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Tree surface temperature in an urban environment

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ABSTRACT

Trees are essential in a dense urban environment not only because of their aesthetic value, but also for their cooling effect during hot periods, which impacts directly on the local microclimate. However, certain trees cope better with high urban temperatures than others. Here, we report tree crown temperatures of 10 common tree species frequently planted in Central European cities (in part, supplemented with stomatal conductance data, g_s). Parts of the city of Basel, Switzerland (7°41′E/47 °34′N) were scanned from a helicopter using a high-resolution thermal camera. A histogram of the composite image shows peaks at 18 °C (water), 26 °C (vegetation), 37 °C (streets) and a less obvious one at 45 °C (roofs). At an ambient temperature of c. 25 °C, tree crown temperatures ranged from c. 24 °C (*Aesculus hippocastanum* trees located in a park) to 29 °C in *Acer platanoides* trees, located in a street. Trees in parks were significantly cooler (c. 26 °C) than trees surrounded by sealed ground (c. 27 °C). The only coniferous species, *Pinus sylvestris* did not vary in temperature with location (park or street) and exhibited foliage temperature close to air temperature. Generally, small-leaved trees remained cooler than large-leaved trees. Stomatal conductance data collected during similar weather conditions suggest that there was no bias in crown temperatures due to locally different water supply between trees. Although the highest leaf temperatures of individuals of *A. platanoides* reached over 5 K leaf-to-air temperature difference (ΔT_{L-A}), we do not expect temperature stress to occur in these conditions. In order to estimate possible effects of future temperature extremes on ΔT_{L-A}, we evaluated the leaf energy balance for a range of stomatal responses and air temperatures, using leaf size, wind speed and the measured species-specific leaf boundary layer resistance. At an ambient temperature of 40 °C, ΔT_{L-A} ranged from 2 to 5 K when g_s was assumed to drop linearly to 50% of its maximum value. When g_s was compromised further (20% of species-specific maxima), the difference in ΔT_{L-A} between species became larger with rising ambient temperature (range 4–10 K). Those species with the lowest leaf temperatures at 25 °C were not necessarily coolest at 40 °C. Species-specific differences in ΔT_{L-A} under extreme temperatures as shown here may be useful for urban tree planning in order to optimise management cost and human comfort.

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