Plant invasions along rural-to-urban gradients: different emerging patterns at different scales

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Besides their present or future detrimental effects on ecosystems, alien plant invasions represent opportunities to understand the processes associated with range expansion and colonization of novel environments. In western Europe, cities display warmer and drier conditions then the temperate climate of rural areas. Urban-to-rural gradients thus exhibit climatic variations at scales ranging from kilometers to meter, due to the urban heat island effects and microclimatic effects. Here is a synthesis of studies performed between 2018 and 2021 about the patterns of plant invasions along rural-to-urban gradients, at different ecological and spatial scales .

Two main patterns clearly emerged:

Pattern 1 - alien species from warmer native ranges were more often found in urban areas, whereas alien species from colder ranges were more rural (FIGURE 1; FIGURE 3)

Pattern 2 - trait variation along the gradients was mainly due to very small-scale variations in environmental conditions, in particular light availability. (FIGURE 2)

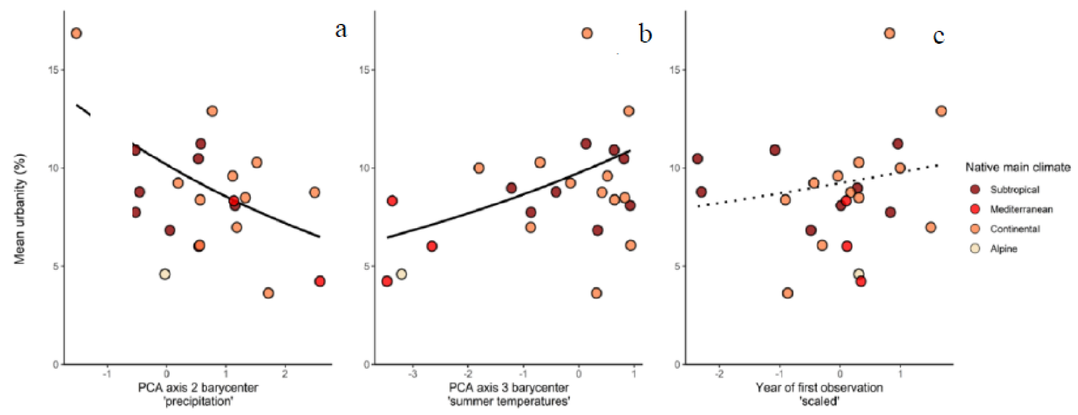

FIGURE 1 Mean urbanity (in %) of the studied alien plant species as a function of their native range barycenter calculated for the three first dimensions of the PCA conducted with WorldClim bioclimatic predictors. Mean urbanity of alien plant species as a function of: a) the barycenter of a species for PCA axis 2, mainly associated with the bioclimatic predictors of "precipitation" with high values indicating more precipitation; b) the barycenter of a species for PCA axis 3, mainly associated with the bioclimatic predictors of "summer temperature" with high values indicating higher temperatures, and c) the scaled year of first observation in the wild, ranging from 1683 (low values) to 2008 (high values). Each point corresponds to a species, colored following the main Köppen-Geiger climate class in which it was observed the most in its modelled native range. Lines correspond to the averaged model output (predicted mean urbanity, %) in oceanic Europe. Full lines correspond to significant effects in the full averaged model, and dashed line corresponds to a non-significant effect in the full averaged model.

"Warm" group

Ailanthus altissima, Buddleja davidii, Paulownia tomentosa, Senecio inaequidens

"Cool" group:

Berberis aquifolium, Cornus sericea, Prunus laurocerasus, Symphoricarpos albus.

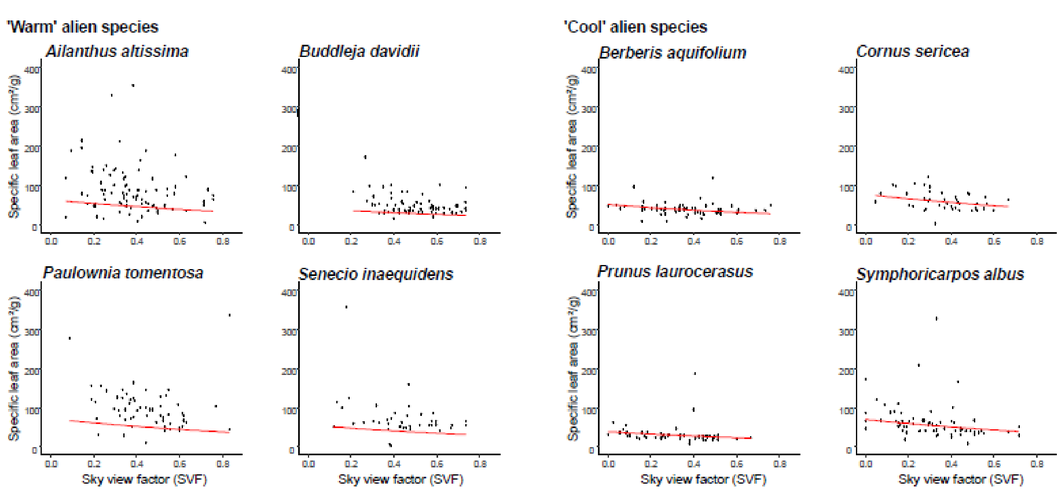

FIGURE 2. Specific leaf area (SLA) as a function of the sky view factor (SVF, measured at the individual) for each of the alien plant species either from the "Warm" or the "Cool" native climate group. Measured values are represented by the black dots, and the modelled trends are in red.

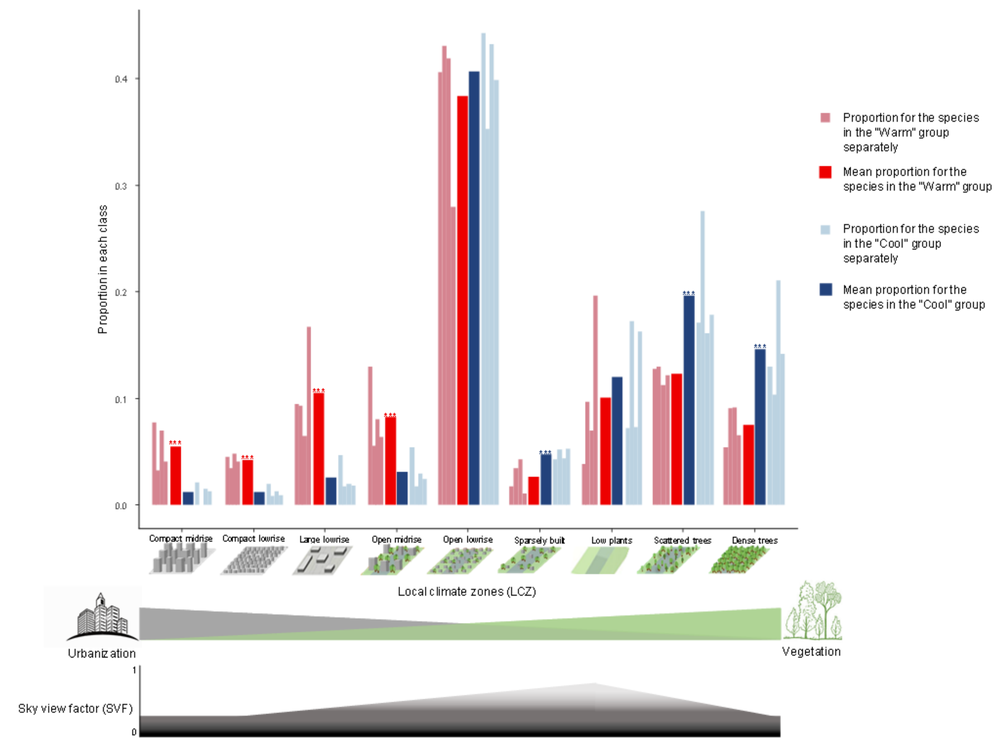

FIGURE 3. Proportion of each woody alien plant species, and mean proportion of the species per "Warm" (red) or "Cool" (blue) native climate group in function of the local climate zones (LCZ) in which they grow in oceanic Europe. Proportion bars are organized as follows: *A. altissima*, *B. davidii*, *P. tomentosa* and *S. inaequidens* from the "Warm" native climate group are represented in this order by the light red bars, the bright red bar represents the mean "Warm" native climate group proportion; *B. aquifolium*, *C. sericea*, *P. laurocerasus* and *S. albus* from the "Cool" native climate group are represented in this order by the light blue bars, the dark blue bar represents the mean "Cool" native climate group proportion. The mean proportions that are significantly higher for one of the two groups in comparison to the other one as tested with a 2-sample proportion z test, are marked with the following code: *** = p < 0.001; ** = p < 0.01; * = p < 0.05, in the color of the one that is higher.

Functional trait variation along gradients was similar for species from both warmer and colder native ranges, despite they distribute differentially. In addition, a third pattern (not shown here) was that no evidence was found for local adaptation to urban conditions but environmental maternal effects and phenotypic plasticity were key in the response to urban conditions. Each pattern emerged at a given scale, and linking the patterns highlights the difficulty to combine different scales in ecology…