Native tree regeneration in urban forest restoration is constrained by herbaceous weeds and microclimatic instability

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Restoring forest structure, composition and function is an important component of urban land management, but we lack a clear understanding of the mechanisms driving native tree regeneration beneath the original planted forest canopy. We hypothesized that light availability, competition with non-native weeds, and microclimate mediate the establishment of the next generation of native trees in restored forests. We investigated relationships between environmental conditions and the plant community in 27 restored urban forests spanning 3 to 70 years in age and in both unrestored and remnant urban forests and used structural equation modelling to determine the direct and indirect drivers of native tree regeneration in the restored forests. Compared to remnant forest, unrestored forest had significantly more light reaching the forest floor annually, non-native weed cover was greater, and there was marginally less native tree regeneration. In restored forests, light transmission through the canopy was reduced to levels found in remnant forests within 20 years of planting, and shortly thereafter herbaceous non-native weeds in the understorey declined and soil temperatures stabilised. Contrary to expectations, light availability was not a direct driver of tree regeneration, but canopy openness did regulate weed cover and soil temperature variation, which were the key drivers of native tree seedling regeneration. These results imply that native tree regeneration in restored urban forests can be understood within a succession theory framework. We also conclude that unrestored urban forests do not provide conditions for native tree regeneration. We recommend that urban restoration plantings be designed to promote rapid canopy closure. This will reduce light and stabilize soil temperatures for native tree regeneration and ensure initial planting efforts lead to resilient and enduring urban forests.