

## Lawn management promoting tall herbs, flowering species and urban park attributes enhance insect biodiversity in urban green areas

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### ABSTRACT

Urban expansion transforms the availability and structure of habitats, shaping urban natural elements. This triggered a worldwide effort to reduce urbanization impact on biodiversity, mostly with biodiversity-friendly and less formal management in urban green areas. In this context, we evaluated the effect of lawn management promoting tall herbs on insects in urban parks. Moreover, we also tested the interplay of mowing regimes and green-area attributes, such as park size and tree distribution, by recording the insect species richness and the total and proportional abundances of several groups (*i.e.*, honeybees, wild bees, wasps, hoverflies, non-syrphid flies, beetles, true bugs, grasshoppers, lepidopterans). The results from the first experimental year demonstrate that unmown sections increase insect abundance and species richness, while the regrowth after the first mowing of tall herbs was only moderately beneficial, compared to frequently mowed areas. Positive contributions by flower richness on the insect richness and by the aggregated tree distributions on insect abundance and richness were recorded. Negative relationships occurred between increasing graminoid cover and insect abundances and between park size and insect richness. Furthermore, most insect groups were promoted by plant height (except honeybees and flies) and they correlated with specific dominant plants in many cases. Overall, this study demonstrates the positive roles of tall herbs in urban parks, clarifying the influence of park attributes and lawn features, pointing out that a less intensive management regime with informal green areas could effectively enhance urban insect biodiversity.

### 1. Introduction

Urban expansion implicates a deep transformation of habitat availability and structure, resulting in environmental changes that affect biodiversity (Li et al., 2022; Simkin et al., 2022). Built-up lands increasingly reduce and fragment green areas in the urban matrix, making it difficult for biodiversity to find adequate shelter, optimal nutritional resources and suitable conditions for reproduction. This contributes to biodiversity decline along urbanization gradients (Fenoglio et al., 2020), affecting butterflies and moths (Belitz et al., 2024; Clark et al., 2007; Iserhard et al., 2019), grasshoppers (Pernat et al., 2024), bees and hoverflies (Biella et al., 2022), and native plants (Ruas et al., 2022), as well as others. Habitat fragmentation bears additional problematics to species life-cycles: for instance, a recent study

clarified that urban bumblebees find less profitable pollen resources as green-area fragmentation increases (Pioltelli et al., 2024), while another study identified increasing stresses associated with urbanization (Tommasi et al., 2022). Under the One-health philosophy, the deterioration of biodiversity resulting from urban expansion brings consequences for humans as well as for nature (Genovesi et al., 2023). Therefore, it is fundamental to find ways to preserve urban nature, for the sake of both society and ecosystem functioning (Bruno et al., 2024).

To locally support biodiversity, two types of actions can be applied to urban green areas: (i) strategies to enhance nature quality in urban green spaces and (ii) biodiversity-friendly management practices. The first one involves adding elements to provide additional foraging and nesting resources, for example urban flower strips (Poole et al., 2024) or various types of nests (Le Roux et al., 2016). The second one prioritizes

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biodiversity over aesthetics or human preferences when managing urban green spaces: e.g. leaving deadwood in park forests benefits many insects (Meyer et al., 2021), and decreasing mowing frequency increases arthropod biodiversity (Proske et al., 2022) and pollinators (Wastian et al., 2016). Biodiversity-friendly management is also referred to as a low-intensity regime or as keeping less-formal green areas (Unterweger et al., 2017; Watson et al., 2020), in contrast to frequent mowing and aesthetic prevalence. Interestingly, a case study shows that a modest reduction of mowing frequency can even benefit administrators, potentially leading to cost savings of up to 36 % (Watson et al., 2020).

Studies aimed at assessing the effects of urban green areas management on insect biodiversity are increasing, although they evaluate different aspects. These works often target one insect group or guild (e.g., only bees as in Lerman et al., 2018, or only some pollinators as in Rada et al., 2024). In other cases, several groups are evaluated in meta-analyses compiling results from several studies (Proske et al., 2022), but field studies rarely investigate multi-taxa responses in the same locations subjected to the same mowing regime. Scientific works also test different management descriptors, such as the mowing frequency in some cases, found to decrease the bee abundance and richness (Lerman et al., 2018) and the plant diversity (Chollet et al., 2018). Other studies compare micro-habitats within parks, such as formal, low-grass areas versus tall-herb sections as in Rada et al. (2024). To the best of our knowledge, in the context of urban mowing, no studies evaluated the influence of additional factors on insects, such as the effect of the relative size of the tall-herb section within parks, the influence of the regrowth after mowing or the consequence of other park attributes such as park size or tree distribution that may serve as refuges to many insect species.

Here, we aimed to investigate the effect of urban park management of lawns and configuration to find solutions promoting high insect biodiversity in urban areas. The main scope of the study was to test if leaving tall-herb areas could increase the local insect biodiversity in terms of abundance and species richness. We targeted several groups of insects and evaluated the effects of mowing (or not, or the regrowth of the tall-herbs after the first mowing) by comparing formal meadows with frequently mown low herbs and tall-herb areas within urban parks. Additionally, we considered the roles of park size, of the proportional cover of the tall-herb section and of the distribution of woody plants (*i.e.*, trees and shrubs) within the parks, as these factors often influence urban biodiversity (Li et al., 2024); we also investigated the contribution of the flower richness and graminoids cover. We expect that all these factors may play a role in keeping high biodiversity in the tall-forb sections: larger parks and larger unmown areas could host more species, in accordance with the island biogeography theory applied to urban green areas (Faeth and Kane, 1978); spatial arrangement of woody vegetation affects urban insect biodiversity as found for birds, where linear trees host less species than aggregated trees (Villaseñor et al., 2021); graminoid cover could favour some insect taxa (Yagui et al., 2024), while flower richness could increase pollinators and other insects as well based on their need to collect resources from flowers (as reviewed in Ollerton, 2017). Furthermore, we also focused on community composition of insect groups by investigating how it changed in different lawn management conditions. We did so in two terms: (i) by studying how each insect group proportion in the community changes with plant height, taken as indication of mowing intensity, and (ii) by looking at the dominant plant species and the lawn management factors to test if they could signal specific insect compositions. Overall, by analysing several factors, some directly related to the mowing regime and some other incidental to how the area is configured, we aimed to reach a mechanistic understanding of how several features of urban green spaces influence urban insect biodiversity in terms of their abundance, richness and community composition.

## 2. Methods

### 2.1. Study area

The study areas were located in a major city in Northern Italy, Milan. During the study, 8 urban parks located in different parts of the city (Table S1 in the Appendix A) were surveyed for their insect biodiversity. The distance between parks was considerable, minimum 1 Km, maximum 10.5 Km. Each park consists of a large area where, for the first time during 2024, the herbaceous vegetation was left to grow since winter in designated sections. The surroundings were regularly mowed (about once a month, mowing treatment type: mown). In some studied sites, the tall herb area was mowed once, a few weeks before our sampling, so that at the time of sampling the plants were regrowing and some were blooming (mowing treatment type: regrowth). Other unmown parks were never cut before the sampling during this year (mowing treatment type: unmown). Hence, in each park we surveyed the mowing treatments of mown vs. unmown or mown vs. regrowth.

### 2.2. Insect surveys

In most of the parks, 12 observation plots were made for each management treatment type, while in two slightly bigger parks more observation plots were made (18–24) per treatment type, for a total of 230 unique plots, plot location being chosen randomly. Data on insect abundance and species richness were recorded in a non-invasive way by counting the insects occurring within the plot during a 10-minute observation period for each plot, similar to Biella et al. (2025), in July 2024. During the observations in the field, seen insect individuals were recoded directly into groups as honeybees, wild bees, hoverflies, non-syrphid flies, butterflies, beetles, grasshoppers and true bugs when counting their abundances per time unit and plot. Within each group, the number of morphospecies was also counted, based on careful evaluations of visible features (e.g. color, size, color pattern, overall appearance, pilosity, etc): insects with visible differences were considered different morphospecies. The approach of using morphospecies is appropriate for rapid assessments when it is not necessary or possible to assign a specific name to them (Hackman et al., 2017). Additionally, morphospecies are very often used to reliably estimate species richness based on their well-known correlations with taxonomic species richness (Hackman et al., 2017; Obrist and Duelli, 2010), especially for making comparisons across sites with similar species pool as in the case of our study (Derraik et al., 2010; Krell, 2004).

### 2.3. Management descriptors

Within each plot, the following management parameters were recorded: (i) the vertical height of the ground vegetation, measured as the distance from the ground to the top of the plants; (ii) the cover of the graminoids, defined as the percentage of ground occupied by grass vegetation, estimated visually; (iii) the species richness of flowering plants, counted as the raw number of species seen in blooming phase in the plot when sampling; and (iv) the most abundant flowering plant species in the plot that could summarize the plant community variations (although we did not characterize the plant community in a finer way).

### 2.4. Park attributes

To describe park features, satellite imagery (Google Earth) were used to categorize the parks into those hosting trees and shrubs mainly distributed in rows from those having trees mostly organized in clusters (hence, alike small forest patches); we retrieved park sizes from the Municipality of Milano database (<https://geoportale.comune.milano.it/sit/patrimonio-del-verde>) and calculated the percentage of unmown/regrowth surface relative to the total area of each studied park (taken from, <https://www.comune.milano.it/aree-tematiche/verde/ma>

**Table 1**

Insect abundance regression model in relation to the mowing treatment type, the flower richness, the graminoid cover, the type of tree and shrub distribution, the cover of the unmowed section and the park size; for each predictor estimated effects, *Chi* squared and significances from likelihood-ratio tests (in bold when <0.05) are indicated.

Response variable	Predictor variable	Regression coefficient estimate or mean difference (in log scale)	$\chi^2$ (d.f.)	P value
Insect total abundance	Mowing treatment	Unmown = 0.179 Regrowth = 0.119 Mown = - 0.298 0.059 (S.E. 0.094)	47.170 (2)	<b>&lt; 0.001</b>
	Mowing: unmown – regrowth			0.525
	Mowing: unmown – mown	0.477 (S.E. 0.075)		<b>&lt;0.001</b>
	Mowing: regrowth – mown	0.417 (S.E. 0.081)		<b>&lt;0.001</b>
	Flower richness	0.001	0.002 (1)	0.969
	Graminoids cover	-0.116	17.116 (1)	<b>&lt; 0.001</b>
	Tree distribution	Linear = - 0.178 cluster = 0.178	5.242 (1)	<b>&lt; 0.05</b>
	Tree distribution: linear - cluster	-0.357 (S.E. 0.13)		<b>&lt;0.01</b>
	Unmown cover	0.045	0.505 (1)	0.477
	Park size	-0.1	1.89 (1)	0.169

nutenzione-progettazione/sfalci-ridotti).

2.5. Statistical analysis

The total abundance or species richness of all insect groups summed together were analysed at the plot level for each urban park using Generalized Linear Mixed Models. Models included predictor variables related to management, such as the mowing treatment (“mown”, “unmown”, “regrowth”), the species richness of flowering plants, the cover of graminoid plants and the park level variables describing variations due to the park contexts as the tree and shrubs distribution within parks (“cluster” vs “linear”), the area of the park (in log scale) and the relative percentage of the surface subjected to the mowing treatment. A

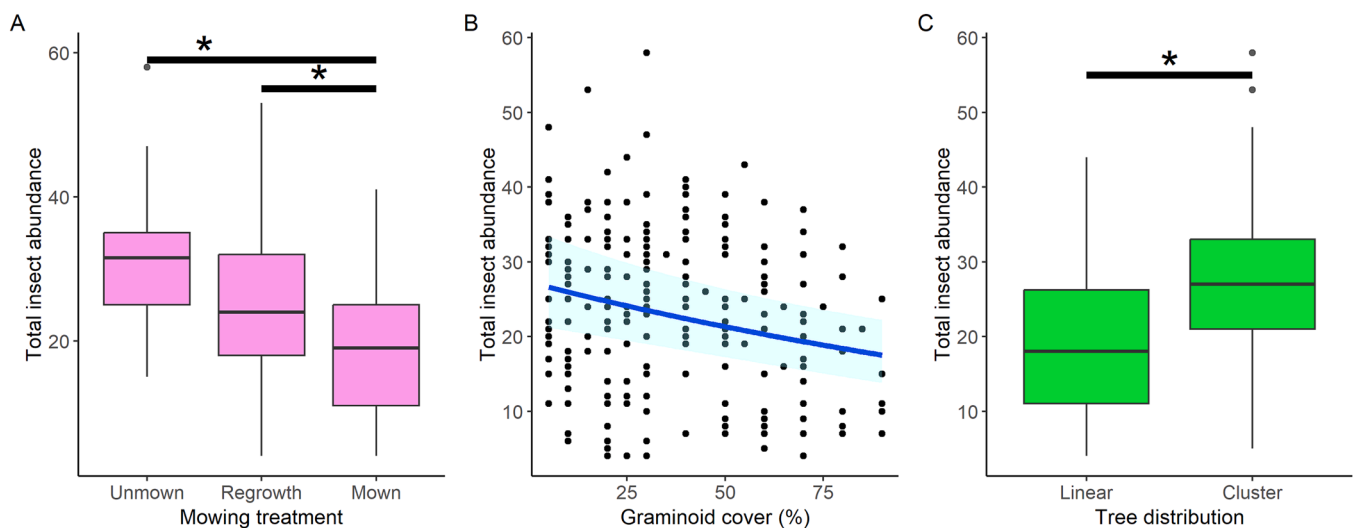
random effect was set accounting for the park identity, the abundance data were fitted with negative binomial error distribution and the species richness with gaussian distribution after evaluating response variable density plot. Regressions were performed with the *glmmTMB* package (Brooks et al., 2017) in R (R Core Team, 2024), variable significance was tested with log-likelihood ratio test (*drop1* function) and post-hoc tests with the *emmeans* package (Lenth, 2020).

The abundance of each insect group was divided by the insect total abundance at a given plot to obtain their proportional abundances. These were analysed by means of Generalised Linear Mixed Models with binomial error distribution, the plant height variable as predictor and the park identity as random factor, with the *glmmTMB* package (Brooks et al., 2017). The significance was tested with the log-likelihood ratio

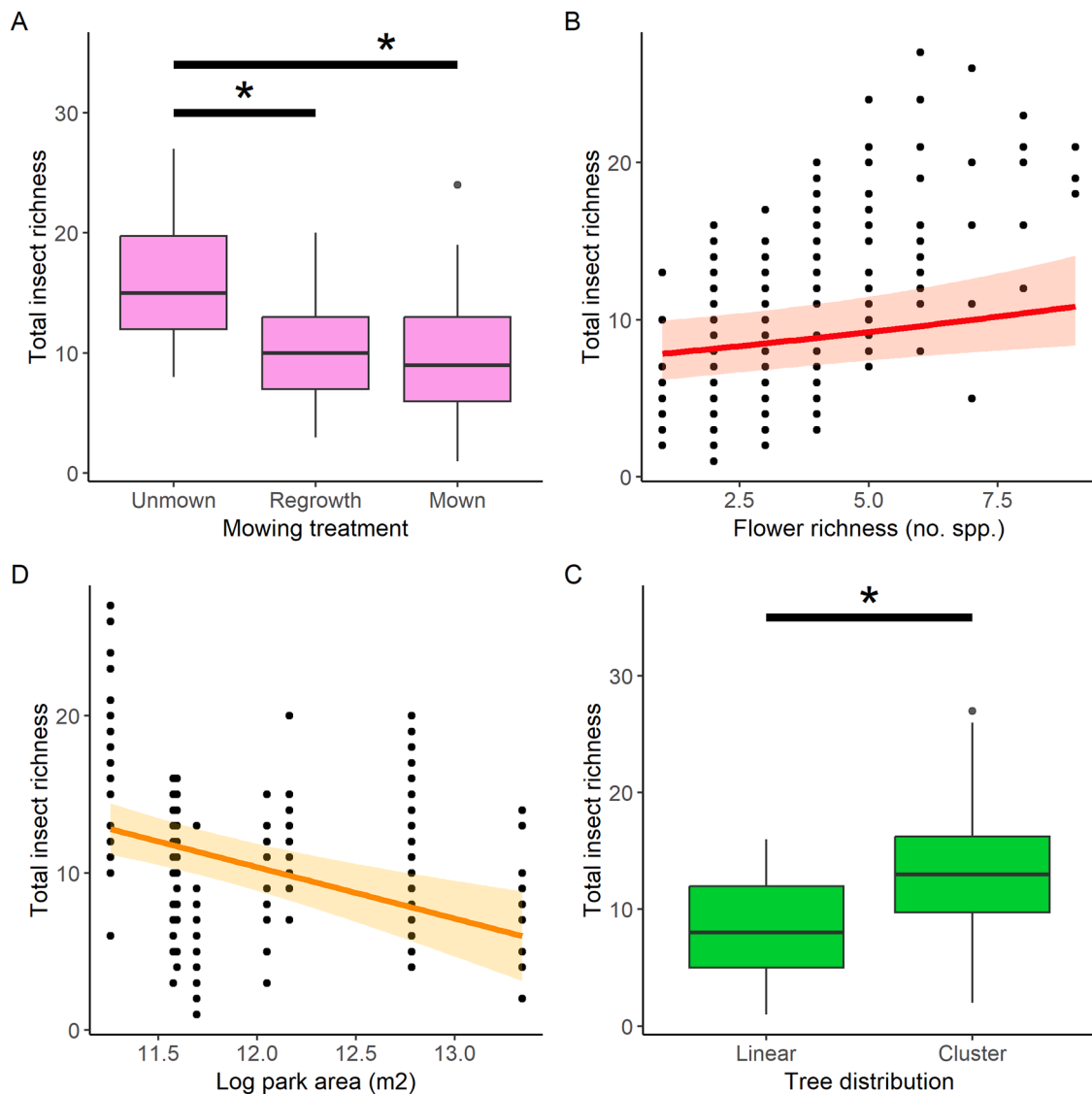
**Table 2**

Insect species richness regression model in relation to mowing treatment type, flower richness, graminoids cover, type of tree and shrub distribution, the cover of the unmowed section and the park size: estimated effects, *Chi* squared, significance from likelihood-ratio tests (they are in bold when <0.05).

Response variable	Predictor variable	Regression coefficient estimate or mean difference (in natural scale)	$\chi^2$ (d.f.)	P value
Insect total richness	Mowing treatment	Unmown = 1.858 Regrowth = -0.419 Mown = -1.439 2.28 (S.E. 0.740)	27.374 (2)	<b>&lt; 0.001</b>
	Mowing: unmown – regrowth			<b>&lt;0.05</b>
	Mowing: unmown – mown	3.30 (S.E. 0.611)		<b>&lt;0.001</b>
	Mowing: regrowth – mown	1.02 (S.E. 0.616)		0.10
	Flower richness	1.158	16.433 (1)	<b>&lt; 0.01</b>
	Graminoids cover	-0.383	3.194 (1)	0.07
	Tree distribution	Linear = - 0.273 Cluster = 0.273	12.341 (1)	<b>&lt; 0.01</b>
	Tree distribution: linear - cluster	-5.47 (S.E. 1.01)		<b>&lt;0.001</b>
	Unmown cover	0.31	0.422 (1)	0.51
	Park size	- 2.202	9.1(1)	<b>&lt; 0.5</b>



**Fig. 1.** Insect total abundance in relation to urban park management of lawns and configuration, in particular in relation to (A) Mowing treatment (unmown vs. regrowth vs. mown), (B) Cover of graminoid plants and (C) Trees and shrubs spatial distribution in the parks. Data originated from 10-minute observation plots within differently managed sections in the urban parks.



**Fig. 2.** Insect total species richness in relation to urban park management of lawns and configuration, in particular in relation to (A) Mowing treatment (unmown vs. regrowth vs. mown), (B) Flower species richness, (C) Park area (in logarithmic scale), (D) Trees and shrubs spatial distribution in the parks. Data originated from 10-min observation plots within differently managed sections in the urban parks.

test (*drop1* function). Plant height was chosen as a concise variable describing the management, as it was aligned with the mowing treatment types (unmowed: plant height mean 63.79 cm, 50 cm as 25 % quantile and 73.75 cm as 75 % quantile; regrowth: mean 35.67 cm, 27 cm as 25 % quantile and 41.25 cm as 75 % quantile; mown: mean 18.33 cm, 15 cm as 25 % quantile and 20 cm as 75 % quantile), and it was correlated with other management-dependent variables like the flower richness ( $r = 0.71$ ) but not with the graminoid cover ( $r = 0.04$ ).

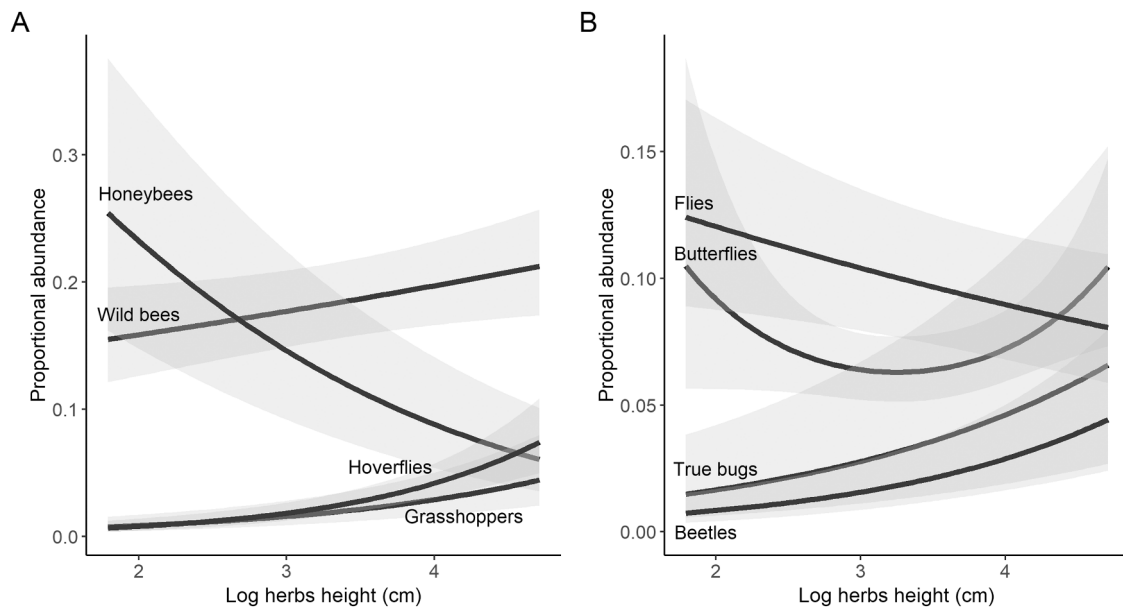
Canonical Correspondence Analysis was used to test the association between each insect group abundance and the dominant plant species in the plots, also considering management-related variables as the flower species richness and the graminoid cover. Also in this case, insect abundances were divided by the total insect abundances. The analysis was performed separately for each type of mowing treatment. Both the full model (all variables together) statistics and the marginal effects of single variables were calculated based on 999 permutations, using the *vegan* package (Oksanen et al., 2018).

### 3. Results

#### 3.1. Insect biodiversity in relation to mowing and park features

The total insect abundance significantly responded to the mowing treatment (*i.e.*, mowed, unmown, regrowth), to the graminoids cover in the treated areas and to tree distribution in the parks (Table 1). In detail, insect abundance was significantly lower in the mowed areas compared to both the regrown (-16.8 %) and unmown areas (-14.9 %), which, in turn, were not significantly different from each other (Fig. 1A). In addition, increasing graminoid cover decreased insect abundance by 34.12 % across the entire variable range, whereas parks having trees distributed in clusters increased insect abundance by a mean of 11.9 % compared to parks with trees distributed along lines (Fig. 1B and C).

Insect richness resulted to be significantly related to the mowing treatment, the graminoid cover, the tree distribution, the flower richness in the meadows, and to the park area (Table 2). In particular, insect richness was significantly lower in the mowed and regrowth areas compared to the unmown areas (Fig. 2A), with mown areas having an average of -27 % richness compared to unmown ones and regrown areas having -18.66 % richness than unmown ones. Moreover,



**Fig. 3.** Proportional abundances of each insect group in relation to herb plant height (in logarithmic scale). Each group is analysed separately, but plotted together with others to ease the comparisons.

**Table 3**

Proportional abundance of single insect groups in models in relation to plant height (that was in logarithm transformation): estimated effects, *Chi* squared, significance from likelihood-ratio tests (they are in bold when <0.05).

Insect group	proportional abundance	Regression coefficient estimate (in log scale)	$\chi^2$ (d.f.)	P value
Wild bees		0.132	4.687 (1)	< 0.05
Honeybees		-0.641	73.203 (1)	< 0.001
Lepidopterans		first order = 0.778 second order = 1.655	6.116 (2)	< 0.05
Syrphid flies		0.855	41.526 (1)	< 0.001
Grasshoppers		0.626	26.4 (1)	< 0.001
True Bugs		0.528	37.763 (1)	< 0.001
Beetles		0.279	4.549 (1)	< 0.05
Non-Syrphid flies		-0.165	5.316 (1)	< 0.01
Wasps		-0.114	3.105	0.078

flowering species richness increased insect richness by 65.2 % across the entire range of these variables (Fig. 2B). Regarding park features, having trees in clusters rather than linearly arranged increased richness by a mean of 41.78 %, and increasing park areas was linearly related to decreasing insect species richness by 53.22 % (Fig. 2C and D).

### 3.2. Insect group proportional responses to plant height

While the proportional abundances of honeybees and non-syrphid flies decreased with increasing plant height, the other groups increased, although with some differences as some increased more than others (Fig. 3): the lowest increases were observed in wild bees and in beetles, while the highest increases were recorded in syrphids, grasshoppers and Hemiptera (Table 3). All trends were significant and linear, except for lepidopterans showing an inverse quadratic trend.

### 3.3. Insect community responses to plant dominant species and meadow parameters

The analysis showed two main aspects (Fig. 4). Firstly, the importance of the dominant plant species, as this variable was always a meaningful predictor in the ordination analysis of each mowing treatment (Table 4). Specifically, the dominant plant species correlated with

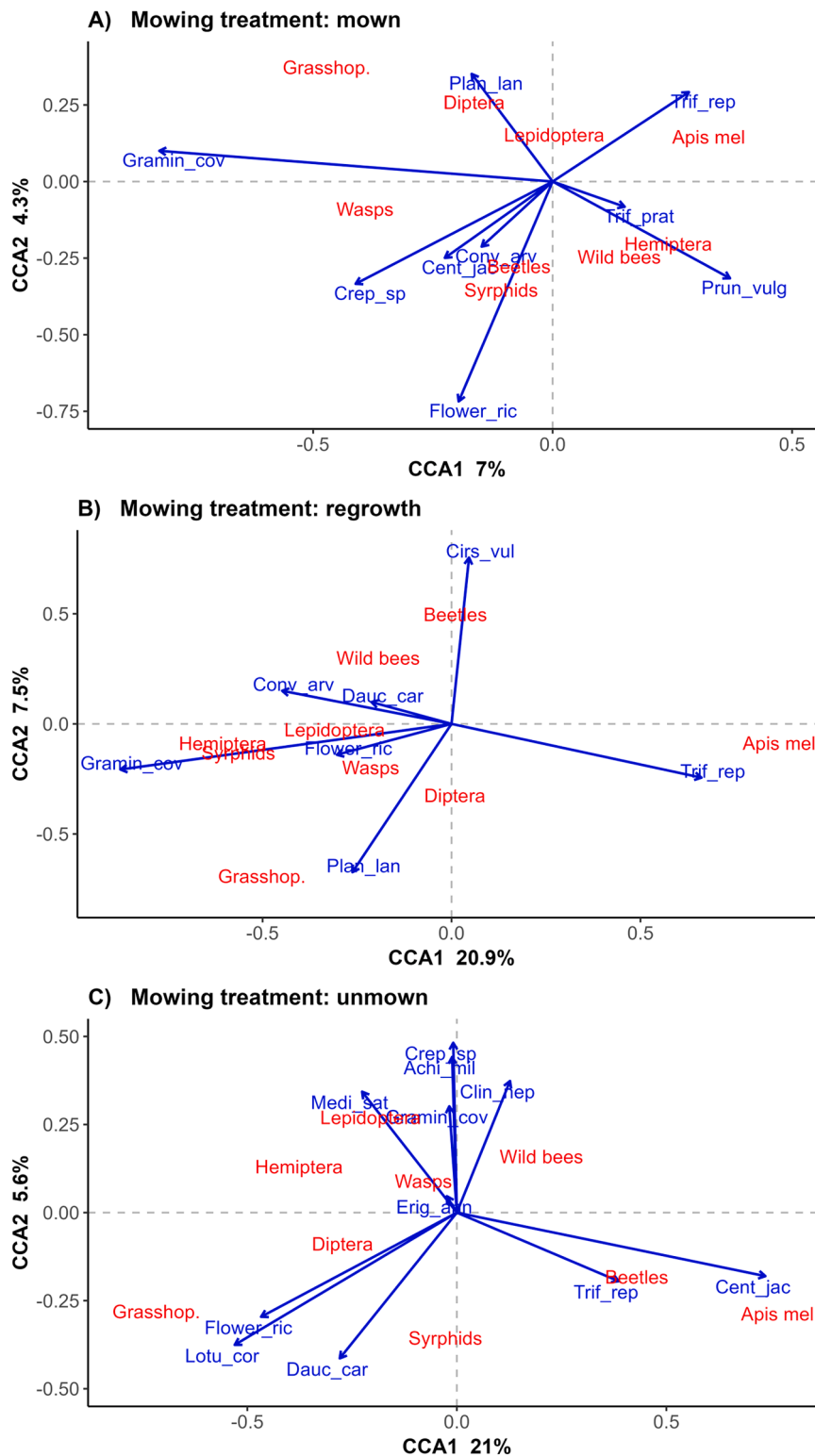
some specific insect groups: for instance the honeybees were more abundant in plots dominated by the plant *Trifolium repens* or non-syrphid Diptera were more prevalent in *Plantago lanceolata* plots in the mown and the regrowth phases, together with other cases present in given mowing treatment types.

Secondly, some of the observed relationships between insect group abundances and covariates (*i.e.*, plants, meadow attributes) were consistently found across all or some mowing treatments: wasps seemed to be related to the graminoid cover, as well as the grasshoppers and true bugs in the mown and regrowth phases; syrphids seemed to be linked to flower richness in all phases, wild bees tended to be in plot regions where there were several plants and, in the mown and regrowth analyses, they were related to flower richness; similarly, the lepidopterans tended to lie in plot regions with many plant species in the regrowth and unmown analyses. In contrast, beetles and other Diptera did not appear to be consistently related to plant and features across the mowing treatments.

## 4. Discussion

In this study, we investigated the effects of urban lawn management and park features on several insect groups in response to the management practices promoting tall herbs in sections of urban parks. These areas with taller herbs are planned to increase biodiversity, and therefore we tested their effect on the cumulative abundance and richness of insects, as well as on single groups as proportions in the communities. Overall, our results indicate that tall-herb sections enhance the biodiversity of all insects collectively and of most of the single insect groups studied here, also due to other variables such as the richness of flowering plant species and the distribution of trees in the parks. These positive responses to factors describing a less intensive management regime of lawns point out that leaving informal areas in the urban green areas could effectively promote local biodiversity.

In our study, the abundance and species richness of all insect groups together depended on the mowing treatment of the urban park lawns (*i.e.*, mown, regrowth, unmown). They were higher in unmown compared to mown areas, in accordance with other studies more focused on single insect guilds (*e.g.*, Rada et al., 2024). This result points clearly out that leaving unmown sections could attract many insects, while also confirming that frequent mowing reduces insect biodiversity (Steidle et al.,



**Fig. 4.** Proportional abundances of each insect group in relation to the dominant plants in the plots (names are shortened as 4 letters of the genus and 3 letters of the species names, full names are in Table S2 of the Appendix A) and other urban park meadow parameters (Flower\_rich = flower species richness, Gramin\_cov = Graminoid cover). Each management treatment is analysed separately.

2022). Intriguingly, our analyses also added that while the regrowth areas host similarly abundant insects as the unmown sections, as found in another study regarding grasshoppers (Klein et al., 2020), instead the species richness in the regrowth was more similar to the mown areas. This disparity between abundance and richness patterns in relation to the regrowth are justifiable with a disturbance event (*i.e.*, mowing tall

herbs), after which the tall forb sections are re-colonized by some insects from the surroundings, attracted to the growing forbs and became abundant after the mowing event. It is important to note that the regrowth may be ineffective in supporting the next generations because, after the first mowing, there may not be enough time to complete the insect life cycles before the adverse season, as observed for butterfly

**Table 4**

Output of the Canonical Correspondence Analysis of insect group proportional abundances across the mowing treatments. Statistics from both the full model (with all variables) and the marginal effects of single variables are provided based on 999 permutations.

Mowing treatment	Model specifics or covariates	R <sup>2</sup> ; R <sup>2</sup> adjusted	Scaled $\chi^2$ (d. f.)	F	P value
Mown	Full model	0.16; 0.10	0.157 (8)	2.534	< 0.01
	Graminoid cover		0.031 (1)	5.151	< 0.01
	Flower richness		0.078 (1)	3.991	< 0.01
	Plant species		0.078 (6)	1.681	< 0.05
	Residual		0.813 (105)		
Regrowth	Full model	0.34; 0.25	0.369 (6)	3.63	< 0.01
	Graminoid cover		0.111 (1)	6.57	< 0.01
	Flower richness		0.034 (1)	2.02	0.06
	Plant species		0.152 (4)	2.24	< 0.01
	Residual		0.696 (41)		
Unmown	Full model	0.33; 0.20	0.214 (10)	2.66	< 0.01
	Graminoid cover		0.016 (1)	1.951	0.07
	Flower richness		0.005 (1)	0.692	0.62
	Plant species		0.163 (8)	2.535	< 0.01
	Residual		0.442 (55)		

oviposition (Knight et al., 2019). This highlights that the timing of the mowing and of the regrowth is a crucial factor to consider for managing the tall herb lawns, thus a careful evaluation should be made by weighting species requirements.

Several additional factors describing the meadows and the parks influenced the abundance and richness of insects found: flowering species, graminoids cover, tree distribution and park size. First of all, flowers promoted insect richness, while graminoid cover negatively affected their abundances. Relationships of this type are usually found for pollinators which seek flowers during their foraging and evidently are promoted by flowering species richness (Ollerton, 2017). However, we found that not only pollinators but also other insects benefit from flower richness as in the case of analyzing the proportional abundance of single insect groups, as in fact many different insect species forage from plants. Furthermore, the negative relationship between park size and insect richness and the positive effect of having clustered tree distributions stem from different reasons. As urban parks are usually greatly isolated from other source areas and they usually host recreational activities and disturbance in most of their surface, having bigger parks does not imply having more insects, similarly to a previous study in this area (Biella et al., 2022) but differently to what expected from island biogeography (Faeth and Kane, 1978). In addition, clustered tree and shrub aggregations could increase nesting and refuge opportunities within parks, insects foraging in the adjacent grassy areas. The role of spatial distribution of shrubs and trees as a source of biodiversity is crucial and it finds support also from what was found for urban birds (Villaseñor et al., 2021), thus confirming the important role of urban forests on insect biodiversity (e.g., Kotze et al., 2022).

Different insect groups reacted similarly to each other in response to the management practices and the lawn features, which was particularly evident when using herb height as a response variable indicating the mowing intensity. Previous studies had shown that plant height promotes arthropod and insect biodiversity (Proske et al., 2022) and pollinators (Dylewski et al., 2019; Granata et al., 2023); however, here we clarified that different groups benefited from plant height at varying degrees, as shown by the different regression slopes and different increase patterns, while some insect groups even decreased. These variations could be explained by looking at the proportional responses of insect groups to the dominant plant species, that was an important variable for group responses: e.g., honeybees and flies decreased with increasing plant height, and in fact they correlated with plots dominated by *Trifolium repens* (honey bee) or *Plantago lanceolata* (non syrphid flies)

in both the mown and the regrown plots, that are species tolerating mowing well. Similarly, honeybees were more frequently associated with smaller herbs also in vineyards in Italy (Biella et al., 2025). Moreover, wasps, grasshoppers and true bugs were usually correlating with the graminoid cover in the ordination plots, as documented in the literature for some of them (Yagui et al., 2024). In contrast, syrphids, lepidopterans and wild bees were related to several flowering species particularly during certain stages of the mowing treatment, as these groups are renown flower visitors (Ollerton, 2017) which could be promoted by flowering diversity and herbs height.

It should be kept in mind that this study was conducted during the first year of the application of the lawn management strategies, that the monitoring lasted for a relatively short time (one month) and only during one season. We chose to perform the study in a month and in a year to minimize phenology and year-by-year variations, in order to have a clearer view of the immediate effects of introducing reduced mowing regimes of the lawns. However, it is likely that longer monitoring could add a comprehensive view of the natural dynamics over time. Likewise, having data from more years of reduced mowing could provide a picture considering cumulative effects over time and especially account for feedbacks from insect populations over time.

## 5. Conclusions

In this study we observed that the lawn mowing management, the dominant plant species and the distribution of trees jointly influence insect biodiversity in urban parks with unmown sections. We also pointed out the role of flowering species, graminoid cover and plant height. Additionally, we addressed the somewhat enigmatic situation regarding the regrowth of the tall herb sections after the occasional mowing. From this study and the responses of insect biodiversity to unmown areas, it appears very clear that leaving tall-herb sections could serve as an effective management strategy for urban parks administrations aiming to mitigate the problems that biodiversity is facing due to urbanization. Although we investigated the effects at the first year of introduction of this strategy, we believe that more studies on this management regime should be conducted to monitor the cumulative effects over time and also the outcomes for other fauna (e.g., soil arthropods, birds and bats).

Here, we advocate that unmown areas could be systematically incorporated into urban green area management, possibly also including simple modifications of that management regime, such as by further calibrating mosaic mowings (Rada et al., 2024) with asynchronous cuts of the lawns and of the tall-herbs to constantly support animal biodiversity (Bruppacher et al., 2016). This could be integrated with other actions aimed at strengthening urban biodiversity (e.g., Poole et al., 2024), in accordance with educational campaigns to help citizens understand their usefulness and increase their well-being (Aronson et al., 2017). It is fundamental to use environmental campaigns to increase people's awareness of the value of urban biodiversity, thus leading citizens to welcome biodiversity-friendly greenspace management (Fischer et al., 2020). Fortunately, it has been demonstrated that providing environmental information can effectively increase people's positive attitude towards the informal management of urban green areas (Unterweger et al., 2017). Thus, campaigns of this type should take place alongside the actual implementation of measures enhancing urban biodiversity.

## CRedit authorship contribution statement

**Paolo Biella:** Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Sara Borghesan:** Writing – review & editing, Investigation. **Beatrice Colombo:** Investigation. **Andrea Galimberti:** Writing – review & editing, Investigation. **Lorenzo Guzzetti:** Writing – review & editing, Investigation. **Davide Maggioni:** Writing – review & editing,

Investigation. **Emiliano Pioltelli**: Writing – review & editing, Investigation. **Fausto Ramazzotti**: Writing – review & editing, Investigation. **Rosa Ranalli**: Investigation. **Nicola Tommasi**: Writing – review & editing, Investigation. **Massimo Labra**: Writing – review & editing, Funding acquisition, Conceptualization.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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### Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.ufug.2024.128650](https://doi.org/10.1016/j.ufug.2024.128650).

### Data availability statement

Data used for this study are made available in a public repository (Figsare) at the link: <https://doi.org/10.6084/m9.figshare.28103585>

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