XIII GIORNATE SCIENTIFICHE SOI | 22-23 GIUGNO 2021

L'impermeabilizzazione del suolo: effetti sull'ecosistema urbano e possibili soluzioni per mitigarli

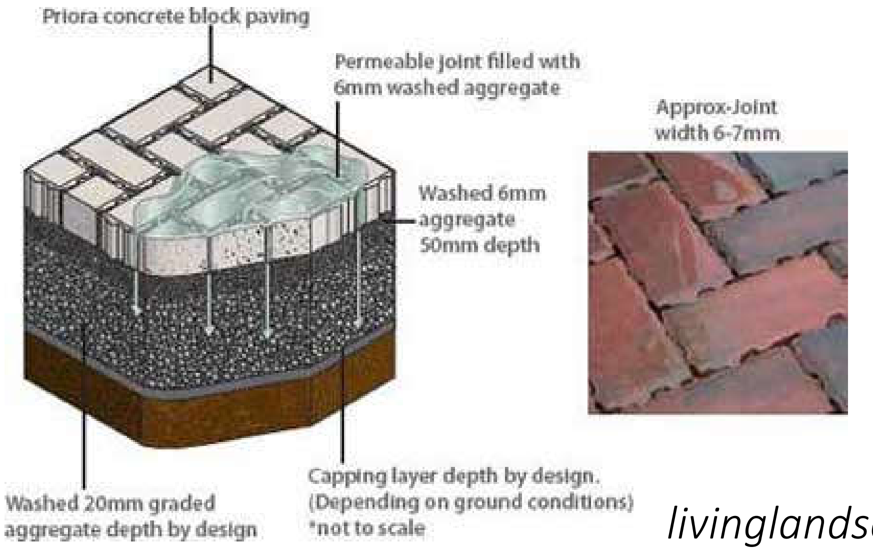
Alessio Fini*, Piero Frangi, Irene Vigevani, Sebastien Comin, Francesco Ferrini

* Presenting author – Dipartimento di Scienze Agrarie e Ambientali – Produzione, Territorio, Agroenergia

Soil sealing, “the covering of soil by buildings, constructions, and layers of completely or partly impermeable artificial materials” is the most pervasive form of land take and it is essentially an irreversible process (*Alberti, 2005*)

Effects of soil sealing include disruption of the water and carbon cycles; higher soil and air temperature; drought stress on trees

To mitigate the effects of soil sealing, the use of pervious pavements is now advokated



livinglandscapes.uk.com

POROUS PAVEMENTS:
The pavements itself is permeable to water across its entire structure

PERMEABLE PAVEMENTS:
Pavements made by impervious modular elements, but voids between elements allow water infiltration

These pavements have infiltration coefficients = 0.5-0.7, compared to 0.15 of asphalt

The aim of this work is to understand the effects of soil sealing and pervious pavements on tree growth, health and physiology.

To achieve this goal, in 2011, an experimental field was built in Vertemate con Minoprio to compare different pavement treatments, using a randomized block design with six blocks

Fraxinus ornus

Celtis *australis*

Four soil treatments were imposed

Impermeable design: asphalt on a concrete sub-grade

Permeable desing: curb on a crushed rock sub-grade

Porous desing: epoxy resin + even-graded inert on a crushed rock sub-grade

Control: unpaved soil (chemical weeding used for weed control)

Research conducted from 2011 to 2015 revealed minor effects of pavement treatments on tree growth and physiology during establishment.
Pavements reduced evaporation, resulting in higher moisture availability compared to bare soil

Environmental Research 156 (2017) 443–454

Contents lists available at ScienceDirect

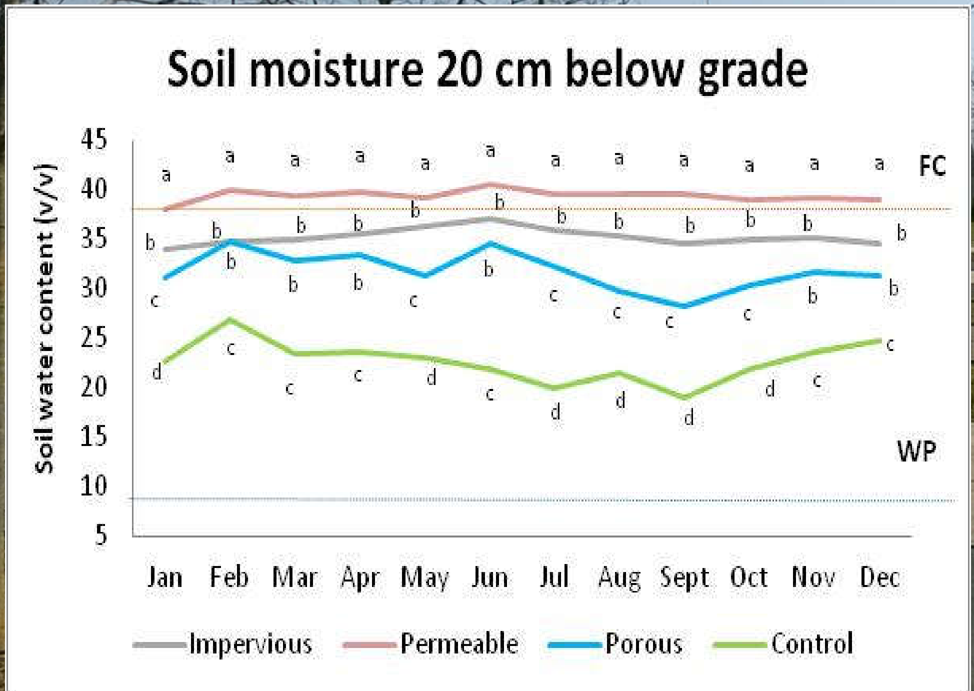
Environmental Research

journal homepage: www.elsevier.com/locate/envres

ELSEVIER

Nature based solutions to mitigate soil sealing in urban areas: Results from a 4-year study comparing permeable, porous, and impermeable pavements

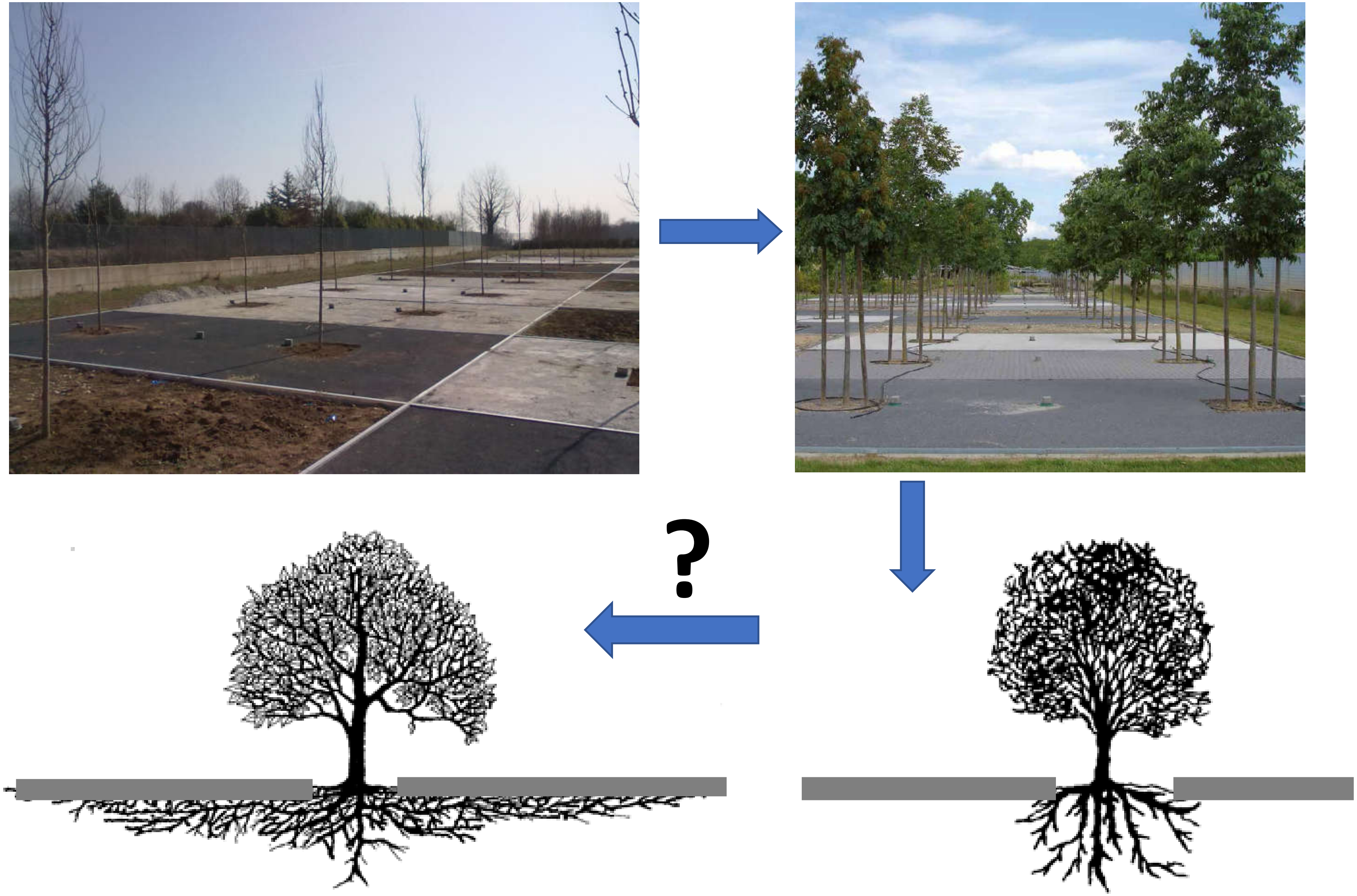
A. Fini[a,e,*], P. Frangi[b], J. Mori[a], D. Donzelli[c], F. Ferrini[a,d]

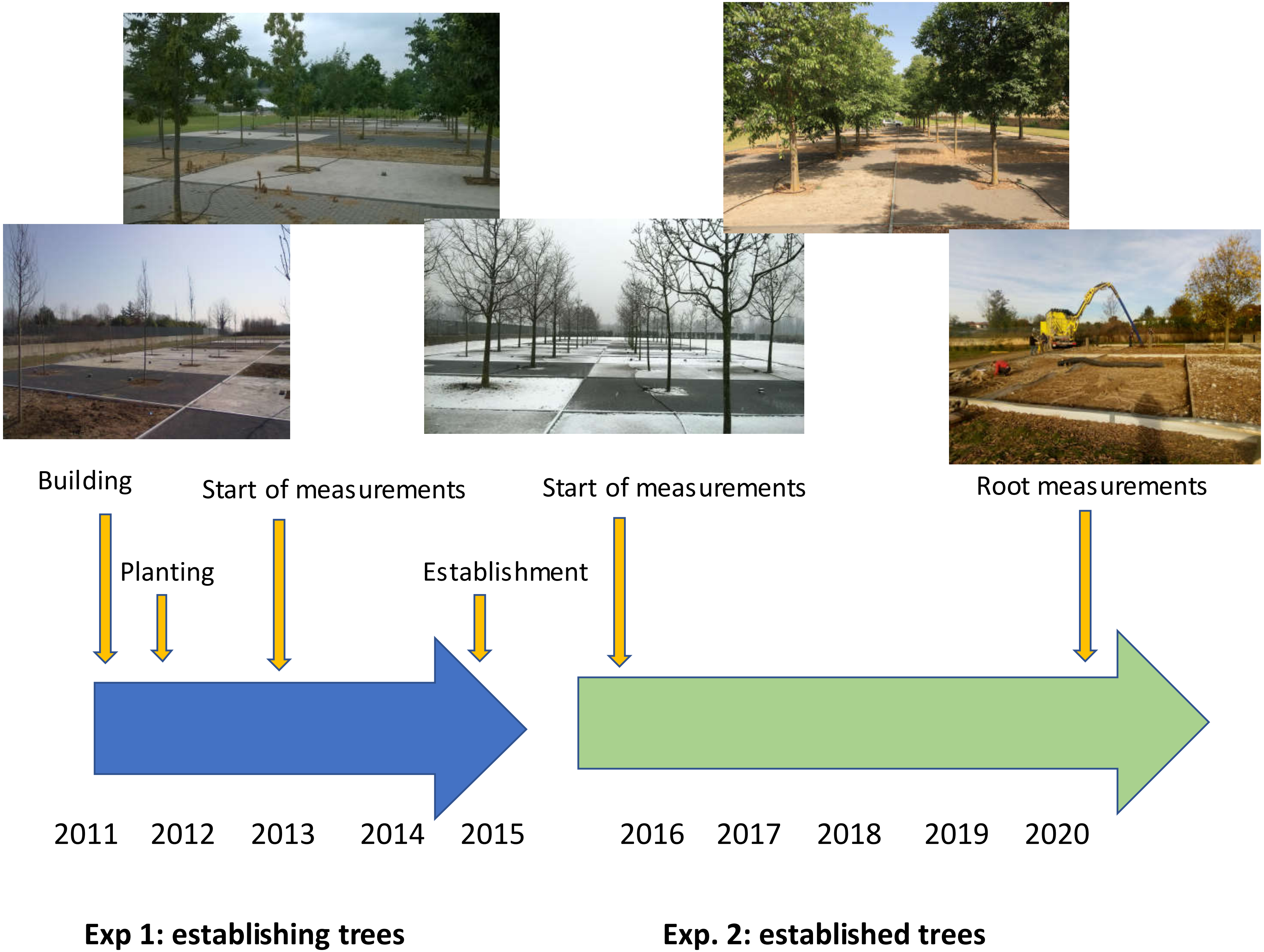


Variation in moisture through the year:

Asphalt: 8%
Permeable: 7%
Porous: 18%
Control: 29%

Limitations (2011-2015 research)



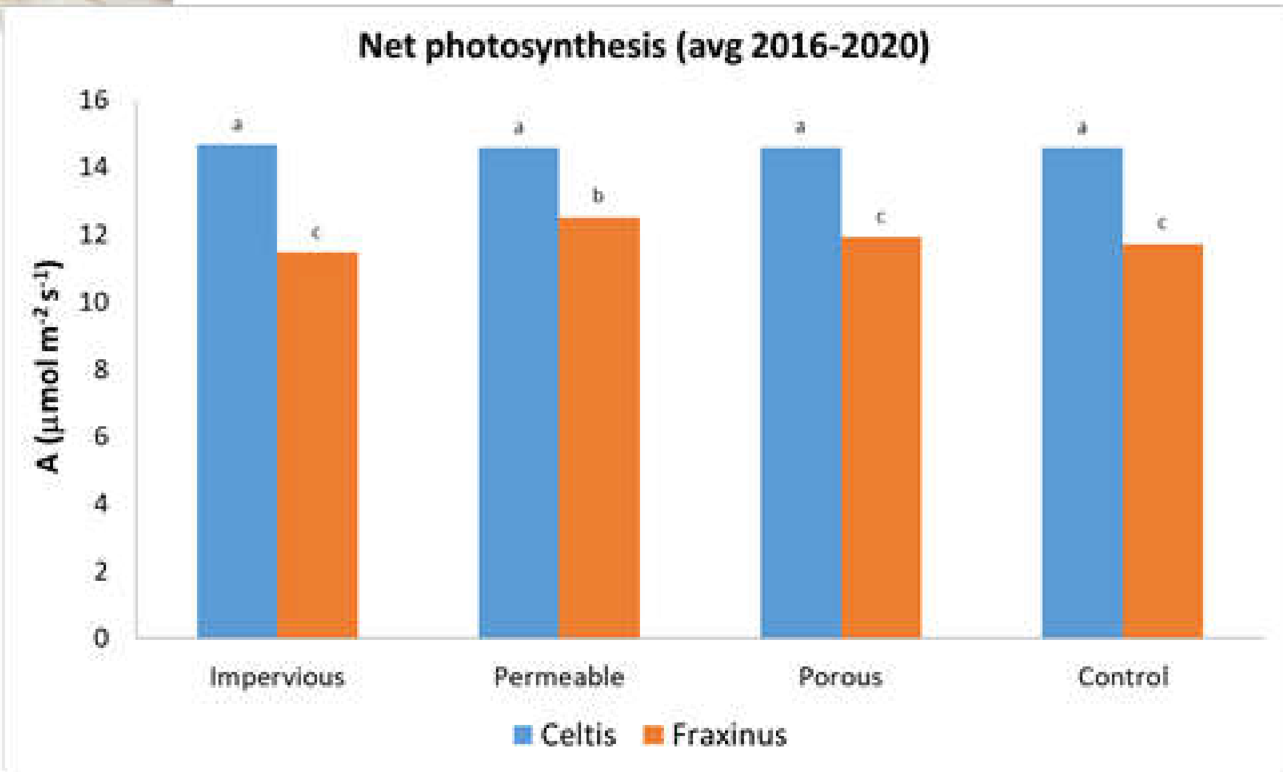

Building
Planting
Start of measurements
Establishment
Start of measurements
Root measurements
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Exp 1: establishing trees
Exp. 2: established trees

Net photosynthesis

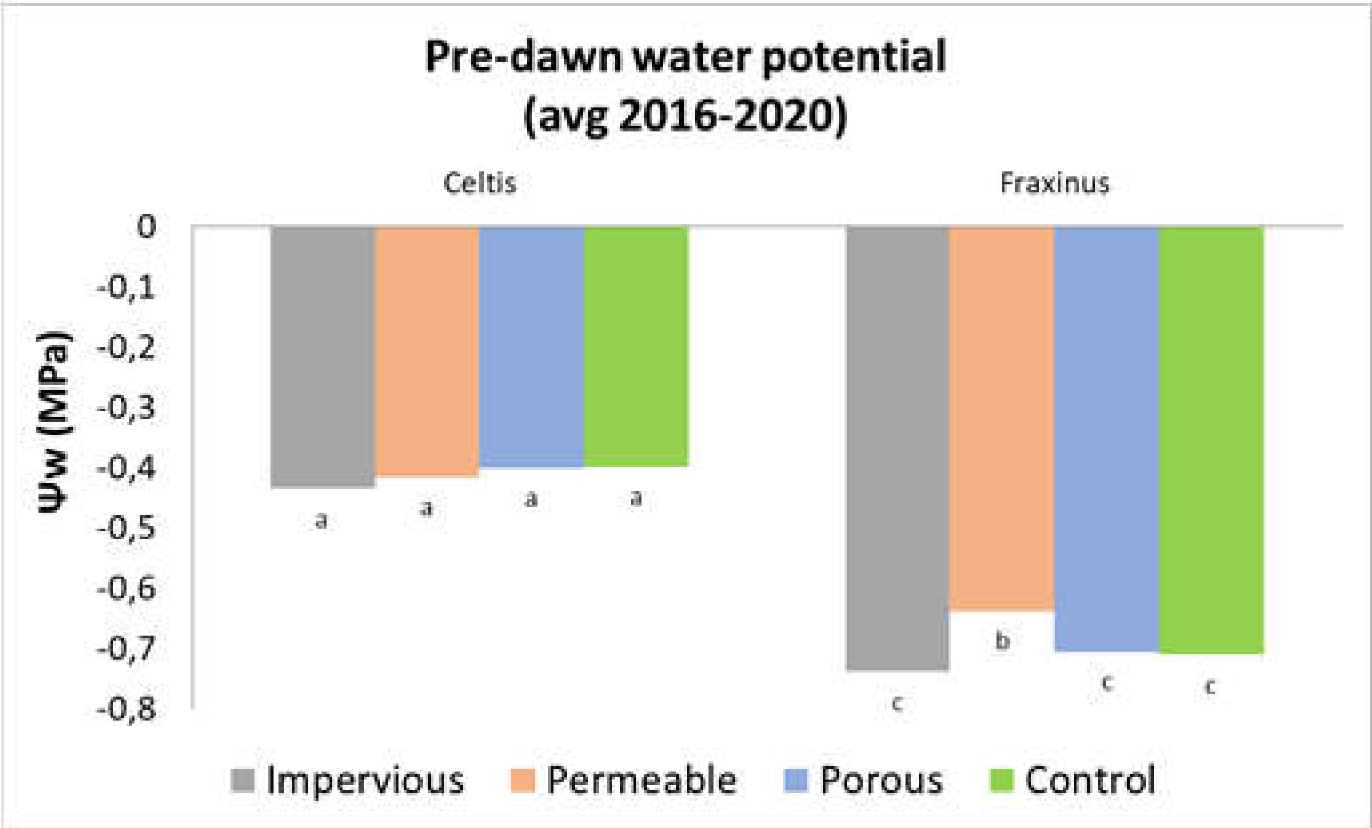
Net photosynthesis was measured using an infra-red gas analyzer, at 400 ppm CO_2, 1300 μmol irradiance, and ambient temperature, from May 2016 to September 2020

Pavements had no effect on Asat in *Celtis.*

Fraxinus growing in permeable pavements had higher Asat than other treatments, but Asat did not differ between sealed soils and control



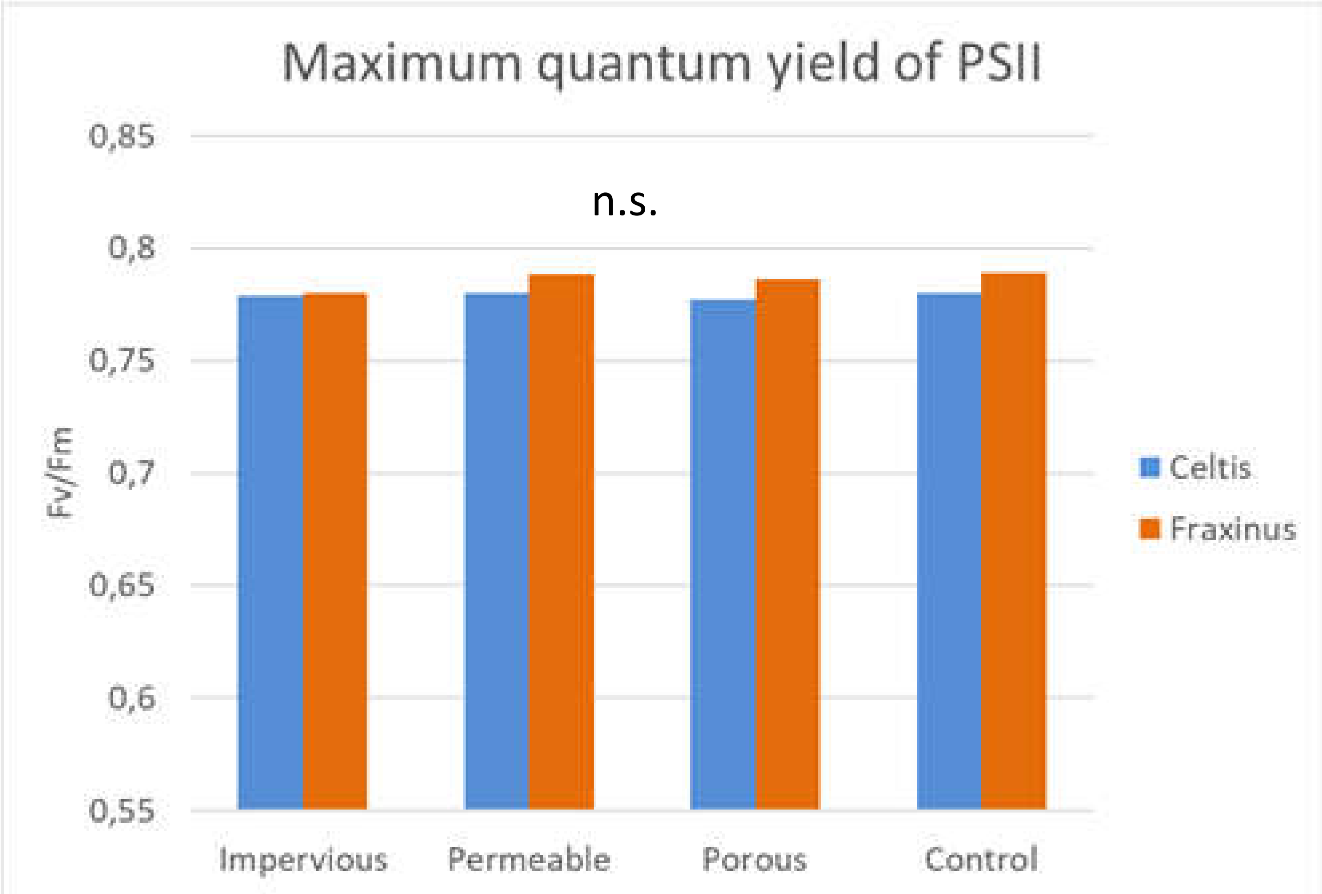
Water relations



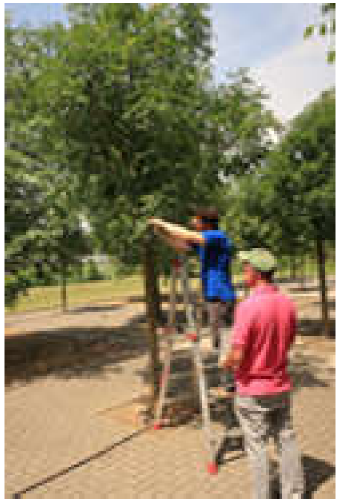
Water relations were measured in July from 2016 to 2020 using a pressure bomb. Measurements were done at pre-dawn, at midday, and at midday on wrapped leaves (xylem water potential)

No evidence that soil sealing triggers less favorable water relations in any species.
Permeable pavements, which allow rainfall infiltration but hasten evaporation, induced more favorable water relations in *Fraxinus.*

Chlorophyll fluorescence



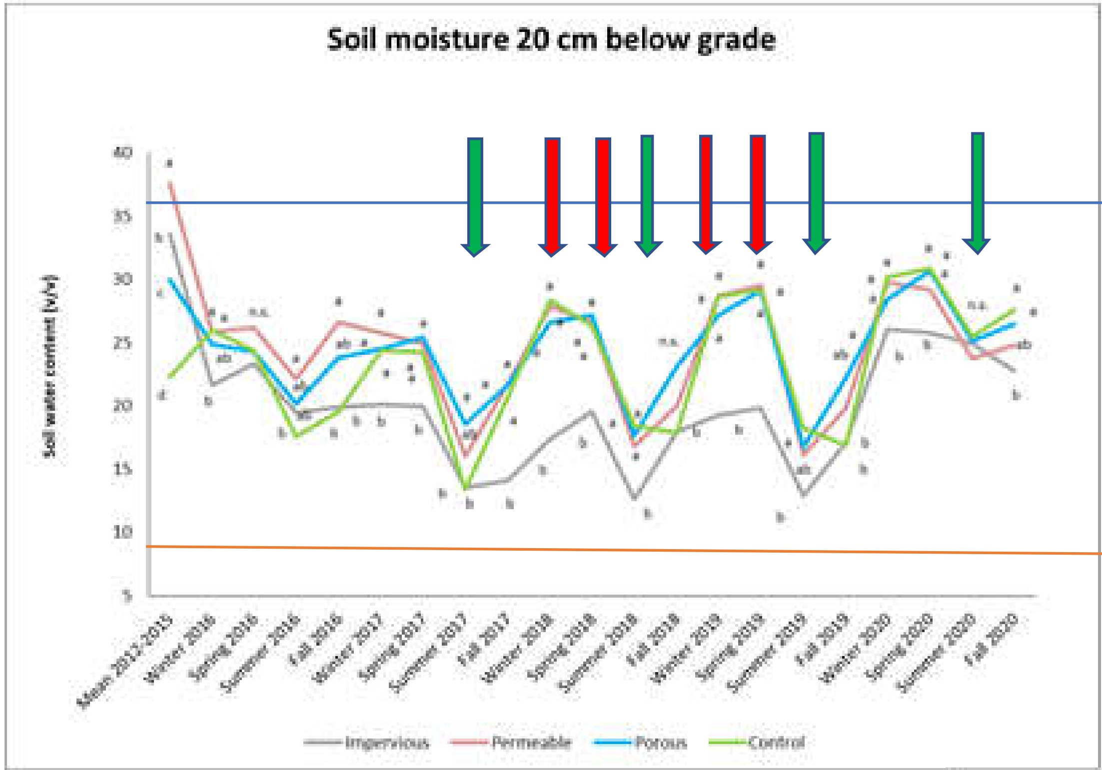
Fv/Fm was measured using a Handy-Pea after a dark acclimation of 40’, from May 2016 to September 2020



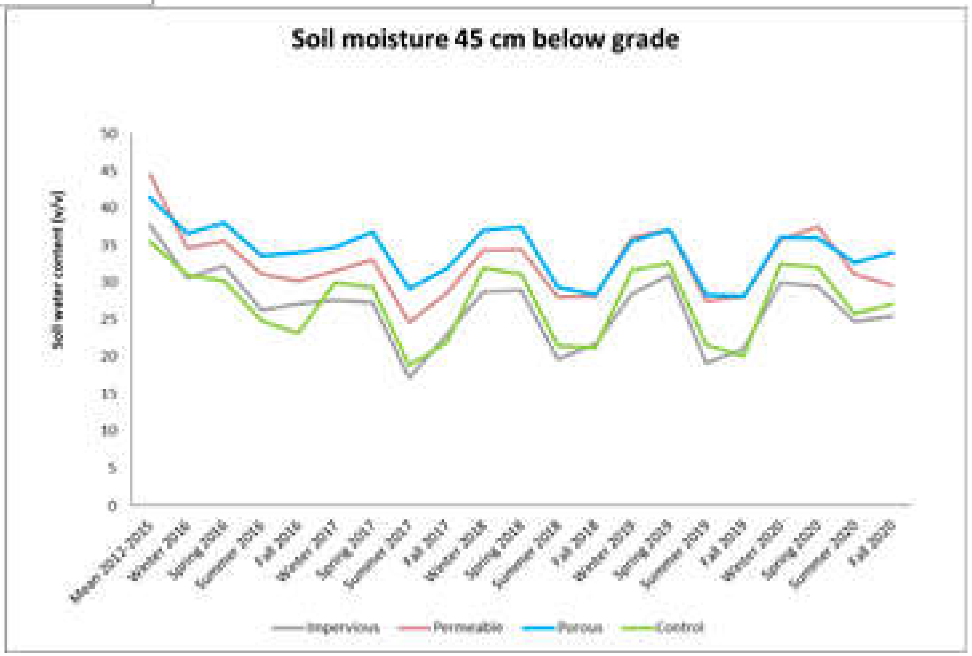
Pavements had little impact on Fv/Fm

Overall, we found no evidence that soil sealing triggered drought stress in established trees

Volumetric soil moisture

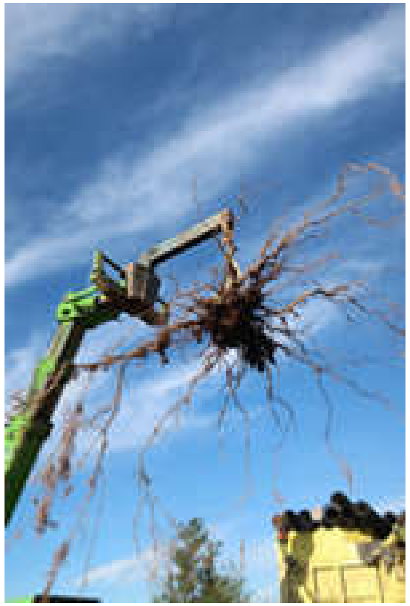


- Transpiration of established trees depleted shallow moisture under asphalt, but moisture never reached WP.
- Larger differences in winter and spring than in summer and fall.
- Deeper in the soil, moisture was similar under asphalt and in bare soil.



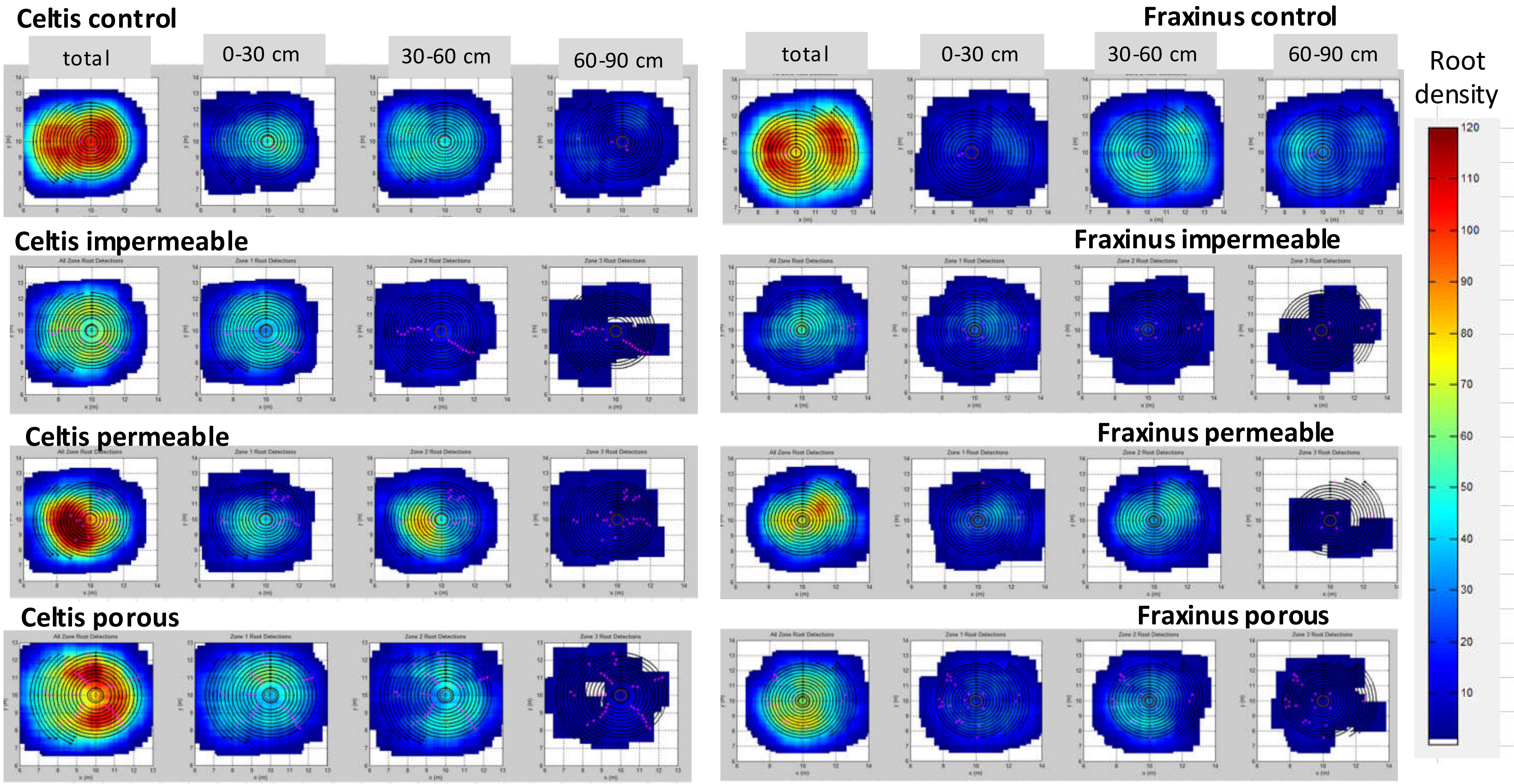
Root measurements (2020)

Size of the root system and root density for coarse roots, assessed in 2020 on 24 plants (3 x treatment) using **Ground Penetrating Radar** (900 MHz antenna). Measurements in 2020 were conducted using TreeRadarUnit (TRU) in cooperation with Studio Planta (Turin, Italy)



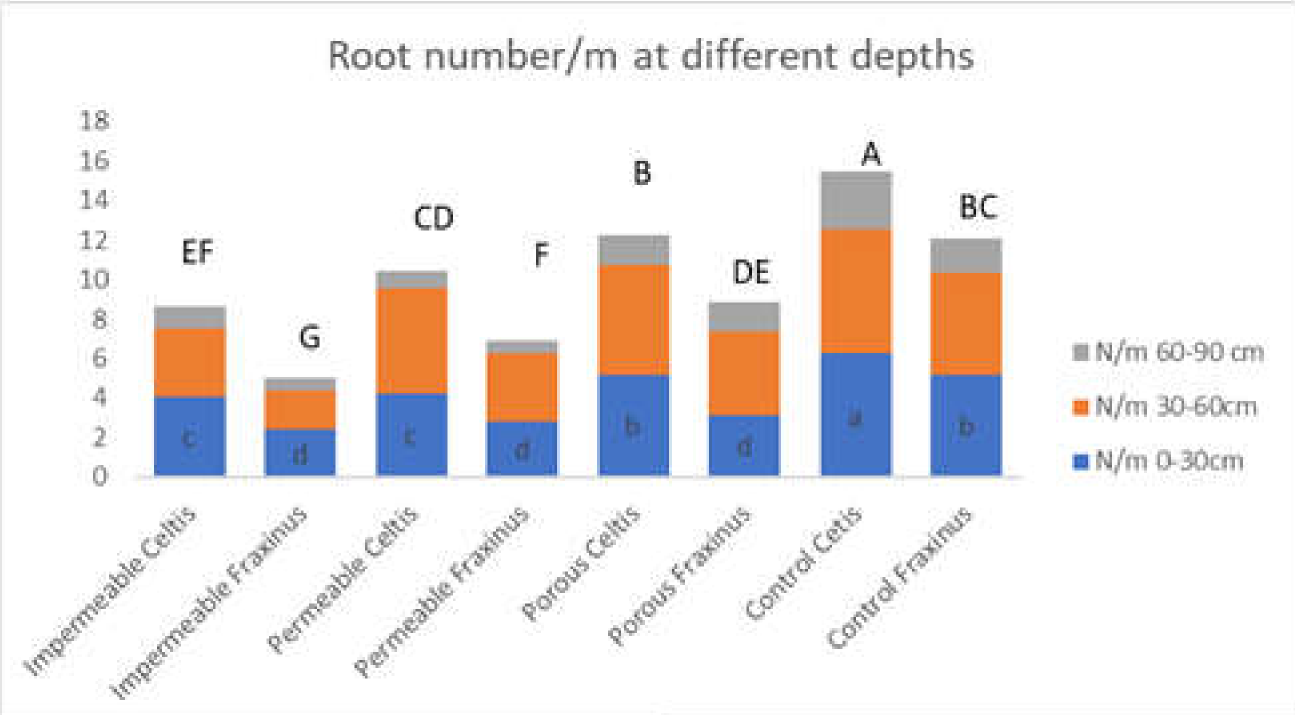
Roots were then dug with a suction excavator, and **fine and coarse root dry biomass** were quantified on individual roots.

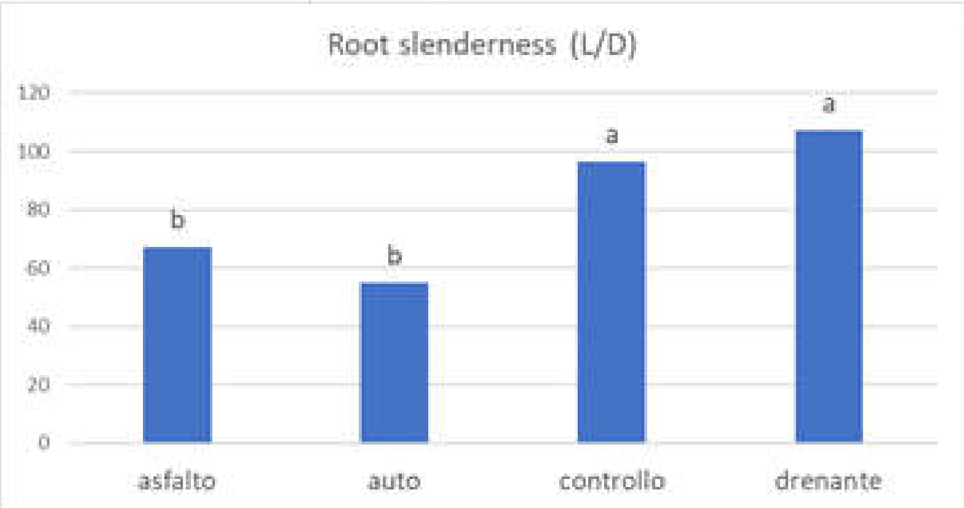
Growth – roots (GPR, preliminary results)

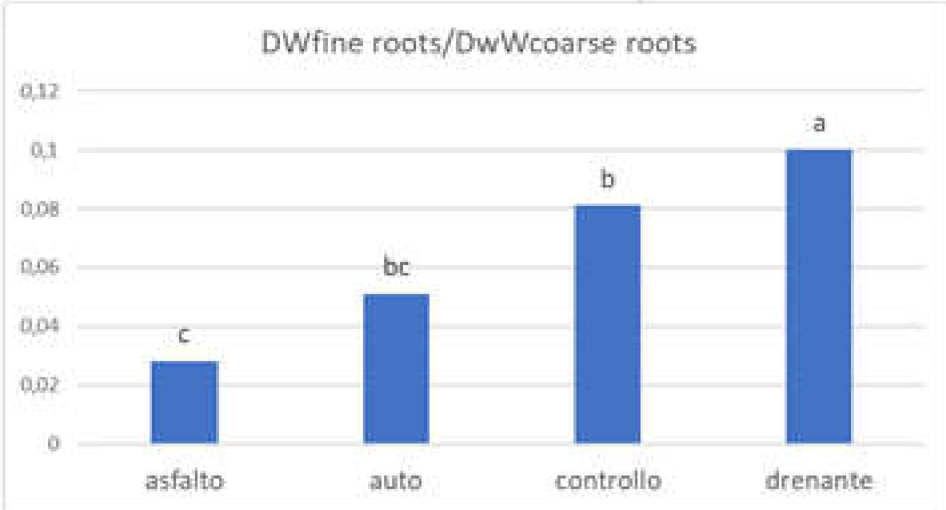


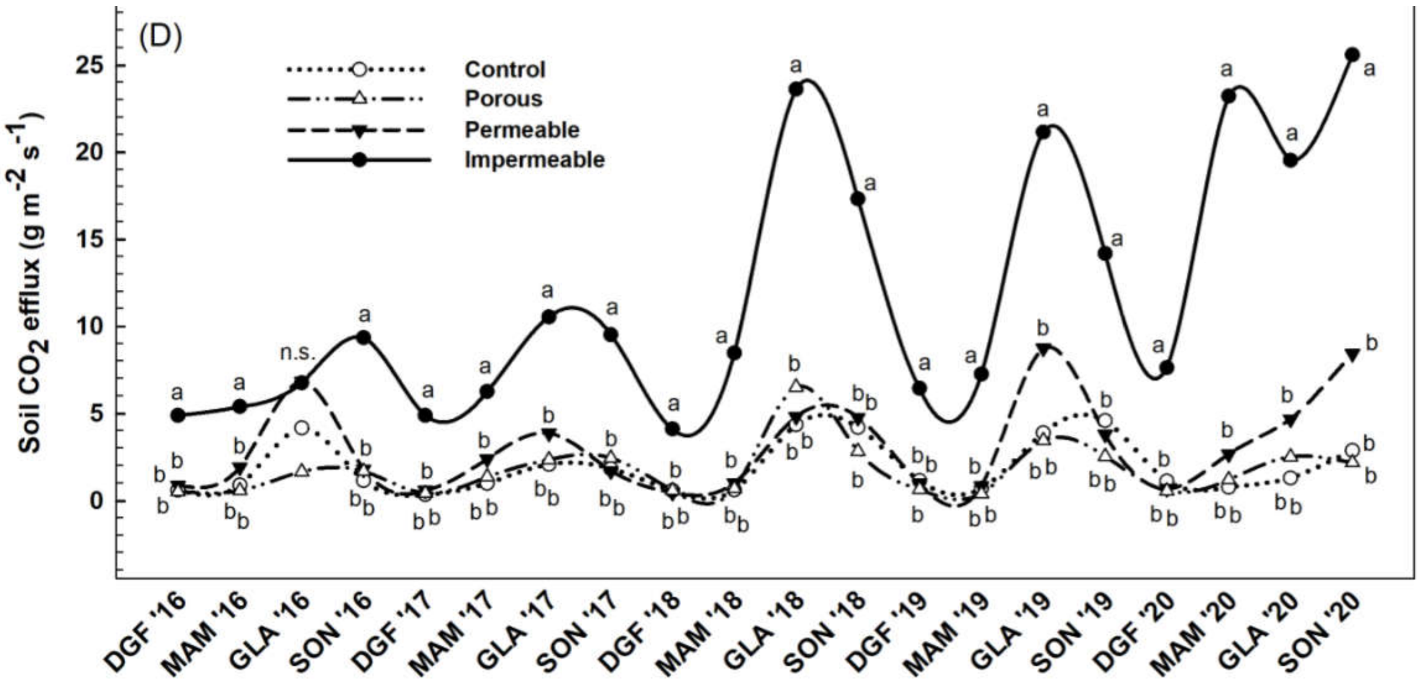

impermeable
Fine roots concentrated in the unpaved planting pit
permeable
porous
Fine roots everywhere
control

Soil sealing reduced root number, increased root thickening and reduced fine roots biomass per unit dry root biomass







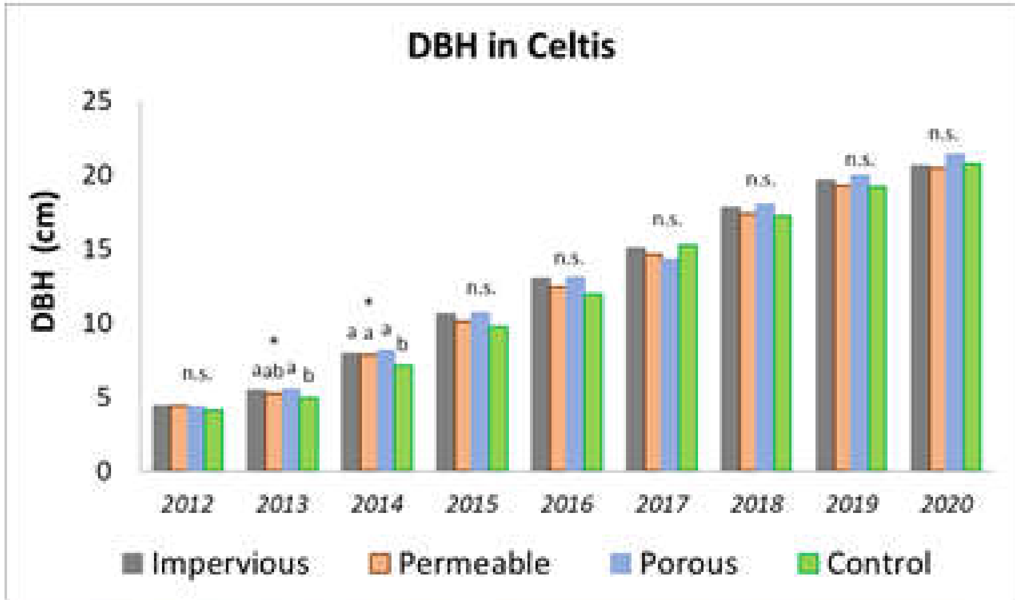


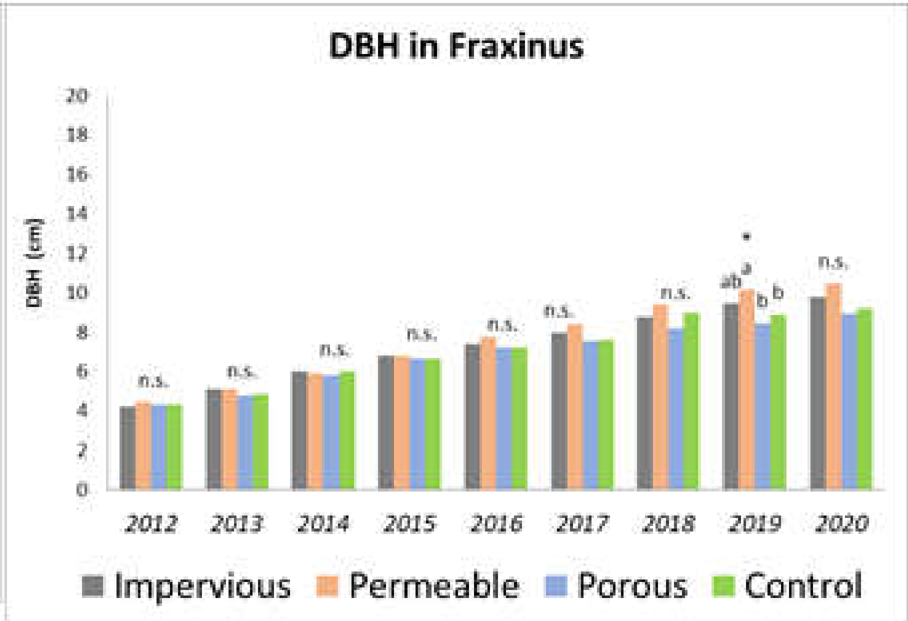
Soil CO_2

Low diffusivity of impermeable pavements to CO_2 resulted in elevated soil CO_2 beneath asphalt.

Elevated soil CO2 is known to depress root activity and growth

Above-gound growth





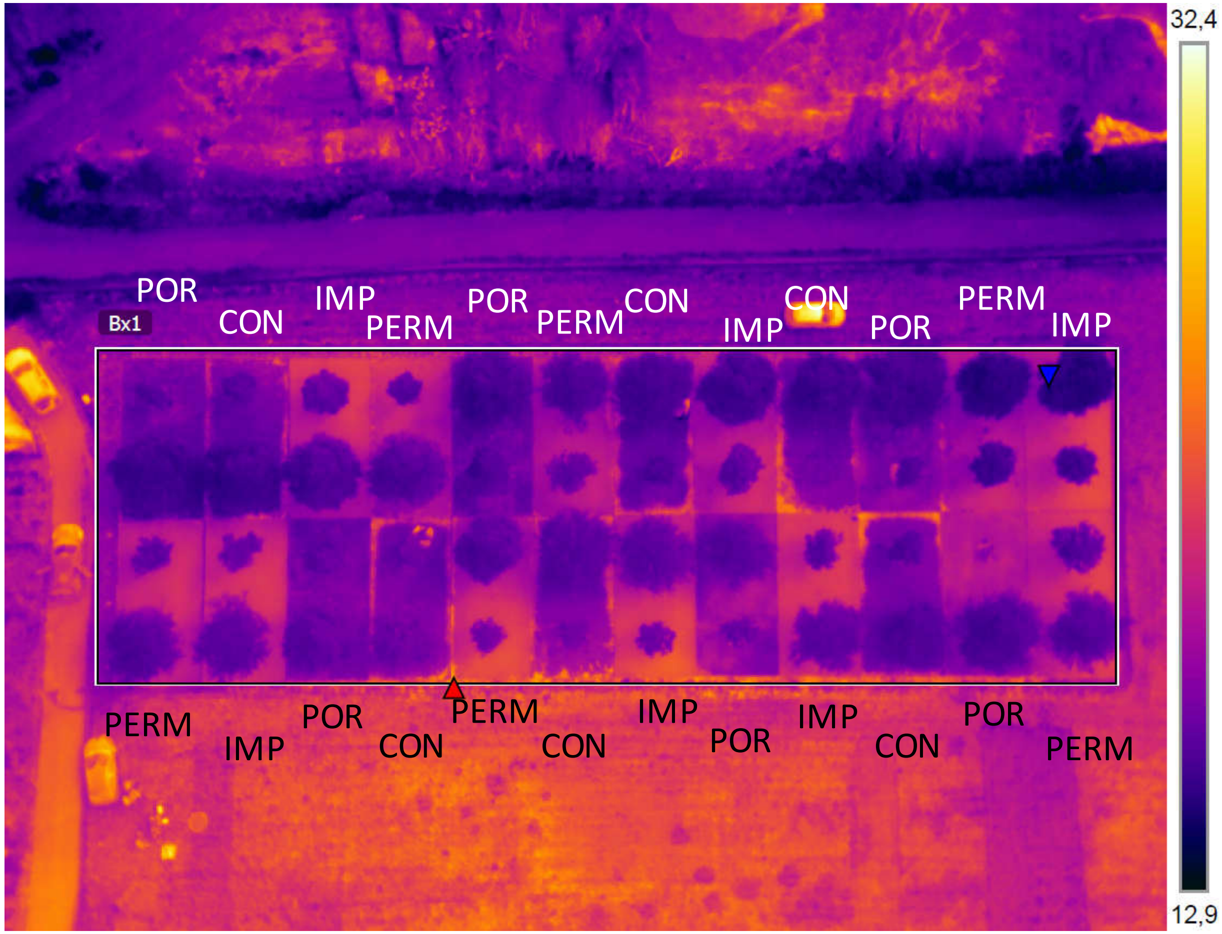
- Minor effects of pavements on DBH growth, canopy growth and leaf area were detected
- Growth-rate was about 3.5 times higher in Celtis than in Fraxinus

Conclusions

- Despite pavements affected moisture availability and root characteristics, trees (Celtis in particular) were extremely plastic to pavement type and showed little change in above-ground growth and physiology.

- From the tree's perspective, growing in a high-quality soil probably matters more than the pavement itself.

UAV with thermal and multispectral camera flying on the pavements



- Impermeable pavements affect water and carbon cycling, which can be effectively mitigated by the use of porous pavements

This research was funded by the **TREE Fund Research Fellowship Grant Program** "Long-term assessment of the effects of impervious, permeable, and porous pavements on the underlying soil and on established trees",

Research Fellowship Grant Program

TREE FUND
Cultivating Innovation

Funding:
100'000 USD

Thank you for your attention

Concentrazione di CO2 in suoli pavimentati (pre-establishment)