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Coarse and fine root development of street-tree species in different planting soil substrate

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Climate change increases the pressure on urban street trees by limited soil-water availability during extended heat and dry summer periods. Young and freshly planted trees are particularly affected by soil drought since their root system is not well developed and spatially limited to the volume of the initial root ball. The vitality and survival of these trees is strongly dependent on their ability to quickly exploit a larger rooting zone.

To investigate early tree development and root growth, we established a field trial in a tree nursery within the metropolitan region of Hamburg, Germany. Three tree species (*Amelanchier lamarckii*, *Quercus cerris* and *Tilia cordata* ‚Greenspire') were grown in two soil substrates (loam, sand) in five replicates. After three years, we excavated a defined soil volume radially from each tree trunk, and determined root biomass (coarse > 2 mm, and fine < 2 mm diameter) in three distances and three depths. Results were compared to species-specific allometric equations, derived from stem diameter measurements.

While no overall substrate effect appeared for total root biomass, the average fine-root biomass between all species was 59% higher in loam compared to sand. Species wise, *A. lamarckii* showed 68% lower total root biomass and a lower root spread in sand substrate, compared to loam. This was mainly related to the near complete absence of *A. lamarckii*'s coarse roots in sand. In contrast *Q. cerris* developed larger root biomass in sand substrate, particularly in form of deep fine roots, with a maximum in 60-90 cm depth. This was not reflected in the allometric equation (r = -0.8), indicating a shift in belowground carbon allocation under water stress. Compared to the restricted root system of *A. lamarckii* and the deep roots of *Q. cerris*, *T. cordata* formed an extensive fine root system, with a reduced fine root abundance in sand substrate.

We conclude that the rooting-zone exploitation in planting pits is strongly affected by soil substrate and differs between tree species. Particularly Q. cerris invests in a large deep rooting system under enhanced water stress (i.e. in sand substrate), which is not reflected by common allometric equation methods. Ensuring a healthy urban tree population under climate change, therefore requires the combined consideration of adaptive tree species and present urban soil substrates for new tree plantings.