



Research Note

From urban lawns to urban meadows: Reduction of mowing frequency increases plant taxonomic, functional and phylogenetic diversity

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A B S T R A C T

In regions where intensive farming is the dominant land use, urban areas are an opportunity for biodiversity conservation. Thence there is an urgent need to promote more biodiversity-friendly cities. Lawns are widely distributed urban habitats which cover important surface in public and private places. However these habitats are currently poor refuges for plant and animal communities due to their intensive management. This study assesses if a reduction in mowing frequency results in a more diverse plant community and changes functional ecological characteristics of urban lawns. We used a quasi-experimental situation resulting from 25 years differentiated management in public green spaces of Rennes (France) to evaluate the effect of reduced mowing frequency on plant taxonomic, functional and phylogenetic diversity. Our results clearly demonstrate that a reduction of mowing frequency induces a dramatic increase in the different components of plant community diversity that results in a switch from urban lawns to urban meadows.

1. Introduction

Urbanization is increasingly considered as both a threat and an opportunity for biodiversity. City development induces a reduction and fragmentation of natural habitats and these negative effects are predicted to increase strongly by 2030, particularly in pantropical areas (Seto, Güneralp, & Hutyra, 2012). On the other hand in regions where intensive farming is the dominant land use such as in Western Europe, cities offer refuges for a large number of species (e.g. Kühn, Brandl, & Klotz, 2004). Moreover urban biodiversity offers other advantages such as opportunities for city dwellers to connect with nature, prevention of “extinction of experience” (Miller, 2005), or improved psychological health (e.g. Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007). These, among other reasons, brought scientists and practitioners to design conservation and restoration projects in urban areas (Dearborn & Kark, 2010).

Among the habitats present in cities worldwide urban grasslands have a great conservation and restoration potential but are still underused (Klaus, 2013). In fact this type of habitat occupies large areas and could represent a great opportunity to increase plant diversity in urban areas. This is particularly important in a context where extensively farmed grasslands are declining, as is the case in Western Europe (Peyraud, Peeters, & De Vliegheer, 2012). In addition to their potential role for plant communities, urban grasslands could also provide resources for animals (e.g. pollinators, insect predators) and play an important role as ecological corridors (see Klaus, 2013 and references therein). However, due to their intensive management, most

grasslands currently found in cities are lawns which host limited diversity and are often dominated by introduced species. Furthermore, nature reconnection is another potential benefit from more biodiverse urban grasslands. Indeed, in contrast to urban habitats such as wastelands or industrial areas, grasslands are widely used by the public for recreational activities (Miller, 2005). Consequently there is an urgent need to develop strategies promoting biodiversity in urban lawns.

Since the early 90's, the city of Rennes (France) has adopted a ‘differentiated management’ approach to urban green spaces (i.e. management varies from one site to another within the city and is environmentally friendly, Aggéri, 2010). In urban grasslands, differentiated management implies to not fertilize nor irrigate, and to adjust mowing frequency to suit the amount and type of use by green spaces by visitors. These management modifications are known to improve the global environmental impact of urban green spaces (see Smetana and Crittenden (2014) for a complete Life Cycle Analysis) but numerous questions persist concerning the effect of these changes on biodiversity as previous studies on urban grasslands management mainly focused on plant species richness and community composition (Bertoncini, Machon, Pavoine, & Muratet, 2012; Rudolph, Velbert, Schwenzfeier, Kleinebecker, & Klaus, 2017).

This study is the first to assess the response of urban grasslands plant communities to differentiated management in terms of taxonomic, functional and phylogenetic diversity. We take advantage of a quasi-experimental situation resulting from 25 years of differentiated management in urban green spaces to study if an easy management measure such as mowing frequency reduction could result in more

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biodiversity friendly urban areas.

2. Methods

2.1. Study site and sampling

The study was conducted in Rennes, a medium sized city (210,000 inhabitants) with a temperate oceanic climate located in north-western France (48°06'N–1°40'W). Public green spaces cover 16% of the city surface and 56% of these public areas are covered by grasslands (i.e. 445 ha). Grasslands selected for this study were originally seeded with *Festuca rubra* and *Lolium perenne*, not fertilized nor irrigated (Rennes parks management staff, pers.com). Mowing frequency varies from 15 to 20 times per year in highly managed grasslands, 7–9 time per year in intermediate and once per year in low managed grasslands. To take into account the 'sampling site effect', we selected only green spaces where at least two of the three mowing frequencies were present, resulting in the selection of six green spaces. The three mowing frequencies were applied in each grasslands every year since 1990 but in 2007 some grasslands mowing frequencies changed. To integrate these changes we included two types of mowing frequency as explanatory variable in our analyses: before and after 2007.

Sampling intensity per green space varied according to their size, and ranged from 10 to 30 plots (see [Appendix A](#)). In May 2016 we randomly sampled 115 plots (3 × 3 m quadrats) at least 20 m apart from each other in grasslands accessible to green spaces users. In each plot we recorded all vascular plant species, their cover (using the Braun-Blanquet abundance scale) and measured soil depth at five points (four corners and center of the quadrat) by pushing a metal stick until reaching a hard layer.

2.2. Taxonomic, functional and phylogenetic diversity

We calculated species richness and Shannon diversity index for each plot (hereafter taxonomic diversity). We based functional diversity (FD) analyses on four functional traits linked to growth, survival and reproduction: specific leaf area, leaf dry matter content, plant height and seed mass (Lavorel & Garnier 2002). All trait data came from the LEDA database (Kleyer et al., 2008). We calculated Functional Richness (FRic) and Functional Divergence (FDiv), which represent respectively the amount filled and the distribution of abundance in the functional multidimensional space (Villéger, Mason, & Mouillot, 2008). We calculated Phylogenetic Diversity (PD) with a phylogeny extracted from the megatree of the Angiosperm Phylogeny Group III (R20120829) using Phylomatic version 3 (<http://phylodiversity.net/phyloomatic/>).

2.3. Statistical analyses

All statistical analyses were performed in the R 3.2.3 environment (R Core Team, 2017).

We studied five response variables (taxonomic richness and diversity, functional richness and diversity, phylogenetic diversity) using model averaging and variance partitioning. For each we evaluated the contribution of nine explanatory variables measured at three spatial scales: green space (age and surface), grassland (age, shape, surface, current and previous 2007 mowing frequency) and plot (proportion of grasslands in a 100 m radius and soil depth, [Table 1](#)). Because of edge effects, plant diversity could be influenced by the grassland's shape, therefore we calculated a shape index ($Shape = \frac{Perimeter}{\sqrt{2 * \pi * Area}}$), a measurement of the edge independent of the grassland surface (Angel, Parent, & Civco, 2010). To evaluate landscape effect we calculated the proportion of grasslands in a 100 m radius around each plot using GIS (Géoportail, www.geoportail.gouv.fr). Because collinearity could induce type I error in regression models we verified its absence by calculating correlation between each explanatory variable ($r < 0.7$,

Table 1

Description, mean and range of explanatory variables used in the models to explain plant taxonomic, functional and phylogenetic diversity.

Variables	Mean	Range
<i>Green space scale</i>		
Age (year)	38.5	15–49
Surface (ha)	36	5–100
<i>Grasslands scale</i>		
Age (year)	28.4	10–46
Shape	1.69	1.16–2.86
Surface (ha)	0.99	0.06–5.37
Mowing frequency		Low, Medium, High
Past mowing frequency		Low, Medium, High
<i>Plot scale</i>		
Grassland proportion in 100 m (%)	37.7	15.4–86.5
Soil depth (cm)	29.6	7–58.4

Appendix B).

We determined the explanatory variables and their relative importance in a two-step procedure. First we used model averaging methodology (package MuMIn, [Barton, 2016](#)) in order to avoid problems inherent to model selection process ([Burnham & Anderson, 2002](#)). For each dependent variable we fitted all possible models, ranked them on the AICc basis and averaged the parameters of the 95% confidence set weighted by Akaike weights. Explanatory variables that did not overlap with zero were considered significant. Finally, we calculated the percentage of explained variance of the most parsimonious model (i.e. smallest AIC). We also determined the proportion of variance explained independently by each explanatory variable considered as significant using hierarchical partitioning approach ([Chevan & Sutherland, 1991](#); [Walsh & Mac, 2013](#)).

We studied the effect of mowing frequency on β diversity by calculating Jaccard dissimilarity distance between each plot. We tested the difference among the three mowing frequency category by comparing the multivariate homogeneity of variances (i.e. ANOVA and post-hoc Tukey test on variance of distances between plots and group centroids).

We identified the indicator species for each mowing frequency category following the [Dufrene and Legendre \(1997\)](#) methodology with 9999 randomizations (package labdsv, [Roberts, 2016](#)). To reduce multiple testing we only considered species found in more than 5 plots in each modality. Moreover we applied a Bonferroni correction for multiple testing resulting in a significance level of 0.001 (0.05/47 species tested).

3. Results & discussion

In the 115 studied plots we found 81 vascular plant species belonging to 22 families. One of them (*Aesculus hippocastanum*) is an introduced species and was present in only one plot. This very low presence of introduced species contrasts with the situation on other continents where the proportion of introduced species in urban grassland could reach 95% ([Stewart et al., 2009](#); [Fischer, Rodorff, von der Lippe, & Kowarik, 2016](#)).

Overall our models explain more than 50% of variance for taxonomic, functional and phylogenetic diversity ([Table 2](#)). The more important variables are those at the 'grassland' scale, those at the 'green space' and 'plot' scale playing only a marginal role ([Table 2](#)). Indeed, before and after 2007 mowing modality are the main determinant of the components of diversity we evaluated, except for functional divergence ([Table 2](#), [Fig. 1](#)). Reduced mowing frequency also increased β diversity ([Fig. 2](#)).

The low mowing frequency category presents a higher plant diversity compared to the high mowing frequency grasslands (from +15% up to 62%, [Fig. 1](#)). This result and the strong dissimilarity of their species composition between plots, could be explained by the

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