POROUS PAVEMENTS INCREASE ABOVE-GROUND GROWTH OF *PLATANUS ORIENTALIS*

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Impervious Urban Surfaces

Source: 1. Soil Conservation Service 1975
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
Pavement is Pervasive

- 93% of roads in America unpaved in 1904\(^2\)
- Change came with the ascendancy of the automobile
- Now, >50% of dense urban cores paved\(^1\)

Photo credit: Joel Tauber
Porous Paving

• Monolithic construction:
  • Pervious paving
  • No-fines paving
  • Open-graded paving
  • Gap-graded paving
  • Percolating paving
  • Percrete
Permeable vs. Porous Paving

• Results apply only to monolithic construction
• Pervious surfaces affect hydrology
  • Infiltration
  • Evaporation
• Infiltration unaffected by porous/permeable
• Evaporation from soil
  • Permeable → direct
  • Porous → indirect
Permeable vs. Porous Paving

- Results apply only to monolithic construction
- Pervious surfaces affect hydrology
  - Infiltration
  - Evaporation
- Infiltration b/w porous and permeable ~ equal
- Evaporation from soil
  - Permeable → direct
  - Porous → indirect
Porous Paving in the Literature

• Search for porous paving on Scopus yielded:
  – 61 articles prior to 1980
  – 118 between 1990 – 2000
  – 409 since 2000

• Research mirrors increased installation of PP
The Motivation

- Too many “factoids”
- Prof. Bruce Ferguson, University of Georgia
  “ideal for protecting trees in a paved environment”\(^1\)
- Tennis et al. 2004, Portland Cement Association
  “increase the longevity of trees by improving moisture and oxygen relations”\(^2\)
- Prof. Vern Schaefer, University of Iowa
  “preserving native ecosystems”\(^3\)
- Where’s the proof?
More Motivation

• Is pervious paving ‘good’ for urban trees?
• Theoretically possible, but we don’t know for certain
  – Research has often found unexpected results
• If true, there may be unintended consequences
  – Increased root growth → Increased conflicts
Hypothesis

Across varying pavement profile designs, porous paving affects tree growth relative to standard impervious paving.
Experiment Site
Experiment Site – Christchurch, NZ

- Population ~ 400,000
- Mean temperature:
  - 10°C in July to 21°C in January
- Mean Annual Rainfall:
  - 600-700mm
  - evenly distributed throughout the year
Treatments

Augmented Factorial Arrangement:

- Control & Pavement Type * Pavement Profile Design
- Pavement Type → Porous, Impervious
- Pavement Profile Design → +/- Compacted subgrade, gravel base
Pavement Profile Design

Structural

Non-Structural
Data Collection

Tree Growth:
- Stem Height
- Stem Diameter
- Shoot/Root Biomass
- Root Diameter and Distribution

Edaphic Factors:
- Water content
- Aeration
- pH
- Nutrient availability
Stem Height Growth

- **Control**
- **Porous**
- **Impervious**

**Pavement Treatment**

- Excluding base and subgrade
- Including base and subgrade

**Total Height Growth (cm):**

- Control
- Porous
- Impervious
- Porous
- Impervious
Stem Diameter Growth

- Control
- Porous
- Impervious

Excluding base and subgrade:
- Porous
- Impervious

Including base and subgrade:
- Porous
- Impervious
Shoot Biomass

Above-Ground Biomass (g)

- Control
- Porous
- Impervious

Pavement Treatment

Excluding base and subgrade
Including base and subgrade
Summary of Findings

- Pavements never reduced any growth attribute relative to controls

- Porous paving yielded greater:
  - Stem height growth
  - Stem diameter growth
  - Above-ground biomass

- True only when pavement profile design excluded structural elements
  - compacted subgrade and gravel base
Implications

• Pavement often blamed for decreased growth or premature mortality\textsuperscript{6,7,8}

• In absence of ‘other’ stressors, trees surrounded by pavement are not disadvantaged
  • Vandalism, air/soil pollution, soil volume, soil compaction, etc.
Further Implications

• If porous pavement is installed to improve conditions for tree growth, important to remember:
  • Profile design supersedes surface course porosity
  • Care for rhizosphere necessary if porous pavement is intended to improve tree growth
  • Take care of the soil and the soil will care for the tree
Further Implications

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

• Allometry $\rightarrow$ Increased above-ground growth implies increased below-ground growth

• Greater growth with porous paving not always desirable

• If increased root growth occurs beneath sidewalks $\rightarrow$ increased incidence of infrastructure conflict
  • Very Expensive Problem

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

• 1 tree species
  • *Platanus orientalis* very hardy

• 1 soil type
  • Fine sandy loam
  • Different texture/compaction levels will affect hydrology completely differently

• Size of pavement treatments
  • Results only applicable to small-scale installations
  • Larger sizes would exaggerate response

• Porous v. Permeable
  • Comparison of response to both types
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References