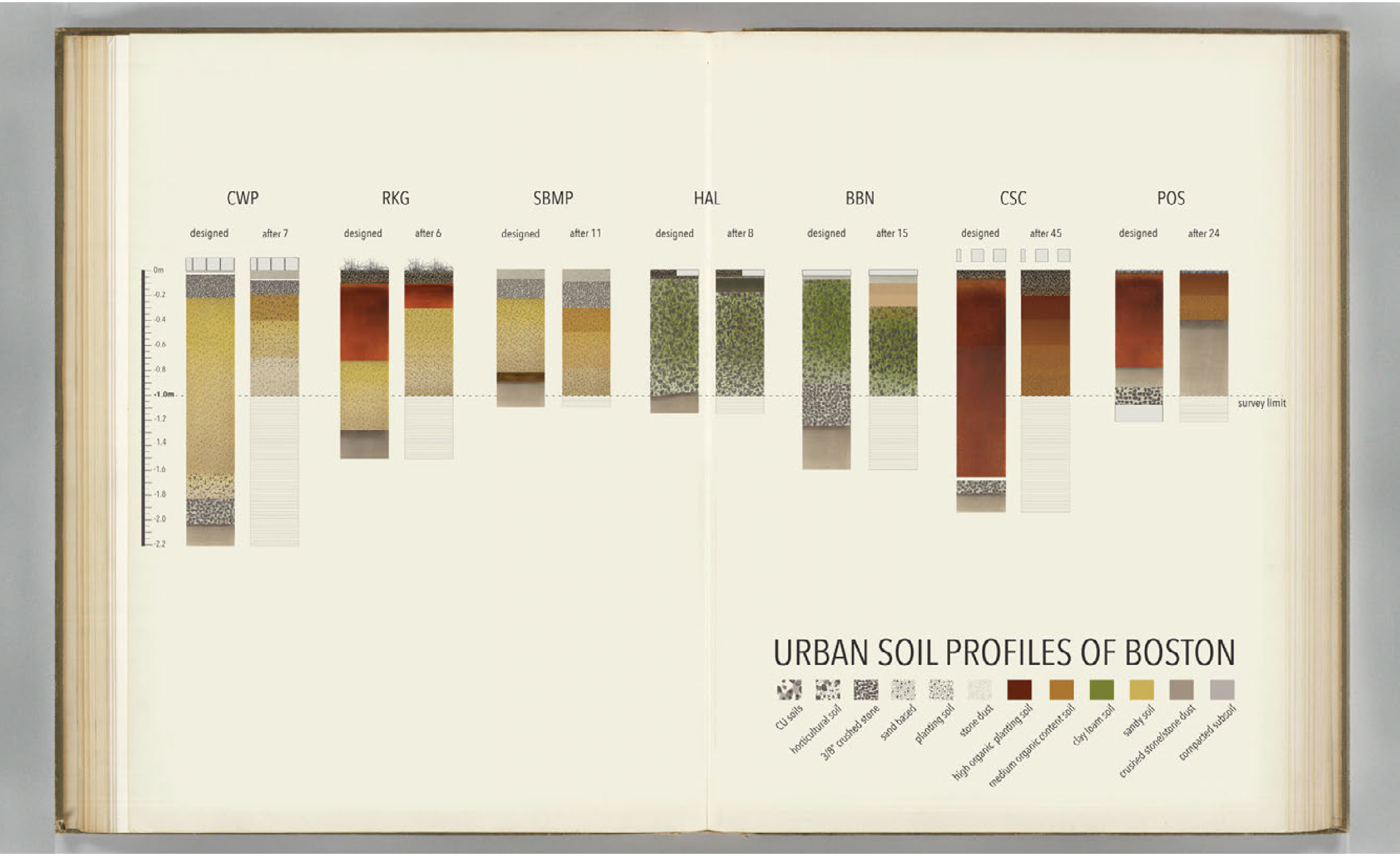


R F KENNEDY GREENWAY SAND BASED SOILS

R F KENNEDY GREENWAY
SAND BASED SOILS

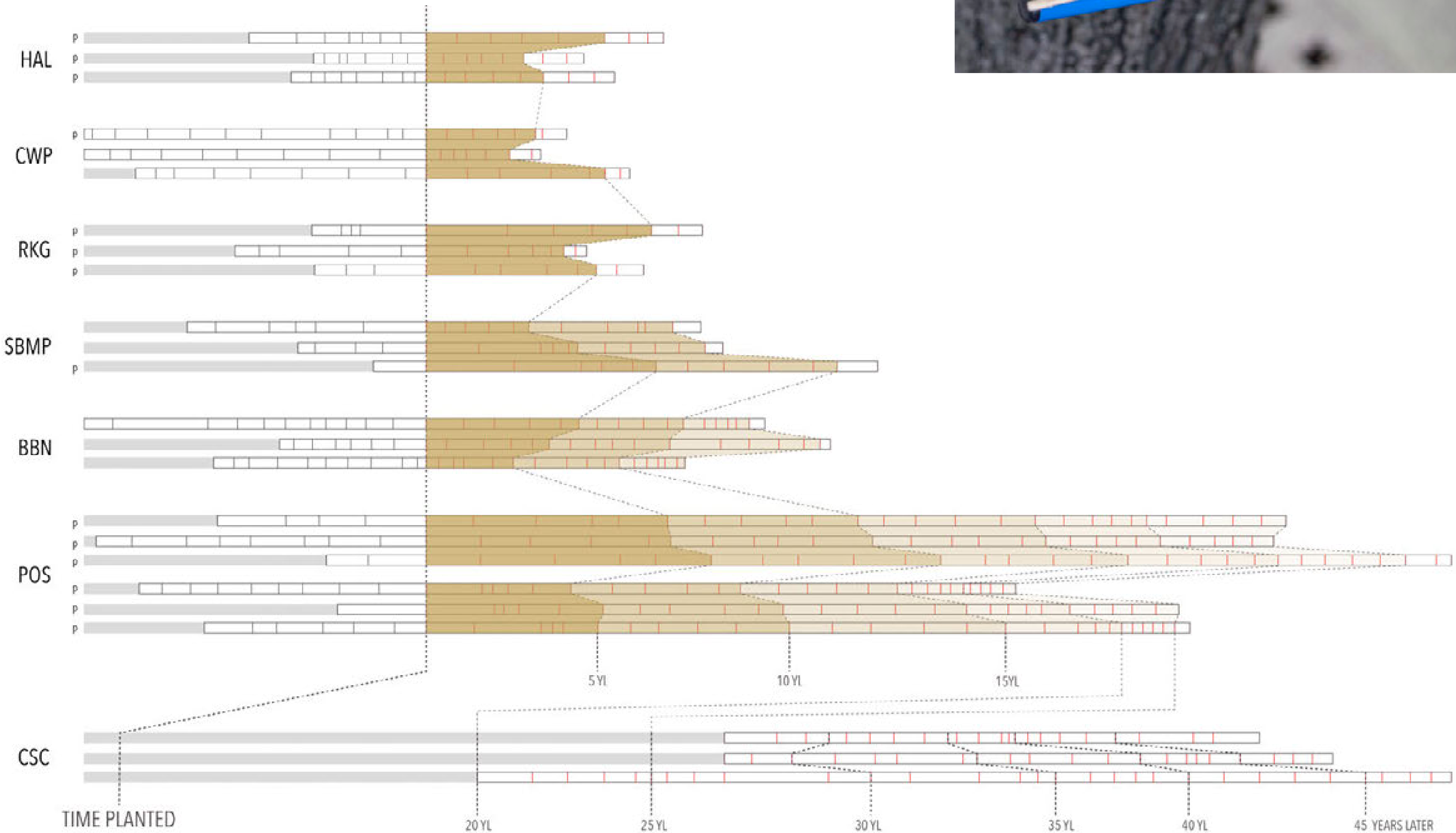


SOIL SECTION ANALYSIS



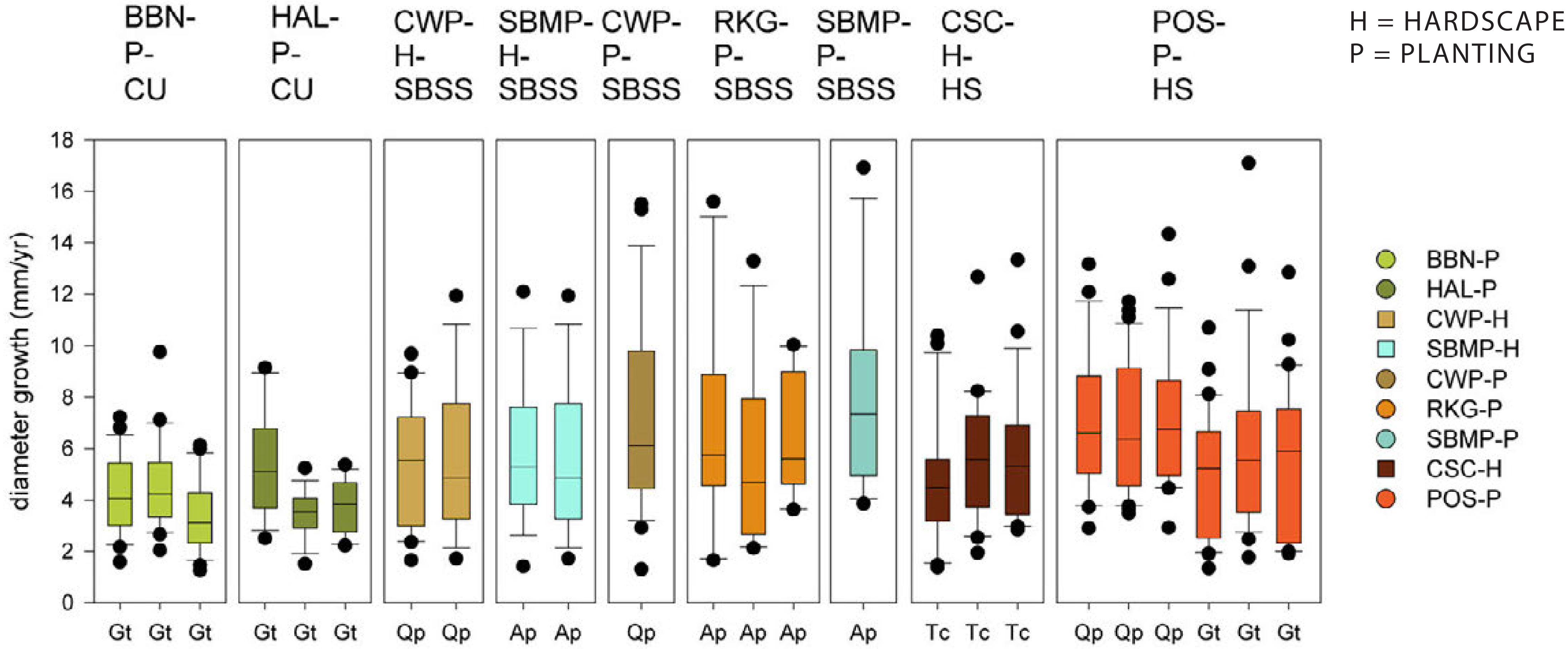
RELATING SOILS + TREES

TREE CORE ANALYSIS



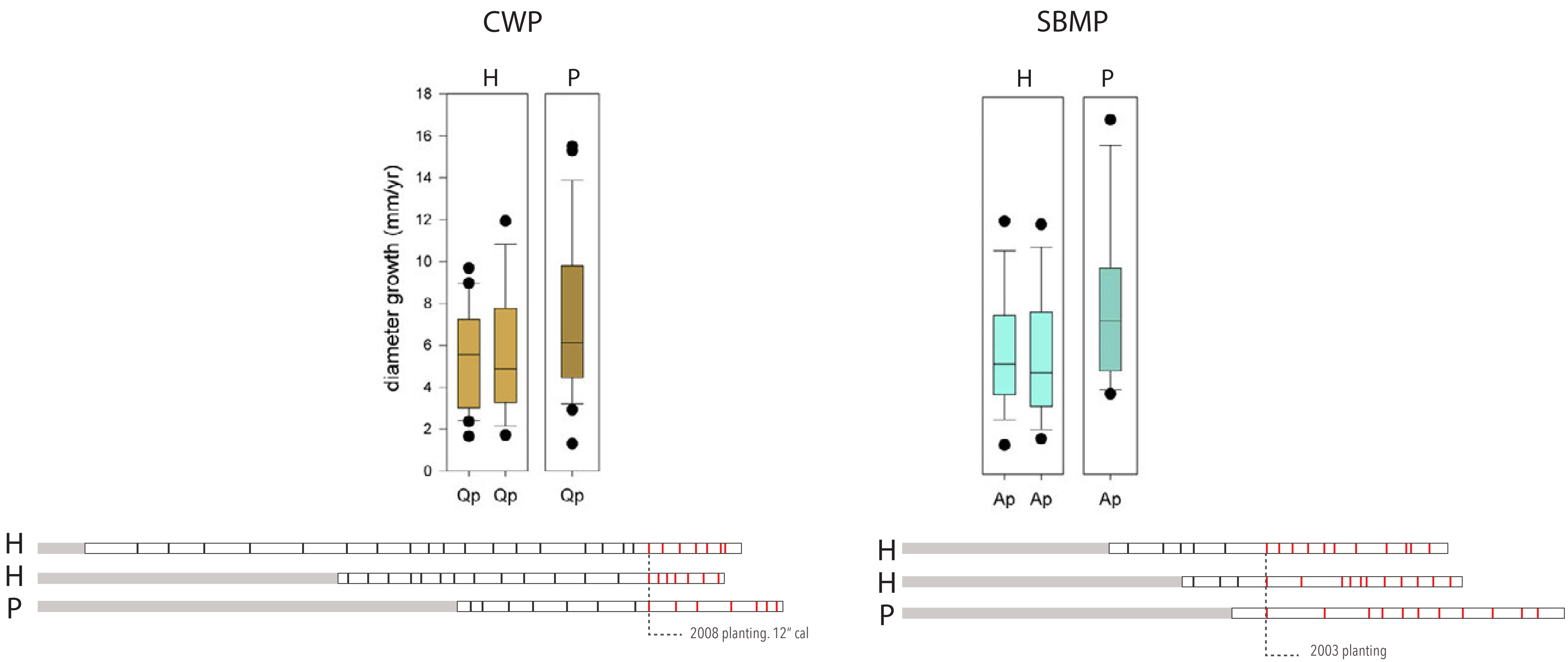
TREE GROWTH RATE

Variation in species, size, age, site conditions and management strategies all influence tree growth rate.



TREE GROWTH RATE

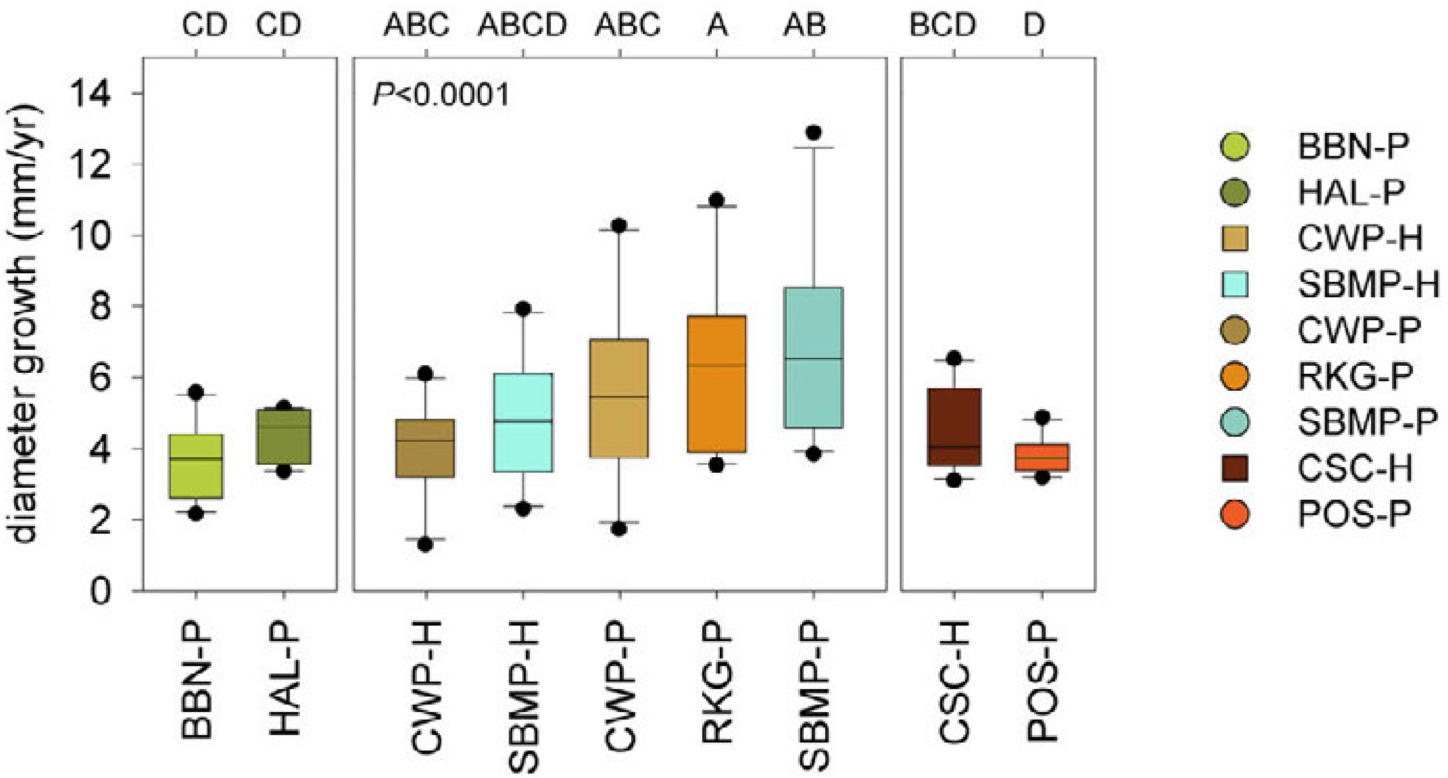
In Sand-Based applications tree diameter growth appears to be reduced in soil under pavement, where organic matter volume is lower.



H = HARDSCAPE
P = PLANTING

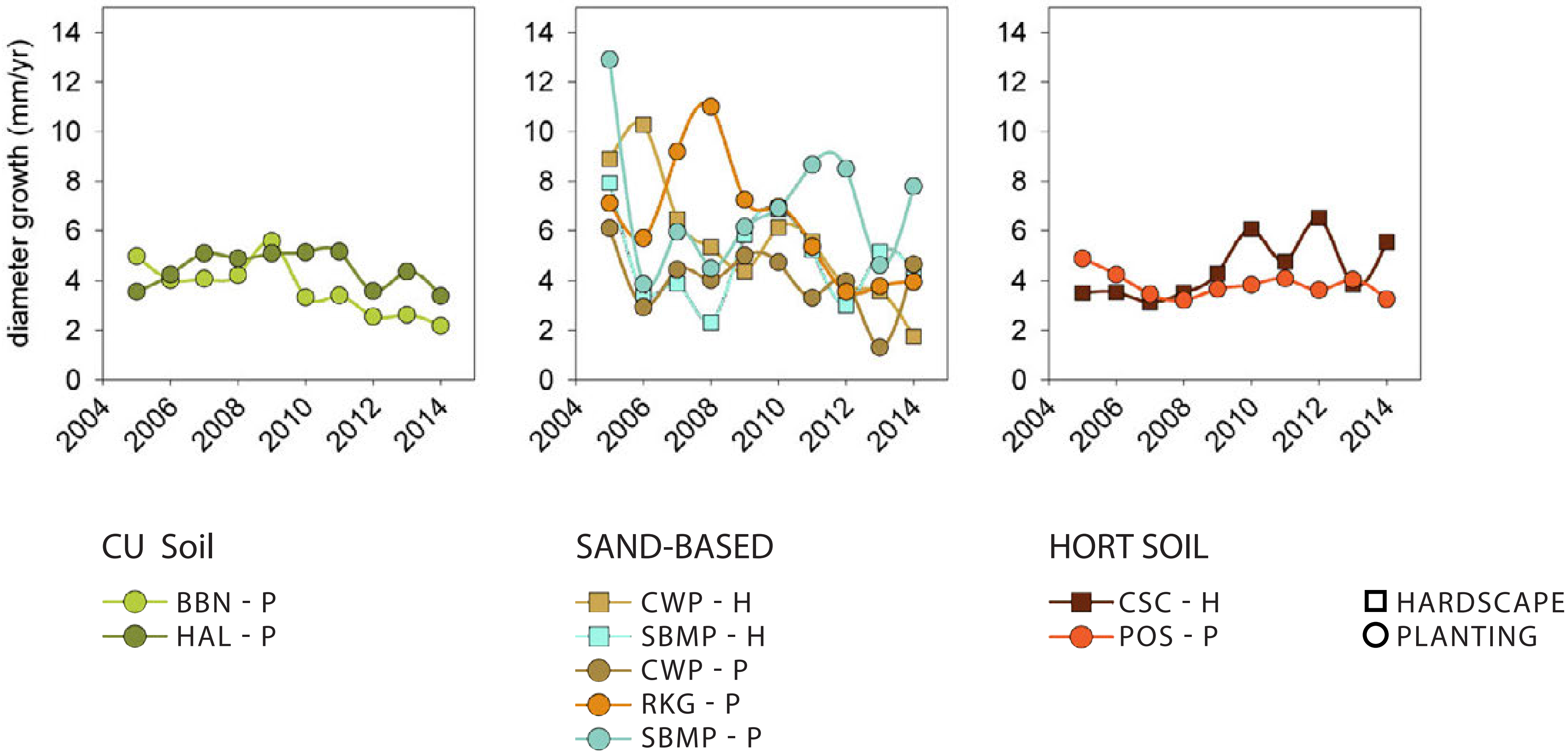
TREE GROWTH RATE

Diameter growth trends were higher and more variable in Sand-Based Soils, but diameter growth may not be the most important metric.



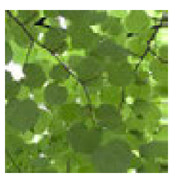
TREE GROWTH RATE

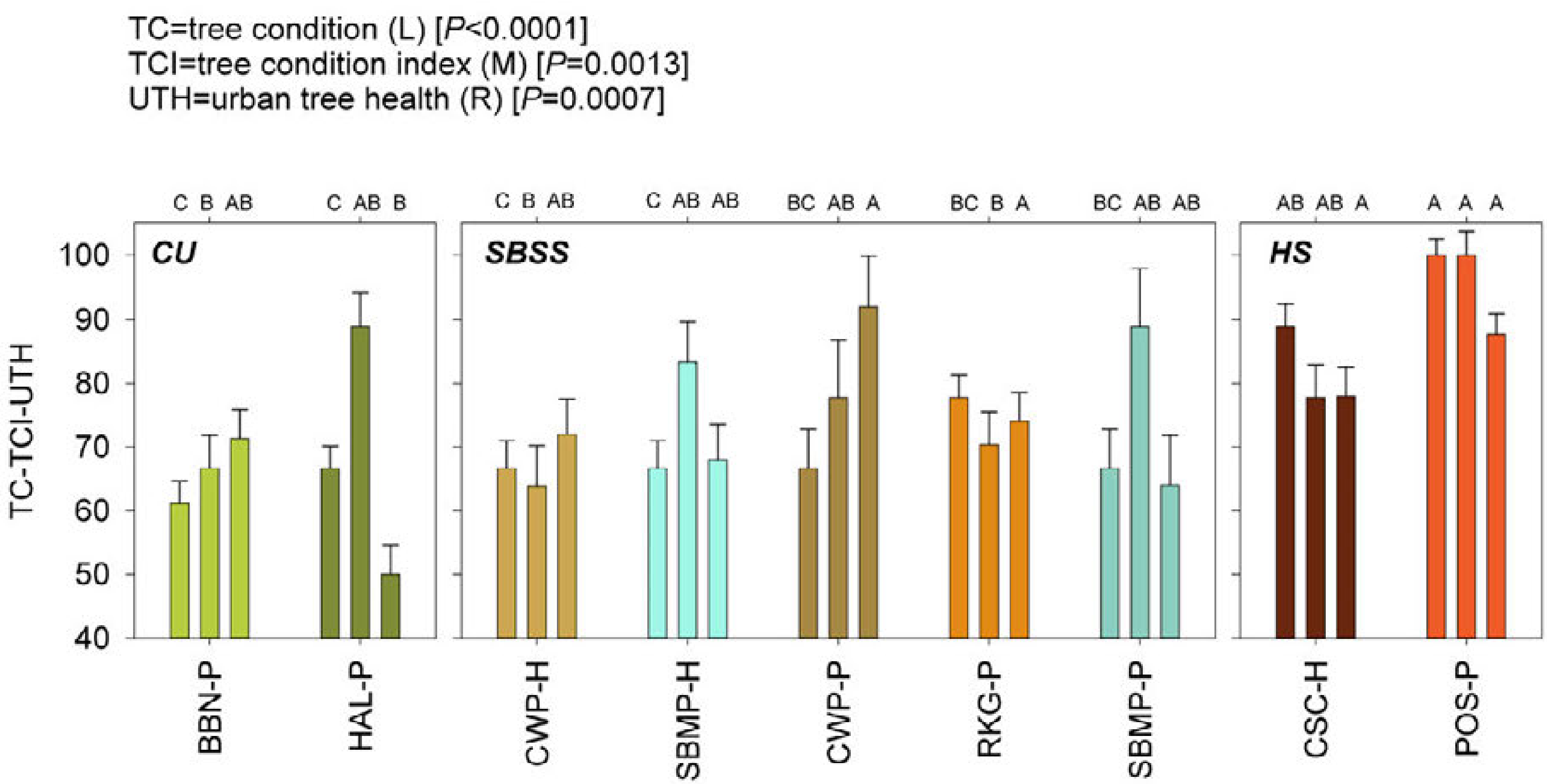
Yearly growth variability within the Sand-Based sites is more pronounced. Sand-Based Soil properties were also variable, a likely influence on tree performance.



TREE CONDITION

Is tree condition a better rating? Even though Sand-Based Soils trended towards more growth, this did not translate into higher quality trees. Management strategies and site conditions also play a critical role in these data.

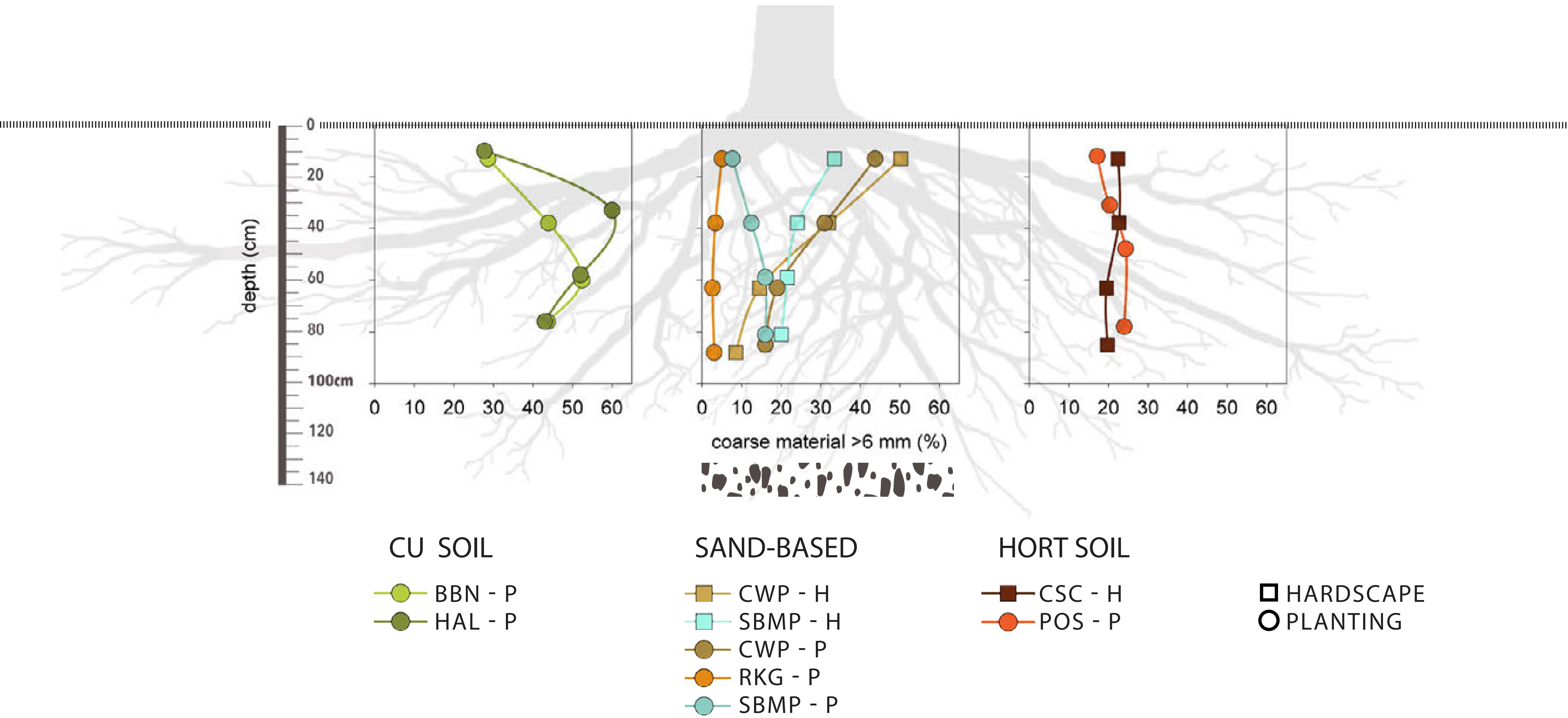




UNDERSTANDING SOIL PHYSICAL PROPERTIES

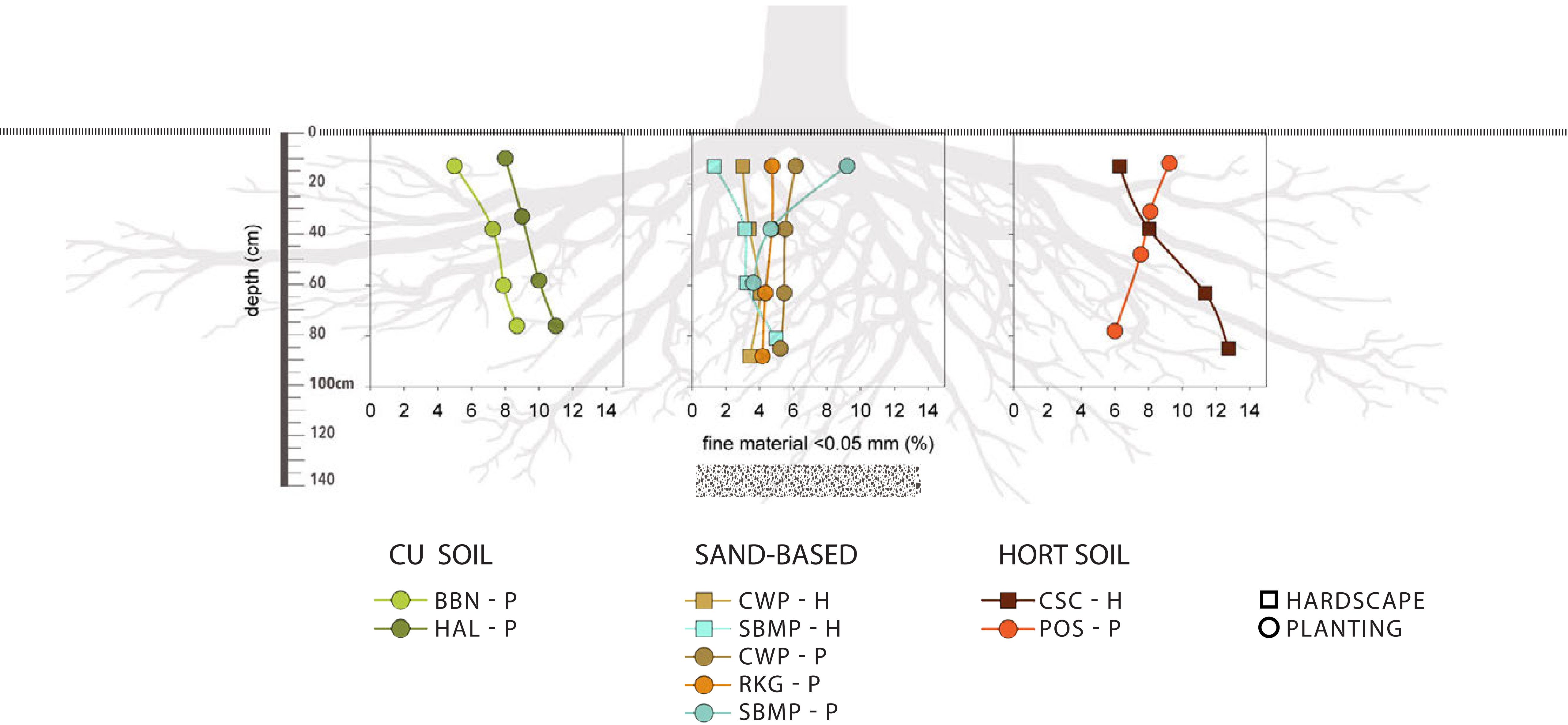
COARSE MATERIAL

CU have high and variable amounts of course material.
Sand-Based Soils under pavement have high amounts in the upper profile.
Hort Soils have more uniform coarse material throughout the profile.



FINE MATERIAL

CU Soils show higher fine material at greater depths.
Sand-Based have lower fine material, especially at depth.
Fines appear to leach over time, especially in Hort Soils.

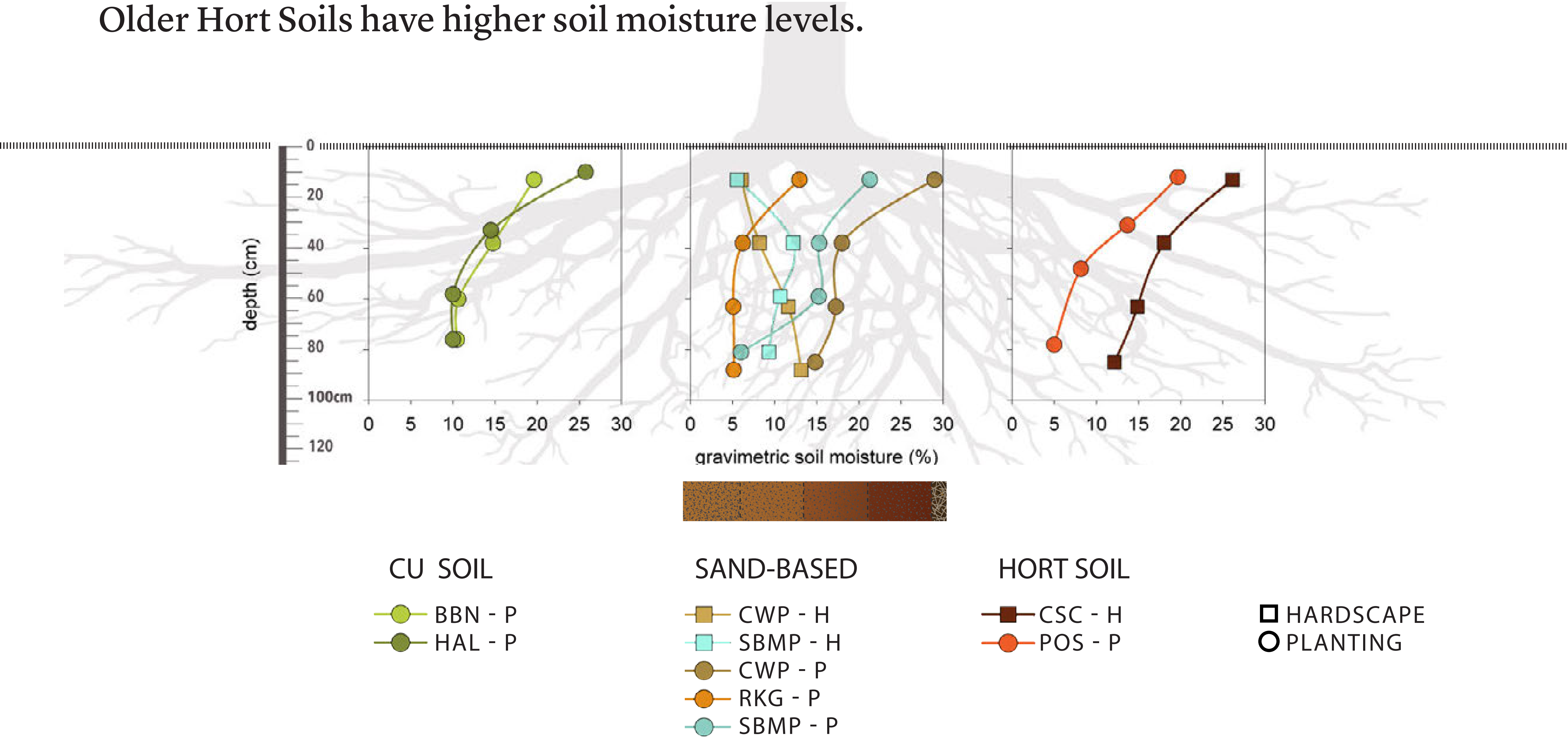


SOIL MOISTURE

Moisture tends to decrease with depth in all soils.

Sand-Based Soils have high variability, but tend to be wetter in planting compared to hardscape.

Older Hort Soils have higher soil moisture levels.

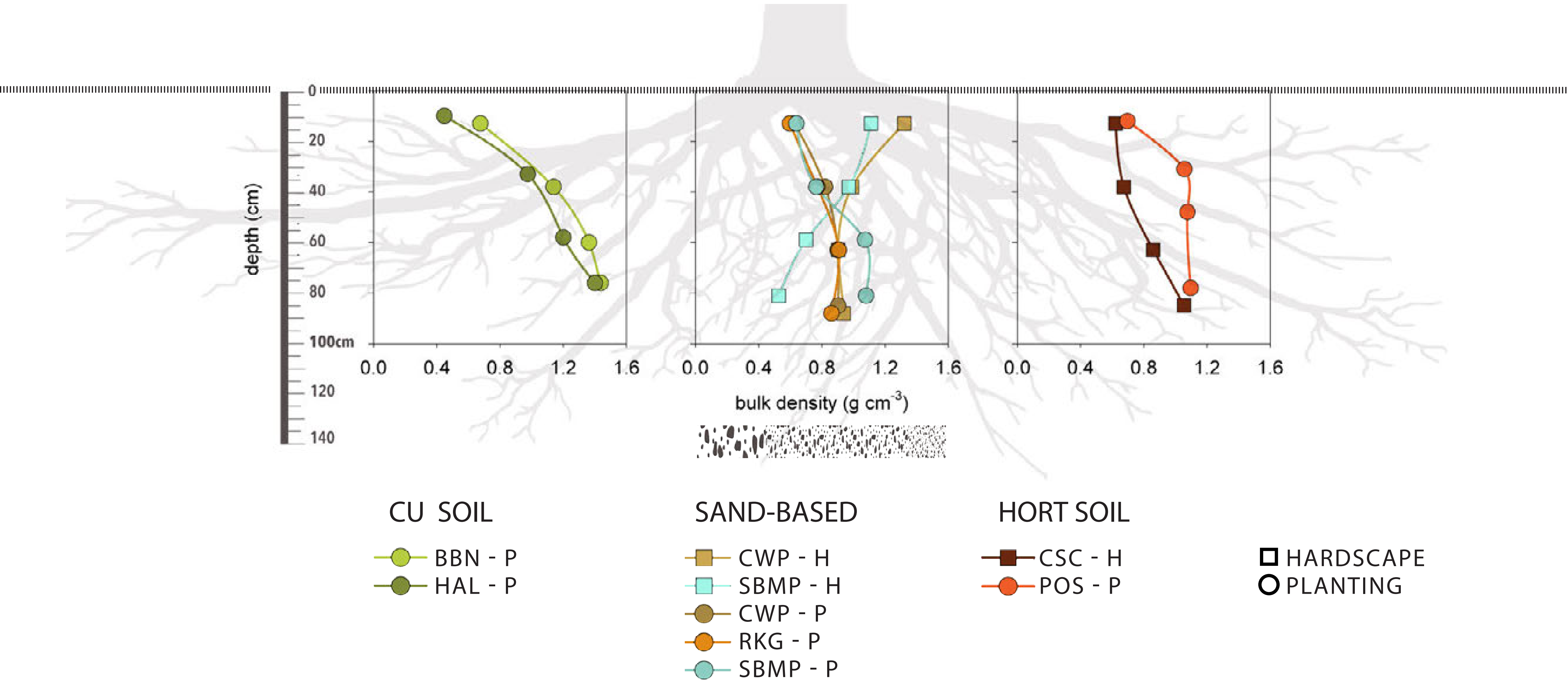


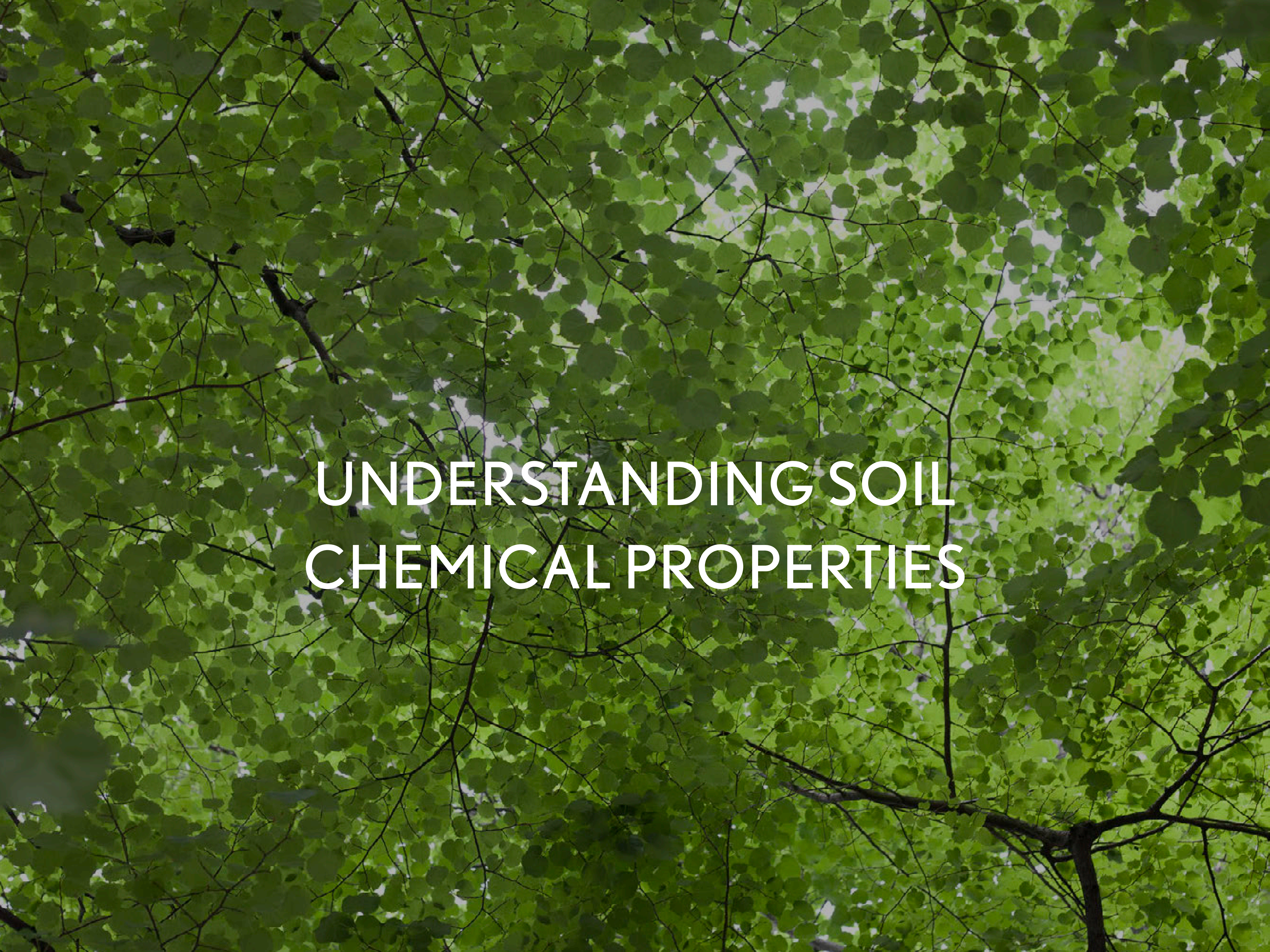
BULK DENSITY

In naturally-occurring soils, bulk density is higher at greater depths. The opposite is usually true in urban soils.

Density tends to increase with depth in soils in planting beds.

Density is highest at the surface in Sand-Based Soils that support pavement.

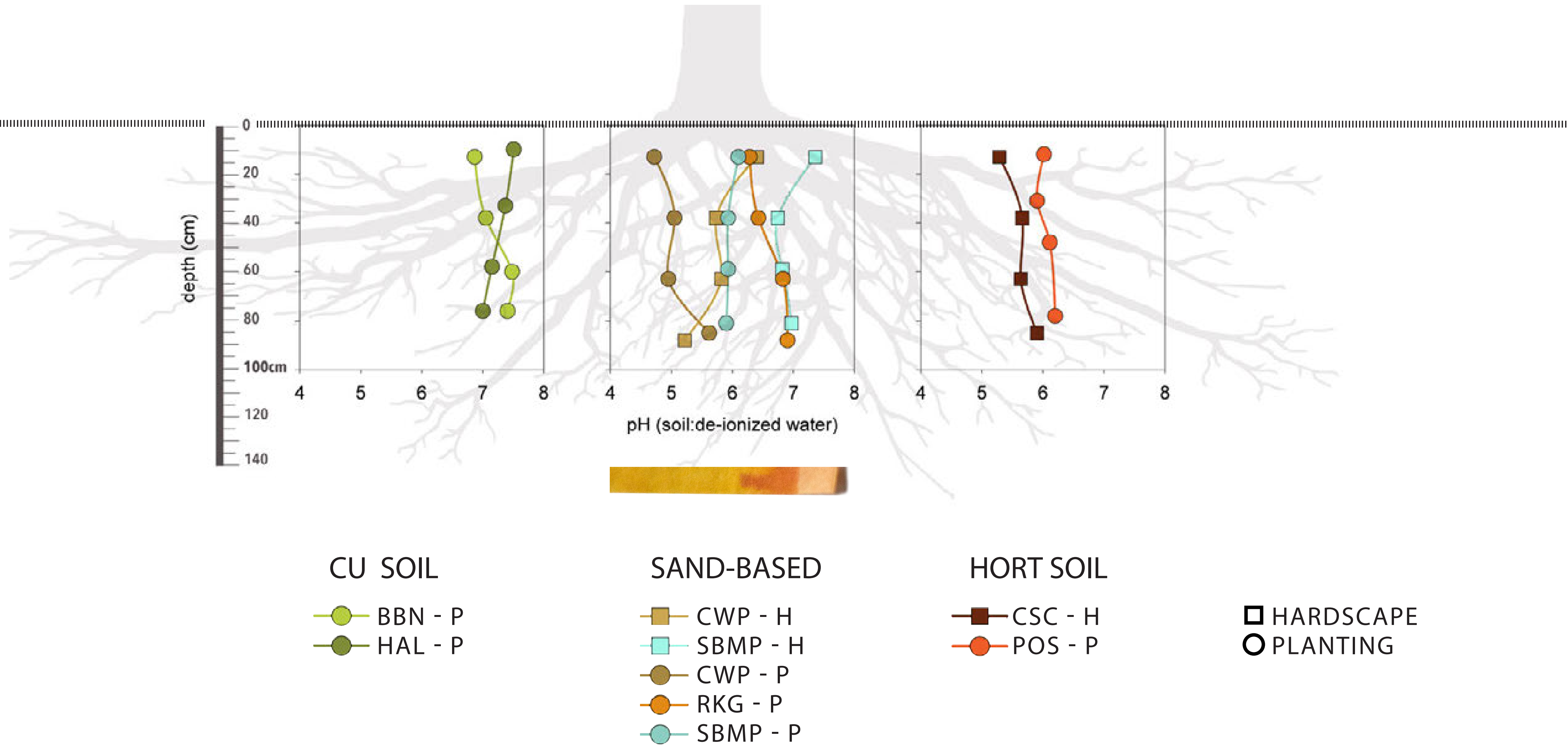




UNDERSTANDING SOIL CHEMICAL PROPERTIES

SOIL pH

CU Soils are more alkaline, Sand-Based are variable and Hort Soils tend towards acidic.
Soils under hardscape tend more alkaline, likely due to pavement weathering.
Hort Soils are more acidic, likely due to biological activity and decomposition.

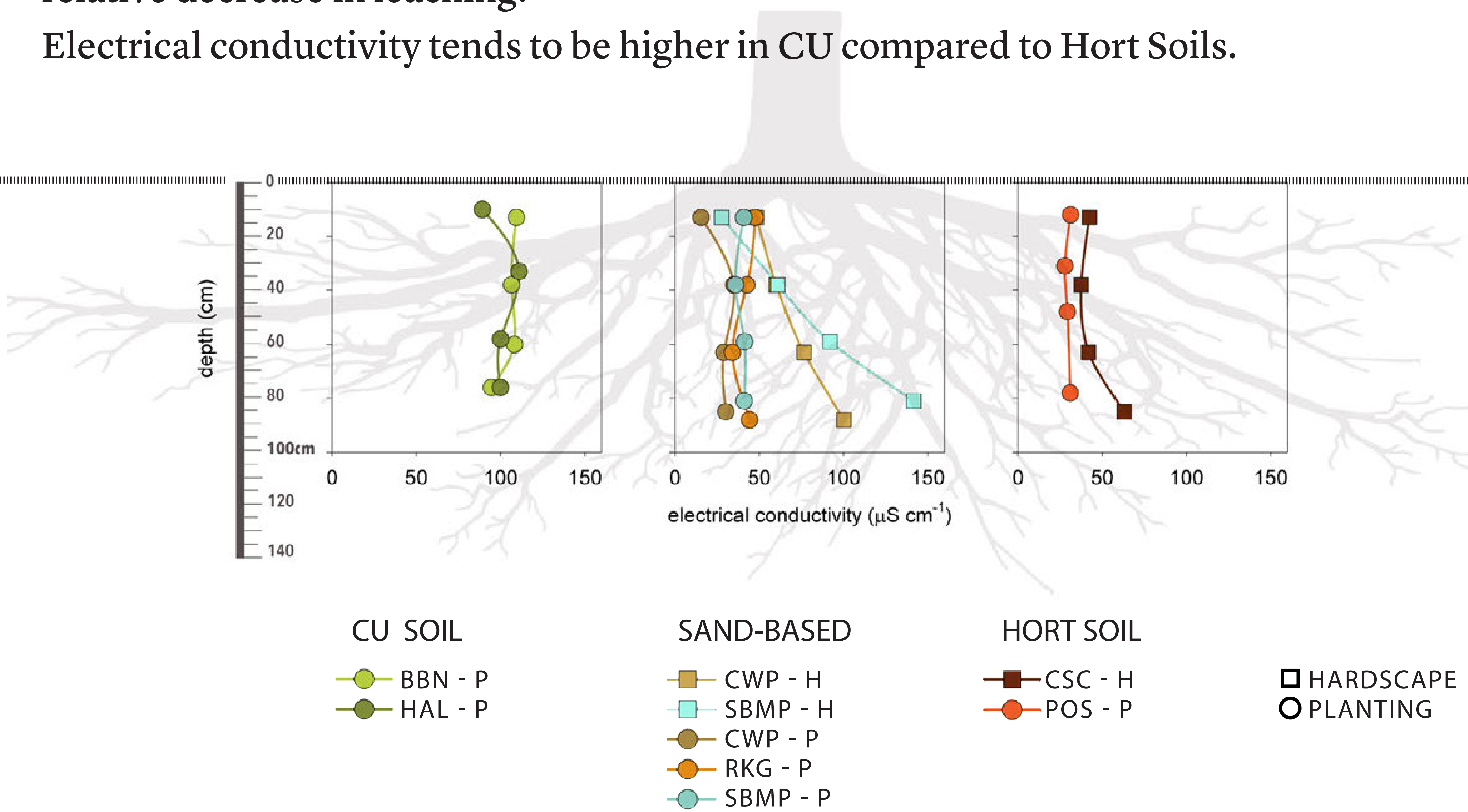


ELECTRICAL CONDUCTIVITY

Sand-Based Soils had higher conductivity at greater depth, likely from salts.

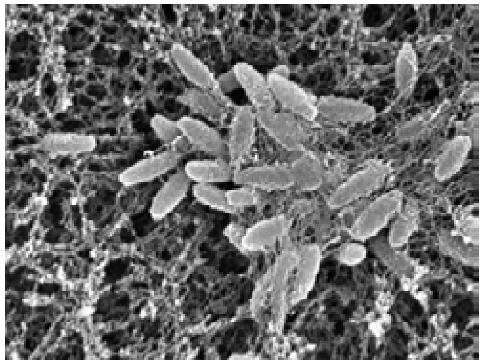
Salinization with depth in Sand-Based Soils is likely from weathering of pavement or a relative decrease in leaching.

Electrical conductivity tends to be higher in CU compared to Hort Soils.



UNDERSTANDING SOIL BIOLOGICAL PROPERTIES

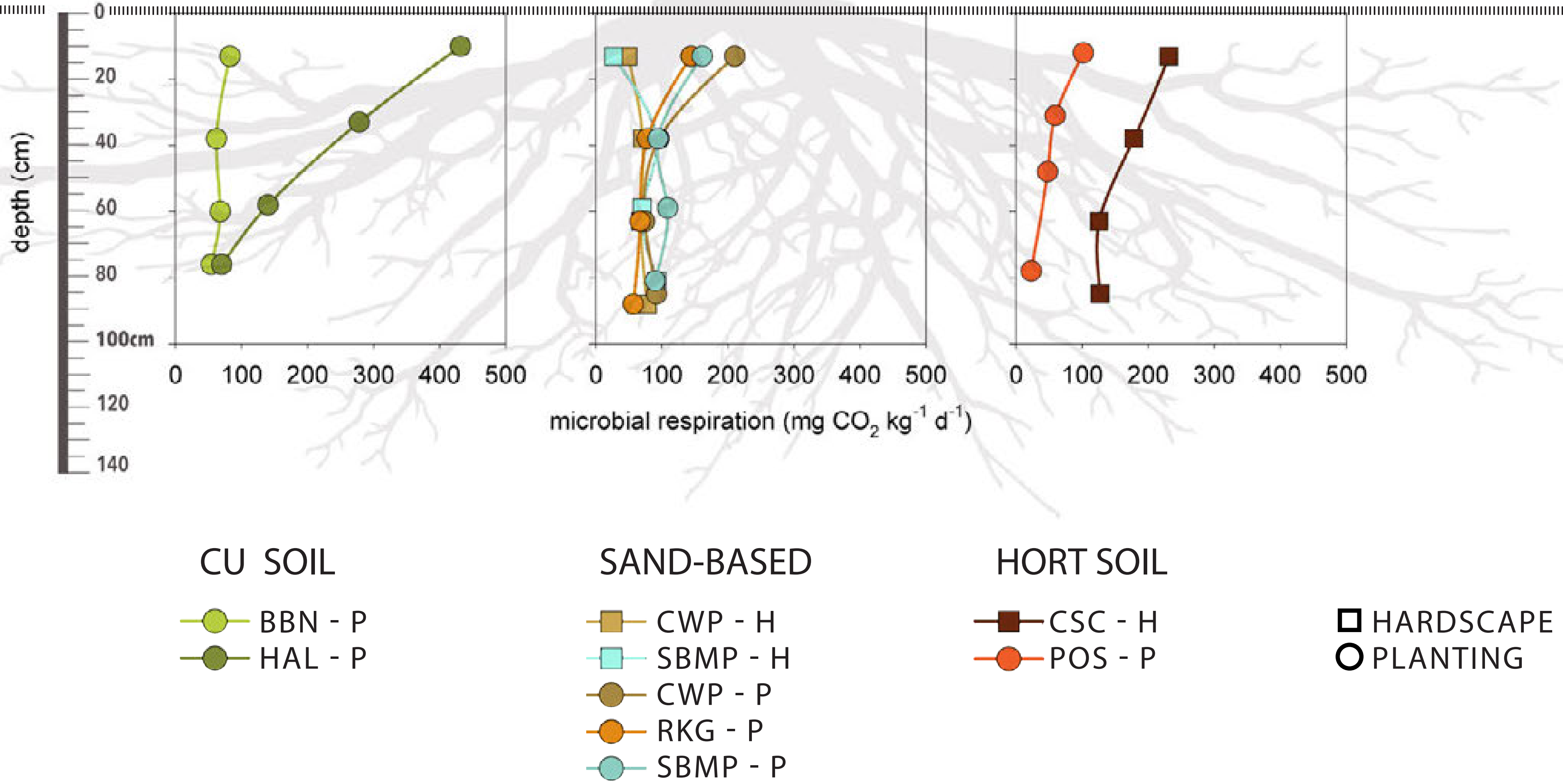
MICROBIAL RESPIRATION



Relatively high respiration at HAL was likely due to input of fresh organic material.

Planting areas had greater respiration compared to hardscape in Sand-Based sites.

Hort Soils had increased respiration with time and organic matter.



ORGANIC MATTER

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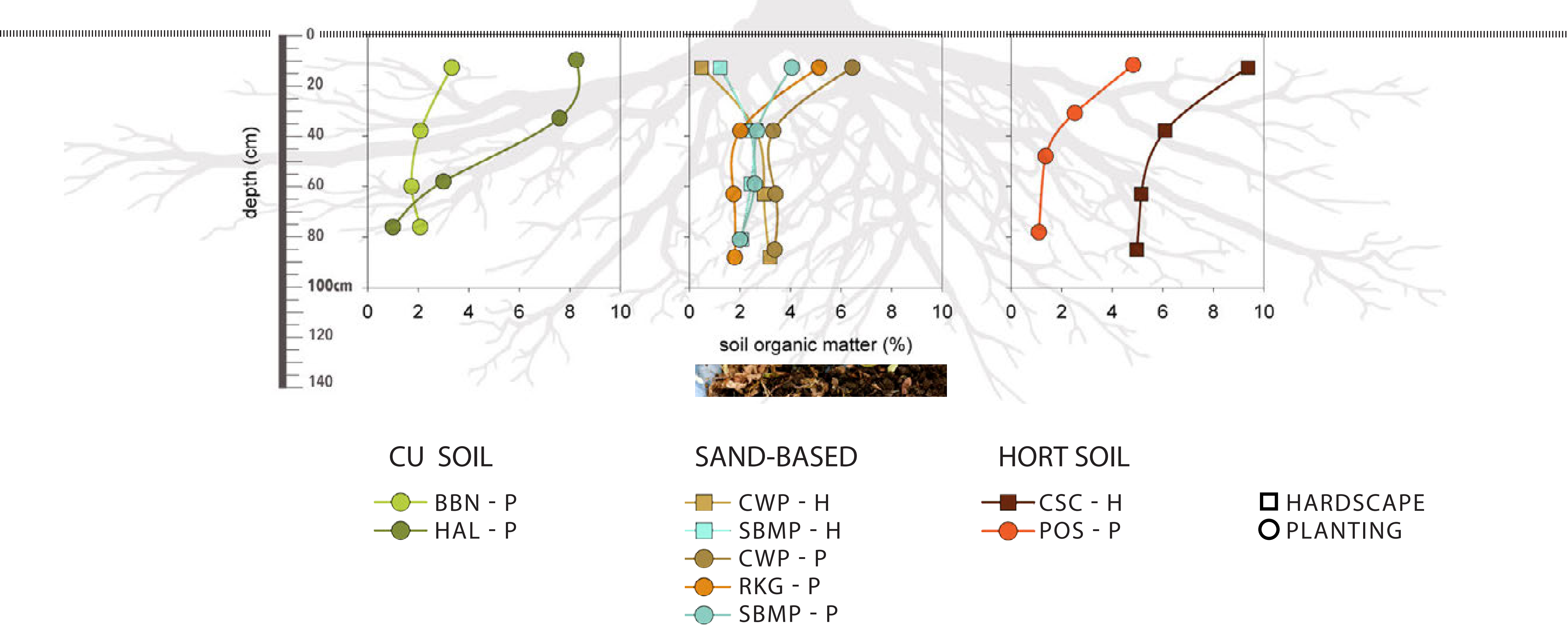
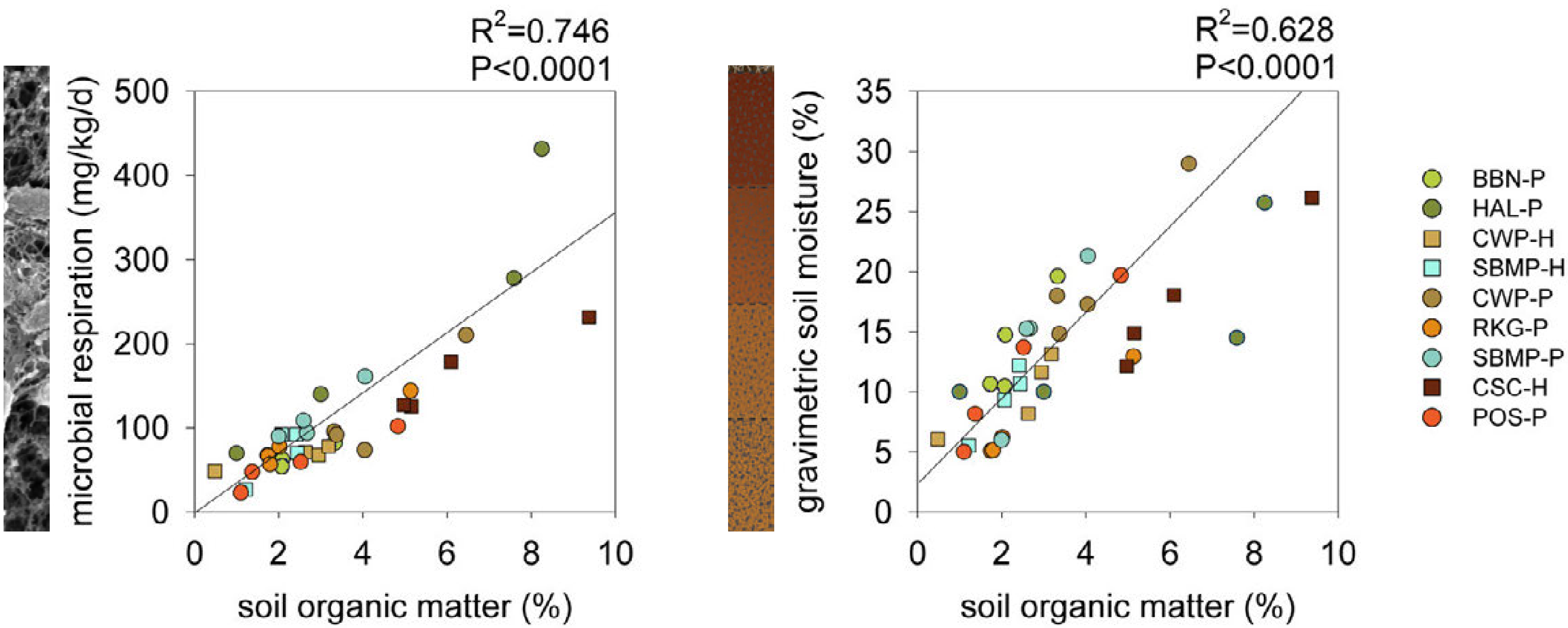
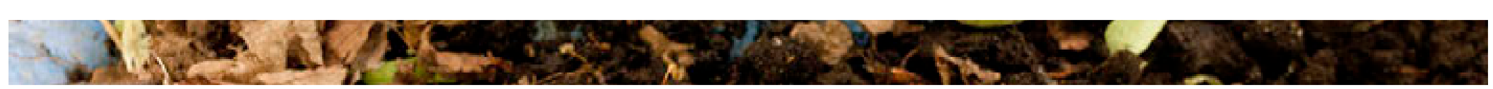


ORGANIC MATTER

Organic matter is a control of microbial activity.
Organic matter is a soil colloid with control on soil moisture.
Organic matter is a key soil property with impact on overall soil quality.

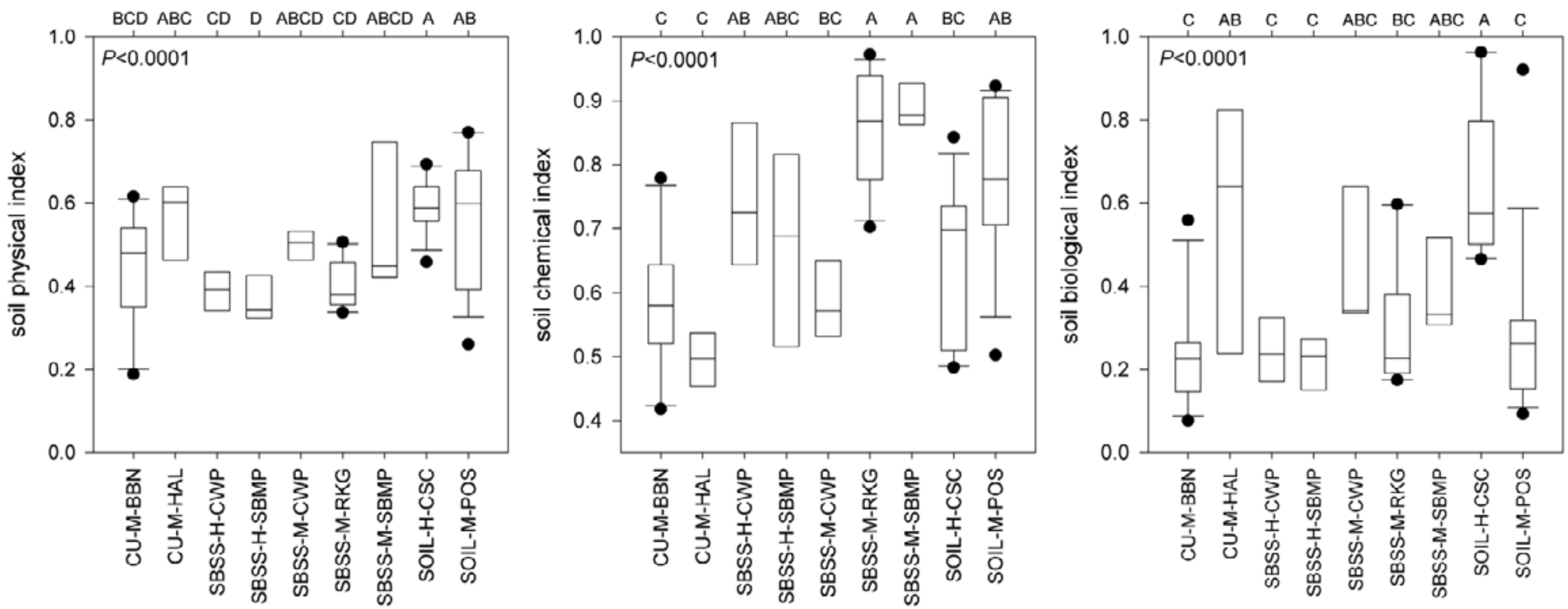




ANALYZING SOILS OVER TIME

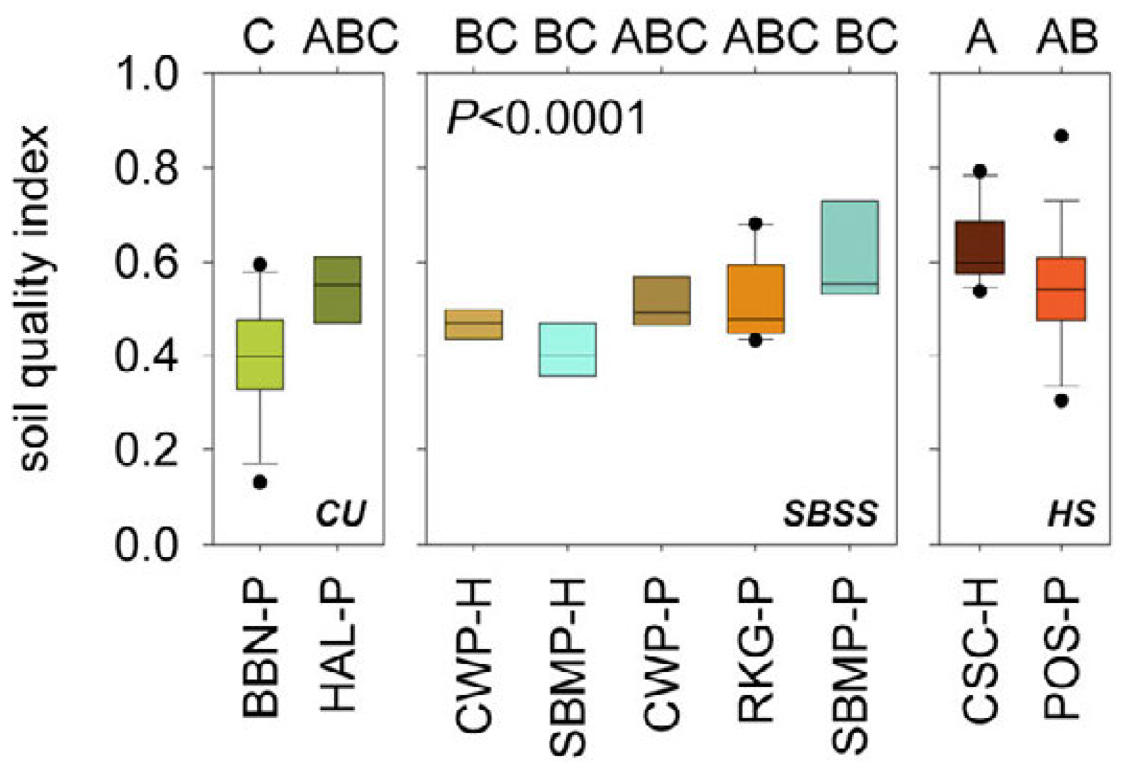
SOIL QUALITY

Soil quality encompasses physical, chemical, and biological soil properties.



SOIL QUALITY

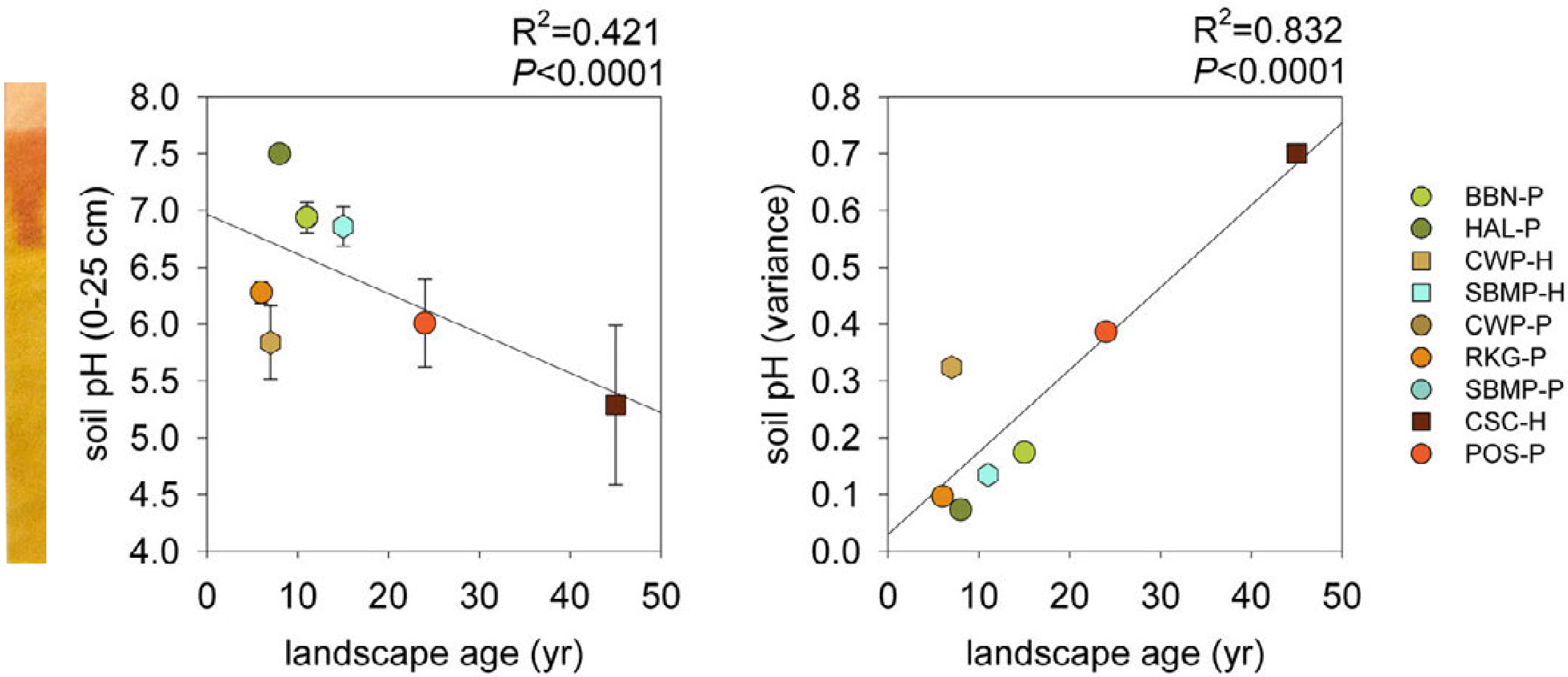
SQ was highest at Christian Science Center and lowest at BBN, why?
SQ tends to increase with organic matter and time.
SQ tends to be higher in planting compared to hardscape.



SOIL DEVELOPMENT - ACIDIFICATION

Acidification is a key weathering process.

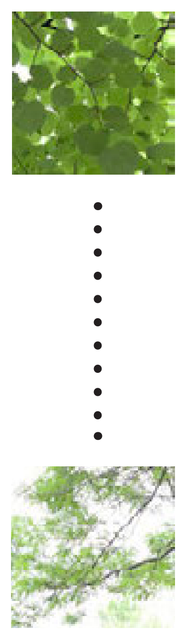
Soil pH is decreasing and profiles are becoming more complex with time.

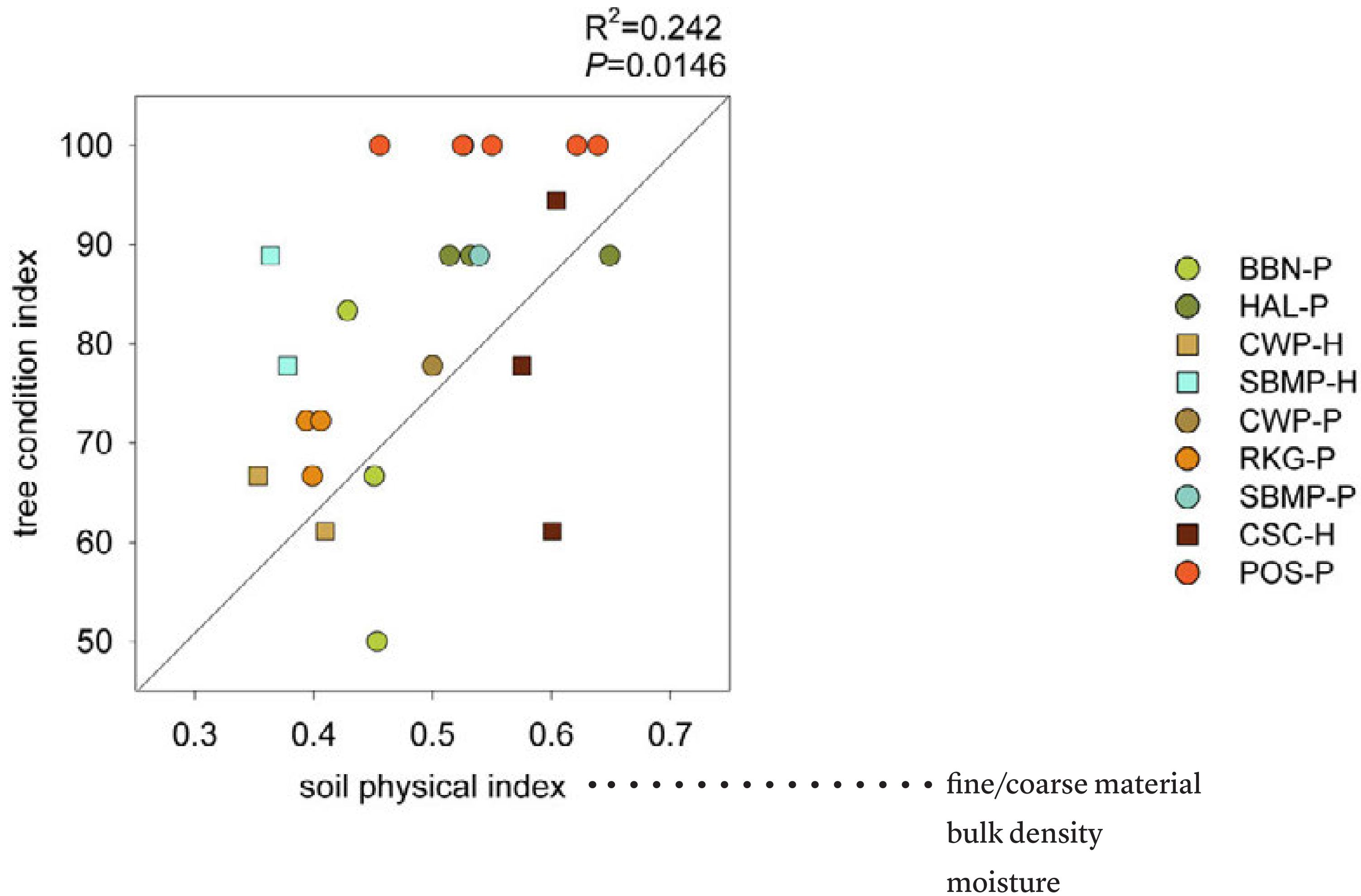


SOIL AND TREE RELATIONSHIPS

Tree condition appeared to be most related to soil physical properties.

Tree condition increased with increased fine material and soil moisture, and decreased with higher bulk density and coarse material.

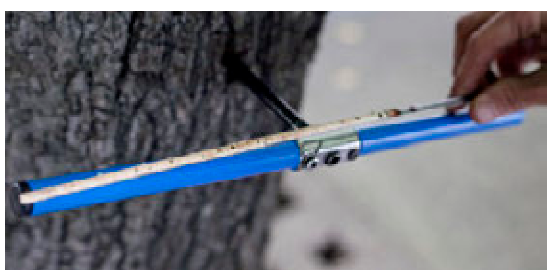


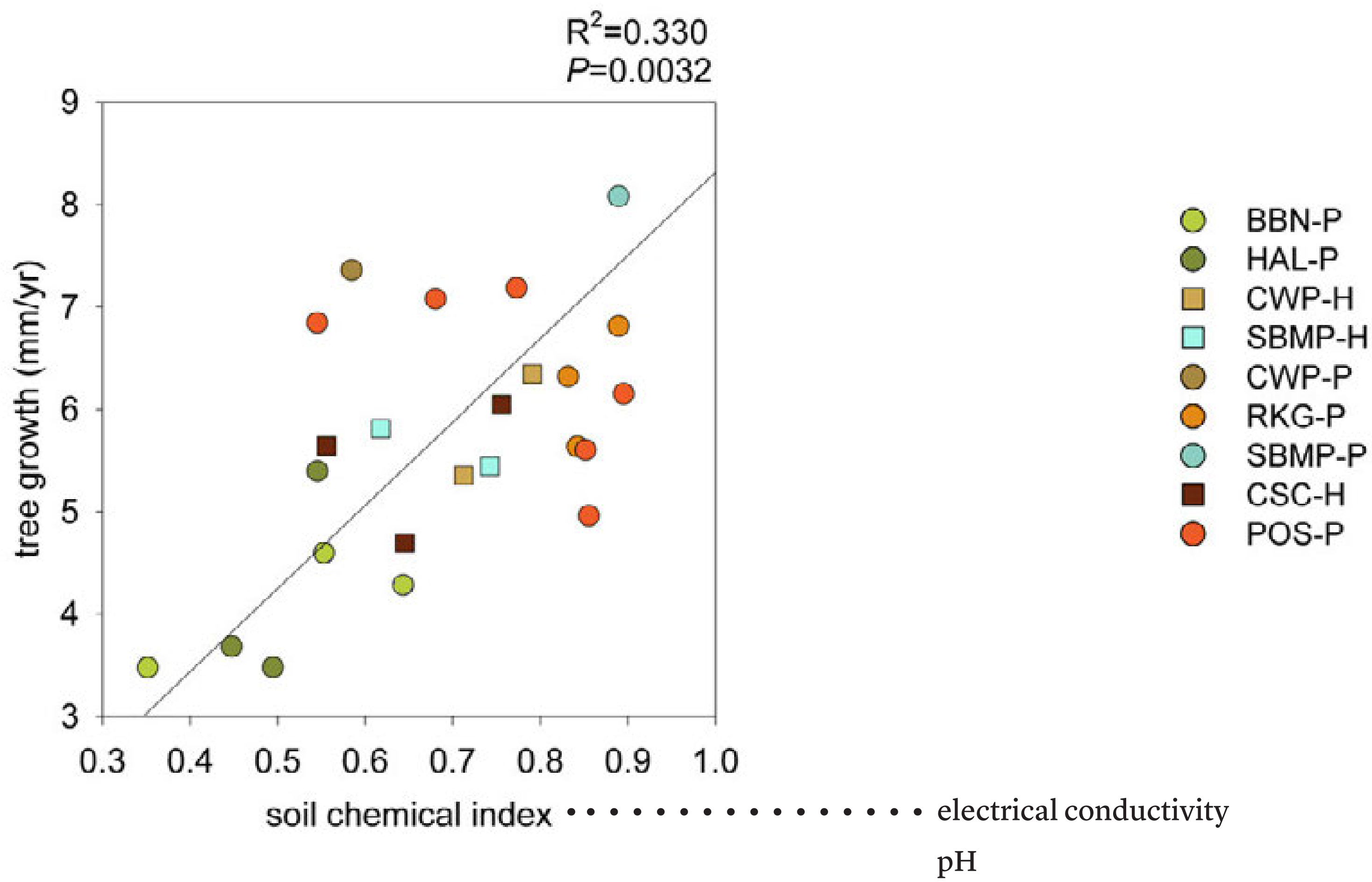


SOIL & TREE RELATIONSHIPS

Tree growth rates appear correlated to soil chemistry.

Tree growth increased as soil pH and Electrical Conductivity decreased.

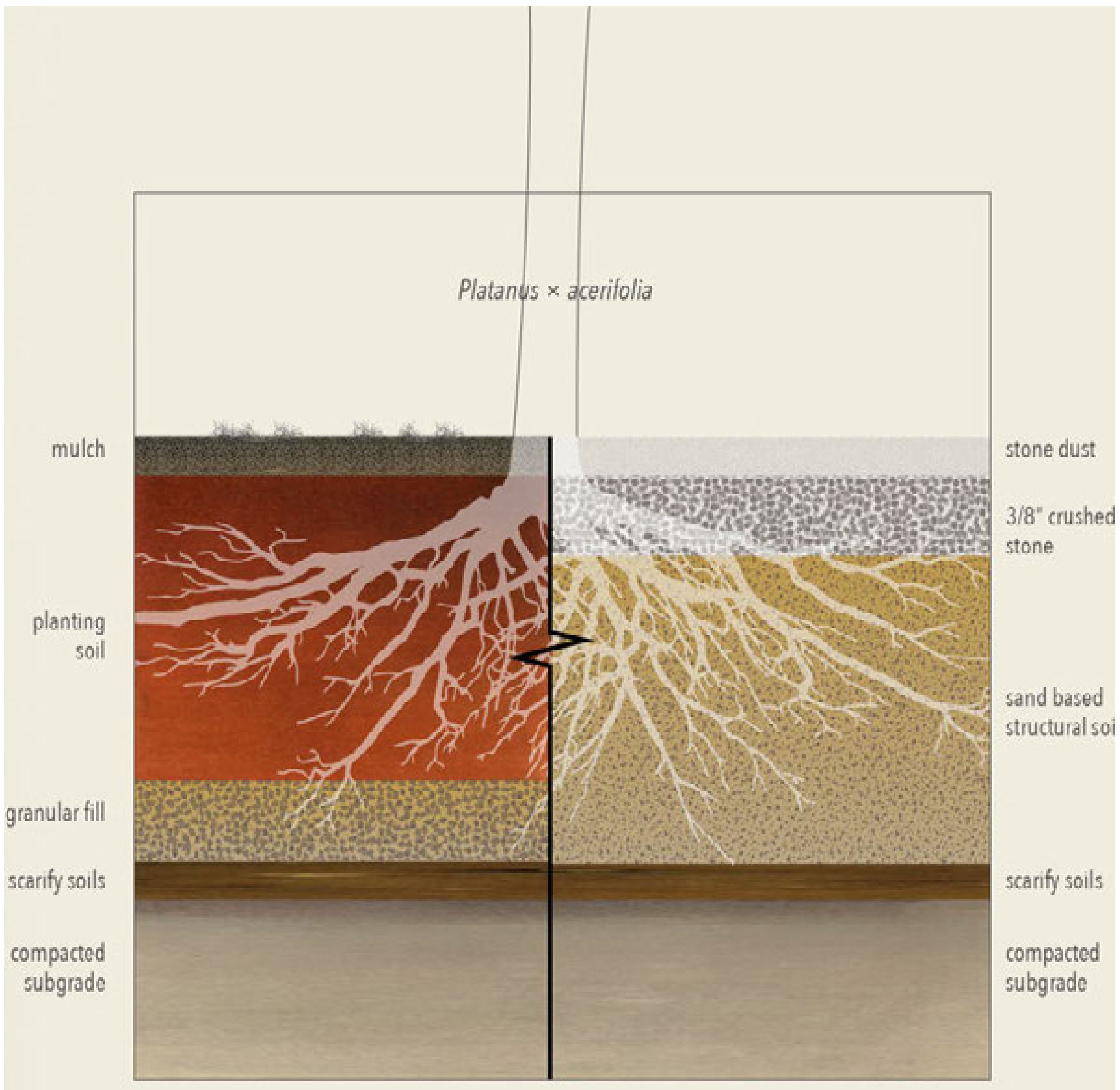


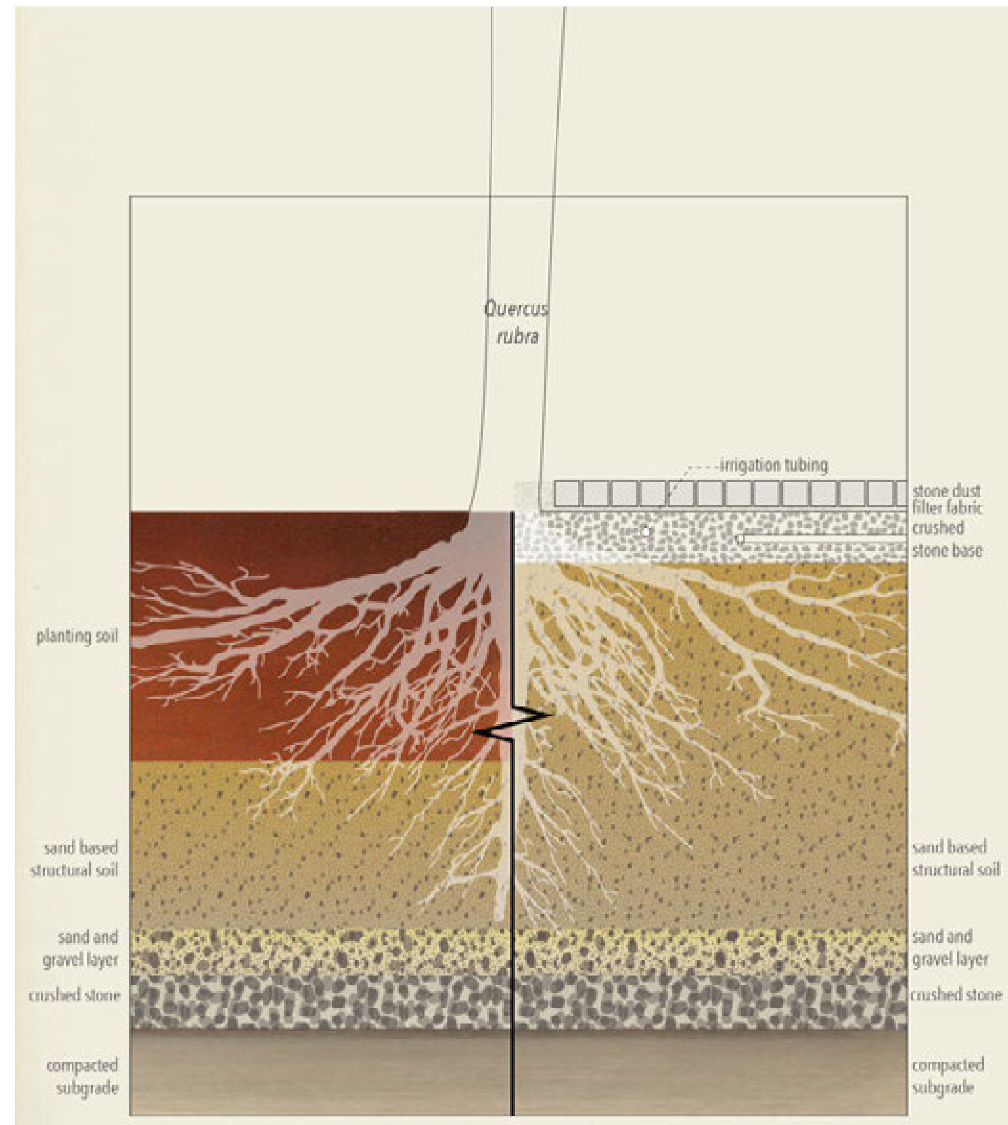


DRAWING CONCLUSIONS + DISCUSSION

PROLOGUE

Manufactured soils may not be the ideal horticultural solution, but they balance competing goals — growing trees in an urban environment and providing a continuous, stable, and durable paving system.





PROLOGUE

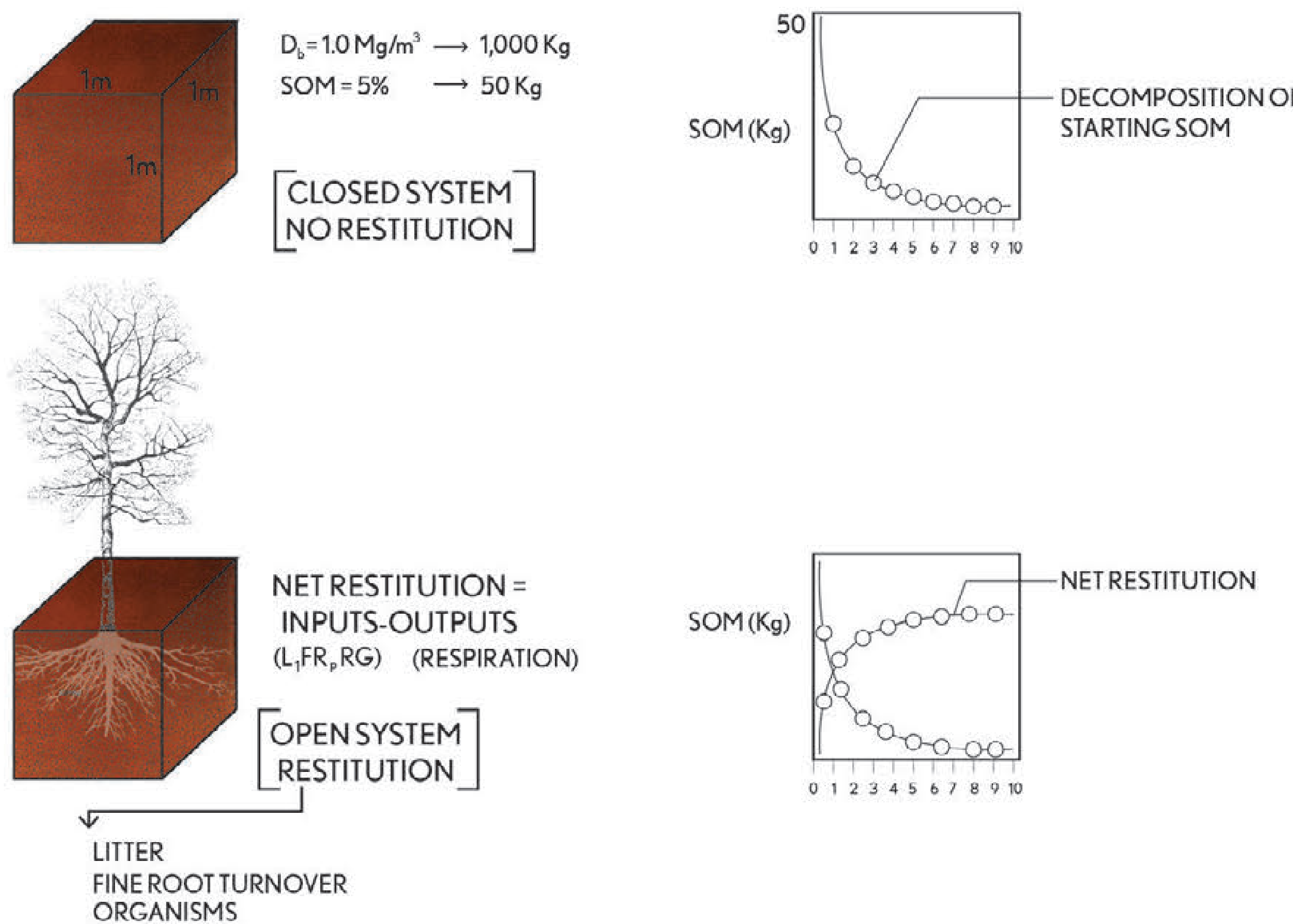
Soils systems are dynamic and therefore require a long term-commitment — from design through construction oversight to on-going monitoring and maintenance.

DISCUSSION TOPICS

1. Organic Matter
2. Soil Dynamics (short-term)
3. Soil Dynamics (long-term)
4. Management and Maintenance
5. Future Research Areas

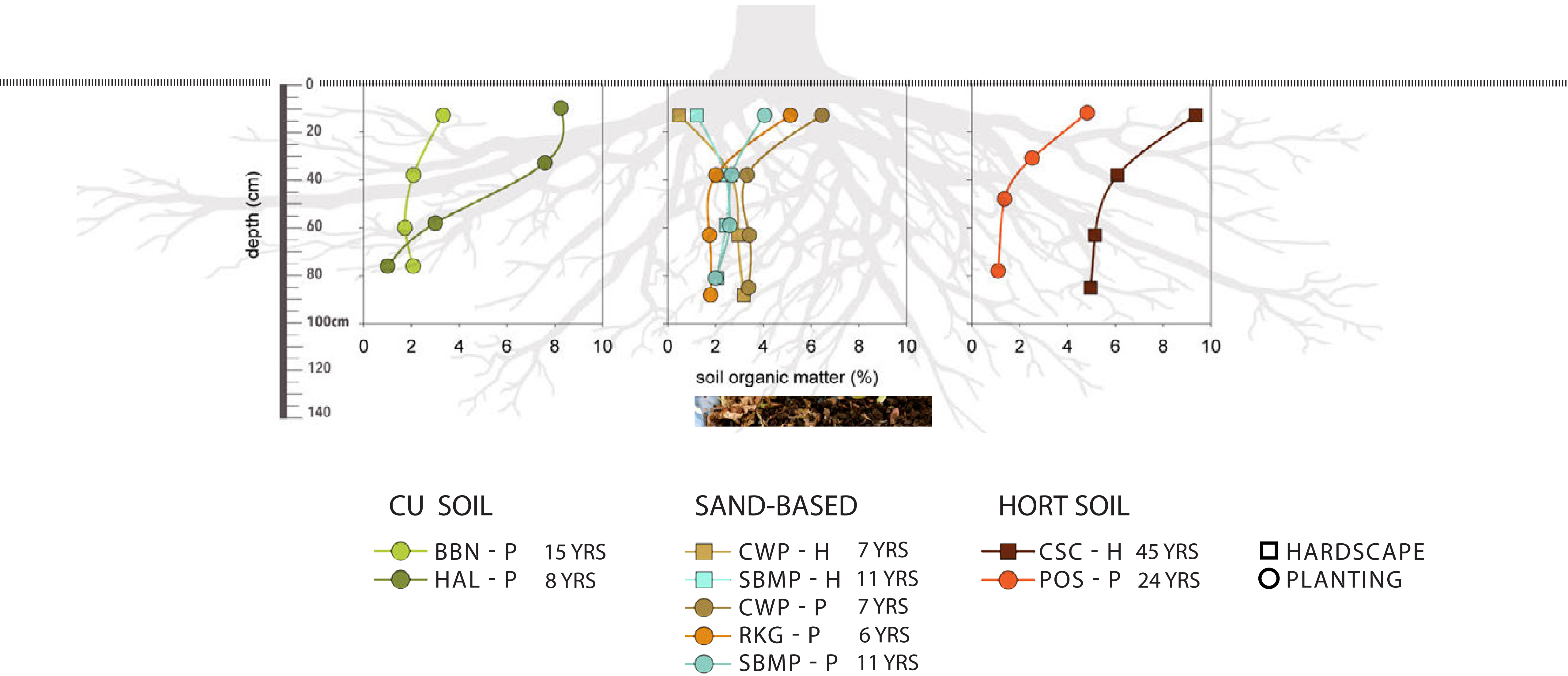
1 ORGANIC MATTER ASSUMPTION

Without organic inputs, SOM decreases over time. Without access to the soil or natural leaf accumulation, organic material will become less available under pavements.



1 ORGANIC MATTER FINDINGS

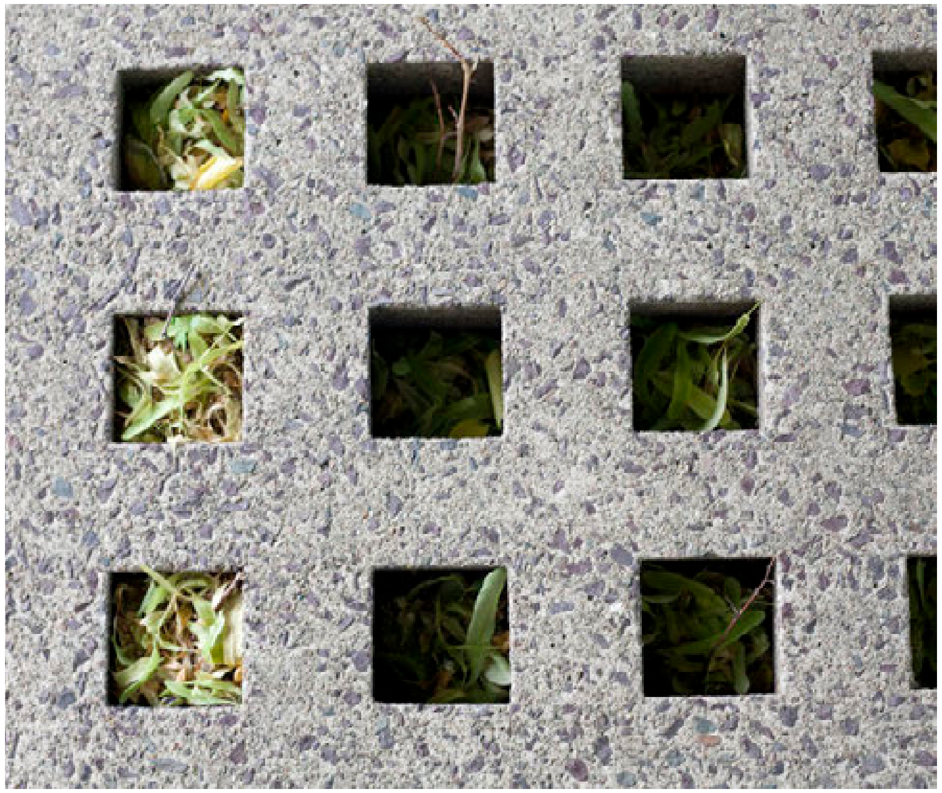
Organic matter does not appear to decrease over time if trees are healthy and have fine root turnover. Returning leaf litter to the soil can increase organic matter.



1 ORGANIC MATTER LESSONS

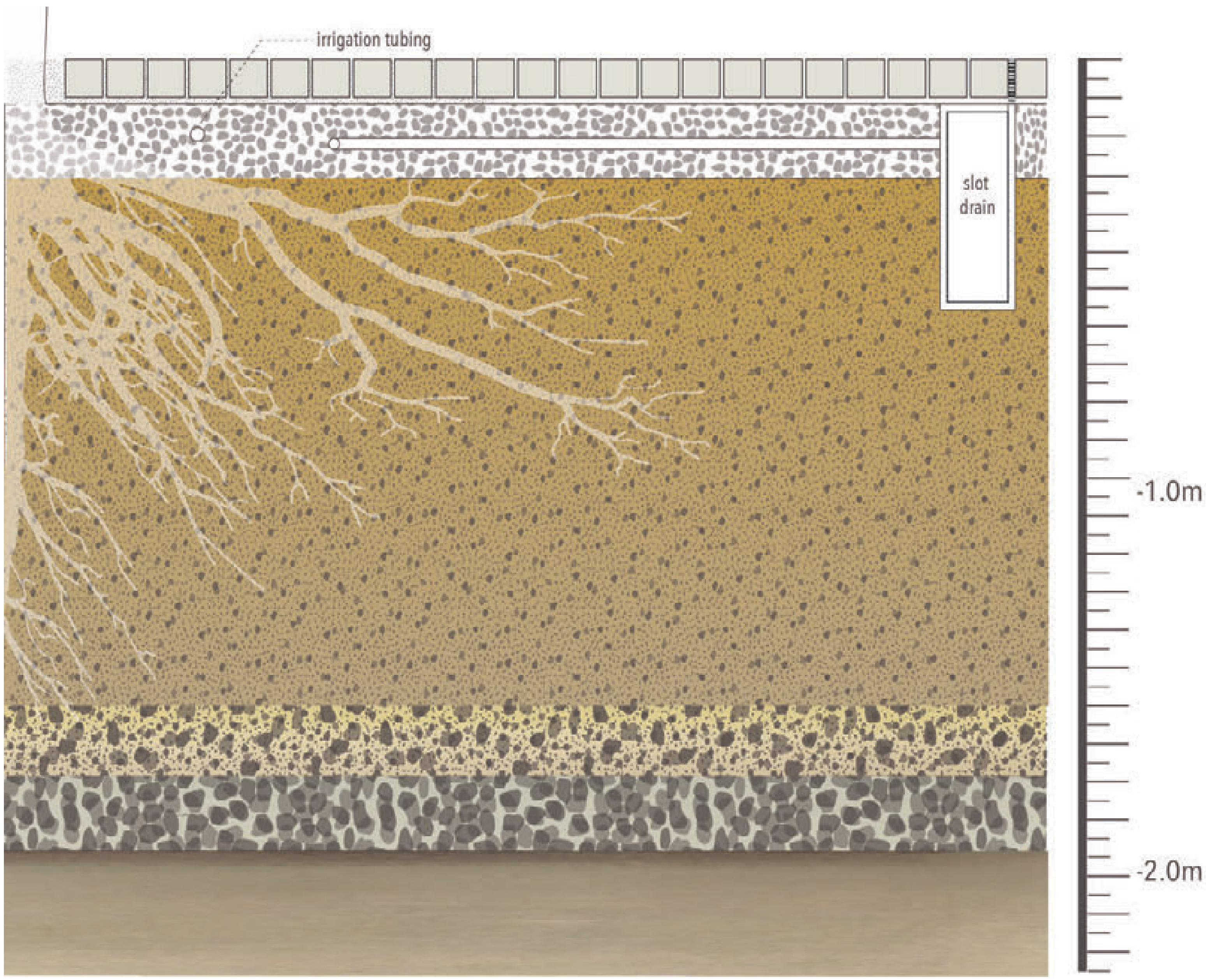
Soil organic matter is critical for healthy trees.

The best way to get organic matter into soils under pavement is through fine root regeneration, which comes from healthy trees.



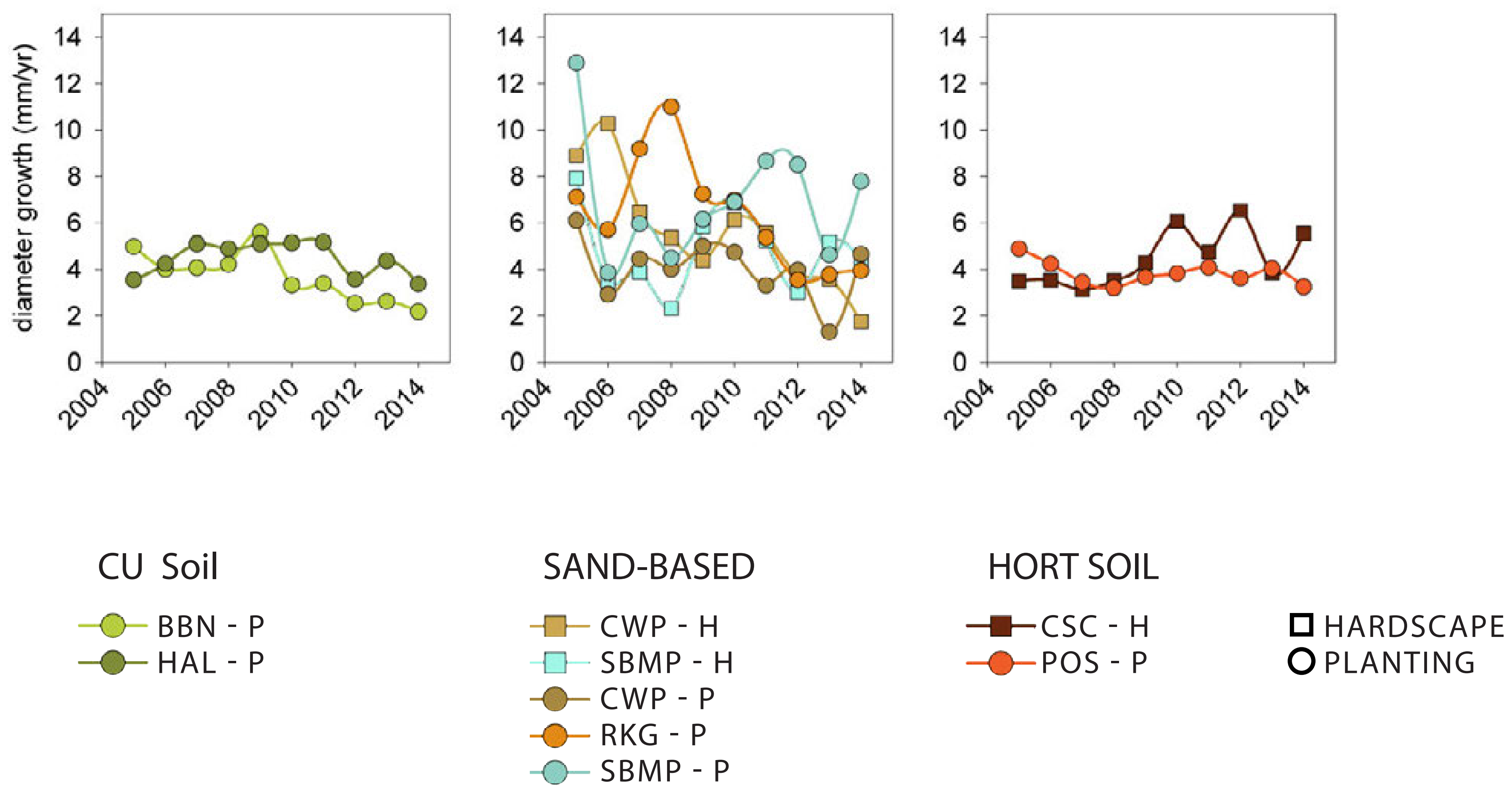
2 SOIL DYNAMICS (SHORT TERM) ASSUMPTION

Soils under pavement are relatively static as they are not influenced directly by outside elements. AKA "set it and forget it."



2 SOIL DYNAMICS (SHORT TERM) FINDINGS

Sand-Based soils appear to be **more** susceptible to changing environmental conditions including moisture, pH, salinity, and respiration.

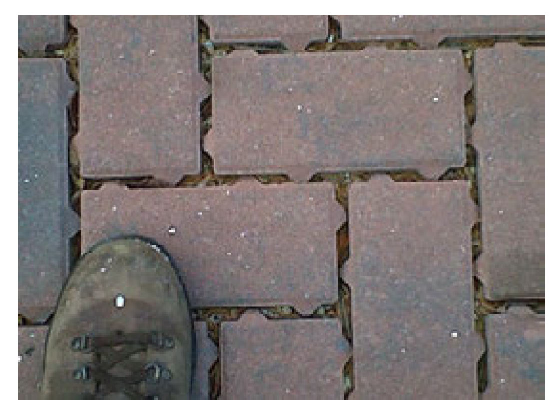


2 SOIL DYNAMICS (SHORT TERM) LESSONS

Soils, even under pavement, are dynamic and respond to environmental conditions.

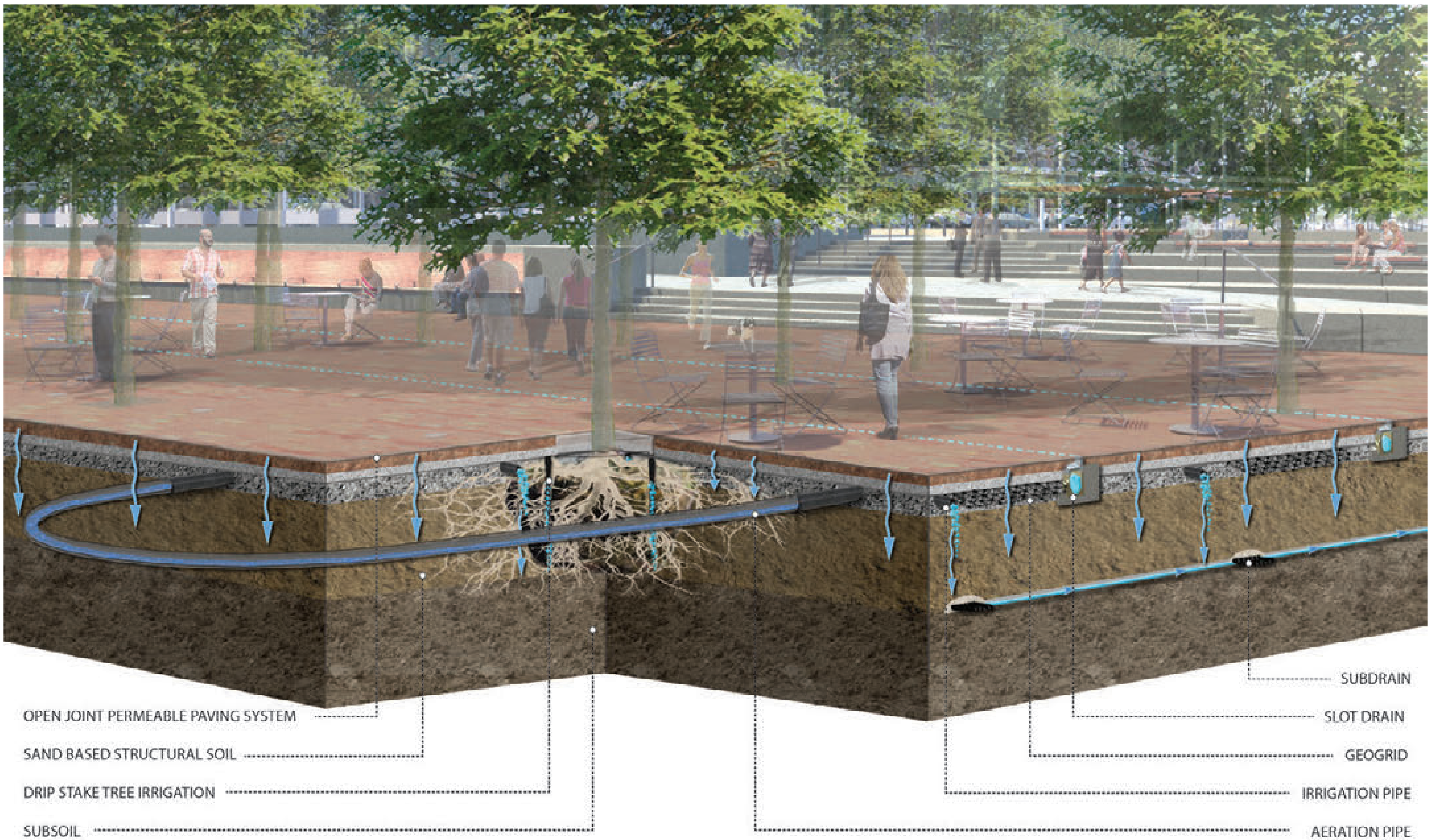
In intensively drained soils under pavement, moisture monitoring and irrigation are likely important to provide horticultural stability.

Permeable pavement systems may allow snow-melt salts to enter soils which can accummulate at lower levels.



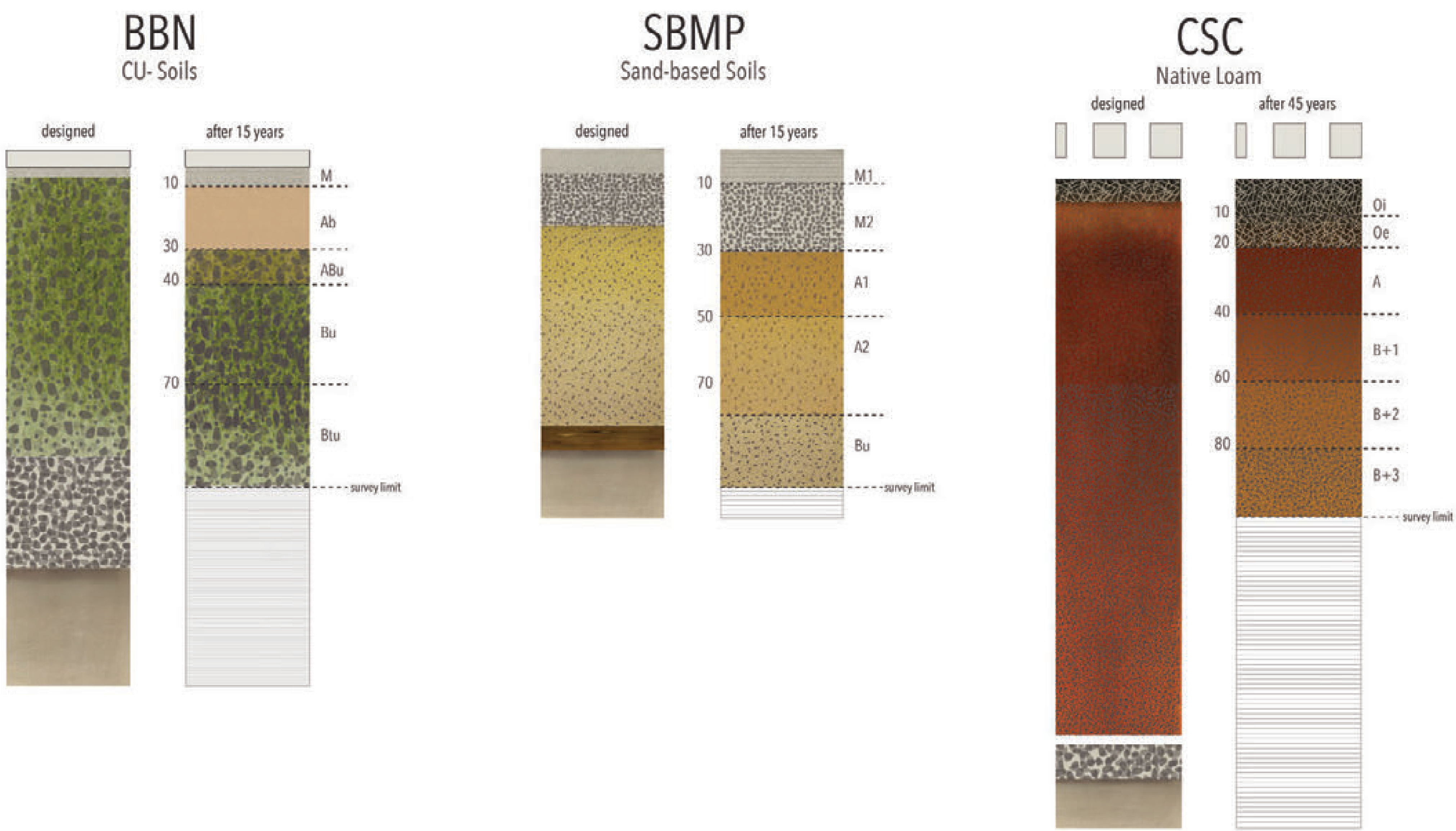
3 SOIL DYNAMICS (LONG TERM) ASSUMPTIONS

"It is a closed system." Soils under pavement are relatively static over time.



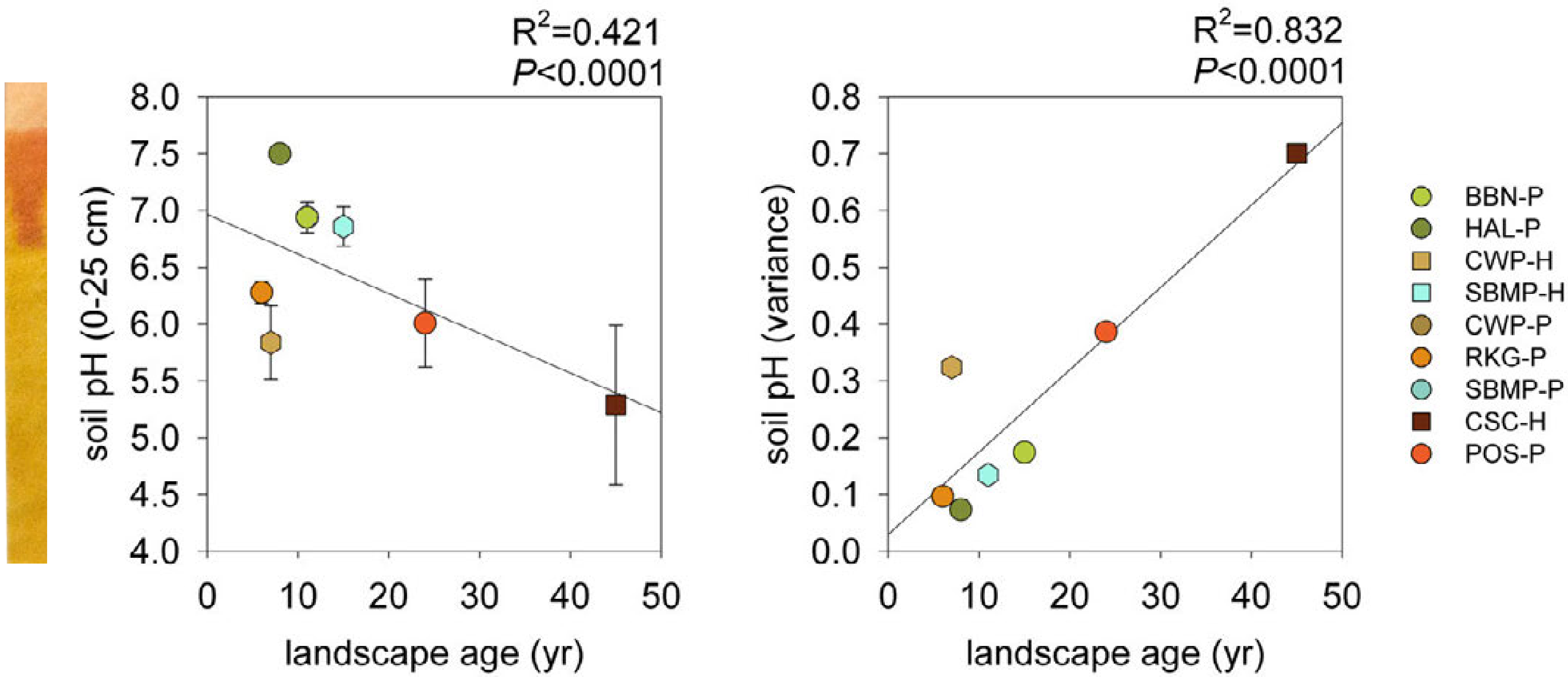
3 SOIL DYNAMICS (LONG TERM) FINDINGS

Increased bulk density at greater depths suggest dynamic flows within the soils section over time.



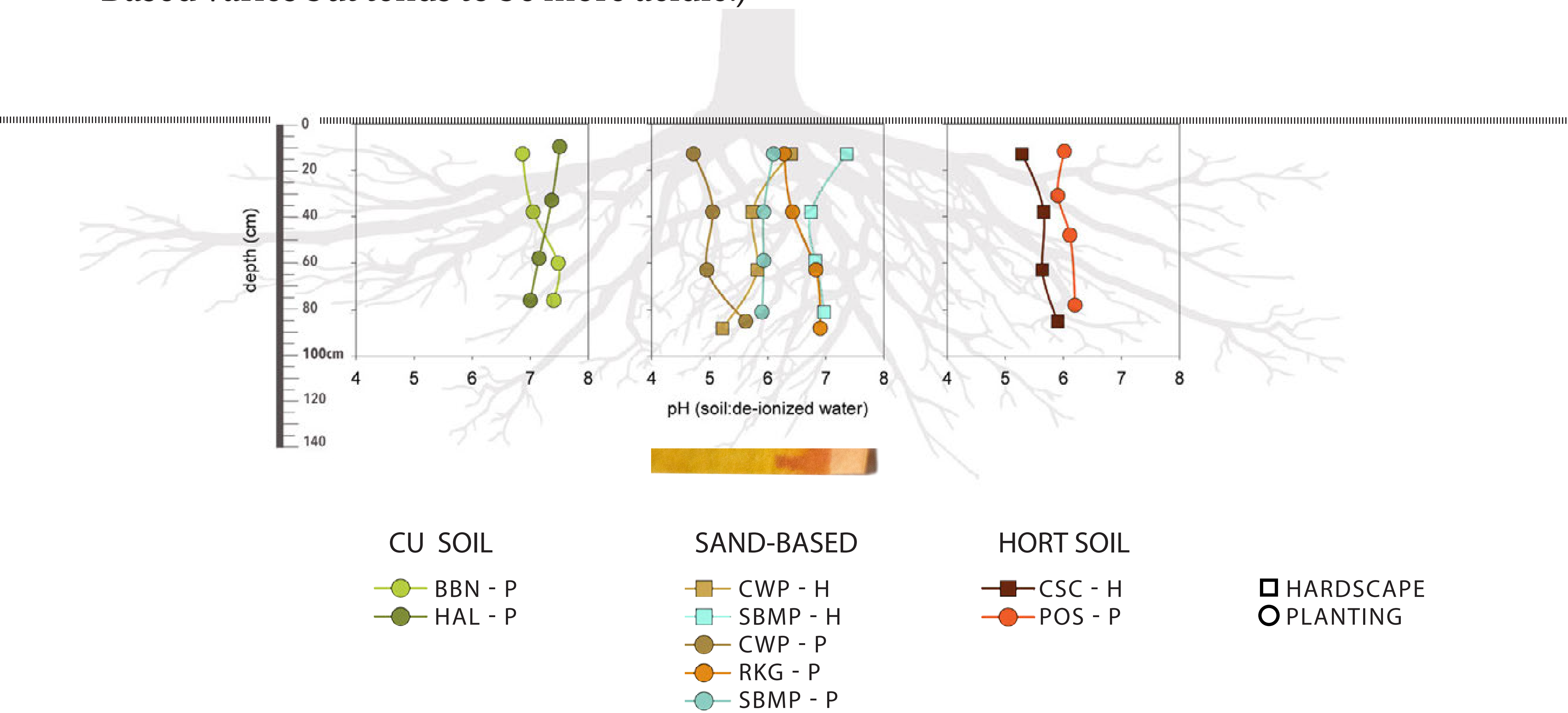
3 SOIL DYNAMICS (LONG TERM) FINDINGS

Soil Systems are not static. They are constantly being influenced by what is in the soils and by outside physical and environmental factors.



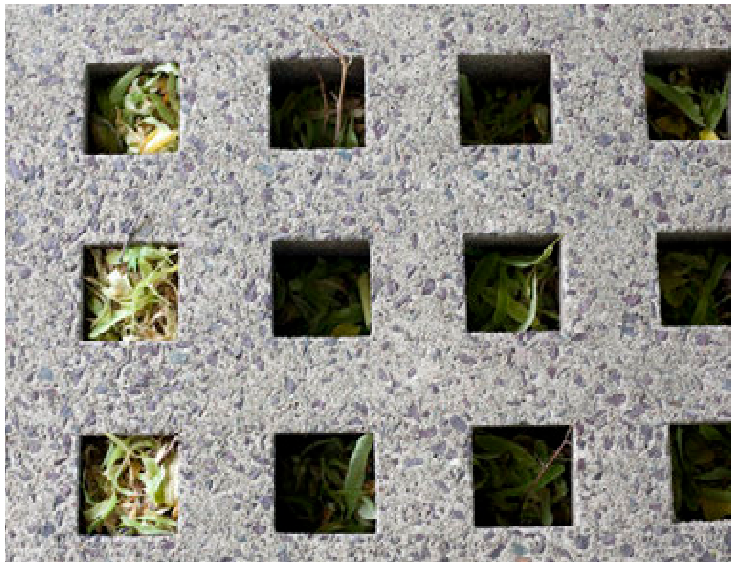
3 SOIL DYNAMICS (LONG TERM) LESSONS

Blended soils tend toward specific pH ranges, so initial selection of tree species which are tolerant of the soil pH is critical. (CU tends to be Alkaline and Sand Based varies but tends to be more acidic.)



3 SOIL DYNAMICS (LONG TERM) LESSONS

Soils need periodic assessment and management. We should design systems that enable post installation access to soils under pavement.



4 MANAGEMENT AND MAINTENANCE ASSUMPTIONS

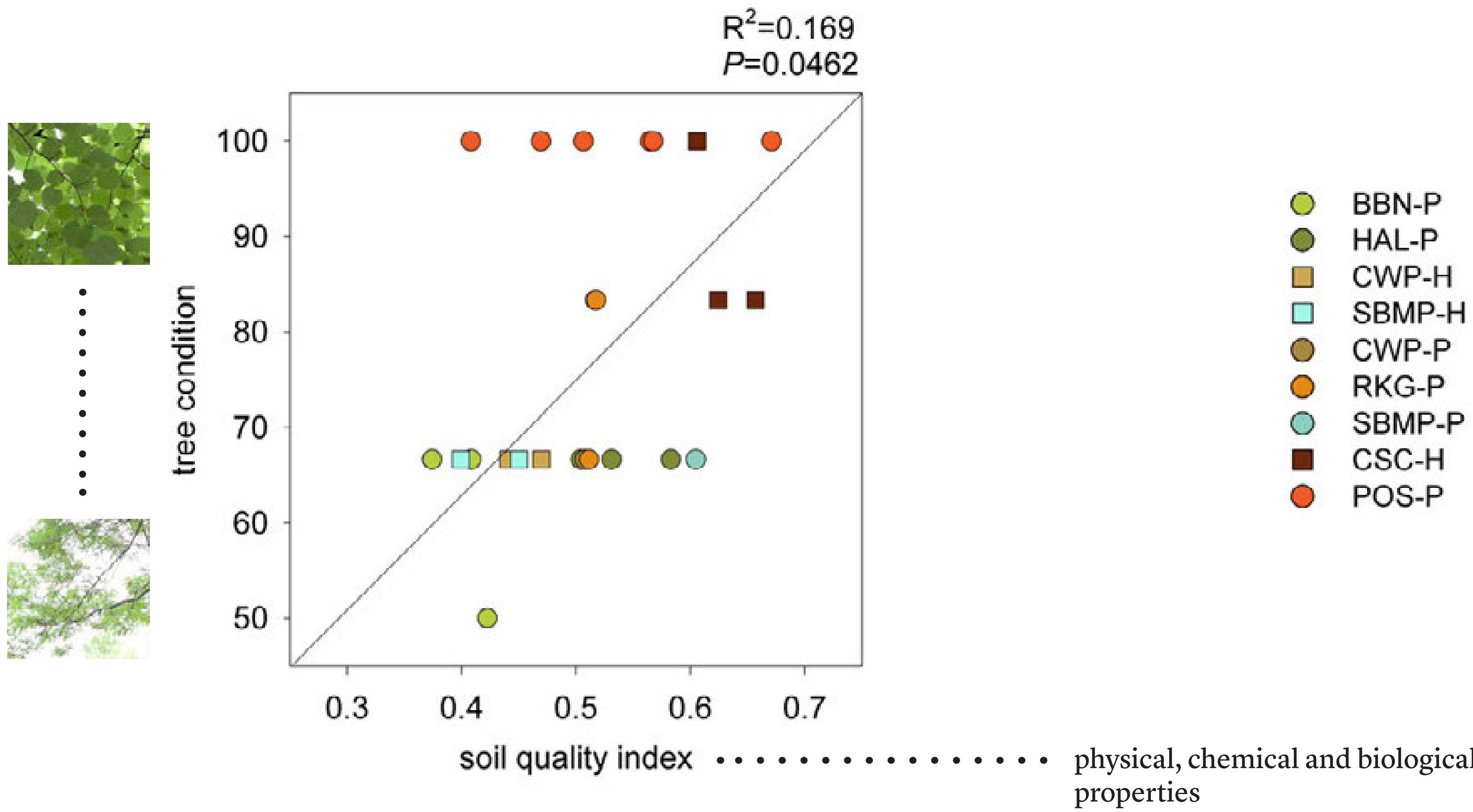
Initial soil specifications are the most important factor in the future health of plantings and the overall performance of the landscape.

4 MANAGEMENT AND MAINTENANCE FINDINGS

The difference between designed and tested conditions varied enough to make us suspect installation practice.

4 MANAGEMENT AND MAINTENANCE FINDINGS

We need to maintain our landscapes. No matter what the soils system, there appears to be a relationship between maintenance and tree performance.



4 MANAGEMENT AND MAINTENANCE LESSONS

An integrated plan for landscape commissioning and a long-term management and maintenance plan support the long-term viability of urban soils.

5 FUTURE RESEARCH

This is just a start. We need more data. We need to work together to get it. Build access ports and add landscape commissioning and long-term data collection into your next project.

CONTINUING EDUCATION

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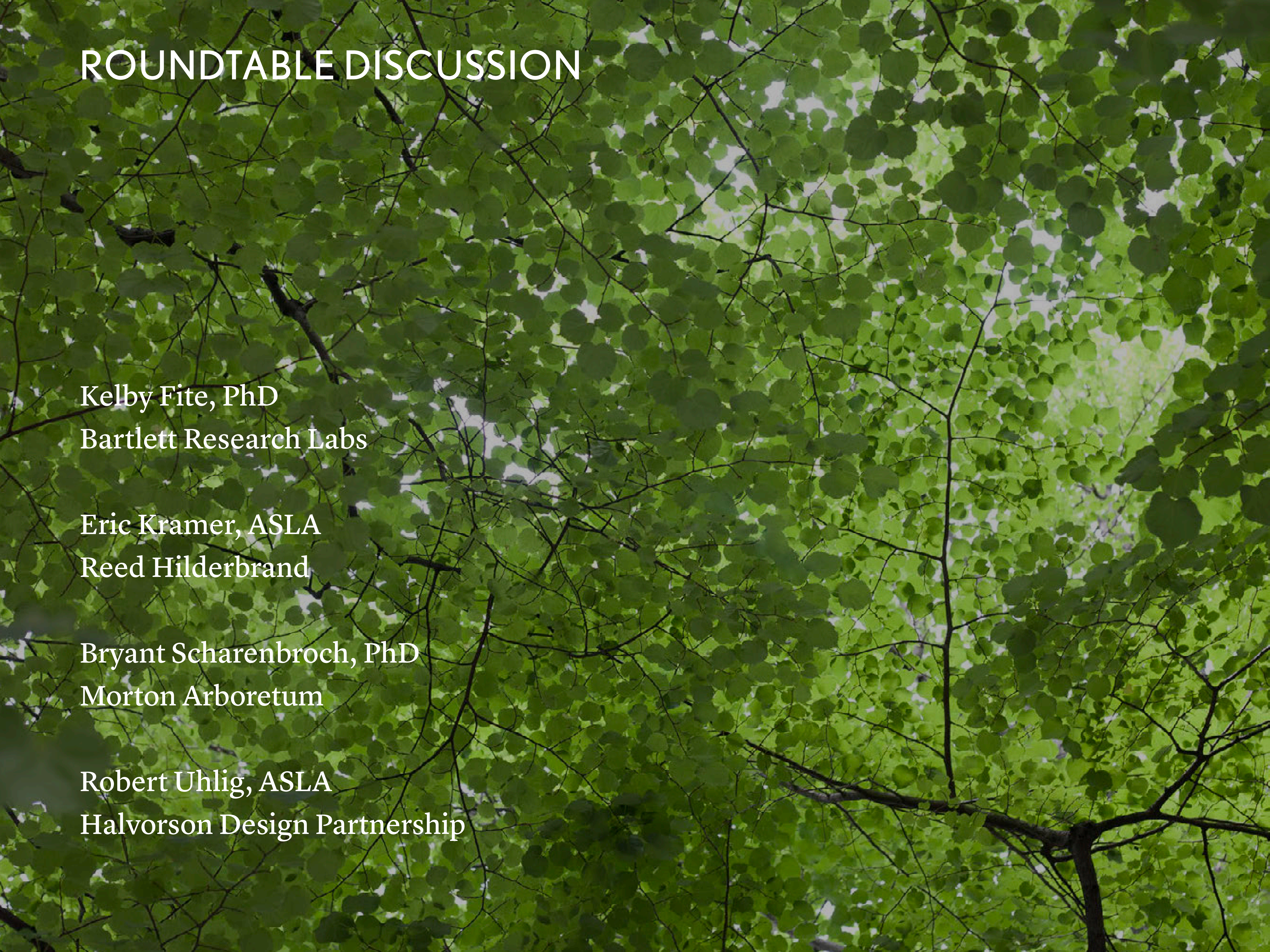

ROUNDTABLE DISCUSSION

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