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Local gardening practices shape urban lawn floristic communities

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ABSTRACT

The large number of green space lawns in cities means that they shelter a high proportion of wild urban species, but the roles of landscape and management on the level of biodiversity in these spaces are little understood. We performed floristic inventories in 100 lawns in the southeast corner of Paris, France and linked their floristic diversity and composition to: (1) the characteristics of urbanization given by the Land Use Pattern and the distance from the centre of Paris, (2) local factors including luminosity and size of the lawn and (3) the type of management, including pesticide and fertilizer use, animal and public access, and mowing frequency. A total of 79 species were identified, of which 9% were naturalized. Distribution of the species was largely conditioned by the management methods applied to the green spaces: specific management strategies were associated with specific community traits and composition. As expected, the highest species richness and/or rarity were found in lawns submitted to private management, low use of pesticides and limited public access. But surprisingly high diversity was also sometimes found in small public lawns. The results establish relationships between human practices and characteristics of plant communities. We use them to make several recommendations on how best to optimize management of lawns with a view to conserving urban biodiversity.

1. Introduction

Currently more than 70% of people from developed countries live in cities (United Nations, 2008). This large-scale human colonization has created, on a local level, fierce competition for space and a growing threat to wildlife (Ding, Reardon, Wu, Zheng, & Fu, 2006; Pautasso, 2007). Although subject to the consequences of very dense human populations, urban areas are becoming an increasingly important refuge for biodiversity compared to other anthropized land types such as intensively farmed areas (Goddard, Dougill, & Benton, 2009; Von der Lippe & Kowarik, 2008). Among the habitats found in cities, a high proportion of vegetal urban space consists of lawns (Attwell, 2000; Muratet et al., 2008; Stewart et al., 2009; Zipperer & Zipperer, 1992), which therefore share a large part of the urban biodiversity.

Given their number and their cumulative surface, lawns certainly play an important role in the dynamics of urban plant populations and especially in landscape connectivity. Indeed, Dearborn and Kark (2010) demonstrated their role as corridors or stepping-stones for gene flow between nearby populations. In addition, Roberts, Ayre, and Whelan (2007) showed that lawns help to increase the distribution and size of rare plant populations, notably by re-establishing genetic connectivity with isolated populations or by maintaining genetic variation lost from natural areas. Altogether, these studies highlighted the importance of lawn habitats in reducing population extinctions due to urban fragmentation.

Even if they are small and frequently disturbed, these green spaces can provide crucially important ecosystem services in the urban context (Beard & Green, 1994; Dearborn & Kark, 2010). Lawns are useful for intercepting and infiltrating stormwater, reducing runoff and diluting numerous pollutants that run off impervious surfaces (Mueller & Thompson, 2009). Thanks to their dense biomass and root system they are efficient at controlling soil erosion (Gross, Angle, Hill, & Welterlen, 1991) and are able to absorb violent sounds much better than hard surfaces (Robinette, 1972). According to Golubiewski (2006), urban lawns are capable of storing far more C pools than native grasslands or agricultural fields, all the more when fertilization and irrigation are performed (Zirkle, Lal, & Augustin, 2011) and act as an important sink for atmospheric N deposition when management is of low to moderate intensity (Raciti, Groffman, & Fahey, 2008). Finally, lawns can provide resources for small mammals and invertebrates and contain a significant number of groups that interact with plants (*e.g.* pollinators, pest-control species, seed dispersers). This is increasingly important in cities given the growing interest in small-scale urban agriculture (Mendes, Balmer, Kaethler, & Rhoads, 2008).

Furthermore studies have shown how green spaces make an important contribution to human well-being, in terms of aesthetic beauty, physical and mental health (Irvine et al., 2010; Ulrich,

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1984), recreation and sociability (Adams, 2005). People frequenting green areas apparently not only perceive different levels of species richness but also benefit psychologically from the plant, butterfly and bird diversity (Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007).

Contrary to other habitats that are less accessible to citizens (*i.e.* industrial land, waste land, private gardens), urban green spaces – mostly lawns – represent one of the only opportunities for city dwellers to connect with nature (Miller, 2005) and for many people offer a unique introduction to environmental processes and conservation (Dearborn & Kark, 2010).

However, mainly for aesthetic reasons, these green spaces are sometimes intensively managed (frequently mowed and highly treated), leading to additional management costs (Caceres, Bigelow, & Richmond, 2010), serious threats to human health (Alumai, Salminen, Richmond, Cardina, & Grewal, 2009; Pimentel, 2005; Steingraber, 2002) and the environment (Byrne, 2005; Byrne & Bruns, 2004; Colborn & Short, 1999). Despite their potentially high ecological, educational and research benefits, urban lawns are still poorly studied ecosystems. The effects of mechanical and chemical management on their biodiversity remain thus barely studied (Robbins & Birkenholtz, 2003). Given the high number of small lawns and the wide variety of human practices applied on them, studying this habitat is an opportunity to examine how plant communities are constituted and how they are modified by anthropic disturbances from taxonomic and functional viewpoints. Furthermore, more knowledge is necessary in order to know how to increase their floristic diversity and favour the maintenance of functional lawn networks in cities.

In this study, we explore the role of lawn management on plant species diversity, composition and traits in 100 urban lawns in Paris, France. In particular, we examined our results with regard to the management initiatives that are required to promote wild species in green areas and thus improve urban biodiversity.

2. Methods

2.1. Study area

Lawn floristic diversity was studied in the southeast corner of Paris (48°51′23.68″N, 2°21′6.58″E) that covers 3 districts and a total area of 16.06 km^2 from the centre to the periphery of the city (Fig. 1). In this area, human density is about 24,000 inhabit./km^2 *i.e.* one of the most densely populated zones of France (INSEE, 2006). The Land Use Pattern provided by the Institute for Planning and Development of the Paris Ile-de-France Region (IAURIF, 2003) shows that open areas cover only 27% of this part of the city (breaking down as 12% parks and gardens, 6% woods, 2% sports areas, 2% water and 5% other open areas). The climate is oceanic with continental trends and the mean annual temperature is 11.7 °C with an annual rainfall of 576.4 mm.

2.2. Sampling design and inventories

A total of 100 lawns belonging to 26 greenspaces were inventoried in the study area (Appendix A). Depending on the greenspace surfaces, two to five lawns were randomly studied per greenspace. In each lawn ten 30 cm × 30 cm quadrats were systematically placed every 50 cm (leading to a total of 0.9 m^2), following a diagonal from the edge to the centre of the lawn. The list of all wild vascular plant taxa was established once in each quadrat during autumn 2007. This single-season sampling did not allow us to estimate the whole diversity present in urban lawns over a year or to evaluate the effect of season and year on floristic diversity (but see Muratet et al., 2009). Regardless, this standardized method

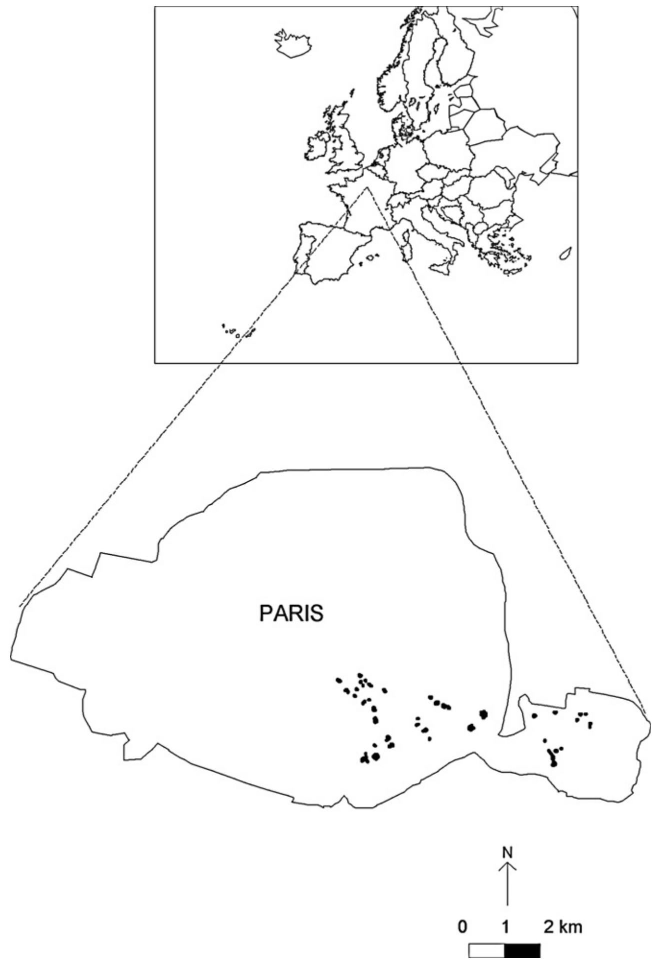

Fig. 1. Location of the study area in Paris. Each polygon corresponds to a studied lawn.

permitted us to have comparable replicates that were sampled at the same time in similar surfaces and that differ only on the local practices applied to them and to the landscape surrounding them.

2.3. Characteristics of the lawns and their surrounding urbanization

Using a geographic information system (MapInfo Corporation, 2008), we calculated the area of each of the inventoried lawns and their distance from the centre of Paris. To characterize the urban environment around lawns we analyzed the Land Use Pattern (LUP, scale = 1:5000, IAURIF, 2003) within a 200 m buffer radius (previously identified as the best radius to detect the influence of urban activity on floristic diversity: Muratet et al., 2008). We calculated the proportion of area occupied by buildings (*vs.* unbuilt areas) in the 200 m radius around each lawn.

Some management and environmental parameters were also recorded for each studied lawn at the local scale *i.e.*: (1) owner type (public *vs.* private), (2) public access (a surrogate of soil compaction) and (3) animal access (both yes *vs.* no), use of (4) fertilizers (yes *vs.* no) and (5) pesticides (regardless of the dose and the type of products) (yes *vs.* no), (6) light (open *vs.* shaded by trees or buildings) and (7) mowing frequency (infrequent = 4–6 times a year; frequent = 12 times a year; and highly frequent = 18–24 times a year; generally, lawns are cut short with export of clippings). This information was provided by the public and private gardeners we interviewed during the inventories (see Appendix A). As this type of self-report data could be associated to several biases, we have chosen not to