Species-specific effects of the Urban Heat Island on tree growth across Berlin

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Abstract

This document serves as a brief overview and outline .

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1 Introduction

Berlin is subject to the most intense Urban Heat Island in Germany due to its large extent and development intensity (Kuttler et al., 2015). Here, substantially higher temperatures have been observed for urban as compared to rural areas, with differences of up to 12 K during day-time and 6 K on average for night-time temperatures (2001-2010, Fenner et al., 2014).

Consequently, urban green (infrastructure) systems are subjected to increased heat more frequently than rural ecosystems, potentially affecting their process dynamics positively or adversely. Their performance and health, however, is closely tied to local energy budgets (Grimmond et al., 1996 ; Hertel and Schlink, 2019), which in turn are decisive for controlling human wellbeing (e.g. Maras et al., 2016), amongst other factors. Assessing the effect of increased temperatures on green infrastructure, as part of the urban landscape, is therefore instrumental for understanding, and ultimately mitigating, the potential impact of future warming and (continued) development on increasingly urban societies (Norton et al., 2015).

Trees, in particular, provide shading as well as transpirative cooling in their vicinity (Gillner et al., 2015; Oke, 1982), and therefore can reduce ambient temperatures, infrastructure power-consumption and (human) thermal discomfort (e.g. Gulyás et al., 2006; Akbari et al., 2001; Hoyano, 1988; Mayer and Höppe, 1987);

simultaneously, they provide numerous other environmental, cultural and psychological services and/or benefits (see Tzoulas et al., 2007 for review).

Tree growth dynamics in urban areas are modulated by air temperature, amongst other factors, with a tendency for enhanced growth rates (compared to rural individuals) as reported by Zhao et al. (2016) and Pretzsch et al. (2017). Hence, temperature increases may also allow using recent tree growth dynamics and trajectories as a proxy for on-going and future warming, providing an additional line of evidence to support the growing knowledge base on future climate- and human-vegetation and dynamics (Zhao et al., 2016). For Berlin, Dahlhausen et al. (2018), showed divergent patterns for young and old trees dependent on urban development intensity for *Tilia cordata* Mill, the most abundant tree of the city, but overall reported an increased growth rate which they attributed to the urban heat island effect (UHI). Similarly, Moser-Reischl et al. (2019) showed positive associations between air temperature and radial growth for two species commonly selected by urban planners (*T. cordata*, *Rubinia pseudoacacia*) in Munich. By contrast, Gillner et al. (2014) highlight decreased growth for *Acer* species (*A. platanoides* and *pseudoplatanus*), *Platanus x hispanica* and *Quercus rubra* with higher summer temperatures of the preceding year, especially when compounded with drought, in another German metropolis (Dresden). **In the future.. drought, both soil moisture and atmospheric drought.. potential issue for street trees .. (Brune, 2016) ??** (Zhao et al., 2016) and (Jia et al., 2018) direction. . . ..

These results indicate a high degree of complexity in effect sizes and directions specific to species and locality. Tree growth in urban settings is affected by other processes and factors, such as water availability, pollution and road-salt loading, structural impedance through infrastructure or management, etc. (Pauleit et al., 2002; Quigley, 2004; Randrup et al., 2001; Rhoades and Stipes, 1999). While multiple (locally) important species have been assessed along urban and UHI gradients reflecting a range of conditions, studies reliant on labour-intensive methods are limited logistically by sampling effort, reducing sample size and coverage (i.e. genera and/or species, and space). This typically hinders the extrapolation from individual sampling sites toward prediction of effect sizes across entire urban areas and tree stocks.

To complement detailed dendroecological analyses in Berlin for key species, we propose inferring growth modulation from a large data set in excess of 650000 individual trees provided by the Berlin Senate Administration (Senatsverwaltung). This data set contains information on location, species, trunk diameter (at breast height; DBH), and height, amongst other variables. In a space-for-time substitution, the absolute growth potential of species can be assessed across the entire urban area, and related to effects of the UHI, while accounting for other location-specific factors, such as street characteristics, development intensity, available soil volume, etc. (Quigley, 2004) .. inferred absolute growth potential for species across demographic strata

2 Background

3 Methods

4 Results

Some results

Figure **??** shows how we can have a caption and cross-reference for a plot

5 Discussion

6 Conclusion

7 Acknowledgements

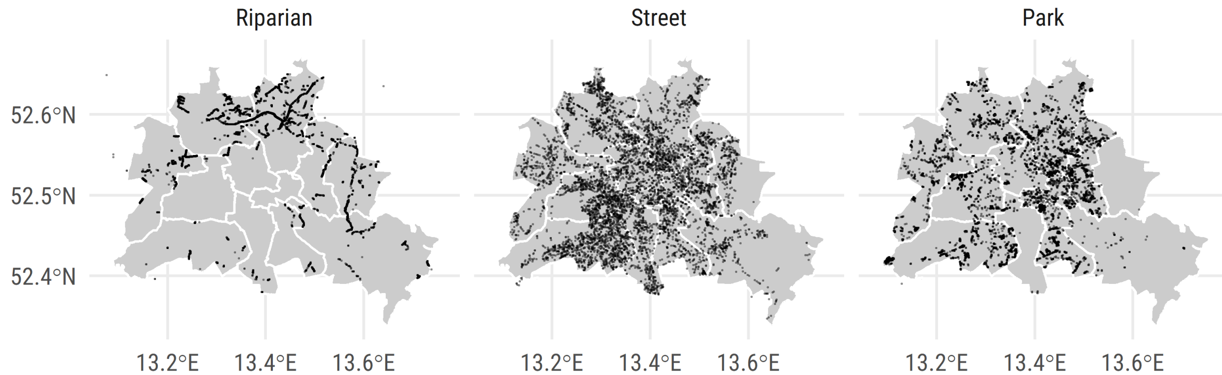

Figure 1: A plot of random numbers

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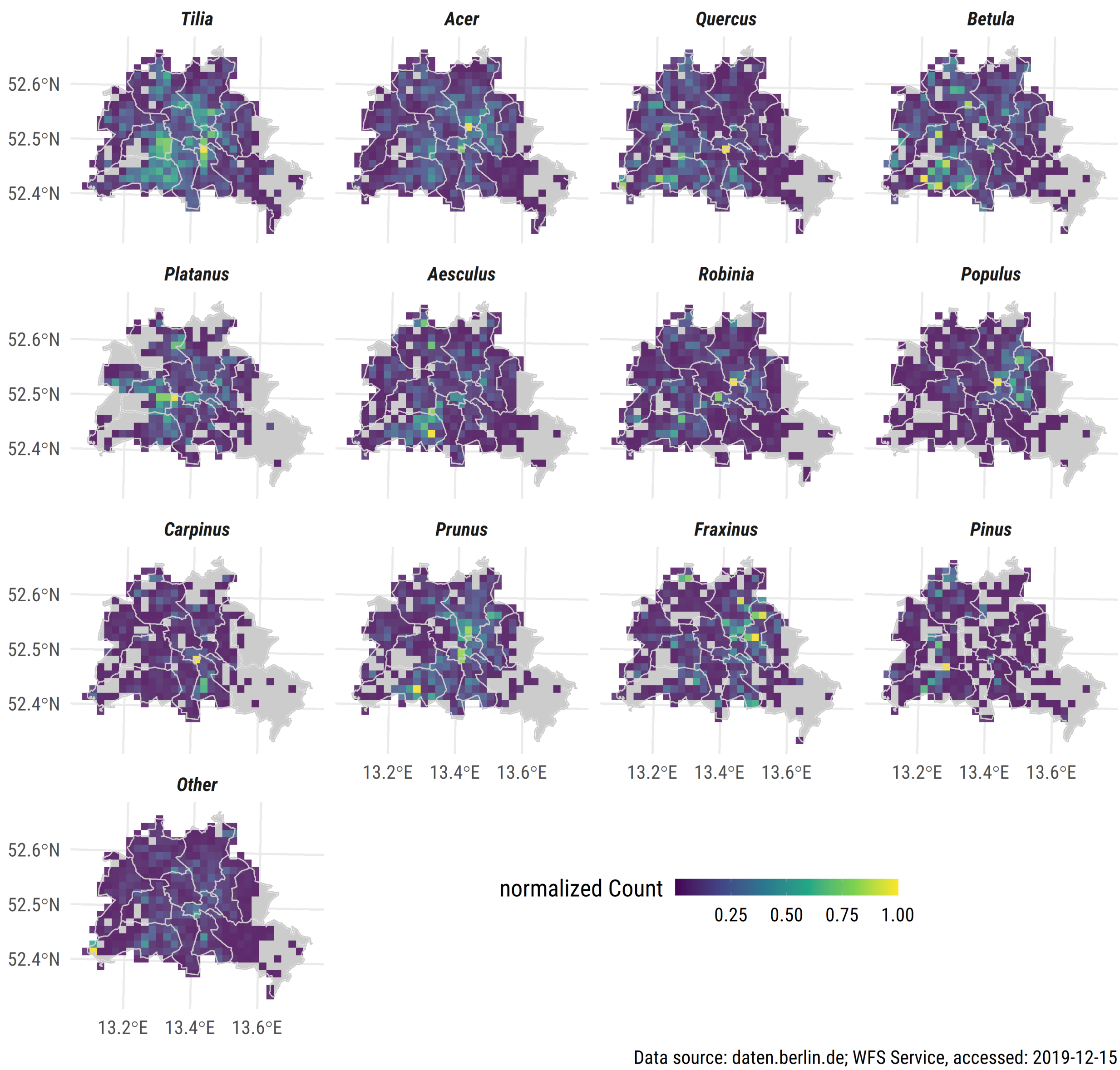

Figure 2: A plot of random numbers

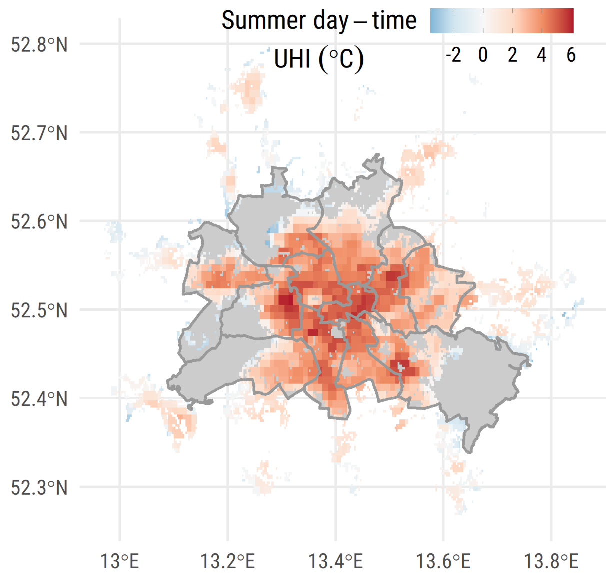

Figure 3: A plot of random numbers

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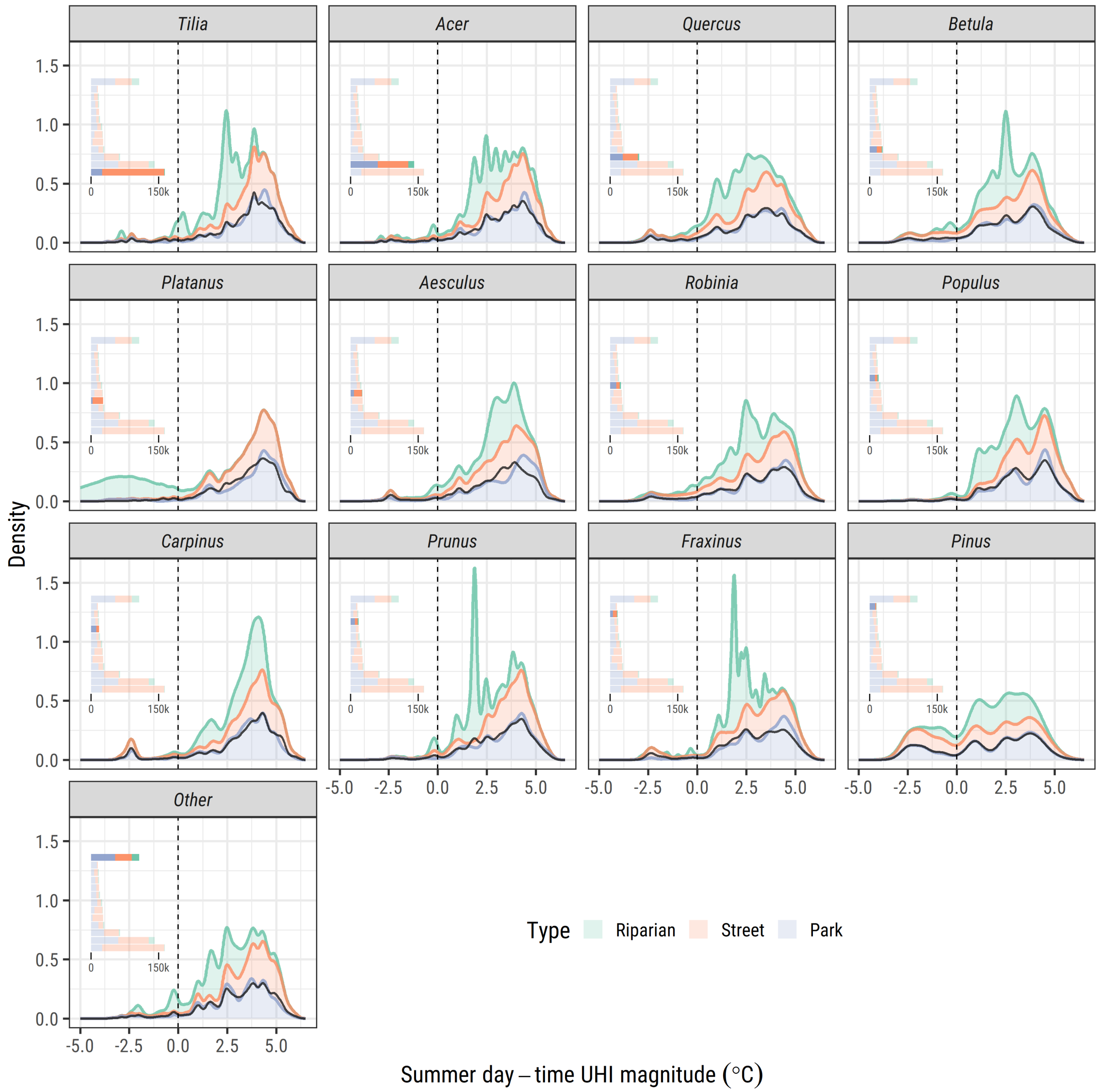

Figure 4: A plot of random numbers

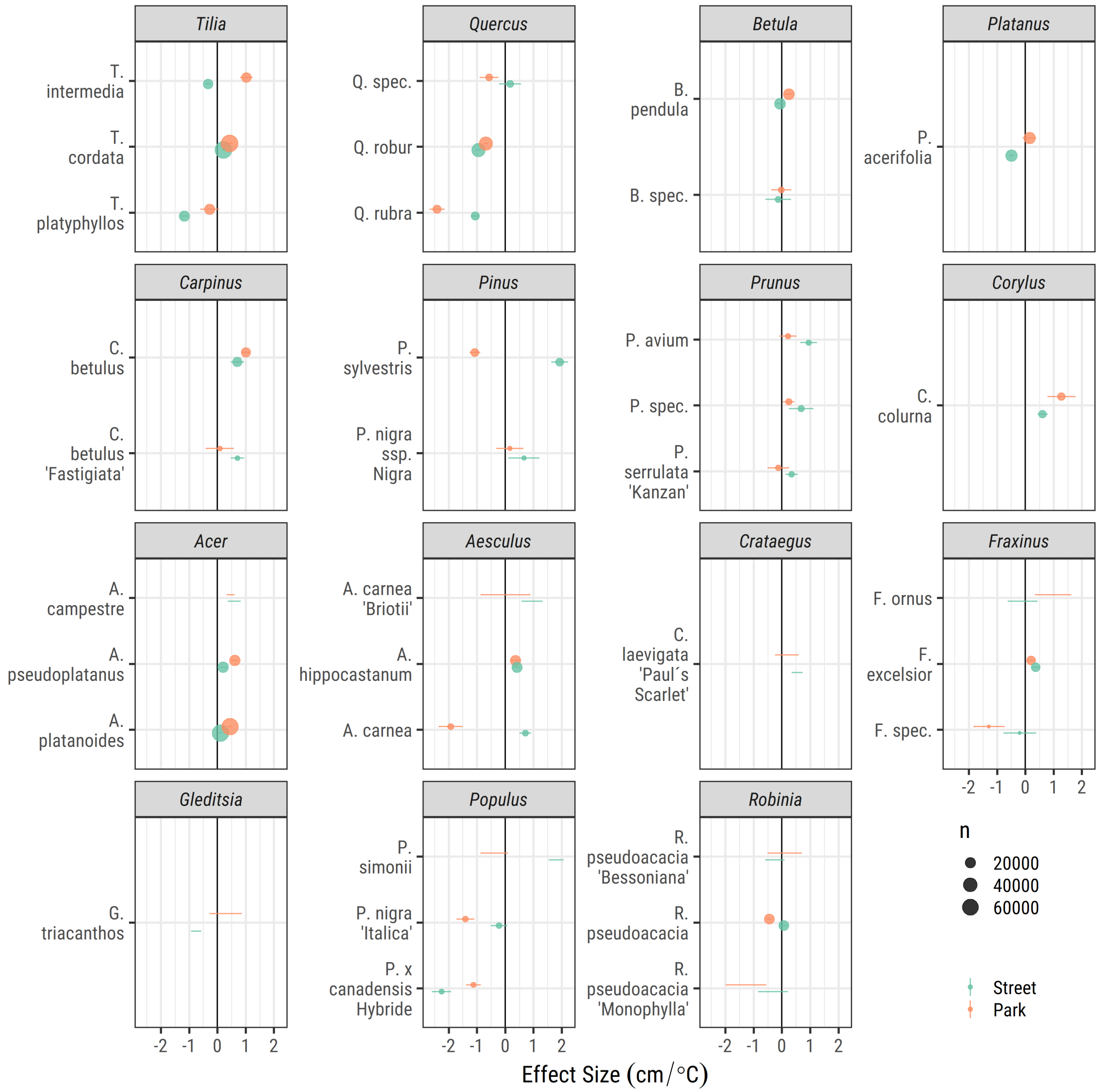

Figure 5: A plot of random numbers

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8.0.1 Colophon

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