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Article

Linking Plant Diversity and Urban Uses at the City-Block Scale to Inform Urban Planning

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Abstract: A challenge for urban ecology is to reduce biotic homogenisation by promoting plant diversity from local to city scales. As ecological and social components constantly interact in cities, an urban landscape characterisation reflecting socio-spatial functioning seems essential. However, spatially explicit description of cities at a relevant scale for urban planning are uncommon in ecological studies. Here, we explored a new approach based on the city-block scale, common in urban geography and planning, to directly link urban uses and patterns of herbaceous plant communities. We characterised all city blocks of a medium-sized French city (Blois). We inventoried grassland and meadows in 129 city blocks (10% of the whole city) for seven public and private urban uses (collective housing, individual housing, industrial, public service, park, land reserve, and road verge). We measured alpha diversity, community composition, regional originality of urban uses, and beta diversity between them. Urban land reserved for future development and parks harbour unique community composition within the city. Collective and individual housings have the same average alpha diversity, but the variability in community composition was higher for individual housing blocks. School and industrial city blocks have important alpha diversity and regional originality. Road verges have the highest alpha diversity but low regional originality and many common urban and regional species. Large green spaces with original communities should be protected during urban densification. The verticalization of residential housing could be an efficient means of internal urban densification if the lowest level of management intensity is promoted to maintain diversified vegetation. Some little-studied uses (schools, industrial city blocks) present opportunities to impede urban homogenisation.

Keywords: gamma diversity; lawn; mowing; private garden; urbanisation; urban management; urban practitioners



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1. Introduction

Urban landscapes have important global effects on plant communities by filtering species adapted to urban abiotic conditions and human activities from the regional pool [1,2]. Even though cities can serve as refuges for rare species [3], urban filters tend to be relatively uniform on a large scale, and participate in an overall homogenisation of floristic

diversity, particularly for native species [4,5]. However, cities are not homogeneous, and some urban spaces with singular abiotic conditions and moderate levels of management can favour varied plant communities [6,7]. Therefore, these urban spaces can be seen as an opportunity to promote urban biodiversity from local to city scales. As urbanization is an ongoing process contributing to the destruction of natural habitats and associated species, designing a biodiverse city could help mitigate this negative effect. In addition, as the majority of humanity now lives in urban areas, human–nature relationships are reduced [8], with negative consequences for human health [9] and humans’ willingness to protect nature [10]. Therefore, biodiverse cities could favour daily interaction between human and non-human beings and have positive outcomes for both. A challenge for urban ecology is to identify urban spaces promoting urban biodiversity and underline their potential, especially to urban planners. As ecological and social components are constantly interacting in the city, integrating relevant social parameters such as urban uses in ecological approaches is required to fully understand community patterns and make conservation recommendations operational [11].

Several approaches have been used to analyse intra-city plant diversity, but their intersection with urban uses and their relevance to urban planning remain limited. Indeed, most city-scale studies approach urban landscapes through urban gradients [12] or coarse land use classifications by comparing “urban”, “peri-urban”, and “rural” biodiversity (80% of studies [13]), and do not consider urban socio-spatial heterogeneity. However, as plants’ distribution, as well as the composition and functional diversity of plant communities respond to different built-up areas in cities [14–16], more refined urban descriptions seem to be useful. For example, the composition and richness of plant communities vary between urban habitat types in 32 European cities [7]. Some other studies also interested in the differences in plant diversity between urban uses exploited ecological data collected in grids and at spatial scales that do not match social, management, and urban planning levels [17,18]. Local studies conducted at the parcel scale (i.e., garden or park) investigate links between plant communities and management practices [19], as well as local abiotic conditions [20], making it difficult to draw recommendations at supra-parcel levels of urban organisation. To better understand social–ecological relationships in urban landscapes and ease the dialogue between ecologists and urban planners, it is of high importance to adopt an urban analysis approach that considers the wide variety of urban uses and enables links between ecological patterns and urban planning from the local to city scale.

The city block, defined as the smallest group of buildings surrounded by roads, is an urban organisation level intermediate between parcel and neighbourhood, largely used in geography and planning [21,22]. The city block can serve to understand the still relatively unknown links between urban uses and biological communities [23]. From an urban perspective, each city block can be seen as a combination of a particular morphology of built and open spaces and social uses associated with public or private owners [21,24]. Urban use can therefore be defined as the combination of these morphologies and social use. From an ecological perspective, each city block is an arrangement of ecological habitats and soil types, with singular management practices. At the city scale, diverse city blocks can be grouped by type of urban use, inherited from the history of city development. European city centre blocks inherited from the Middle Ages are compact, comprising small buildings, stores, and limited open spaces. From the 19th century onwards, new urban morphologies appeared, adapted to increasing urban demographics, new lifestyles, and car use [25]. Mass housing estates, promoted in the 1960s [26], are made up of bars or towers, and are often associated with public green spaces managed by municipalities [27]. Private home ownership—blocks of detached houses with enclosed gardens—has been spreading since the 1960s in Europe [28] and the USA [29]. At the edges of cities, commercial

and industrial blocks have been developing since the 1970s [30]. Well connected by road networks, these blocks are made up of large buildings, extensive parking lots, and green spaces of varying size. In addition to these built blocks, other scattered urban elements complete the complexity of urban landscapes, such as public services, parks, roadsides, and land reserved for future development. To plan cities and simultaneously promote urban plant diversity requires understanding how plant communities are influenced by different urban uses, some of which are little studied in ecology (e.g., industrial, collective housing). In particular, it is important to know which urban uses promote local plant diversity and help to increase diversity on a citywide scale.

The descriptions of urban and intra-urban diversity are complex, and different measures are required. The biodiversity of urban areas can be broken down into different components, corresponding to the diversity of the local pools composing the city. The diversity of a specific site within a studied area is the alpha diversity. In an urban study interested in the variation in biodiversity between urban sites, the alpha diversity would be the diversity of each use considered. A very common measure of alpha diversity is species richness [13], i.e., the number of different species within a site. But from one site to another, beyond the difference in the number of species, variations in community compositions (i.e., species identities) could arise, constituting beta diversity. In urban areas, beta diversity is the result of differences in species number, abundance, or identity from one use to another [31]. Two processes underpin beta diversity: species turnover, i.e., the replacement of some species at one site by different species from another site, and species nestedness, i.e., the loss of some species from one site to another [32]. An urban use with important differences in beta-diversity (i.e., species composition) compare to other urban uses could be seen as original at the urban scale, by harbouring species not or rarely encountered in other uses. The alpha and beta diversities together form gamma diversity, which is the overall diversity of the entire city. Finally, the diversity of the studied city depends on the regional pool of species encompassing it. Based on this interdependency, information about the rarity of species based on the frequency of the species on a regional scale can be used locally. In this way, an index of community regional originality can be calculated for each inventoried site. Together, these measures of biodiversity (alpha diversity, beta diversity and its underpinning processes, regional rarity) provide a complete picture of urban biodiversity and its various components. This makes it possible to link diversity to urban uses and identify those that are original on an urban or regional scale, offering the possibility of urban biotic homogenization.

Establishing this link between biological communities and urban uses is particularly useful in the current European debate on urban densification ('No net land take' legislative objective [33]), where the aim is to limit the artificialisation of non-urban land by limiting the expansion of cities within their existing limits. In this frame, the internal densification of cities implies changes in the amount and configuration of urban uses, especially urban green spaces (such as private gardens and urban land reserves), which are regarded as already artificialized [34]. For example, the verticalization of cities to favour large housing complexes over detached houses leads to a change in urban morphology, and eventually to a strong impact on biodiversity. For birds, moderate-to-high human population density in cities leads to decreased avian biodiversity and abundance, and only a few common species benefit marginally from urban densification (more than 2000 people/km² [35,36]). Urban densification decreases the surface area of urban green spaces, grasslands, and tree cover to a greater extent than urban expansion [37].

In this study, we explored a new approach based on the city-block scale to make direct links between herbaceous plant communities and urban uses at different spatial scales and provide operational recommendations for urban planning. We aimed to identify, in an

urban pool already restrained in diversity by homogenisation and urban environmental filtering, which urban uses harbour original species at urban and regional scales. In the context of urban densification, where these uses could disappear, we attempted to underline their potential from an urban conservation perspective. We first used an urban geographic approach to map and characterise all city blocks of a medium-sized French city (Blois). We then inventoried the herbaceous plant communities in 129 city blocks designated for seven urban uses, considering different owners and management practices (collective housing, individual housing, industrial, public service, park, land reserve, and road), finding a wide range of urban landscape heterogeneity. From this, we analysed (1) how different urban uses shape the species richness (alpha diversity) and regional originality of plant communities, and (2) how plant compositions of different urban uses complement each other (beta diversity) to promote city-wide plant diversity (gamma diversity). We expected to find high alpha diversity and original species in urban uses allowing low levels of management practices, such as large parks and urban land reserves [38]. We also expected to find differences in alpha diversity between urban uses with different built morphologies and different types of owners. For example, plant communities of individual housing blocks, which include multiple private gardens with various owners and management practices, were expected to have higher species richness than those of collective housing city blocks, where large common green spaces are uniformly managed by the municipality. Some urban uses likely harbour original species at the regional scale (i.e., species with low frequency at the regional scale), making them of particular interest in avoiding biotic homogenisation. Finally, we expected to find various levels of complementarity in community composition (i.e., species turnover) between city blocks depending on their urban uses, with parks, road verges, and collective housing expected to have similar composition, while individual housing, land reserves, schools, and industrial city blocks would be more variable.

2. Materials and Methods

2.1. City Description

The urban area of Blois (50,000 inhabitants, 22 km²) is located in central-western France (47°34'59" N, 1°19'59" E) in the Centre-Val de Loire region, known for its diverse ecological habitats and large regional plant species pool (n = 1809, [39]). The mean temperature is 11.6 °C and annual rainfall is 640 mm. The surrounding landscape is predominantly agricultural, with two large, forested massifs to the west and south. The Loire River traverses the city (Figure 1). The built area of Blois and La Chaussée-Saint-Victor to the northeast form a continuous urban zone referred to as “Blois” for this study.

Blois has a rich historical heritage, with its core dating back to the medieval and Renaissance periods, characterised by compact urban forms. The city’s expansion started during the mid-19th century and accelerated post-World War II, coinciding with population growth (from 28,190 inhabitants in 1954 to 47,243 in 1982), leading to new urban uses (Figure 1). Large collective housing blocks were built between 1958 and 1973. They are associated with large, impervious parking lots and municipally managed green spaces comprising lawns, linear hedges, and isolated trees (Appendix A).

Subsequently, the construction of individual housing began in the 1950s but expanded in the 1970s. These are single-family houses with private gardens that are densely planted with well-maintained lawns, or sparsely managed (Appendix A) according to owner preferences. The commercial and industrial zone expanded between the 1960s and 2010s. Industrial areas are typically large, housing multiple industries within the same city block. Buildings often sprawl extensively and are associated with spacious parking, sometimes shaded by tree lines. Green spaces in these areas vary, encompassing small, well-tended

lawns and planted beds with corporate aesthetics, as well as larger, less maintained green spaces (Appendix A).

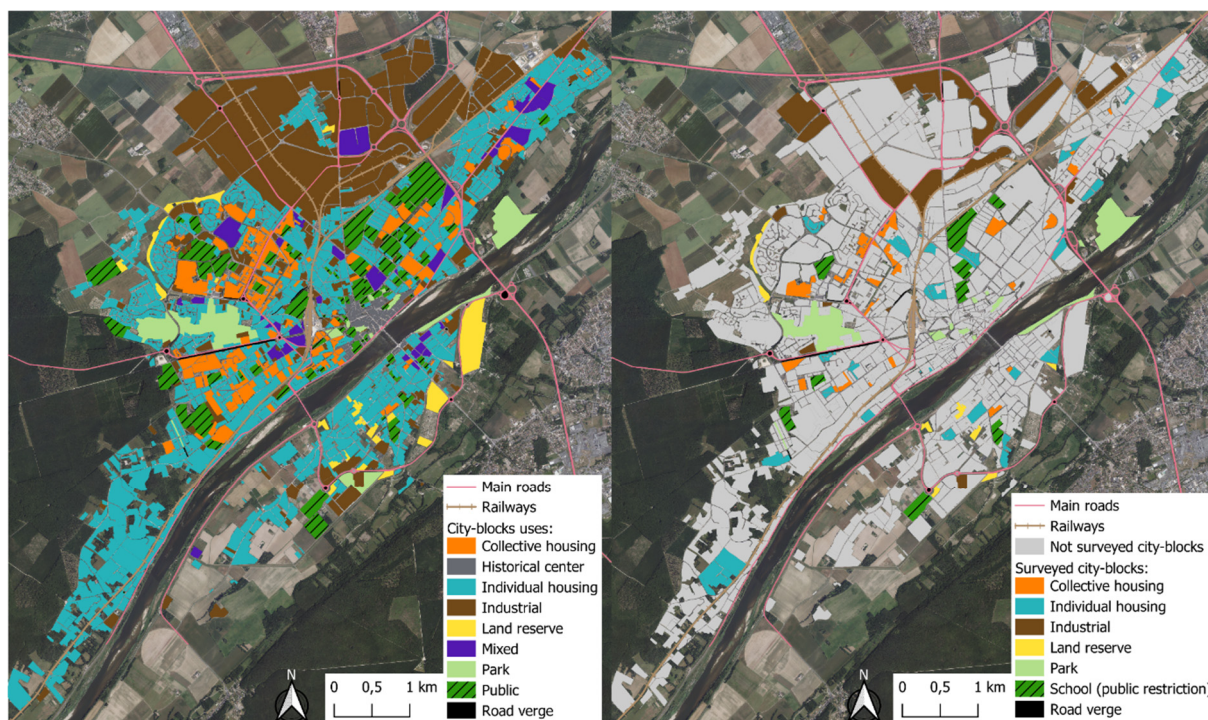


Figure 1. Maps of Blois. **(Left)** All city blocks ($n = 1314$). **(Right)** Surveyed (129) city blocks. Aerial images from IGN.

In addition to these three prominent urban uses, other urban uses are scattered in the urban landscape (Figure 1), including public services in the form of schools, with their own green spaces and management teams, large parks with differentiated management, and smaller manicured city centre parks (Appendix A), as well as municipally and extensively managed urban land reserves.

2.2. Characterisation and Selection of City Blocks

To characterise the variability of Blois, we mapped urban uses at the city-block scale (Figure 1). A city block is a set of contiguous parcels of similar use, bounded by roads; the measure is frequently used in urban planning [21]. Our map is based on IGN parcel data (<https://www.ign.fr/institut/identity-card> (accessed on 19 December 2024)) and contains 1314 city blocks (Figure 1).

Each city block was assigned to an urban use (Table 1) identified using aerial photographs and in situ observations. Individual housing is the most widespread urban use (744 city blocks), followed by industrial use (199) and collective housing (131). We also described public services areas, parks, land reserves dedicated to the future development of the city, and road verges to consider the whole diversity of urban uses. We associated each city block with the median construction date of its constituent buildings, categorised by decade (1950–2020 [18]). City blocks built after 1950 were previously farmland.

Table 1. Presentation of the 1314 city blocks of the city of Blois. The first six uses are sensu stricto city blocks; the last three are unbuilt uses but were considered in this study in order to be representative of the whole city and the diversity of urban uses.

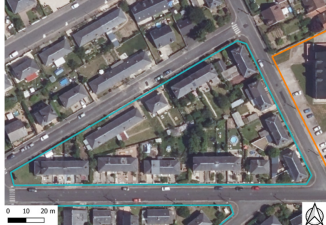




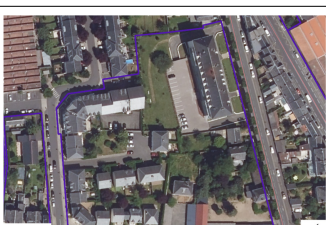

Use	Description	Number of City Blocks in Blois	Building Date Mean [min:max]	Mean Area (m ²) [min:max]	Aerial Pictures (IGN Data)
Individual housing	Single houses, whether detached or not, with their gardens. Small one- and two-storey buildings, featuring first-floor gardens exclusively maintained by the inhabitants, were also considered.	744	1968 [1949:2020]	10,914 [333:172,592]	
Industrial	Buildings and associated spaces for industrial, commercial, and tertiary activities.	199	1980 [1949:2019]	28,203 [255:269,142]	
Collective housing	Multi-family buildings with associated common green spaces.	131	1977 [1957:2010]	13,257 [747:71,534]	
Public	Buildings and associated open spaces for public services (e.g., schools, administrative buildings, cemeteries).	72	1965 [1949:1996]	25,555 [501:236,068]	
Historic centre	Small collective buildings (up to four floors) featuring ground-floor shops.	68	1866 [1300:2003]	3033 [271:17,768]	
Mixed	Contains at least three uses.	41	1970 [1949:2018]	19,571 [862:129,357]	

Table 1. Cont.

Use	Description	Number of City Blocks in Blois	Building Date Mean [min:max]	Mean Area (m ²) [min:max]	Aerial Pictures (IGN Data)
Land reserve	Municipal unbuilt areas retained for future development.	21	NA	12,086 [2687:29,953]	
Road verge	Road verges, directional islands, roundabouts.	21 *	NA	3240 [88:25,942]	
Park	Green spaces with public access.	17	NA	53,172 [2250:310,201]	

* Not all road verges have been mapped.

We selected 129 city blocks (10% of total) for the inventory of spontaneous herbaceous vegetation using stratified random sampling based on city-block use, building period, and unbuilt surfaces (difference between the entire surface and the surface covered by buildings in the city block; Table 2). This selection was representative of the city's heterogeneity and maximised building period and area diversities within uses. For urban public service city blocks, only schools were inventoried. For individual housing, we deviated from the stratified selection due to access constraints. Once access to a first garden was obtained, we increased our efforts (door-to-door and distribution of flyers) to access other gardens of the same city block. As the stratification criteria (building period, unbuilt area) were less relevant for road verges and land reserves, they were not used and the road verges were chosen to maximise management differences and land reserves to cover the whole city.

The vegetation management type assigned to each city block was based on mowing frequency and the aesthetic or practical aims associated with it (Table 3). For industrial sites, individual housing, and schools, we obtained information from site contacts (i.e., owners, directors, or managers). For other uses which are public, municipal services provided the information. For 34 city blocks, management was unknown (Table 3).

Table 2. Information on inventoried city blocks (NA corresponds to unavailable information) and inventoried quadrats within city blocks. See Table 3 for a description of management levels.

Urban Uses	Number of City Blocks	Building Date Mean [min:max]	Area in m ² Mean [min:max]	Management Level (% of City Blocks of This Use)	Total Number of Quadrats	Mean Number of Quadrats per City Block	Habitat Repartition Within Quadrats (% of Quadrats)
Individual housing	37	1954 [1805:2006]	20,877 [412:105,778]	Level 4: 3% Level 3: 30% Level 2: 51% Level 1: 11% NA: 5%	446	12	Lawn: 52% Sandy: 17% Wooded: 23% Wooded sandy: 1% Meadow: 7%
Industrial	18	1989 [1958:2011]	70,267 [2613:186,116]	Level 3: 11% Level 2: 33% NA: 56%	310	17	Lawn: 46% Sandy: 18% Wooded: 26% Wooded sandy: 1% Meadow: 8%
Collective housing	26	1974 [1957:2010]	14,094 [1890:62,235]	Level 3: 42% Level 2: 8% NA: 50%	300	11	Lawn: 55% Sandy: 9% Wooded: 27% Wooded sandy: 9%
School	9	1975 [1949:1996]	48,036 [22,373:116,760]	Level 3: 11% NA: 89%	182	20	Lawn: 51% Sandy: 13% Wooded: 34% Wooded sandy: 3%
Land reserve	8	NA	14,456 [6306:29,953]	Level 1: 100%	116	14	Meadow: 100%
Road verge	17	NA	3109 [100:25,942]	Level 4: 6% Level 3: 35% Level 2: 35% NA: 24%	110	6	Lawn: 40% Sandy: 13% Wooded: 38% Wooded sandy: 9%
Park	14	NA	44,957 [2250:310,201]	Level 4: 50% Level 3: 22% Level 2: 14% Level 1: 14%	242	17	Lawn: 49% Sandy: 2% Wooded: 31% Wooded sandy: 3% Meadow: 15%

Table 3. Different levels of management considered.

Management Level	Description	Mowing Frequency by Year	Number of City Blocks
Level 4	Highly managed for aesthetic or security purposes	18–25	9
Level 3	Managed for leisure activities	10–15	31
Level 2	Managed “as needed”	3–9	29
Level 1	Avoiding overgrowth	1–2	10
Variable	Mixed management type in the same city block	Variable	16
Unknown	Unknown management	NA	34

2.3. Plant Data Collection

We inventoried the spontaneous herbaceous vegetation in the 129 city blocks during June and July 2020 and 2021. Due to the pandemic situation (COVID-19), we focused on free-access city blocks such as collective housing, road verges, and parks in 2020. In 2021, we inventoried industries, individual housing, and land reserves. Five and four schools were inventoried in 2020 and 2021, respectively.

The city blocks presented various soil and ecological conditions likely influencing plant communities. To capture the variability in environmental conditions and plant communities within city blocks, we differentiated five habitat types categorised by soil aspect (sandy or topsoil) and tree shading (yes or no). Four habitats were regularly mowed: two on topsoil substrate (topsoil lawn named “lawn” and topsoil lawn with canopy named

“wooded”) and two on sandy substrate (sandy substrate lawn named “sandy” and sandy substrate lawn with canopy named “wooded sandy”). We also considered urban meadows, which are herbaceous vegetation on topsoil without tree shading that are mowed annually (“meadows”).

In each city block, we estimated habitat type from aerial photographs, eventually adjusted in situ. These habitat areas determined the number of 50 cm × 50 cm quadrats used to inventory the herbaceous community in each city block. The minimum number of quadrats was 4 (1 m²) and the maximum was 20 (5 m²), resulting in a variable number of quadrats by city block (Table 2). These quadrats were chosen to be small to fit the sometime small and scattered vegetated spaces within city blocks. They were localised randomly in different vegetated areas within city blocks to capture the entire plant variability of the block. As we inventoried only herbaceous vegetation with a maximum height of 30 cm, the small quadrat size was appropriate. We inventoried 1706 quadrats in total, with an exhaustive sampling of vascular herbaceous species associated with Braun-Blanquet cover values.

2.4. Statistical Analysis

All analyses were performed at the city-block level (n = 129) using R (version 4.2; R Core Team 2022). Our alpha diversity measure was the Jackknife 2 estimator, divided by the inventoried surface of the city block and rounded to obtain discrete values. This method takes into account every species in all quadrats at the city-block scale and counterbalances methodological particularities (partly inventoried city blocks and inconstant inventoried surface; see Béguinot, 2016 [40]). We investigated the effect of urban uses and management levels on alpha diversity using one-way analysis of variance (ANOVA) followed by Tukey’s pairwise comparison test where relevant. As homoscedasticity was not validated, we used a Poisson distribution. There was no spatial autocorrelation in the residuals (checked by computing univariate spline correlogram, package *ncf*, Bjornstad 2022).

We used an existing rarity index of species at the regional scale [39] to calculate our index of the regional originality of plant communities. The existing index of [39] ranges from one (extremely rare species, present in >1% of municipalities) to eight (extremely common species, present in >64% of municipalities), and 79% of our species were referenced. This index excludes introduced species as long as they are not naturalised. We computed our regional originality index of plant communities based on community-weighted mean abundance species data from [39]. We then used the same statistical analysis as for alpha diversity.

We investigated the effects of urban uses and management levels on community composition using three complementary methods. Firstly, we performed an indicative species analysis using the *indicspecies* package [41]. The significance of indicator values was tested by the permutation test (N = 999 permutations), as implemented in the *indicspecies* package. An indicative species is a species specifically associated with the urban use where it is encountered, either because the species occurs (quasi) exclusively in this urban use or because the species is particularly abundant in this urban use [41].

Secondly, we used a species-by-community matrix with a mean species value of abundance among quadrats to calculate a matrix of Bray–Curtis dissimilarity distances between city blocks. Using this dissimilarity matrix, we performed non-metric multidimensional scaling (NMDS) using the *vegan* package [42]. For convergent NMDS, we excluded four city blocks with a very different plant composition from all other city blocks, mostly due to the dominance of *Lolium perenne* (L.). We then projected urban uses and management levels as supplementary variables on the NMDS factorial plan to visually explore differences in

community composition between city blocks and identified original communities at the urban scale (i.e., communities far from others in the NMDS plan).

Finally, we used beta diversity measures. To estimate the variability in intra-urban use and intra-management level, we calculated the multiple-site dissimilarity index β_{BC} (*betapart* package [43,44]) and its partitions: $\beta_{BC.BAL}$, accounting for balanced variation in abundance, where individuals of some species at one site are substituted by the same number of individuals of different species from another site (equivalent to species turnover between communities); and $\beta_{BC.BRA}$, reflecting abundance gradients, where some individuals are lost from one site to another (equivalent to species nestedness between communities [43]). We also explored the beta diversity between city blocks of different uses and different management levels. We calculated d_{BC} , accounting for abundance-based pairwise dissimilarities for each pair of urban uses or management levels, and its partitions: d_{BC-bal} , accounting for balanced variation in abundance between different uses or managements; and d_{BC-gra} , accounting for abundance gradients between uses or managements [45,46]. We randomly sampled eight city blocks for each use and nine city blocks for each management level (corresponding to the lowest number of city blocks in use or management categories) and calculated the d_{BC} , d_{BC-bal} , and d_{BC-gra} values. To obtain robust values, we repeated this procedure 100 times, then calculated means and standard deviations based on those 100 values.

3. Results

We recorded 331 herbaceous species. The 10 most common species (in percentage of occurrence across the 129 inventoried city blocks) were *Lolium perenne* (89% of city blocks), *Bellis perennis* L. (86%), *Hypochaeris radicata* L. (84%), *Taraxacum* spp. (81%), *Festuca rubra* L. (80%), *Plantago lanceolata* L. (77%), *Crepis capillaris* (L.) Wallr. (74%), *Convolvulus arvensis* L. (73%), *Medicago lupulina* L. (72%), and *Poa annua* L. (68%). Species names were checked based on World Flora Online (accessed in June 2022). Fifty-five species were common to every use, whereas the number of species specific to one use varied from two for roads to thirty-nine for individual housing (Appendix B). Our regional originality index varied from 0.32 to 6.65, with a mean originality of 2.01.

3.1. Alpha Diversity and Regional Originality of Communities

The Jackknife 2 value was variable between city blocks (min = 3.25, max = 132.04, mean = 59.79) and strongly correlated with species richness ($r = 0.98$). We found a significant difference in alpha diversity (i.e., Jackknife 2 corrected by effective sampling area, min = 3, max = 42, mean = 22) between uses (ANOVA $\chi^2 = 58.63$, $df = 6$, $p = 8.56 \times 10^{-11}$; Figure 2A). Roads had the highest mean alpha diversity and parks the lowest. Individual, industrial, and road uses displayed a high intra-variability of alpha diversity values (Figure 2A). Alpha diversity was significantly different between management levels (ANOVA $\chi^2 = 37.99$, $df = 4$, $p = 1.13 \times 10^{-7}$; (1) in Appendix C). Level 2 had the highest alpha diversity and level 4 the lowest, with the other two having intermediate values.

Regional originality and alpha diversity gave different information about plant communities as they were poorly correlated ($r = -0.34$). Regional originality varied significantly among urban uses (ANOVA $\chi^2 = 24.90$, $df = 6$, $p = 3.56 \times 10^{-4}$; Figure 2B). Land reserve, industrial, and school city blocks contained the most original communities, while road, collective housing, and individual housing city blocks were the least original. Industrial and park uses had high intra-variability for regional originality. For management levels, there was a non-significant decrease in regional originality from level 1 to level 4 ((2) in Appendix C).

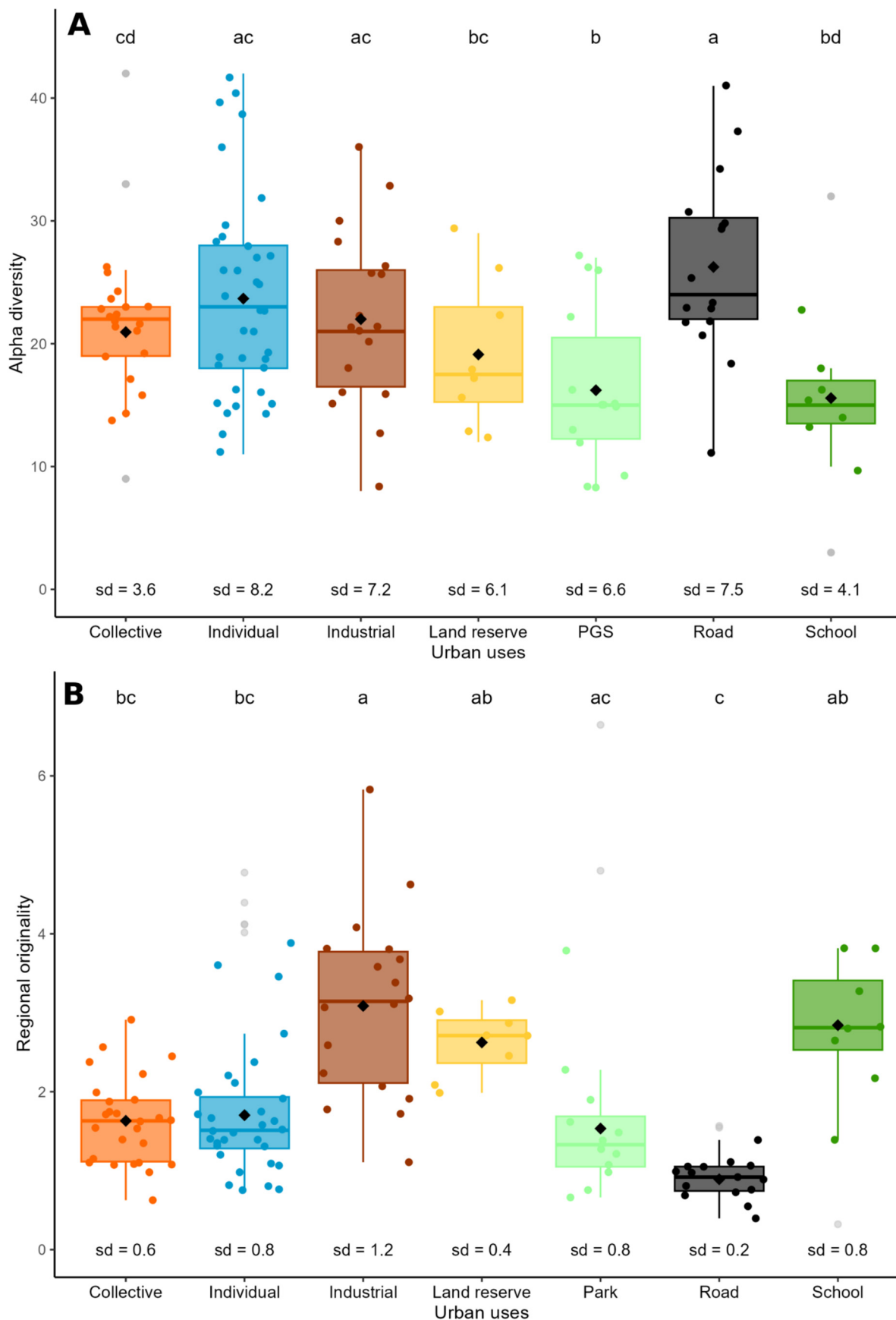


Figure 2. (A) Alpha diversity and (B) regional originality between urban uses. Letters represent pairwise Tukey’s comparison test. Black dots = averages. Grey points = excluded outliers (exclusion had no impact on results). sd = standard deviation.

3.2. Community Composition and Beta Diversity

Sixty-five species were indicative of urban uses (Table 4). Collective housing and roads were not associated with any species, while industries and land reserves had the highest number of indicative species (21 and 22, respectively; Table 4).

Table 4. Significant indicative species of city block use or management level, ranked by decreasing *p*-value. Significance was calculated based on 999 permutations.

Uses	Species
Collective	None
Individual	<i>Euphorbia peplus</i> ; <i>Trifolium repens</i> ; <i>Taraxacum</i> spp.; <i>Senecio vulgaris</i> ; <i>Digitaria sanguinalis</i>
Industrial	<i>Lathyrus tuberosus</i> ; <i>Aphanes</i> sp.; <i>Trifolium campestre</i> ; <i>Torilis nodosa</i> ; <i>Sanguisorba minor</i> ; <i>Myosotis</i> sp.; <i>Sherardia arvensis</i> ; <i>Catapodium rigidum</i> ; <i>Cerastium glomeratum</i> ; <i>Helminthoteca echinoides</i> ; <i>Bellis perennis</i> ; <i>Trifolium dubium</i> ; <i>Medicago arabica</i> ; <i>Ranunculus</i> sp.; <i>Hypericum perforatum</i> ; <i>Sonchus asper</i> ; <i>Cirsium vulgare</i> ; <i>Prunella laciniata</i> ; <i>Echium vulgare</i> ; <i>Veronica arvensis</i> ; <i>Ophrys apifera</i>
Public green space	<i>Veronica agrestis</i> ; <i>Alopecurus pratense</i> ; <i>Stellaria pallida</i> ; <i>Cerastium</i> sp.
Road	None
School	<i>Bromus hordeaceus</i> ; <i>Veronica officinalis</i> ; <i>Trifolium pratense</i> ; <i>Medicago</i> sp.; <i>Crepis setosa</i> ; <i>Alliaria petiolata</i> ; <i>Leotodon saxatilis</i> ; <i>Phleum pratense</i> ; <i>Daucus carota</i>
Land reserve	<i>Poa angustifolia</i> ; <i>Vicia hirsuta</i> ; <i>Arrhenatherum elatius</i> ; <i>Helictotrichon pubescens</i> ; <i>Vicia sativa</i> ; <i>Elymus repens</i> ; <i>Campanula rapunculus</i> ; <i>Rumex acetosa</i> ; <i>Lathyrus latifolius</i> ; <i>Lolium arundinaceum</i> ; <i>Holcus lanatus</i> ; <i>Silene latifolia</i> ; <i>Medicago sativa</i> ; <i>Jacobea vulgaris</i> ; <i>Artemisia vulgaris</i> ; <i>Galium verum</i> ; <i>Tanacetum vulgare</i> ; <i>Vicia cracca</i> ; <i>Anthoxanthum odoratum</i> ; <i>Poa pratensis</i> ; <i>Ranunculus acris</i> ; <i>Agrimonia eupatoria</i> ; <i>Dianthus deltoides</i> ; <i>Luzula campestris</i> ; <i>Saponaria officinalis</i> ; <i>Trifolium incarnatum</i>
Management	Species
Level 1	<i>Vicia hirsuta</i> ; <i>Poa angustifolia</i> ; <i>Arrhenatherum elatius</i> ; <i>Vicia sativa</i> ; <i>Helictotrichon pubescens</i> ; <i>Elymus repens</i> ; <i>Campanula rapunculus</i> ; <i>Silene latifolia</i> ; <i>Lathyrus latifolius</i> ; <i>Holcus lanatus</i> ; <i>Medicago sativa</i> ; <i>Rumex acetosa</i> ; <i>Artemisia vulgaris</i> ; <i>Galium verum</i> ; <i>Tanacetum vulgare</i> ; <i>Vicia cracca</i> ; <i>Anthoxanthum odoratum</i> ; <i>Agrimonia eupatoria</i>
Level 2	None
Level 3	None
Level 4	<i>Veronica agrestis</i> ; <i>Lolium perenne</i> ; <i>Plantago major</i> ; <i>Ranunculus bulbosus</i>

Regarding beta diversity measures, β_{BC} ranged from 0.82 to 0.88, indicating important intra-use variation in community composition (Appendix D). Species turnover is the principal process involved therein, as $\beta_{BC.BAL}$ ranged from 0.76 and 0.85, whereas $\beta_{BC.BRA}$ (i.e., nestedness) ranged from 0.01 to 0.08 (Appendix D).

In terms of dissimilarities in composition between uses, the values of d_{BC} were highest for land reserves (Figure 3A), indicating a distinct composition compared to other uses. This is consistent with the high number of indicative species for land reserves (Table 4) and the absence of overlap between land reserves and other uses in NMDS (Figure 4). Road uses also had high d_{BC} values and few overlaps in NMDS (only with collective and park uses, and minimally with individual housing uses; Figure 4), but no indicative species (Table 4). The ellipses of park, road, and individual uses were extensive, indicating important intra-compositional variation (Figure 4).

As the d_{BC-bal} values (Figure 3B) were higher than the d_{BC-gra} values (Figure 3C) for almost all use comparisons, the compositional variation between uses was mostly explained by species turnover. The abundance gradient still explained a significant portion of compositional variation for some pairs of uses, particularly those involving roads (Figure 3C).

We also explored compositional differences between management levels. Twenty-two species were significant indicators of management levels (Table 4). Level 1 was associated with 18 indicative species and level 4 with 4, while level 3 and level 2 were associated with no indicative species.

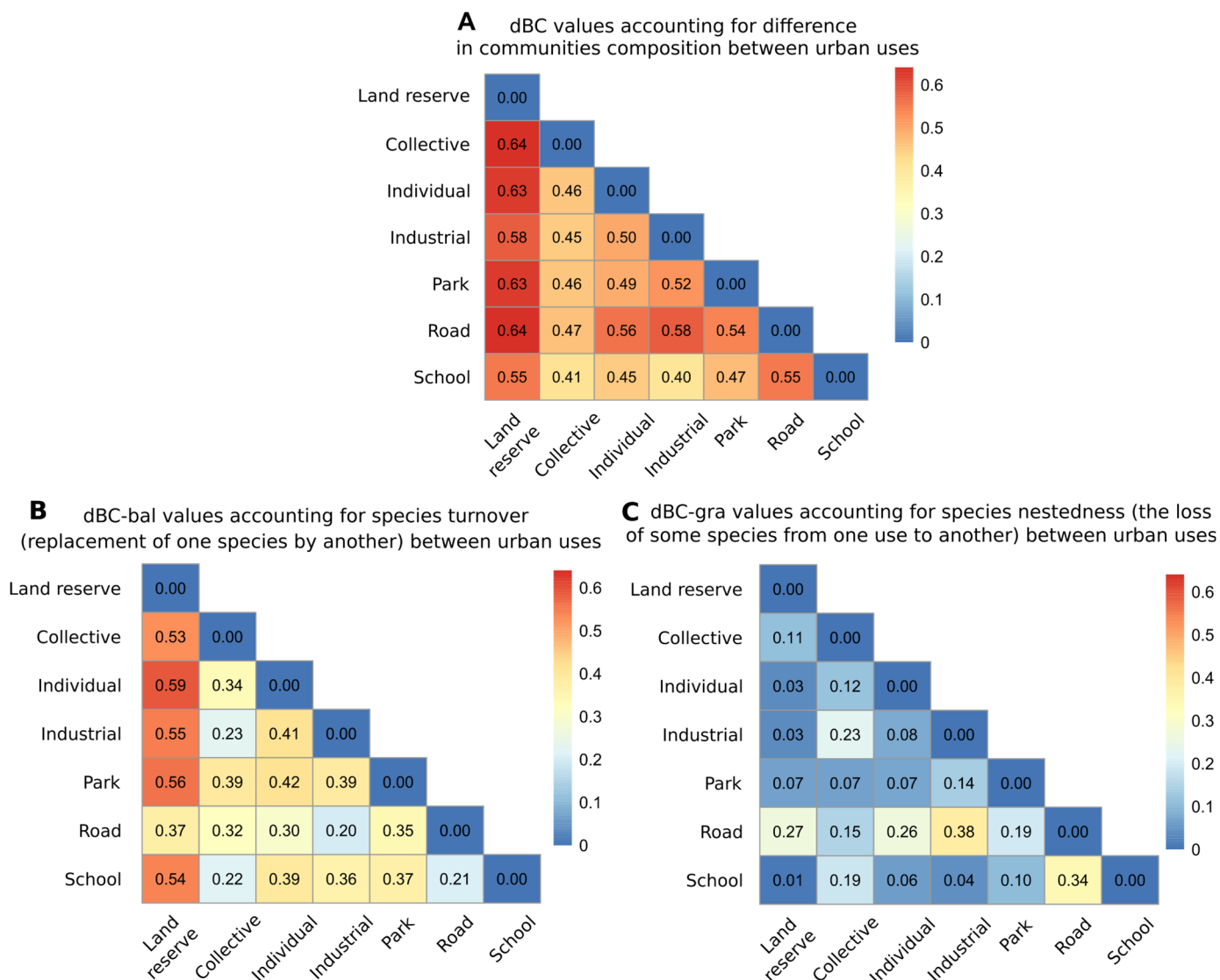


Figure 3. Differences in species composition between city blocks with various urban uses, measured with abundance-based pairwise dissimilarity in communities (A–C). Total dissimilarity values d_{BC} (on top) measure how different the species composition of one urban use is from all the other uses. Values are broken down into d_{BC-bal} to account for species turnover, i.e., the replacement of some species in one urban use with different species from another urban use, without variation in total number of species (B), and into d_{BC-gra} to account for species nestedness, i.e., the loss of some species from one urban use to another (C).

Again, high values of β_{BC} (0.84 to 0.87) indicated important intra-management level compositional variation (Appendix D), almost exclusively related to species turnover ($\beta_{BC,BAL}$; Appendix D), as for urban uses. Values of d_{BC} were relatively high (Appendix E), indicating important dissimilarities between management levels. The compositions of level 1 and level 4 were the most dissimilar (Appendices E and F). Again, species turnover explained most of the compositional variation between management levels, as d_{BC-bal} values (Appendix E) were higher than d_{BC-gra} values (Appendix E) for all comparisons.

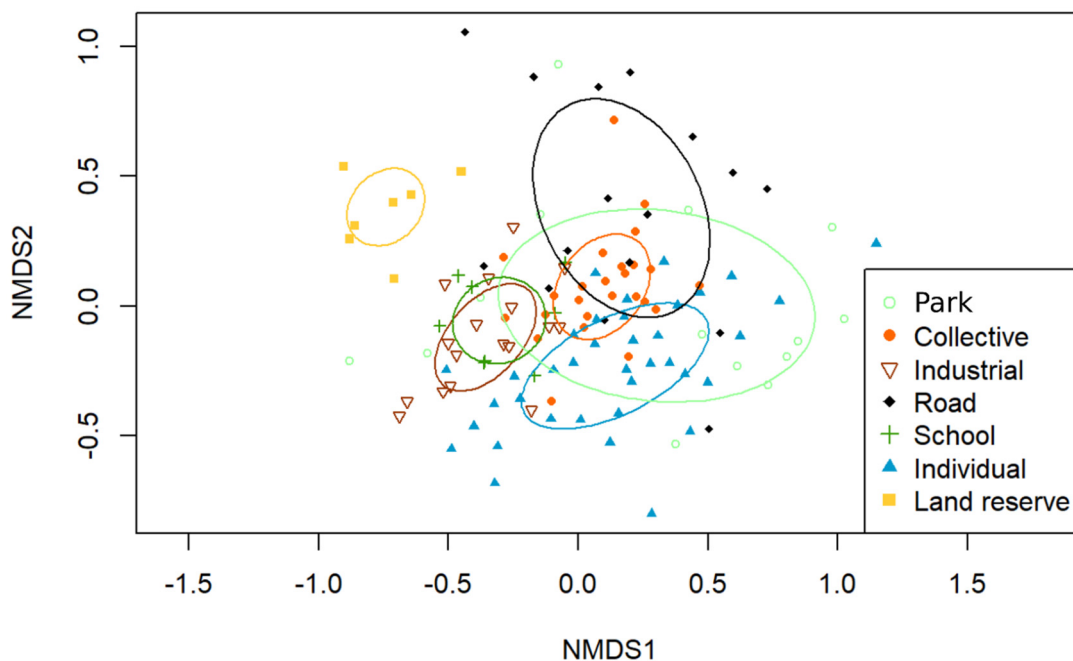


Figure 4. NMDS ordination plot of city-block vegetation composition based on Bray–Curtis dissimilarity values (stress 0.23, non-metric fit, $R^2 = 0.945$). Ellipses indicate standards. Colours and symbols represent different urban uses ($n = 125$). Species coordinates are listed in Appendix G.

4. Discussion

By adopting a new scale of urban landscape analysis derived from urban planning (i.e., the city-block level) and applying it to various public and private uses at a large spatial extent (i.e., 10% of the city blocks of Blois inventoried), our study enables us to make links between the diversity of urban uses, associated management types, and plant diversity at several scales. We highlight the effects of urban uses on plant communities and make applied recommendations for urban planning and management to counter the biotic homogenisation of cities. We then discuss the interests and limitations of this new approach.

4.1. Urban Uses with Low Management Intensity Favour Original Communities

Our first hypothesis about the most diverse and original communities being found in urban uses with the lowest management intensity is partly validated. Urban land reserves dedicated to future construction displayed moderate local plant diversity. The stress tolerators (e.g., *Anthoxanthum odoratum*, *Helictotrichon pubescens*) and competitive species (e.g., *Tanacetum vulgare*, *Rumex acetosa*) associated with this urban use could explain this low diversity [47]. However, urban land reserves harbour the most original communities at both regional and urban scales. The low mowing frequency (once a year) in this urban use leads to an increase in typical meadow species [38]. While urban land reserves may be built in the future, particularly in a context of urban densification, their preservation could be an opportunity to mitigate urban biotic homogenisation. If these areas are nevertheless lost due to high demographic and economic pressure, the level of management in other urban uses will have to be reduced to compensate for the loss of biodiversity, as we discuss in the following sections.

Public parks typically exhibit low vegetation diversity, which nuances the assertion that parks are biodiversity hotspots in cities [48], as far as spontaneous herbaceous plants are concerned. However, we found great variability in terms of species richness, beta diversity, and regional originality between parks. We interpret this pattern as related to

the important variability in park functions and aesthetic aims, from tiny, manicured parks in the city centre to extensive parks with differentiated management on the outskirts of the city. The large size of two extended parks (considered as outliers in Figure 2) results in diverse ecological habitats contributing to plant diversity, compared with smaller parks [6], and allows the presence of low-managed areas without compromising more managed spaces for outdoor human activities (e.g., sport and play areas). If these large urban parks are reshaped and built upon in a process of internal urban densification, it will lead to loss of urban diversity that may be impossible to compensate for through the creation of multiple tiny parks [49].

4.2. Comparative Benefits of Residential Blocks for Biodiversity

This study is among the first to compare plant communities between residential areas with different building morphologies. Contrary to our hypothesis, no difference was observed between individual and collective housing blocks regarding average alpha diversity. However, alpha diversity and the composition of individual housing were highly variable between city blocks, in accordance with previous studies [20,50]. The diverse management choices of owners (Table 2), related to contrasting socioeconomic characteristics and aesthetic objectives, can explain this result [51,52]. By contrast, plant communities of collective housing blocks were much more homogeneous, probably due to the consistent medium management level applied by the municipality (Table 2). The internal densification of cities could result in the transformation of private gardens of new houses, and the verticalization of cities would favour collective housing over individual housing [53]. These two processes would lead to the homogenisation of urban vegetation communities. Limiting the transformation of private gardens of new buildings and promoting low management levels in large green spaces belonging to collective housing could mitigate this homogenisation, while allowing densification by verticalization. However, this transition is restrained by the habit of regularly managing spaces alongside residential buildings. It must be accompanied by communicating with residents and support for municipal field operatives to limit psychosocial and technical obstacles [54]. In individual housing areas, different strategies are emerging to guide owners of private gardens towards biodiversity-friendly management practices, but they remain scarce [55].

4.3. Some Little-Known Uses Could Mitigate Urban Homogenisation

Urban homogenisation is an important issue of urban conservation. We sought to identify some urban uses that harbour original species at a regional scale, and could therefore limit urban homogenisation. Industrial blocks and schools have high values of regional originality. Industrial city blocks were associated with high and variable alpha diversity, and relatively few ruderals compared with other uses. Our results align with other studies indicating a small positive effect of industrial areas for plant species richness, compared with other urban uses [14], and that industrial areas exhibit up to 12.9% of plants considered as rare at the regional scale [56,57]. Both uses exhibit various ecological habitats (Table 2), including meadows in large industrial areas and sandy areas in schools, presumably due to the multifaceted purposes of the exterior spaces, which could explain these results. In industrial areas, the characteristics of soil due to current or past activities could create specific conditions suitable for few rare species [58], in addition to the presence of rubble or pebbles due to construction [59] and the thinness of the soil. School and industrial uses cover large city areas and could promote interactions between city dwellers (pupils, employees, etc.) and biodiversity, but they have not received much attention in terms of urban ecology. For conservation objectives, these urban uses are of particular interest as they could reduce regional homogenisation, but more studies are needed to

understand the ecological processes explaining the results. In addition, as very few studies are interested in these urban uses and even fewer in biodiversity in schools, more studies are needed to explore their importance for urban biodiversity.

4.4. Complementarity of Plant Communities

In general, beta diversity among urban uses was high and supported by species turnover, in accordance with our hypothesis. This result indicates that vegetation composition differs between uses, due to the replacement of species from one use to another, with only 55 of 139 species shared by all uses ((2) in Appendix B), and industrial and land reserves associated with more than 20 indicative species. Measures of beta diversity and of the underpinning processes explaining it are rarely accounted in urban areas, albeit their contribution to the understanding of diversity at the city scale (i.e., gamma diversity) is of high importance [31]. Therefore, our study gives precise insights into intra-urban biodiversity based on this analysis. One urban use, road verges, proved less distinctive than others, with differences in beta diversity compared to other uses driven by species nestedness. However, roads were the urban use with the highest number of species. This highest richness could be due to the presence of many common ruderal and stress-tolerant species [47] adapted to the high-management and harsh environmental conditions of road verges, especially when they are composed of concrete with a thin layer of soil. Road verges seem to be of less interest for urban biodiversity than other uses studied here, as they mainly host species common at both urban and regional scales. They cover large urban surfaces [60], which could be a concern from a conservation perspective, and changes in management (reducing mowing frequency or changing mixes used for seedling [61]) could be a way to maximise the originality of these communities. The road verge results illustrate the need to balance species richness with other components of biodiversity. Especially in a context of internal densification leading to arbitration between different urban uses, having a complete picture of urban biodiversity could limit the risk of discarding uses with moderate or low species richness but original communities at the regional scale, or unique species at the urban scale.

4.5. Strengths and Limitations of City Analysis at the City-Block Scale

The scale of analysis to be used to limit mismatches between ecological processes and the levels of organisation and management of human activities is an established debate in ecology [62] that has yet to be fully addressed in urban landscapes. In this study, we used the city block as a medium urban planning scale to link urban uses and plant communities. From an applied and conservation perspective, we believe it is very useful as most cities are built based on this organisation level. However, given the high diversity of habitats and abiotic conditions within city blocks, this scale has limitations in accurately revealing ecological mechanisms. Therefore, this approach must be coupled with more local studies that disentangle the effects of abiotic factors such as soil parameters. The main advantage of this scale of analysis is that it allows ecological data to be better combined with human dimensions to inform planning. Other studies could pursue this approach by using the city-block scale to combine multi-taxa ecological approaches with physical data (e.g., temperature [63]) and data on user perceptions and social risks (e.g., homicide [64]). Such an approach would make it possible to identify city-block configurations that limit antagonisms and promote synergies between the ecological and social functions of cities.

5. Conclusions

Through a new analytical approach at the city-block scale, this study reveals how public and private urban uses associated with various management practices shape urban

plant diversity at various scales. The results provide new insights and bridge the gap between global studies that compare vegetation between cities and those that analyse the local effects of abiotic conditions and management within a given urban use. Our study also underlines the importance of considering different dimensions of biodiversity to obtain a complete picture of urban communities. We show that to promote plant diversity at the city scale, urban planning choices on the spatial configurations of green and built spaces have to be considered in conjunction with owner types and management practices. This would lead to biodiverse cities with a positive outcome on human–nature relationships. Large green spaces, such as extended parks or reserved lands, which may be threatened by urban densification, have conservation value due to reconciling areas managed for human activities and vast, little-managed spaces, allowing original flora to establish. These large green spaces should therefore be retained in the urban planning of future cities due to their specific communities. Beyond these open spaces, the intensity of management should also be reduced in built-up areas. Vertical collective housing is an opportunity for urban densification that preserves large common green spaces. With diversified vegetated structures and management practices in their green spaces, collective housing could be a great opportunity for plant diversity in urban areas. However, the feasibility of such a change of practices would seem to depend on usage, aesthetic expectations, and the type of public or private ownership. If large housing estates are developed to concentrate housing and limit urban sprawl, municipalities could change the design of their associated green spaces to integrate the needs of residents while promoting the greater autonomy of ecological processes. This choice of vertical collective housing could preserve urban private gardens, which currently tend to disappear in urban densification, causing the disappearance of various original communities. Industrial areas and schools may present interesting opportunities for conservation with numerous original species. These uses could then be seen as great opportunities to reduce the extinction of experiences with nature in places where people spend the majority of their time. This is especially true for schools, as contact with nature for children is of paramount importance in their lifelong relationship with nature. Finally, a special focus is needed for road verges. They represent an important proportion of green spaces in cities but harbour mostly common species. A reflection on the quality and thickness of road verge substrates, as well as the choice of seed mixes used during their implementation, could increase their interest at the urban scale. New strategies need to be developed to accompany these changes in different urban uses, and we encourage ecologists to join discussions with social scientists and urban actors to initiate them.

Author Contributions: M.D.: Conceptualisation, Methodology, Formal analysis, Investigation, Resources, Writing—original draft, Visualisation, Supervision; N.L.: Conceptualisation, Methodology, Investigation, Writing—Review and Editing, Supervision; A.C.: Investigation, Resources; C.D.: Investigation, Resources; U.G.: Investigation, Resources; F.I.-N.: Writing—Review and Editing, Supervision; S.B.: Conceptualisation, Methodology, Investigation, Writing—Review and Editing, Supervision. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: All data supporting the findings of this study are available as open data via the Data.InDoRES online data repository: <https://doi.org/10.48579/PRO/MRCPW9>.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

(1) Pictures of different collective housing in Blois. (2) Pictures of different individual housing blocks in Blois, ranging from lowest to highest management intensity. (3) Pictures of different industries in Blois, with examples of sandy areas (bottom). (4) Pictures of different parks in Blois with diverse management levels. Photographic credit: Muriel Deparis.

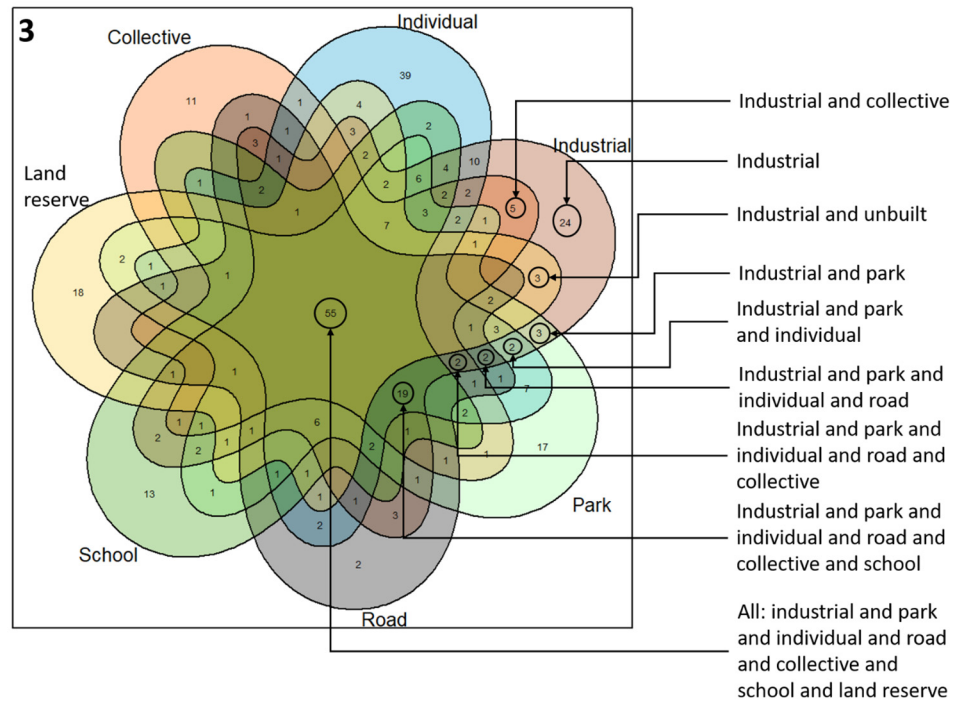
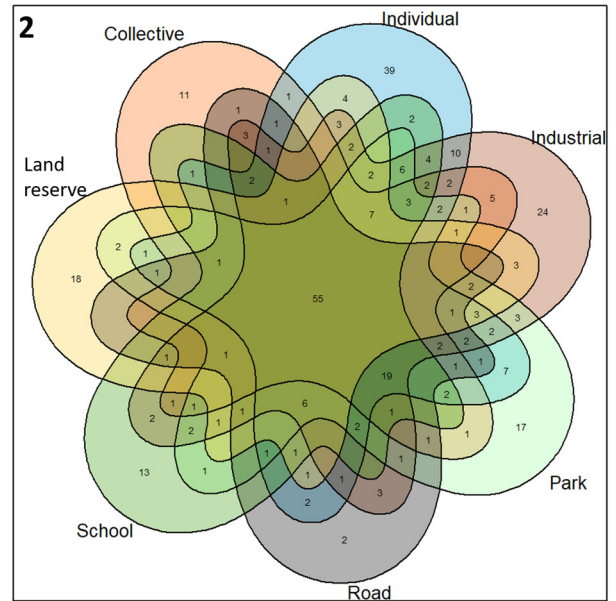
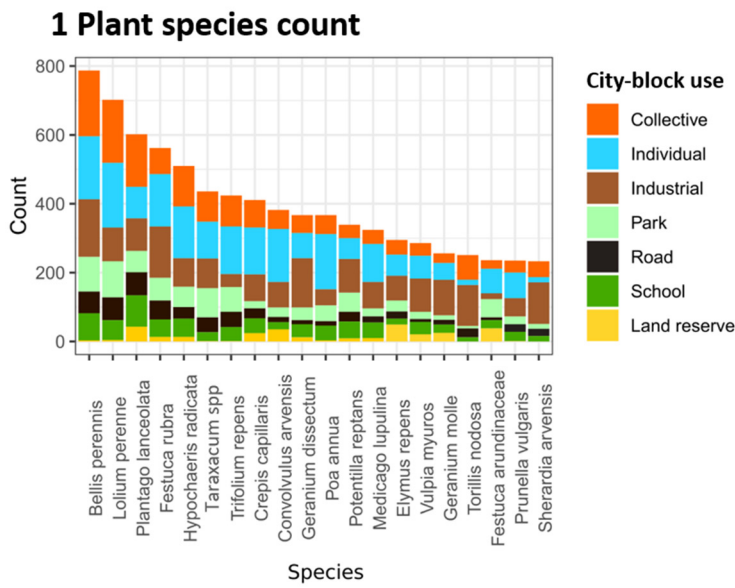






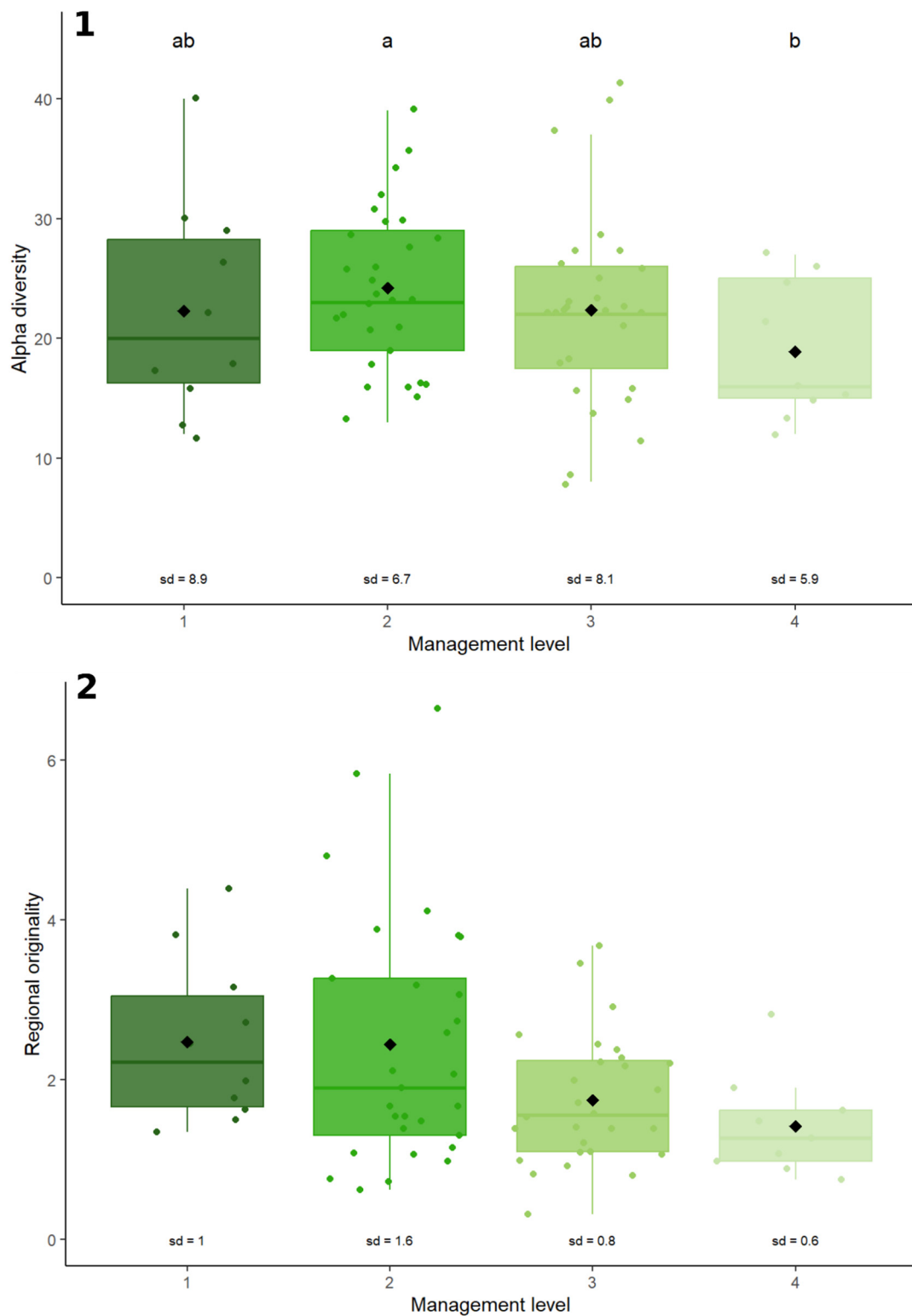
Appendix B

(1) Number of occurrences of the 20 most common species in the 1706 inventoried quadrats, classified by urban use. (2) Venn diagram of species in different city-block uses, showing the number of species exclusive to each use type, and those with overlapping uses. Shared species are represented by the overlap of each use envelope. (3) Labelled Venn diagram explaining overlapping uses.



Appendix C

(1) Comparison of alpha diversity (Jackknife 2 estimation of species pool divided by inventoried area) between management levels, with letters for Tukey’s comparison test. (2) Comparison of regional originality between management levels; no significant differences. Black dots represent averages by management level. Note that city blocks with multiple management levels or with no information were excluded from analysis.



Appendix D

Values relative to variation in composition between city blocks of the same use or of the same management level. β_{BC} accounts for total dissimilarity. $\beta_{BC.BAL}$ accounts for balanced variation in abundance between communities whereby the individuals of some species at one site are substituted with the same number of individuals of different species from another site (species turnover). $\beta_{BC.BRA}$ accounts for abundance gradients whereby some individuals are lost from one site to another (nestedness).

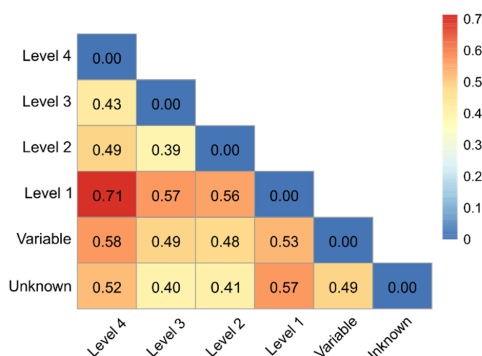
Use	Mean β_{BC}	Sd β_{BC}	Mean $\beta_{BC,BAL}$	Sd $\beta_{BC,BAL}$	Mean $\beta_{BC,BRA}$	Sd $\beta_{BC,BRA}$
Land reserve	0.83	0	0.81	0	0.01	0
Road	0.88	0.01	0.85	0.02	0.03	0.01
Collective housing	0.82	0.01	0.77	0.02	0.05	0.01
Industrial	0.84	0.01	0.79	0.02	0.05	0.01
School	0.84	0.01	0.77	0.01	0.07	0.01
Park	0.88	0.01	0.81	0.02	0.07	0.02
Individual housing	0.84	0.01	0.76	0.02	0.08	0.02

Management	Mean β_{BC}	Sd β_{BC}	Mean $\beta_{BC,BAL}$	Sd $\beta_{BC,BAL}$	Mean $\beta_{BC,BRA}$	Sd $\beta_{BC,BRA}$
1	0.86	0	0.81	0	0.05	0
2	0.84	0.01	0.79	0.02	0.05	0.01
3	0.87	0.01	0.81	0.02	0.06	0.02
4	0.86	0.01	0.83	0	0.03	0.01

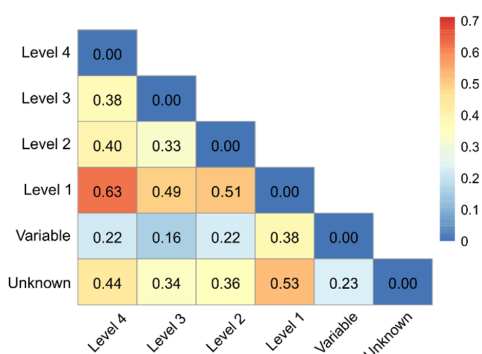
Appendix E

Abundance-based pairwise dissimilarity in communities between city blocks of different management levels. Total dissimilarity values dBC (on top) are broken down into dBCbal to account for species turnover (B) and dBCgra to account for species nestedness (C).

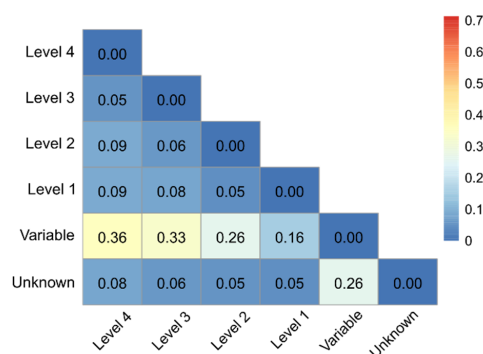
A dBC values accounting for pairwise dissimilarity in composition between management levels



B dBC.bal values accounting for balanced variation (species turnover) between management levels

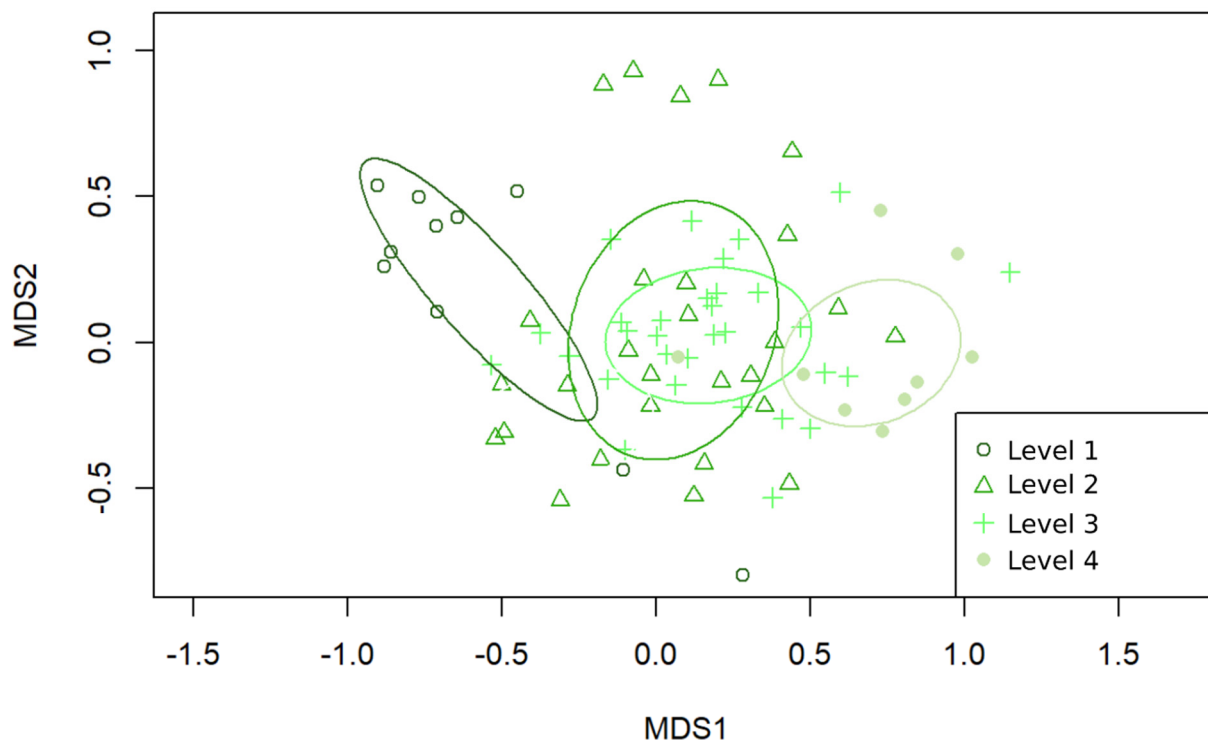


C dBC.gra values accounting for abundance gradient (species nestedness) between management levels



Appendix F

NMDS ordination plot of city block vegetation composition, based on Bray–Curtis dissimilarity values. Ellipses indicate the standard. Colours and symbols represent different management levels (n = 79). Species coordinates are listed in Appendix G.



Appendix G

Coordinates of the species in the NMDS. The four first letters represent the genus and next four letters code the species.

MDS1:

AJUGPYRA 1.37	ALCEROSE 1.24	ALLIPETI 0.99	ALLIVINE 0.90
ALOPMYOS 0.82	ALOPPRAT 0.81	AMARBLIT 0.78	AMARSP 0.71
ANAGARVE 0.64	ANCHARVE 0.59	ANTHARVE 0.56	ANTHODOR 0.55
ANTHSYLV 0.53	APHASP 0.49	AQUIVULG 0.48	ARCTLAPP 0.47
ARENCILI 0.46	ARENSERP 0.43	ARRHELAT 0.42	ARTEVULG 0.42
ASPAOFFI 0.42	AVENFATU 0.39	AVENSTER 0.39	BALLNIGR 0.36
BELLPERE 0.34	BRACPINA 0.33	BRACSYLV 0.33	BRIZMAXI 0.32
BROMARVE 0.31	BROMDIAN 0.31	BROMEREC 0.31	BROMHORD 0.30
BROMINER 0.29	BROMSP 0.29	BROMSTER 0.27	BRYOCRET 0.24
CALEOFFI 0.23	CALYSEPI 0.23	CAMPPEPERS 0.23	CAMPRAPU 0.22
CAMPSP 0.22	CAPSBURS 0.21	CARDCRIP 0.19	CARDHIRS 0.19
CARDSP 0.18	CAREDIVU 0.18	CAREECHI 0.17	CAREHIRT 0.17
CAREPALL 0.16	CAREREMO 0.16	CARESP 0.16	CARESPIC 0.15
CARESYLV 0.15	CATARIGI 0.15	CENTERYT 0.14	CENTJACE 0.14
CENTNIGR 0.12	CENTRUBE 0.12	CENTSP 0.11	CERAFONT 0.11
CERAGLOM 0.11	CERASP 0.11	CHELMAJU 0.10	CHENALBU 0.10
CHENVULV 0.08	CICHINTY 0.07	CIRSACAU 0.07	CIRSARVE 0.06
CIRSSP 0.06	CIRSVULG 0.05	CLEMVITA 0.05	CLINVULG 0.05
CONVARVE 0.03	CRASTILL 0.02	CRATMONO 0.01	CREPCAPI 0.01
CREPSETO 0.01	CREPSP 0.01	CRUCLEAV 0.00	CYNOCRIS 0.00
CYNODACT 0.00	CYPEERAG 0.00	DACTGLOM -0.01	DAHLPINA -0.01
DAUCCARO -0.01	DIANARME -0.02	DIANDELT -0.02	DIGISANG -0.03
ECHIVULG -0.05	ELYMREPE -0.07	EPILPARV -0.07	EPILSP -0.08
EPILTETR -0.08	EQUIARVE -0.09	EQUIFLUV -0.09	EQUIRAMO -0.10
EQUISP -0.11	ERAGMINO -0.12	ERIGSP -0.12	ERODCICU -0.12
ERODMOSC -0.12	ERYNCAMP -0.13	ESCHCALI -0.13	EUPHEXIG -0.14
EUPHHELI -0.15	EUPHMACU -0.15	EUPHPEPL -0.15	EUPHPROS -0.15
EUPHRASP -0.18	EUPHSP -0.18	FAGOESCU -0.19	FALOCONV -0.19
LOLIARUN -0.19	FESTFILI -0.19	FESTPALL -0.19	FESTPRAT -0.20

FESTRUBR	-0.20	FILASP	-0.21	FRAGVESC	-0.22	FUMAOFFI	-0.22
GALIALBU	-0.23	GALIAPAR	-0.23	GALIMOLL	-0.24	GALIMURA	-0.28
GALIPARI	-0.28	GALISP	-0.28	GALIVERU	-0.28	GERACOLU	-0.29
GERADISS	-0.29	GERAMOLL	-0.30	GERAPURP	-0.30	GERAPUSI	-0.31
GERAPYRE	-0.31	GERAROBE	-0.31	GERAROTU	-0.31	GERASANG	-0.32
GERASP	-0.33	GEUMURBA	-0.33	GLECHEDE	-0.35	HEDEHELI	-0.36
HELIPUBE	-0.36	HELMECHI	-0.36	HERASPHO	-0.37	HERNGLAB	-0.38
HIBISP	-0.39	HIERSP	-0.39	HIMAHIRC	-0.39	HOLCLANA	-0.40
HOLCMOLL	-0.41	HORDMURI	-0.42	HYPEPERF	-0.42	HYPORADI	-0.42
IRISSP	-0.43	JACOVULG	-0.43	JUNCBUFO	-0.43	KNAUARVE	-0.44
LACTSERR	-0.44	LAPSCOMM	-0.45	LATHLATI	-0.45	LATHNISS	-0.45
LATHPRAT	-0.47	LATHPUSI	-0.47	LATHSP	-0.47	LATHTUBE	-0.47
LEONCRIS	-0.48	LEONHISP	-0.48	LEONSAXA	-0.48	EUCVULG	-0.49
LINAREPE	-0.50	LINAVULG	-0.51	LIPAPOLY	-0.51	LOLIMULT	-0.51
LOLIPERE	-0.52	LOTUCORN	-0.53	LUZUCAMP	-0.54	LYSIVULG	-0.54
MALVNEGL	-0.55	MATRCHAM	-0.55	MATRDISC	-0.55	MEDIARAB	-0.55
MEDILUPU	-0.55	MEDIMINI	-0.55	MEDIPOLY	-0.55	MEDISATI	-0.55
MEDISP	-0.58	MELAPRAT	-0.59	MELIALBU	-0.60	MELIOFFI	-0.60
MENTSPIC	-0.60	MENTSUAV	-0.62	MERCANNU	-0.62	MYOSSP	-0.62
NASSTENU	-0.62	NIGEDAMA	-0.62	ODONVERN	-0.62	OENOBLEN	-0.62
ONONSPIN	-0.63	OPHRAPIF	-0.64	OPHRINSE	-0.64	ORIGVULG	-0.64
ROBARTE	-0.64	OXALCORN	-0.66	PAPARHOE	-0.66	PARIJUDA	-0.66
PASTSATI	-0.67	PERSMACU	-0.68	PETRNANT	-0.69	PHACTANA	-0.69
PHLEPRAT	-0.69	PHYTAMER	-0.69	PICRHIER	-0.69	PICRSP	-0.69
PILOOFFI	-0.69	PIMPSAXI	-0.70	PLANCORO	-0.70	PLANLANC	-0.72
PLANMAJO	-0.72	POAANGU	-0.73	POAANNU	-0.73	POACOMP	-0.73
POANEMO	-0.75	POAPRAT	-0.75	POASP	-0.75	POATRIV	-0.76
POLYAVIC	-0.77	POLYTETR	-0.77	PORTOLER	-0.77	POTERECT	-0.77
POTEREPT	-0.77	PRIMVULG	-0.77	PRUNLACI	-0.77	PRUNVULG	-0.78
RANUACRI	-0.79	RANUBULB	-0.79	RANUREPE	-0.79	RANUSP	-0.80
RAPIRUGO	-0.80	RESELUTE	-0.80	RHINMINO	-0.81	ROSAARVE	-0.81
ROSTCRIS	-0.82	RUMEACEA	-0.82	RUMEACET	-0.85	RUMECONG	-0.86
RUMECRIS	-0.86	RUMEOBTU	-0.90	SAGIAPET	-0.90	SAGIPROC	-0.91
SAGISUBU	-0.93	SALVPRAT	-0.94	SANGMINO	-0.94	SAPOOFFI	-0.94
SAXITRID	-0.94	SCABCOLU	-0.94	SCLEANNU	-0.94	SEDUACRE	-0.94
SEDUALBU	-0.94	SEDURUBE	-0.94	SEDURUPE	-0.94	SEDUSEXA	-0.94
SEDUSP	-0.96	SEDUSPUR	-0.96	SENEVULG	-0.97	SESLCAER	-0.97
SETAVERT	-0.97	SHERARVE	-0.97	SILELATI	-0.98	SILESP	-0.99
SILEVULG	-0.99	SONCARVE	-1.00	SONCASPE	-1.00	SONCOLER	-1.02
SONCSP	-1.02	SPERRUBR	-1.02	STELMEDI	-1.03	STELPALL	-1.05
STELSP	-1.08	TANAVULG	-1.08	TARACAMP	-1.08	THYMPRAC	-1.09
TORDMAXI	-1.10	TORARVE	-1.11	TORINODO	-1.11	TRAGPRAT	-1.11
TRIFARVE	-1.11	TRIFCAMP	-1.11	TRIFDUBI	-1.11	TRIFFRAG	-1.16
TRIFGLOM	-1.17	TRIFINCA	-1.19	TRIFPRAT	-1.20	TRIFREPE	-1.20
TRIFSCAB	-1.21	TRIFSP	-1.22	TRIFSTRI	-1.23	URTIDIOI	-1.23
VALESP	-1.23	VERBNIGR	-1.26	VERBOFFI	-1.26	VERBTHAP	-1.26
VEROAGRE	-1.26	VEROARVE	-1.26	VEROCHAM	-1.30	VEROFILI	-1.32
VEROHEDE	-1.32	VEROMONT	-1.32	VEROOFFI	-1.36	VEROOPAC	-1.36
VEROPERS	-1.36	VEROPROS	-1.36	VEROSCU	-1.39	VEROSERP	-1.43
VEROSP	-1.44	VICICRAC	-1.47	VICIHIRS	-1.47	VICILATH	-1.47
VICILUTE	-1.50	VICIPARV	-1.50	VICISATI	-1.57	VICISP	-1.64
VICITETR	-1.64	VINCMINO	-1.68	VIOLHIRT	-1.68	VIOLSP	-1.68
VULPMYUR	-1.68						

MDS2:

AGROSP	1.27	AGROSTOL	1.16	AJUGPYRA	1.14	ALCEROSE	1.14
ALLIPETI	1.11	ALLIVINE	1.09	ALOPMYOS	1.09	ALOPPRAT	1.09
AMARBLIT	1.08	AMARSP	0.94	ANAGARVE	0.90	ANCHARVE	0.88
ANTHARVE	0.86	ANTHODOR	0.85	ANTHSYLV	0.83	APHASP	0.81
AQUIVULG	0.81	ARCTLAPP	0.81	ARENCILI	0.79	ARENSERP	0.78
ARRHELAT	0.78	ARTEVULG	0.77	ASPAOFFI	0.76	AVENFATU	0.72
AVENSTER	0.72	BALLNIGR	0.70	BELLPERE	0.69	BRACPINA	0.69
BRACSYLV	0.68	BRIZMAXI	0.68	BROMARVE	0.68	BROMDIAN	0.67
BROMEREC	0.63	BROMHORD	0.63	BROMINER	0.63	BROMSP	0.60
BROMSTER	0.59	BRYOCRET	0.59	CALEOFFI	0.57	CALYSEPI	0.57
CAMPPERS	0.54	CAMPRAPU	0.51	CAMPSP	0.49	CAPSBURS	0.48
CARDCRIP	0.47	CARDHIRS	0.45	CARDSP	0.44	CAREDIVU	0.43
CAREECHI	0.41	CAREHIRT	0.41	CAREPALL	0.41	CAREREMO	0.38
CARESP	0.38	CARESPIC	0.36	CARESYLV	0.34	CATARIGI	0.33

CENTERYT 0.32	CENTJACE 0.32	CENTNIGR 0.30	CENTRUBE 0.30
CENTSP 0.29	CERAFONT 0.29	CERAGLOM 0.29	CERASP 0.25
CHELMAJU 0.24	CHENALBU 0.23	CHENVULV 0.23	CICHINTY 0.23
CIRSACAU 0.23	CIRSARVE 0.23	CIRSSP 0.23	CIRSVULG 0.22
CLEMVITA 0.22	CLINVULG 0.20	CONVARVE 0.19	CRASTILL 0.19
CRATMONO 0.18	CREPCAPI 0.17	CREPSETO 0.17	CREPSP 0.16
CRUCLEAV 0.16	CYNOCRIS 0.14	CYNODACT 0.14	CYPEERAG 0.13
DACTGLOM 0.13	DAHLPINA 0.12	DAUCCARO 0.12	DIANARME 0.12
DIANDELT 0.10	DIGISANG 0.10	ECHIVULG 0.09	ELYMREPE 0.09
EPILPARV 0.08	EPILSP 0.08	EPILTETR 0.07	EQUIARVE 0.07
EQUIFLUV 0.07	EQUIRAMO 0.07	EQUISP 0.06	ERAGMINO 0.05
ERIGSP 0.05	ERODCICU 0.05	ERODMOSC 0.04	ERYNCAMP 0.02
ESCHCALI 0.02	EUPHEXIG 0.02	EUPHHELI 0.02	EUPHMACU 0.02
EUPHPEPL 0.01	EUPHPROS 0.00	EUPHRASP 0.00	EUPHSP 0.00
FAGOESCU -0.01	FALOCONV -0.01	LOLIARUN -0.01	FESTFILI -0.02
FESTPALL -0.03	FESTPRAT -0.03	FESTRUBR -0.04	FILASP -0.05
FRAGVESC -0.05	FUMAOFFI -0.06	GALIALBU -0.07	GALIAPAR -0.07
GALIMOLL -0.07	GALIMURA -0.07	GALIPARI -0.07	GALISP -0.07
GALIVERU -0.08	GERACOLU -0.08	GERADISS -0.09	GERAMOLL -0.09
GERAPURP -0.10	GERAPUSI -0.10	GERAPYRE -0.10	GERAROBE -0.11
GERAROTU -0.12	GERASANG -0.13	GERASP -0.14	GEUMURBA -0.14
GLECHEDE -0.14	HEDEHELI -0.14	HELIPUBE -0.15	HELMECHI -0.15
HERASPHO -0.15	HERNGLAB -0.16	HIBISP -0.16	HIERSP -0.16
HIMAHIRC -0.16	HOLCLANA -0.17	HOLCMOLL -0.17	HORDMURI -0.17
HYPEPERF -0.17	HYPORADI -0.17	IRISSP -0.18	JACOVULG -0.18
JUNCBUFO -0.18	KNAUARVE -0.20	LACTSERR -0.20	LAPSCOMM -0.20
LATHLATI -0.21	LATHNISS -0.21	LATHPRAT -0.21	LATHPUSI -0.22
LATHSP -0.22	LATHTUBE -0.22	LEONCRIS -0.23	LEONHISP -0.23
LEONSAXA -0.23	LEUCVULG -0.24	LINAREPE -0.25	LINAVULG -0.27
LIPAPOLY -0.27	LOLIMULT -0.27	LOLIPERE -0.27	LOTUCORN -0.29
LUZUCAMP -0.29	LYSIVULG -0.29	MALVNEGL -0.30	MATRCHAM -0.30
MATRDISC -0.30	MEDIARAB -0.30	MEDILUPU -0.31	MEDIMINI -0.32
MEDIPOLY -0.32	MEDISATI -0.32	MEDISP -0.32	MELAPRAT -0.32
MELIALBU -0.33	MELIOFFI -0.33	MENTSPIC -0.34	MENTSUAV -0.35
MERCANNU -0.36	MYOSSP -0.37	NASSTENU -0.37	NIGEDAMA -0.37
ODONVERN -0.38	OENOBIE -0.39	ONONSPIN -0.40	OPHRAPIF -0.40
OPHRINSE -0.40	ORIGVULG -0.40	OROBARTE -0.40	OXALCORN -0.40
PAPARHOE -0.40	PARIJUDA -0.40	PASTSATI -0.40	PERSMACU -0.40
PETRNANT -0.42	PHACTANA -0.42	PHLEPRAT -0.42	PHYTAMER -0.43
PICRHIER -0.43	PICRSP -0.44	PILOOFFI -0.45	PIMPSAXI -0.45
PLANCORO -0.46	PLANLANC -0.46	PLANMAJO -0.46	POAANGU -0.46
POAANNU -0.47	POACOMP -0.47	POANEMO -0.47	POAPRAT -0.47
POASP -0.47	POATRIV -0.47	POLYAVIC -0.47	POLYTETR -0.48
PORTOLER -0.48	POTERECT -0.48	POTEREP -0.48	PRIMVULG -0.48
PRUNLACI -0.49	PRUNVULG -0.50	RANUACRI -0.51	RANUBULB -0.52
RANUREPE -0.53	RANUSP -0.54	RAPIRUGO -0.54	RESELUTE -0.54
RHINMINO -0.54	ROSAARVE -0.55	ROSTCRIS -0.58	RUMEACEA -0.59
RUMEACET -0.59	RUMECONG -0.59	RUMECRIS -0.59	RUMEOBTU -0.59
SAGIAPET -0.59	SAGIPROC -0.60	SAGISUBU -0.60	SALVPRAT -0.60
SANGMINO -0.62	SAPOOFFI -0.63	SAXITRID -0.63	
SCABCOLU -0.64	SCLEANNU -0.64	SEDUACRE -0.67	
SEDUALBU -0.67	SEDURUBE -0.67	SEDURUPE -0.67	SEDUSEXA -0.67
SEDUSP -0.67	SEDUSPUR -0.68	SENEVULG -0.68	SESLCAER -0.69
SETAVERT -0.70	SHERARVE -0.72	SILELATI -0.72	SILESP -0.72
SILEVULG -0.73	SONCARVE -0.74	SONCASPE -0.76	SONCOLER -0.77
SONCSP -0.78	SPERRUBR -0.78	STELMEDI -0.78	STELPALL -0.81
STELSP -0.81	TANAVULG -0.81	TARACAMP -0.81	THYMPRAC -0.81
TORDMAXI -0.82	TORJARVE -0.83	TORINODO -0.83	TRAGPRAT -0.83
TRIFARVE -0.84	TRIFCAMP -0.85	TRIFDUBI -0.85	TRIFFRAG -0.86
TRIFGLOM -0.88	TRIFINCA -0.88	TRIFPRAT -0.89	TRIFREPE -0.89
TRIFSCAB -0.91	TRIFSP -0.92	TRIFSTRI -0.93	URTIDIOI -0.93
VALESP -0.93	VERBNIGR -0.93	VERBOFFI -0.95	VERBTHAP -0.95
VEROAGRE -0.97	VEROARVE -1.00	VEROCHAM -1.02	VEROFILI -1.02
VEROHEDE -1.02	VEROMONT -1.02	VEROOFFI -1.02	VEROOPAC -1.02
VEROPERS -1.03	VEROPROS -1.05	VEROSCU -1.05	VEROSERP -1.06
VEROSP -1.09	VICICRAC -1.11	VICIHIRS -1.15	VICILATH -1.19
VICILUTE -1.19	VICIPARV -1.19	VICISATI -1.21	VICISP -1.21
VICITETR -1.21	VINCMINO -1.21	VIOLHIRT -1.29	VIOLSP -1.35
VULPMYUR -1.50			

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