UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Impacts of Porous Pavements on Soil Environment and Street Tree Growth

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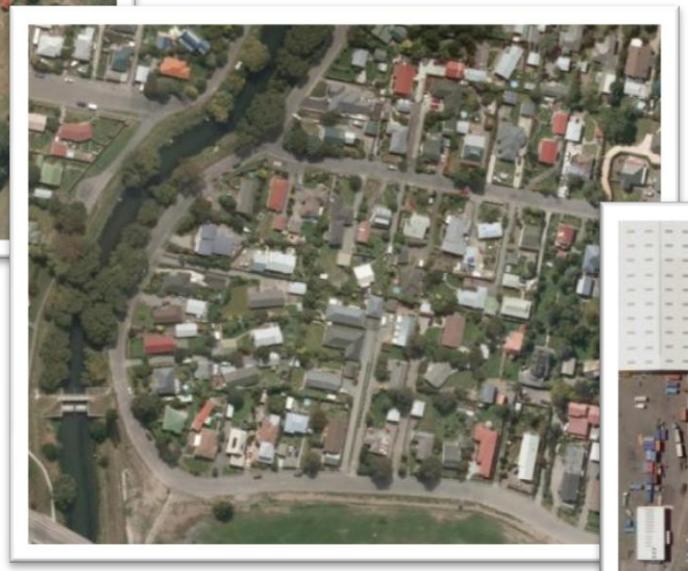
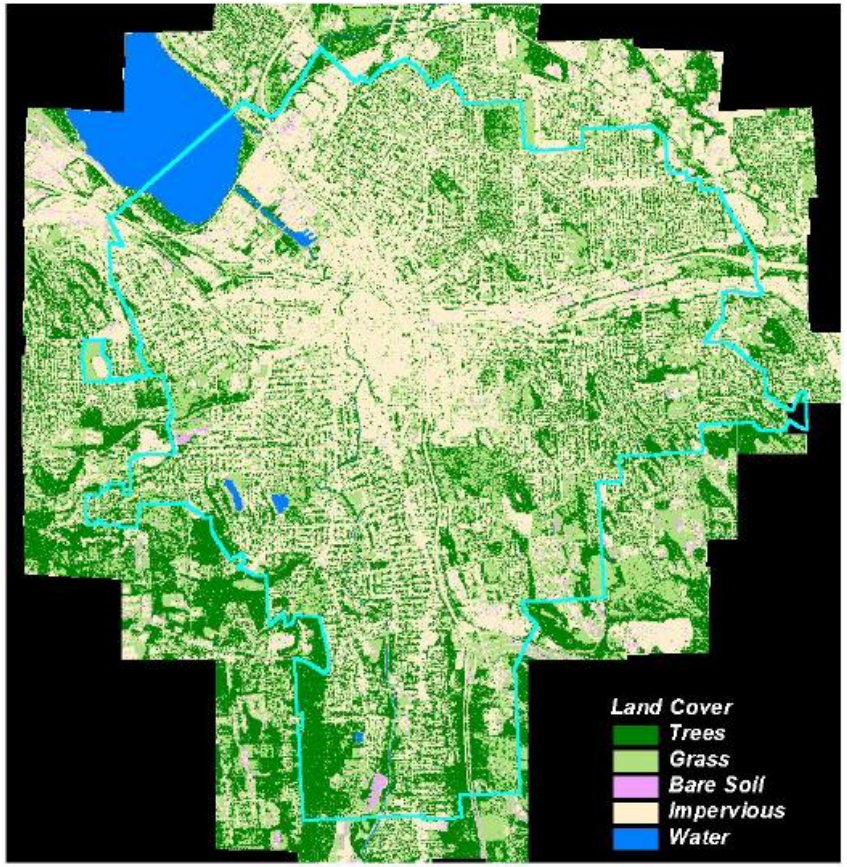
Impervious Urban Surfaces



Impervious Urban Surfaces

- Disrupt hydrological cycle
  - Local flooding, drought, limits evaporation, etc
- Associated with urban heat island effect
- Believed to hinder tree growth and physiology
- Reflected in canopy cover



Pavement is Pervasive

- 93% of roads in America unpaved in 1904
- Change came with the ascendancy of the automobile
- Now, >50% of dense urban cores paved

Photo credit: Joel Tauber

Porous Paving

- Monolithic construction:
  - Pervious paving
  - No-fines paving
  - Open-graded paving
  - Gap-graded paving
  - Percolating paving
  - Percrete
- NOT permeable paving
  - Blocks
  - Turfstone

Porous Paving

- Main reasons for installation:
  - improved stormwater management
  - safety
- Alleged to provide great benefits to urban trees
- But do they?

Here's What the Experts Think

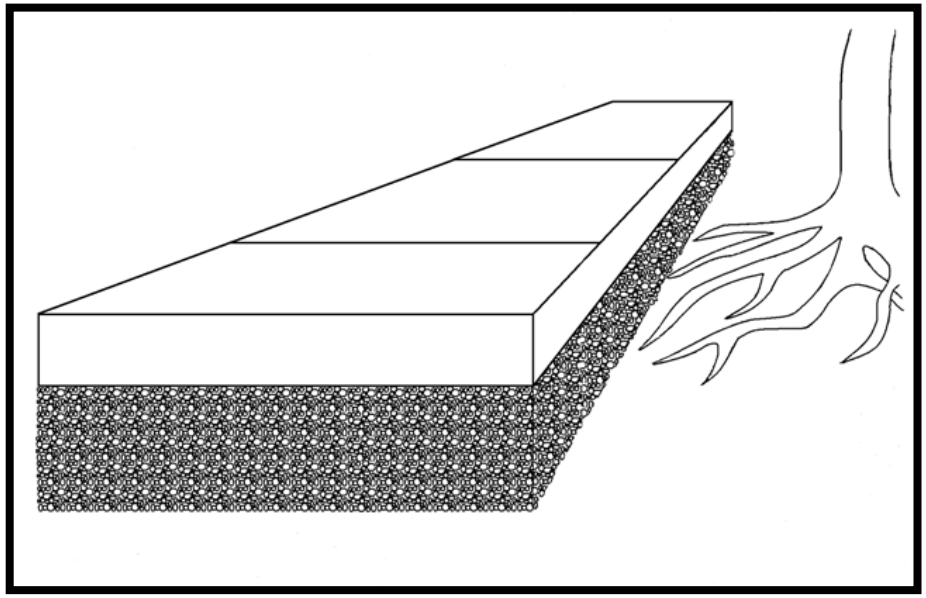
- Prof. Bruce Ferguson, Landscape Architect, University of Georgia "***ideal for protecting trees in a paved environment***"
- Paul D. Tennis, Civil Engineer, Portland Cement Association "***increase the longevity of trees by improving moisture and oxygen relations***"
- Prof. Vern Schaefer, Civil Engineer, University of Iowa "***preserving native ecosystems***"
- Where's the proof?

The Big Question

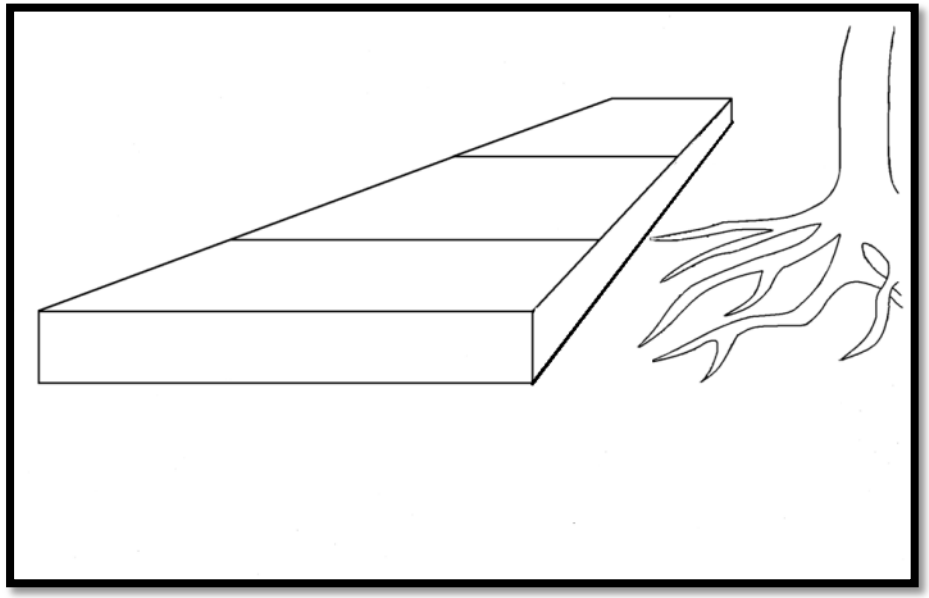
Across varying pavement profile designs, does porous paving affect tree growth relative to standard impervious paving

Pavement Type

Pavement Profile Design



Structural



Non-Structural

Treatments

1. Control
2. Porous / Structural
3. Porous / Non-structural
4. Impervious / Structural
5. Impervious / Non-structural

Data Collection

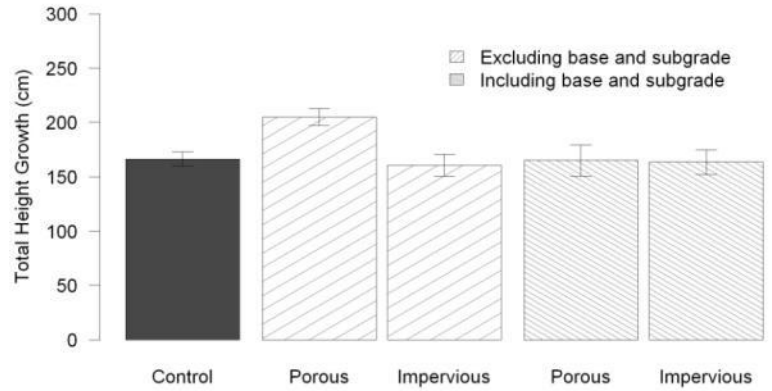
Tree Growth:

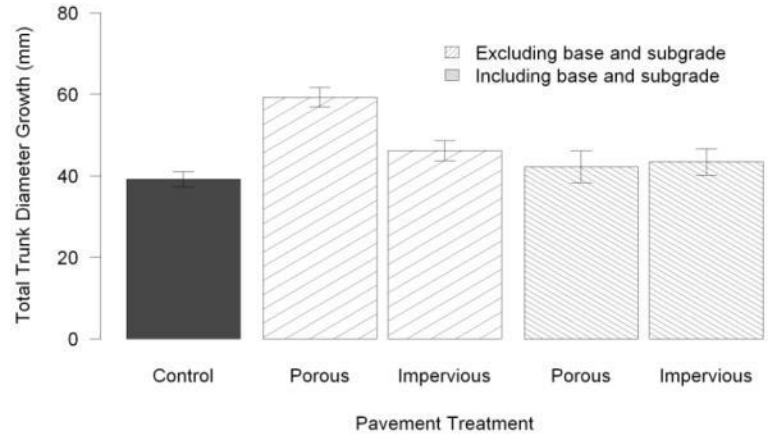
- Stem Height
- Stem Diameter
- Shoot/Root Biomass
- Root Diameter and Distribution

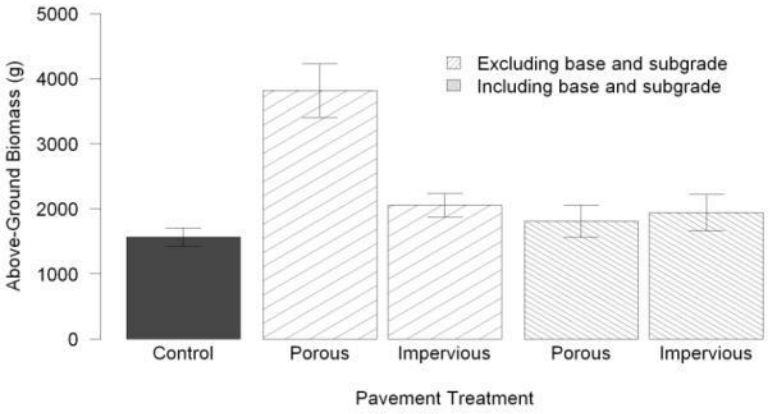
Soil Factors:

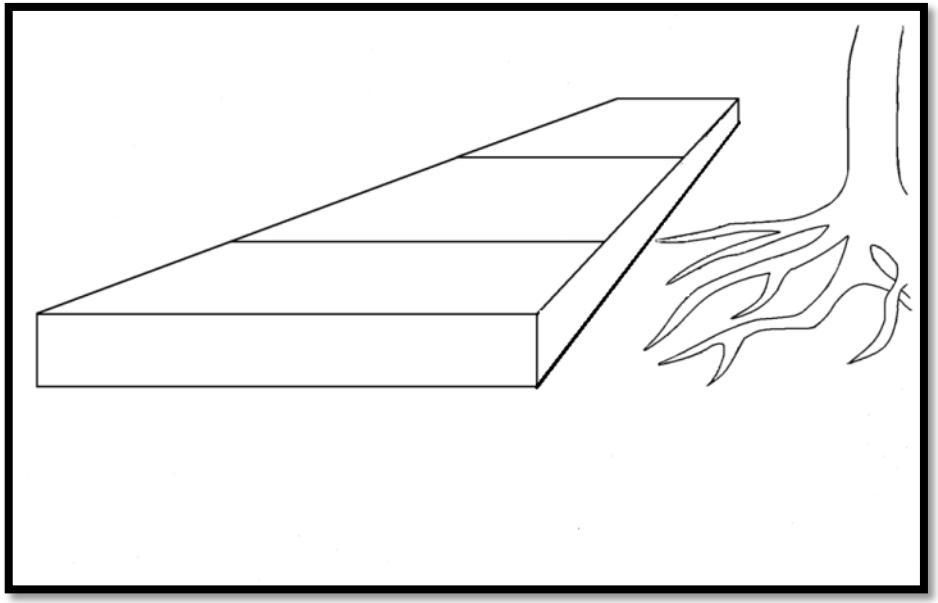
- Water content
- Aeration
- pH

Did the 4 different pavement treatments affect above and below-ground tree growth?

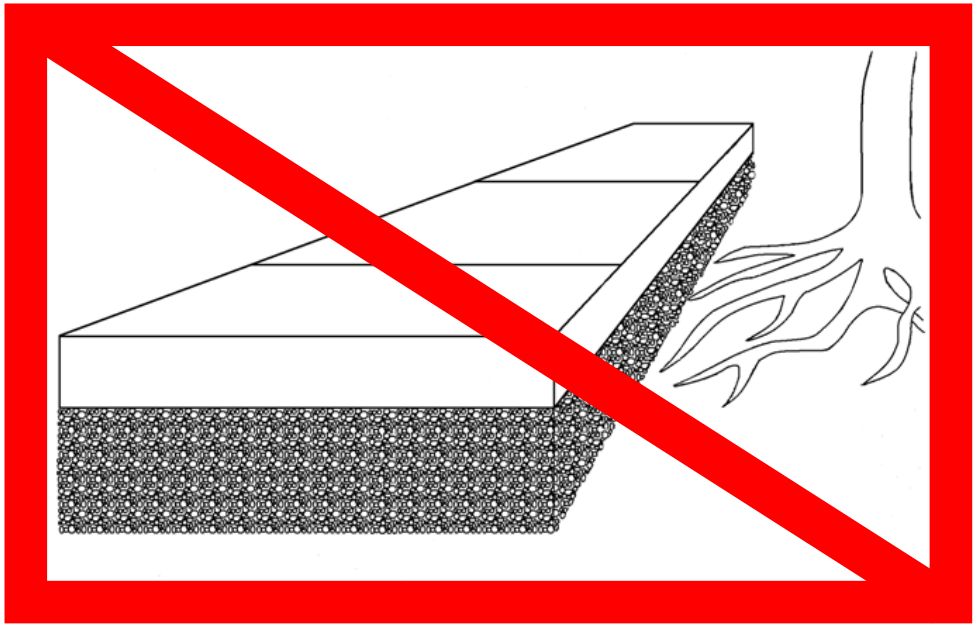






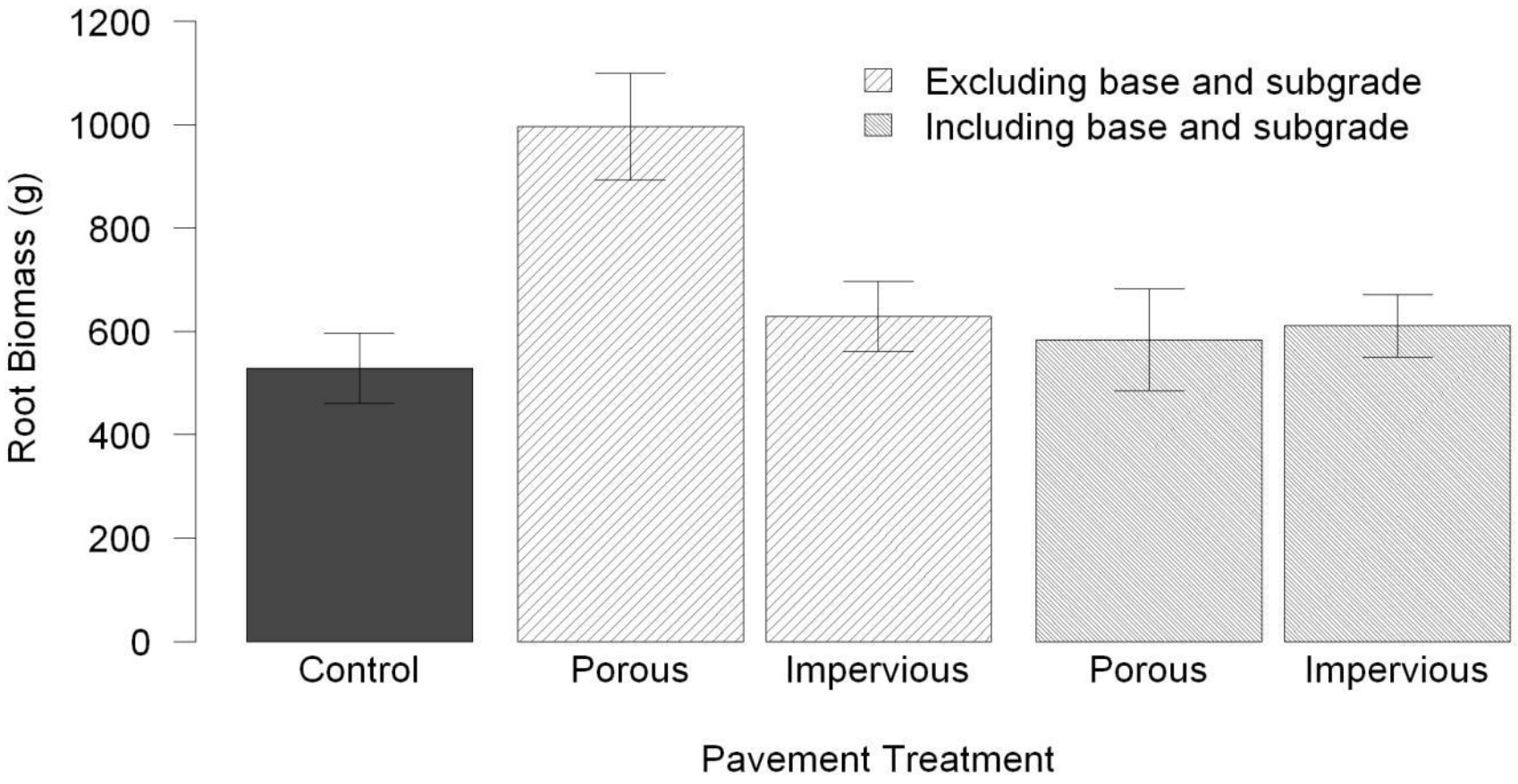


Diameter Growth



Why is above-ground growth consistently greater with porous pavement?

Root Biomass



Increased Root Growth

- Not always desirable
- Shallow root growth problematic
- Increased incidence of infrastructure conflict
  - Very Expensive Problem
- So how did pavement affect root distribution?

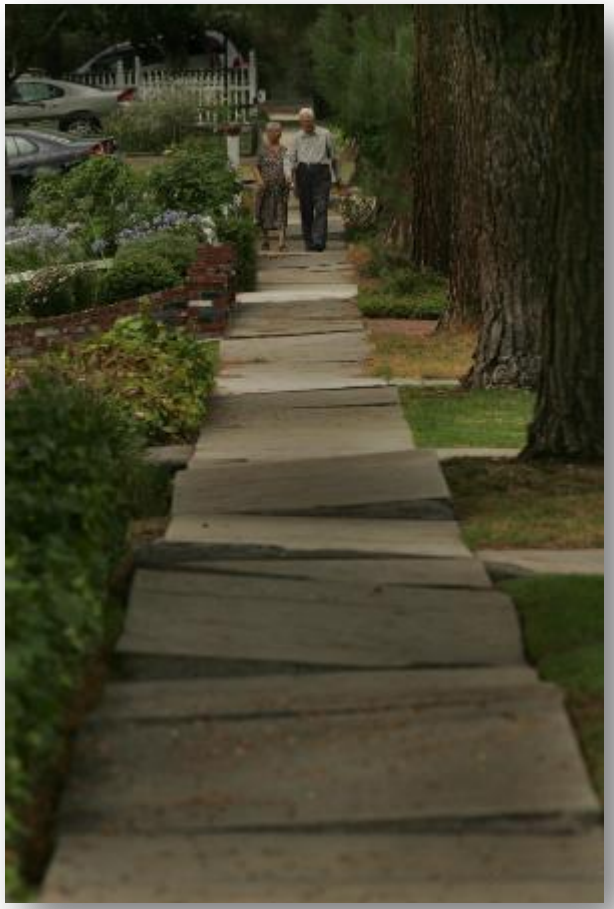
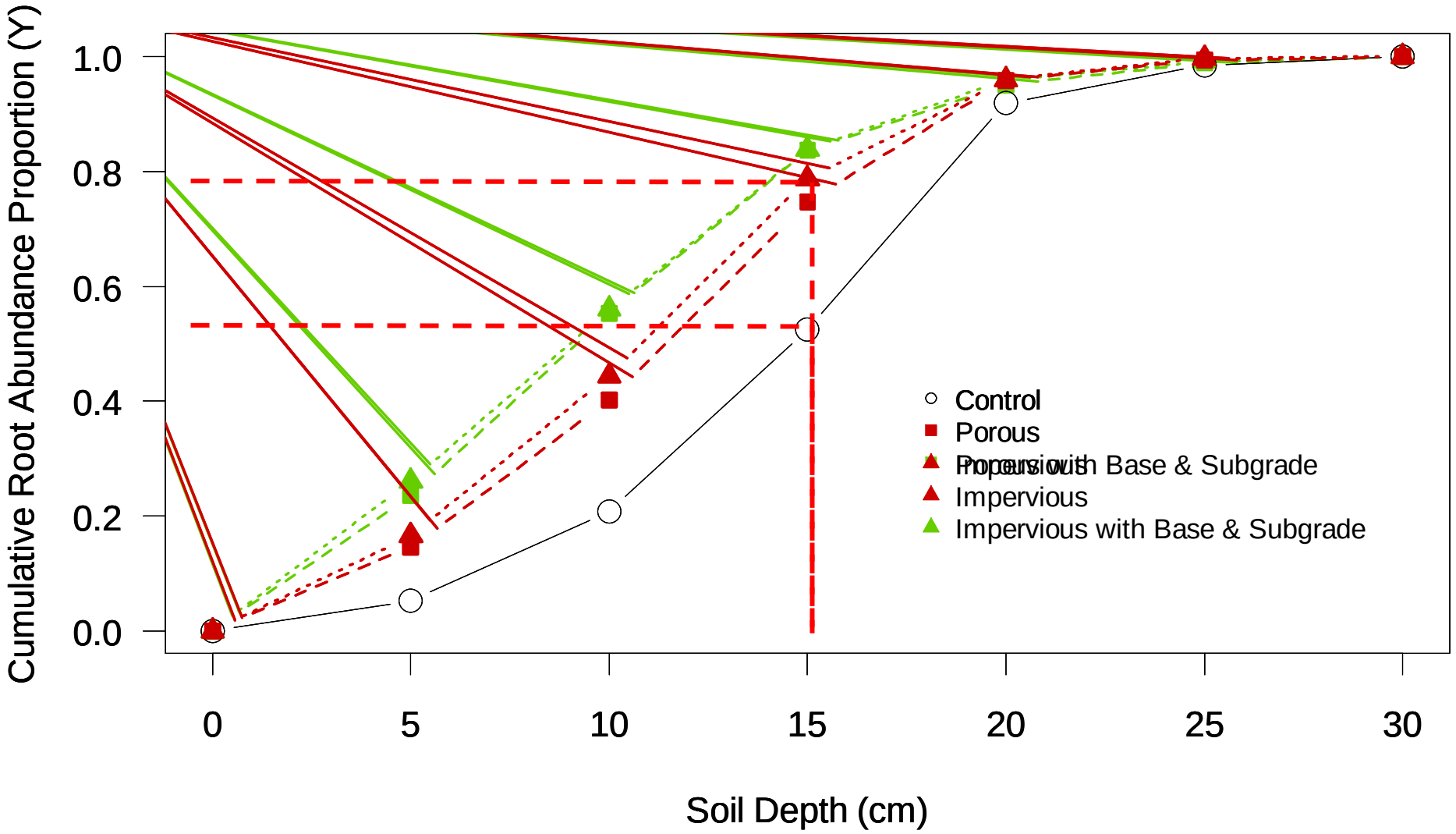


Photo: Cracked, uneven sidewalk along Cabanas Avenue in Tujunga in 2006.
Credit: Richard Hartog / Los Angeles Times

Root Distribution



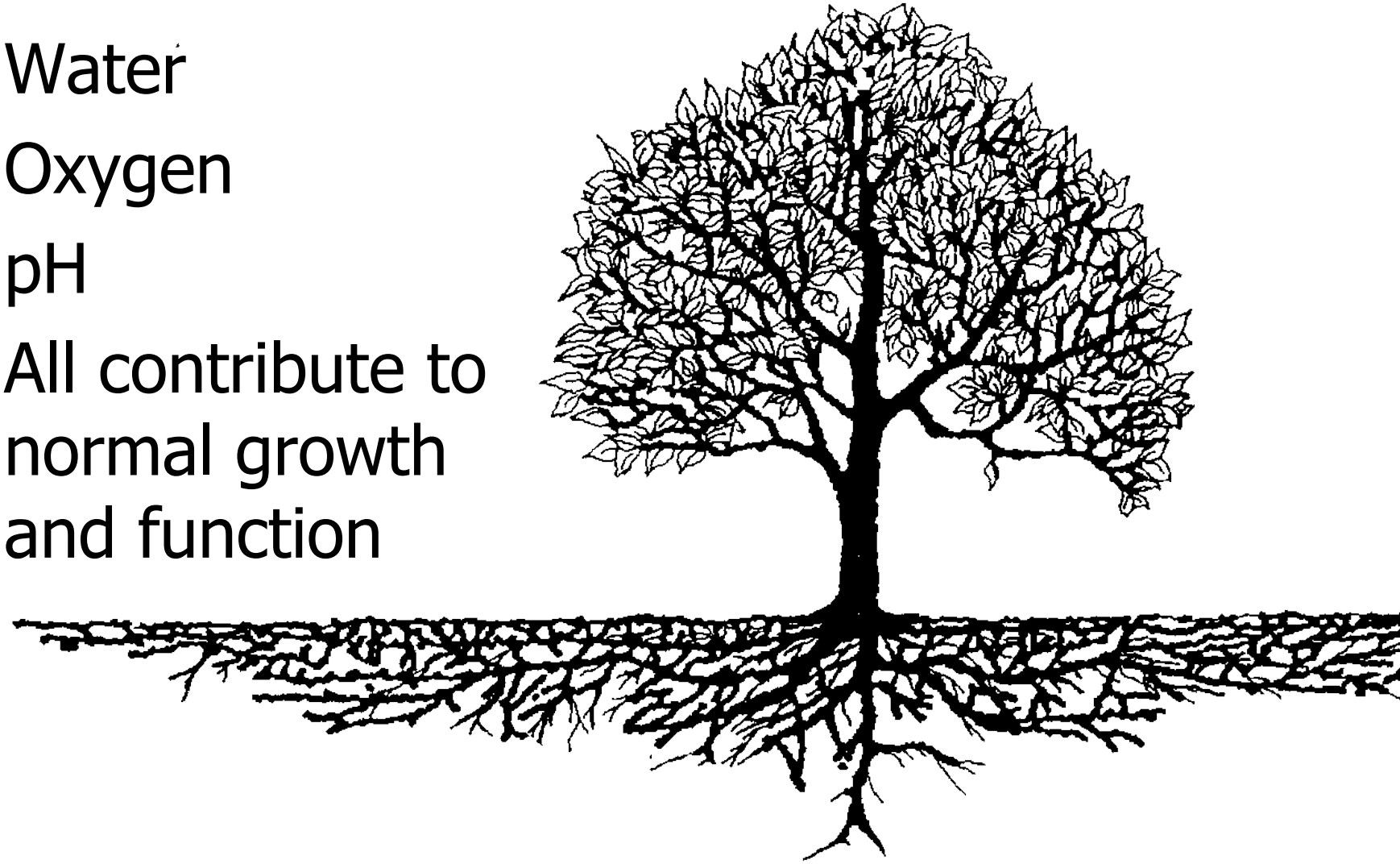
Tree Growth Summary

- Porous paving yielded greater:
  - Stem height and diameter growth
  - Shoot and root biomass
- True only when pavement profile design excluded structural elements
- All pavements resulted in shallow root growth

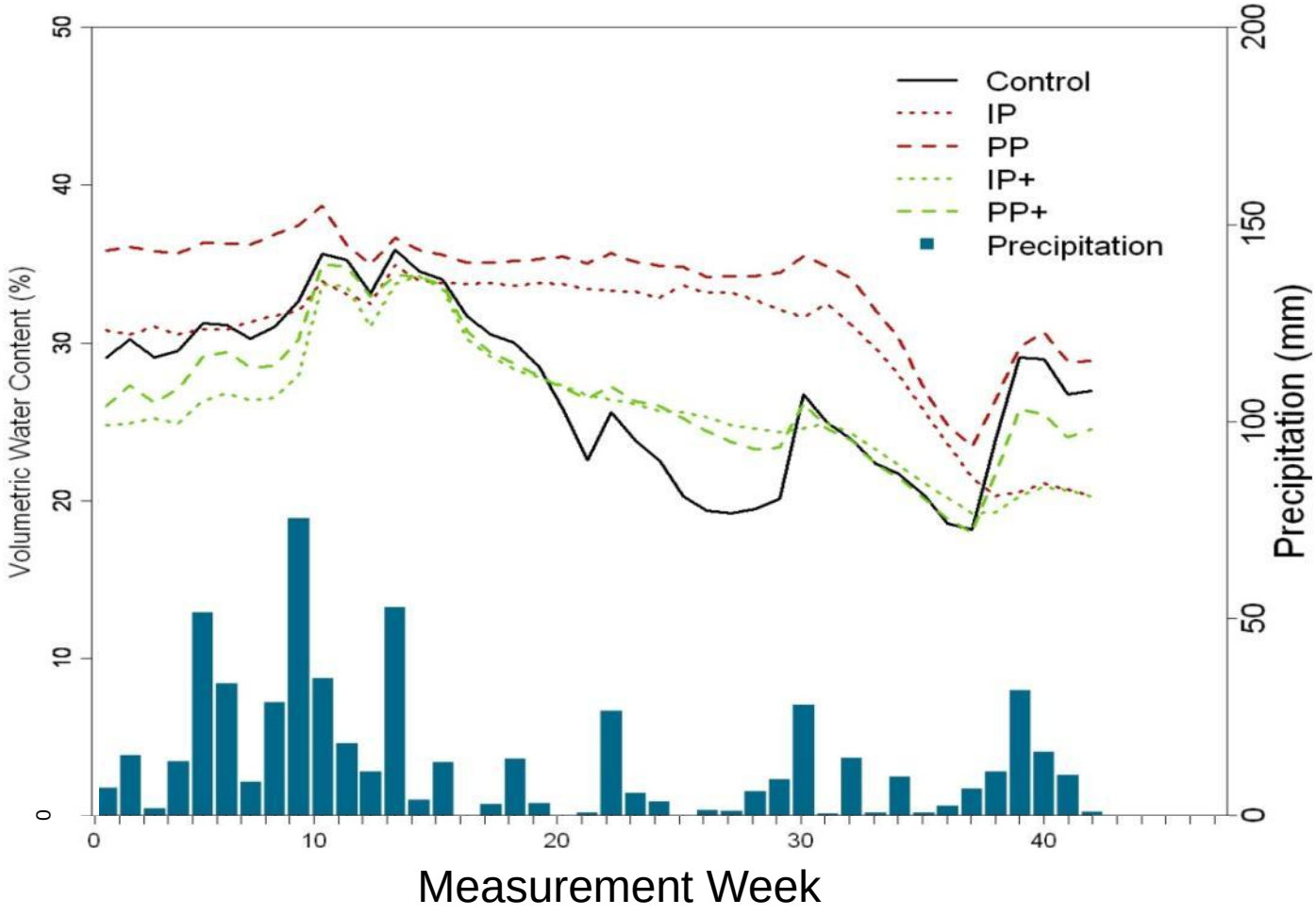
What is it about porous pavements that allows trees to grow larger?

Why are Trees Growing Larger?

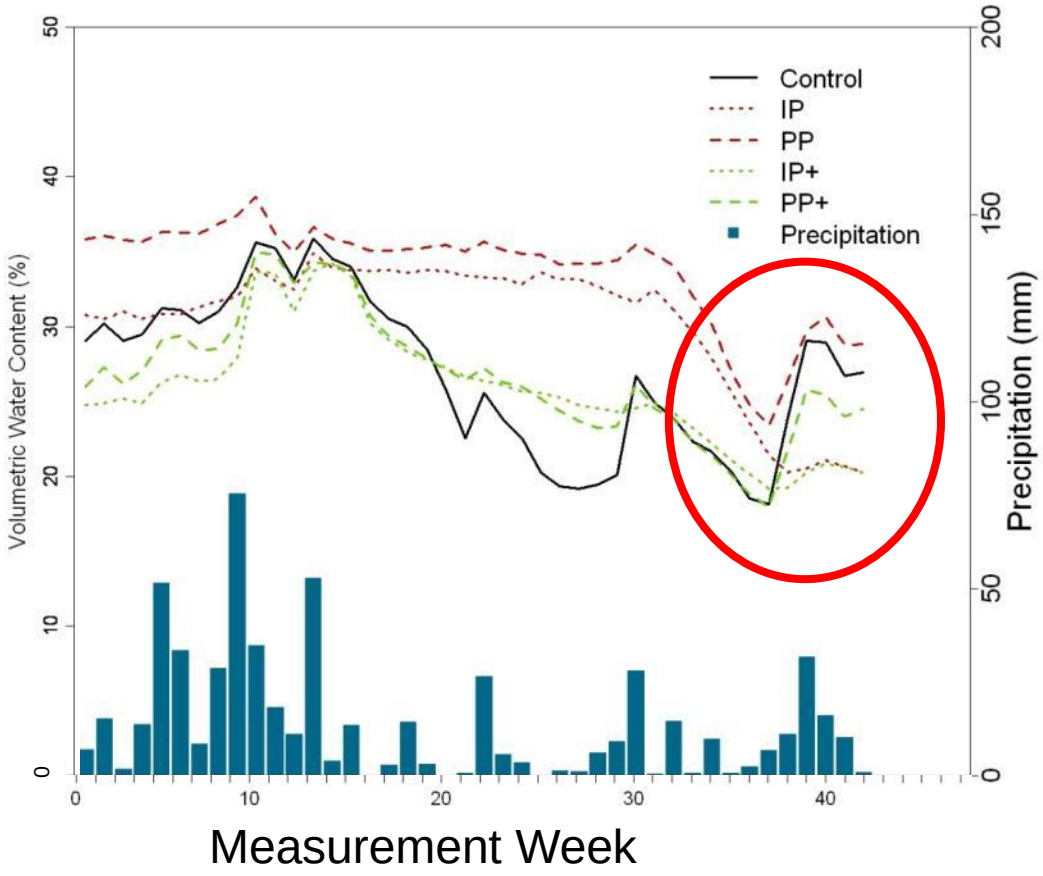
- Water
- Oxygen
- pH
- All contribute to normal growth and function



Why are Trees Growing Larger?



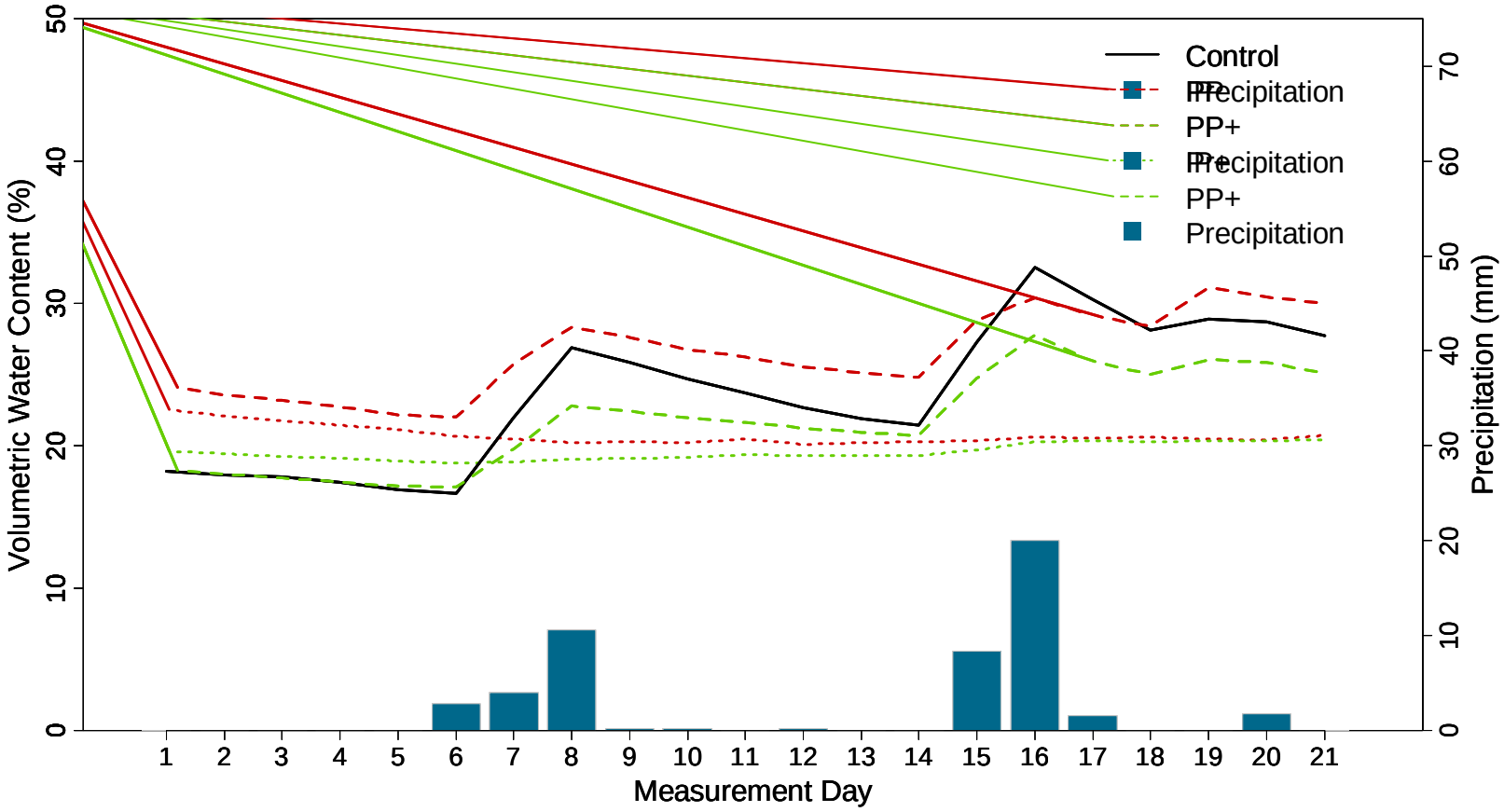
1 - Infiltration



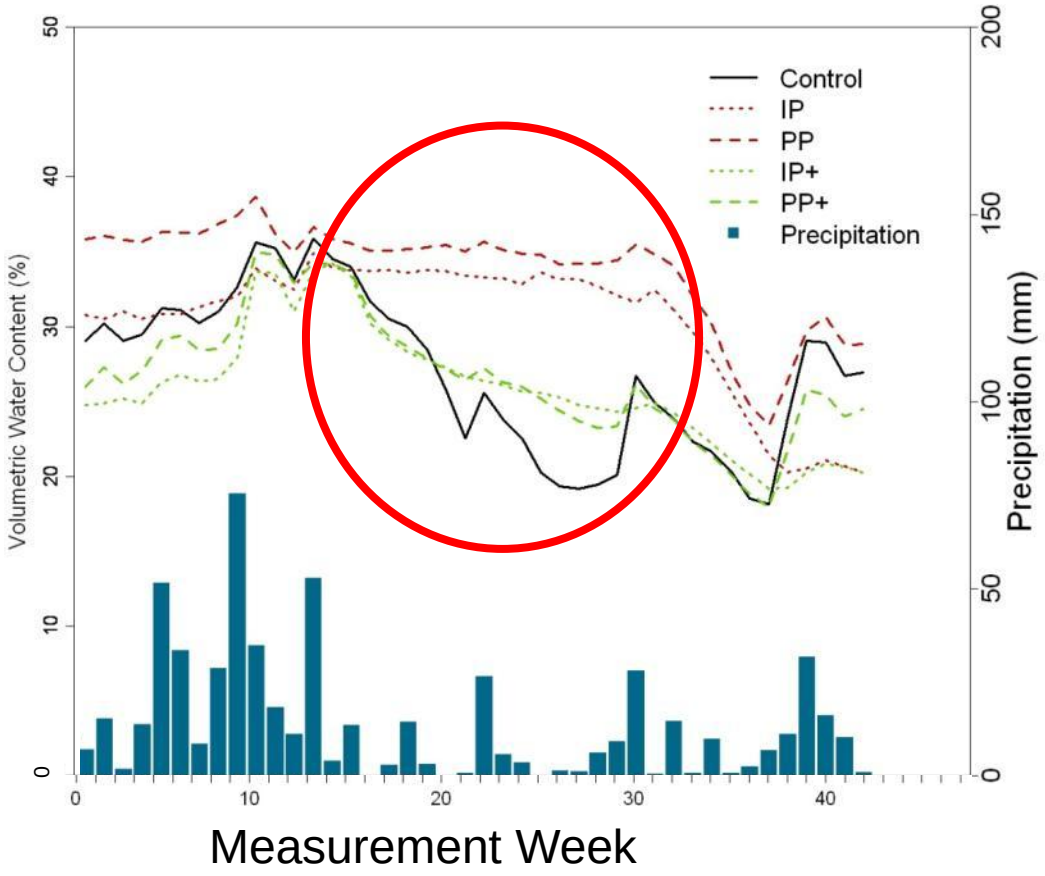
- Porous pavement allows for rapid infiltration of rainfall
- Importance depends on current soil moisture

1. Infiltration

Increased infiltration at key times – late summer

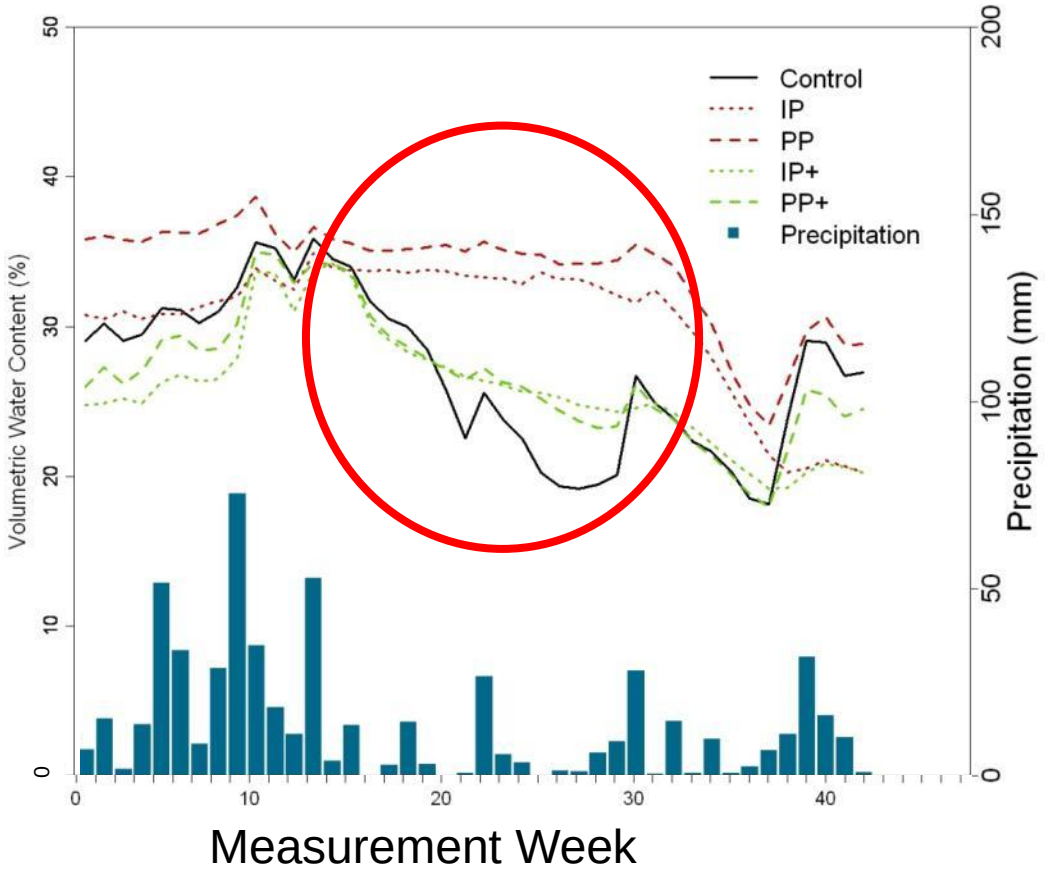


2 - Evaporation



- Pavement prevents evaporation of soil moisture
- Just like mulch
- Why didn't all pavements do the same thing?

3 - Distillation

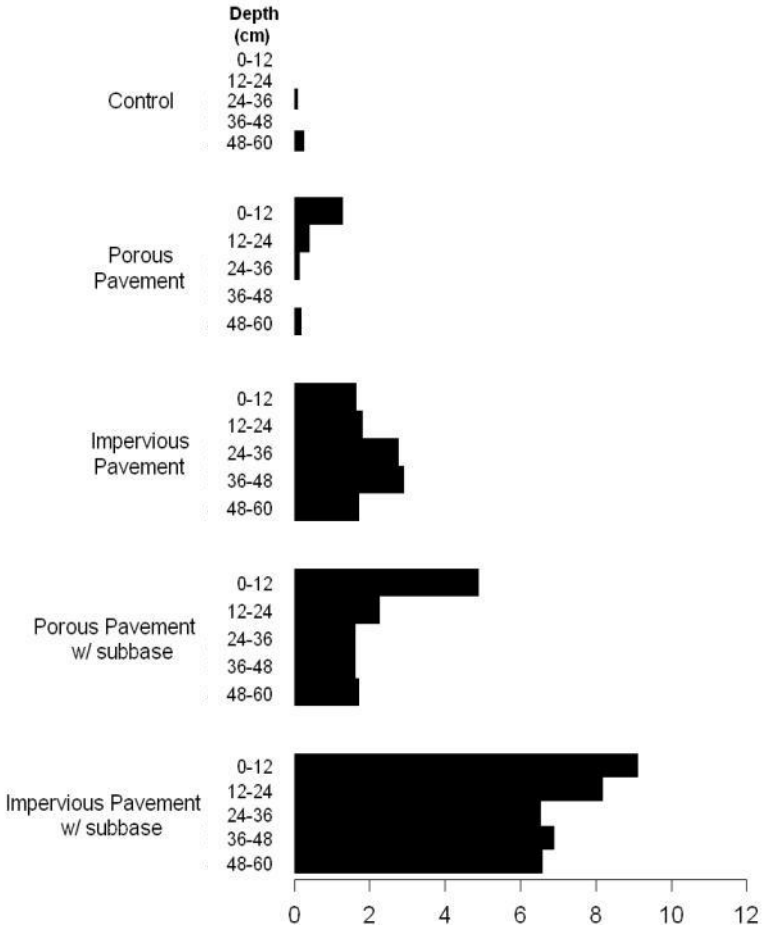


- Water follows temperature gradient
- Pavement cools faster than soil
- Gravel layer acts as capillary break

Soil Moisture Summary

1. Soil moisture higher beneath paved surfaces due to buffering from evaporation
2. Soil moisture higher without gravel subbase due to distillation effect
3. Soil moisture higher beneath porous pavement due to infiltration

Why are Trees Growing Larger?



- During wet spring, no difference
- During dry summer, porous has greater aeration than impervious
- Likely related to diurnal soil moisture dynamics

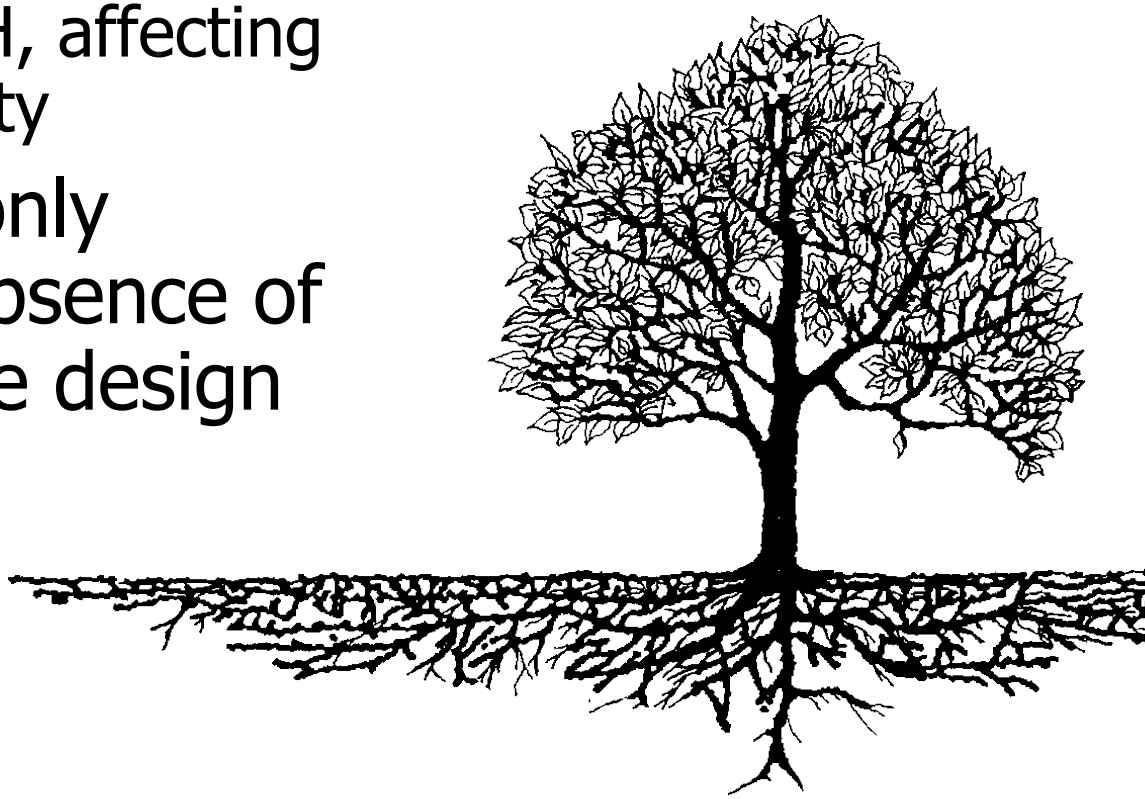
Why are Trees Growing Larger?

- Neutralisation of acidic soil via leaching of cations from pavements

Treatment	pH
Control	5.75
Impervious	6.00
Porous	6.35
Impervious + Structural	6.26
Porous + Structural	6.58

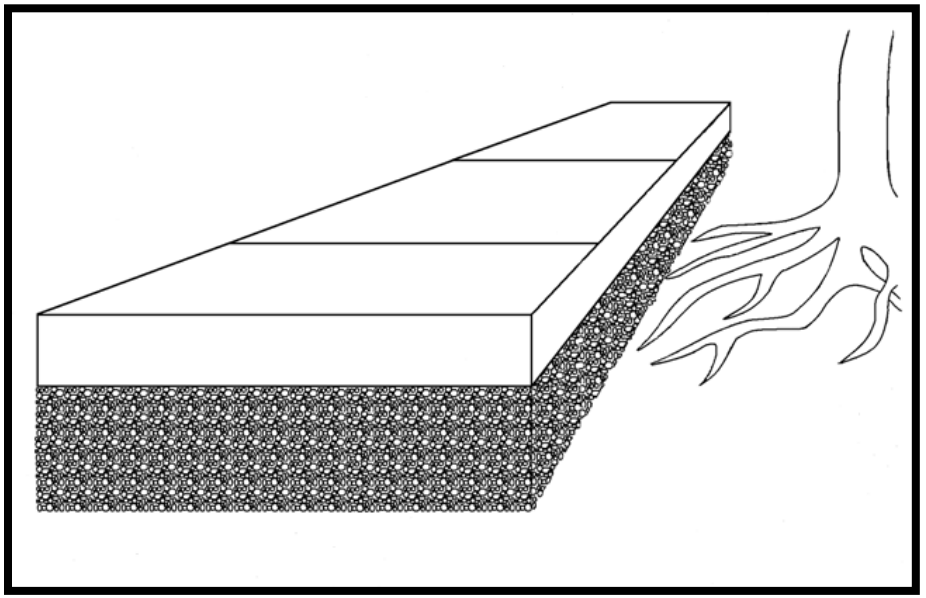
Why are Trees Growing Larger?

- Porous pavement improved tree growth by:
  - Allowing for infiltration of rain at key times
  - Allowing for higher soil aeration
  - Increasing soil pH, affecting nutrient availability
- But tree growth only occurred in the absence of a structural profile design
- Why?



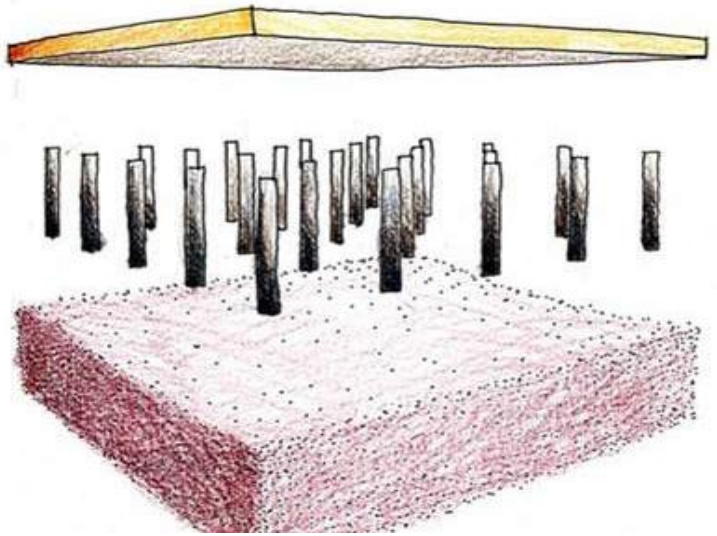
Soil Compaction

- In structural plots, soil strength was 3x greater
- Compaction acted as a bottleneck
  - Prevented roots from taking advantage of better growing conditions



Ideal Uses of Porous Pavement

- Porous pavement may be used effectively in conjunction with:
  - Suspended pavements
  - Engineered soils



Take-Home Messages

- If porous pavement is installed to improve conditions for tree growth, important to remember:
  - Porous pavement is not a miracle cure
  - Care for soil necessary if porous pavement is intended to improve tree growth
  - Take care of the soil and the soil will care for the tree

Acknowledgements

Funding: TREE Fund, University of Canterbury, New Zealand School of Forestry, Auckland City Council, Christchurch City Council, The McKelvey Fund, The Robert Bruce Trust

Supervisors: Dr. Rien Visser, Dr. Graeme Buchan, Dr. James Mackechnie

Field work: Joe Cartman, Lachlan Kirk, Nigel Pink, Alwyn Williams, Lisa Kulczycki, Neil Smith