Vorlagenummer: FB 36/0542/WP18
Öffentlichkeitsstatus: öffentlich
Datum: 29.10.2024

FLIP - Projekt: Sachstand und Ausblick

Vorlageart: Kenntnisnahme
Federführende Dienststelle: FB 36 - Fachbereich Klima und Umwelt
Beteiligte Dienststellen: E 18 - Aachener Stadtbetrieb
Verfasst von: 36/100

Beratungsfolge:

Datum	Gremium	Zuständigkeit
25.02.2025	Ausschuss für Umwelt und Klimaschutz	Kenntnisnahme
11.03.2025	Betriebsausschuss Aachener Stadtbetrieb	Kenntnisnahme

Erläuterungen:

Das FLIP-Projekt:

In Stadt und StädteRegion Aachen wird seit März 2020 das FLIP-Projekt umgesetzt. In den zuständigen Ausschüssen für Umwelt und Klima der Stadt Aachen sowie Aachener Stadtbetrieb wurde wiederholt, zuletzt 2022, über den Stand im Projekt informiert. Im Projekt FLIP (**F**örderung der **L**ebensqualität für **I**nsekten und Menschen durch **p**erfekte Wiesenwelten) geht es darum, in Stadt und StädteRegion auf öffentlichen, privaten und landwirtschaftlichen Flächen Glatthaferwiesen zu etablieren, um dadurch in erster Linie für Insekten und Spinnentiere Lebensräume zu schaffen und diese zu vernetzen. Außerdem geht es darum, die Menschen in der Region für das Thema Artenvielfalt durch Wiesen aus Wildpflanzen zu begeistern und darüber Wissen zu vermitteln. Das Projekt wird gefördert im Bundesprogramm Biologische Vielfalt vom Bundesamt für Naturschutz mit Mitteln des Bundesministeriums für Umwelt, Naturschutz und nukleare Sicherheit. Das Projekt läuft seit dem 01.04.2020 bis zum 31.03.2026. Das Projekt umfasst folgende Partner und Aufgaben:

- RWTH Aachen, Institut für Umweltforschung – Projektleitung & -koordination, ökologisches Monitoring, Übertragbarkeitsstudie
- RWTH Aachen, Lehrstuhl für Kommunikationswissenschaft – sozio-psychologisches Monitoring, Übertragbarkeitsstudie
- Stadtbetrieb Aachen, Grünflächen- und Friedhofswesen – Flächenauswahl, Anlage und Erhalt von Glatthaferwiesen auf öffentlichen Flächen
- Stadt Aachen Fachbereich Klima und Umwelt, Abteilung Umweltvorsorgeplanung und Grünplanung – Flächenauswahl
- Stadt Aachen Fachbereich Klima und Umwelt, Abteilung Verwaltung, Umweltinformation, Umweltinformationssysteme – Bürger*innen-Netzwerk, regionale Öffentlichkeitsarbeit
- StädteRegion Aachen, Bildungsbüro – pädagogisches Konzept und Material

- StädteRegion Aachen, untere Naturschutzbehörde – fachliche Unterstützung
- Staatliches Museum für Naturkunde Karlsruhe – überregionale Öffentlichkeitsarbeit.

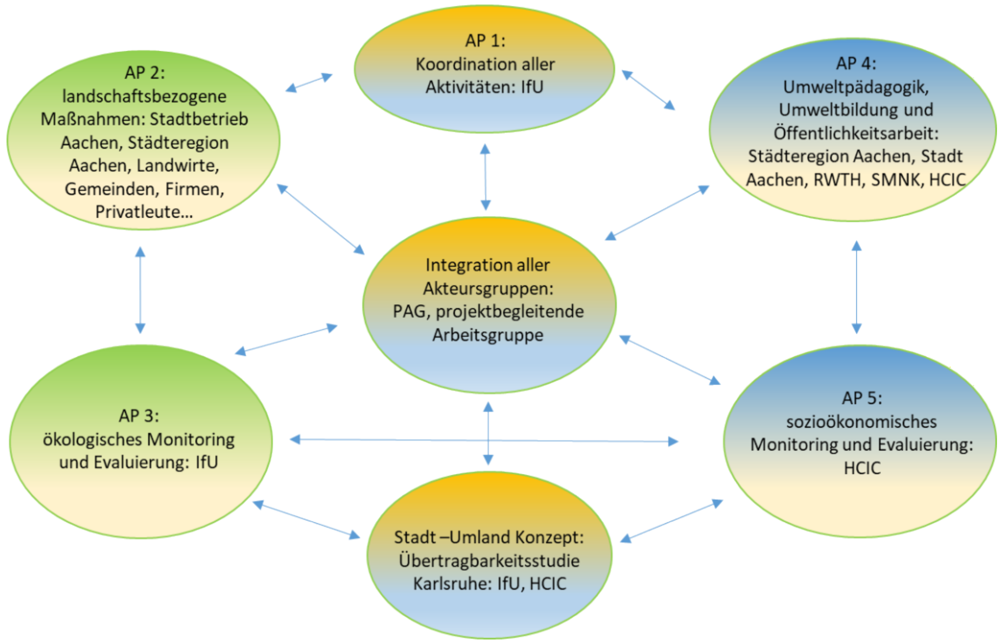

Abbildung 1: Schematische Struktur zur Abbildung des Projektnetzwerkes und der Arbeitspakete AP1-5. Abkürzungen: IfU - Institut für Umweltforschung, RWTH Aachen University; HCIC - Lehrstuhl für Kommunikationswissenschaft, RWTH Aachen University; SMNK - Staatliches Museum für Naturkunde Karlsruhe; PAG – projektbegleitende Arbeitsgruppe.

Projektmanagement und Multiplikator*innen-Ansprache:

Die über das Projektmanagement und die Projektkoordination erarbeiteten Netzwerk- und Arbeitsstrukturen im Projekt wurden verstetigt und führen zu einer engen Zusammenarbeit innerhalb des Projekts. Bei den regelmäßigen themenbezogenen Arbeitstreffen der Teilprojekte (Öffentlichkeitsarbeit, Wiesenmaßnahmen, ökologisches Monitoring etc.) wurden der fachliche Austausch zwischen den jeweiligen Arbeitsbereichen sichergestellt und die Aktivitäten (Wiesenpflege, Monitoring, Exkursionen) auf den Flächen zeitlich koordiniert.

Von allen Projektpartner*innen wurde in verschiedenen Formaten (z.B. wissenschaftliche und nicht-wissenschaftliche Vorträge, Workshops, Exkursionen) mit diversen Zielgruppen (u.a. BürgerInnen, SchülerInnen, Gremien, WissenschaftlerInnen) über das Projekt informiert. Bis 2024 fanden im Projekt FLIP etwa 20 eigene Veranstaltungen für BürgerInnen und 15 Workshops für MultiplikatorInnen statt. Mit einem Informationsstand wurde das Projekt auf knapp 20 weiteren Veranstaltungen repräsentiert. Besondere „Highlights“ waren 2023 der Multivision-Vortrag von Roland Günter, 2023 und 2024 ein Vortrag bei der RWTH-Wissenschaftsnacht sowie 2024 die Teilnahme bei Aufführungen des Theaterstücks „Stummer Frühling“. Hier waren die Projektpartner*innen der RWTH Aachen aus dem Institut für Umweltforschung anwesend, um nach den Aufführungen als Expert*innen für Fragen und Diskussionen zu Verfügung zu stehen. Das Theaterstück wurde zum Thema „Biodiversitätsverlust in der Kulturlandschaft“ konzipiert und richtet sich an Schulen im Land Nordrhein-Westfalen und Ostbelgien. Außerdem war das Projekt im September 2024 mit einem Fachvortrag auf der Jahrestagung der GfÖ (Gesellschaft für Ökologie) vertreten.

Die Wiesenführungen für Schulklassen, die über das Bildungsbüro der StädteRegion Aachen gebucht werden können und von externen Naturpädagoginnen durchgeführt werden, wurden 2023 und 2024

insgesamt über 100 Mal gebucht. Somit wurden in der Projektlaufzeit in knapp 140 Wiesenführungen rund 3700 SchülerInnen Wissen und Naturerlebnis zum Lebensraum Wiese vermittelt.
Das Bildungsbüro der StädteRegion Aachen stellt darüber hinaus didaktische Materialien für die Klassen 1 und 2, sowie für die Klassen 3 und 4 zur Verfügung.

Vernetzungsarbeit:

Auch die Vernetzungsarbeit außerhalb des Projektverbunds wurde weiter ausgebaut. Durch die Projektleitung konnte als wichtiger Partner der Wasserverband Eifel-Rur (WVER) gewonnen werden, der über viele Liegenschaften in der StädteRegion Aachen verfügt und ein großes Interesse daran hat diese ökologisch zu gestalten. Hier fanden mehrere Treffen und Flächenbegehungen statt, die in erste Wiesenanlagen im Herbst 2024 mündeten. Zusätzlich konnten enge Verknüpfungen mit der thematisch ähnlich gelagerten Privatinitiative „Heimat blüht auf“ hergestellt werden. Verschiedene Projektmitglieder haben an mehreren Netzwerktreffen teilgenommen. Aus dieser Vernetzung ging 2024 ein Treffen mit Vertreter*innen der Stadt Erkelenz hervor, die sich beim FLIP-Projektteam in Aachen in einem halbtägigen Austausch die bisherigen Erfahrungen und Ergebnisse aus dem Projekt vorstellen ließen. Ziel der Stadt Erkelenz ist es, die Möglichkeit der Anlage insektenfreundlicher Wiesen in Erkelenz nach dem Vorbild aus FLIP zu prüfen. Ein weiterer Austausch zum selben Thema, dieses Mal mit der Stadt Hückelhoven, ist bereits in Planung. Neben den Erfahrungen des Stadtbetriebs zu der praktischen Wiesenanlage und -pflege sind hier besonders die Ergebnisse des sozio-psychologischen Monitorings des Projektpartners RWTH Aachen, HCIC zur Wahrnehmung der Wiesen durch die Öffentlichkeit von Interesse. Auch ist es gelungen einen Beitrag zum Nachhaltigkeitsleitbild der RWTH zu leisten. Hier wurde festgelegt, in einer Potentialanalyse die Außenflächen bis Ende 2024 dahingehend zu prüfen, ob und wo Flächen ökologisch aufgewertet und nachhaltig bewirtschaftet werden können. Die künftigen Wiesenflächen sollen von Seiten der RWTH beschildert und weitere Kommunikationswege erschlossen werden, um ein Bewusstsein für das Thema Biodiversität innerhalb der Hochschule zu schaffen.

Flächenbilanz:

In Bezug auf die landschaftsbezogenen Maßnahmen wurden eine Reihe neuer Flächen als FLIP-Wiesen für das Projekt umgewidmet. Neben privaten Flächen des BürgerInnen-Netzwerks wurden vom Aachener Stadtbetrieb FLIP-Wiesen in öffentlichen Grünflächen entwickelt. Die FLIP-Wiesen auf öffentlichen und landwirtschaftlichen Flächen gehen bereits jetzt über die im Vorhaben geplanten Flächen hinaus und belaufen sich nun auf knapp **80 Teilflächen** mit insgesamt rund **13 Hektar Glatthaferwiesen und artenreichen Magerwiesen**. Die FLIP-Wiesen im öffentlichen Raum können im Familienstadtplan des Geodatenportal von aachen.de eingesehen werden. Die Wiesenflächen werden vom Stadtbetrieb insektenschonend in entsprechender Art und Weise (Mosaikmahd-ähnliches Konzept) und mit entsprechenden Gerätschaften gepflegt. Dabei findet ein regelmäßiger und enger Austausch zwischen den Projektpartnern Stadtbetrieb Aachen und RWTH, Institut für Umweltforschung sowie dem Fachbereich Klima und Umwelt, Abteilung Umweltvorsorgeplanung und Grünplanung statt.
Aufgrund der positiven Erfahrungen aus den vorherigen Projektjahren wird die Wiesenanlage gemeinschaftlich fortgeführt. Im Sinne einer Verstetigung der Projektimpulse über die Projektlaufzeit hinaus ist dies eine positive Erkenntnis der bisherigen Projektphase.

Monitoring:

Das **ökologische Monitoring** durch die RWTH Aachen, Institut für Umweltforschung (Insekten, Spinnentiere und Vegetation) wurde 2024 abgeschlossen, die Auswertung wird im kommenden Jahr fertiggestellt. Hier konnten nun zum ersten Mal Vorher-Nachher Vergleiche mit den Daten aus 2020 durchgeführt werden, die z.T. in Abschlussarbeiten, Manuskriptskizzen und wissenschaftlichen Veröffentlichungen verarbeitet wurden (siehe auch Anlage: Bach, A., Jedamski, J., Daniels, B., Roß-Nickoll M. (2025): From lawns to meadows: spiders (Arachnida: Araneae) as indicators to measure urban grassland restoration success. Urban Ecosyst 28, 1–14. https://doi.org/10.1007/s11252-024-01626-x).

Die Maßnahmen im Projekt werden außerdem durch ein **sozio-psychologisches Monitoring** begleitet.

Dieses beinhaltet sowohl repräsentative Studien zur Wahrnehmung ökologisch aufgewerteter Wiesen im Stadtgebiet (Frank, M., Zaunbrecher, B. S., Himmel, S., Ziefle, M. (2024): Bug city life: Public acceptance of urban insect-friendly meadows in Germany, Austria, and Switzerland. Urban For Urban Green 99, 128426. https://doi.org/10.1016/j.ufug.2024.128426.), als auch lokale Erhebungen zur Wahrnehmung der FLIP Wiesen in Aachen. Seit 2022 haben dazu jährlich „Wieseninterviews“ mit insgesamt über 500 befragten Passanten stattgefunden. Es hat sich gezeigt, dass rund 9 von 10 Befragten insektenfreundliche Wiesen in der Stadt befürworten und kaum Konkurrenz zu einer anderweitigen Nutzung der Flächen gesehen wird. In den Gesprächen mit den Passanten ist auch deutlich geworden, dass der Mehrwert der FLIP Wiesen über die Ökologie hinausgeht, da sie auch emotional und naturpädagogisch positive Auswirkungen haben können.

Aus allen Studien ging hervor, dass das Wissen um den ökologischen Nutzen der Wiesen entscheidend für die Akzeptanz ist. Die Erkenntnisse aus den Studien werden deshalb zur zielgerichteten Entwicklung insektenfreundlicher Wiesen im urbanen Bereich und der begleitenden Öffentlichkeits- und Bildungsarbeit genutzt. Der ständige Austausch und die enge Zusammenarbeit mit der Projektpartnerin von der RWTH Aachen, HCIC unterstützt die Öffentlichkeitsarbeit maßgeblich. So wurden 2023 im Rahmen einer Lehrveranstaltung Kommunikationsplattformen, digitale und nicht-digitale Vernetzungsformate und Wettbewerbe für private FLIP-WiesenbesitzerInnen von Studierenden entwickelt. Dazu wurde zunächst eine Anforderungsanalyse als Befragung unter den WiesenbesitzerInnen durchgeführt, um die spezifischen Bedarfe an die Vernetzungsangebote zu ermitteln. Die Ergebnisse münden unmittelbar in die Konzeption eines abschließenden Beteiligungsformats für das BürgerInnen-Netzwerk, das dann Teil der Öffentlichkeitsarbeit im FLIP-Projekt ist.

Öffentlichkeitsarbeit:

Durch den Fachbereich Klima und Umwelt der Stadt Aachen, Abteilung Verwaltung, Umweltinformation, Umweltinformationssysteme wurden viele der Veranstaltungen, Fortbildungen und Wiesenexkursionen organisiert und auch das sogenannte Bürger*innen-Netzwerk betreut. Viele Stunden konkreter Beratungen vor Ort haben zu einer stattlichen Anzahl an FLIP-Wiesen von 36 BürgerInnen, 3 Kindertagesstätten, 5 Patenschaften, 10 Schulen und 18 Sonstigen wie Vereine, Kirchen, Firmen mit insgesamt **3,3 Hektar Wiesenflächen** geführt.

Ein weiteres Angebot der Öffentlichkeitsarbeit sind die Forscherrucksäcke, die verteilt auf verschiedene Stadtteile zum Verleih bereit stehen (siehe Familienstadtplan „Nachhaltigkeit“ – „FLIP-Wiesen Rucksack-Ausgabestellen“). Zu den weiteren Maßnahmen gehören neben Mitteilungen in der Presse und den sozialen Netzwerken auch der digitale FLIP-Newsletter über den projekteigenen

Mailverteiler sowie die Bewerbung der FLIP-Aktivitäten über den Newsletter des Bildungsbüros der StädteRegion Aachen.
Durch Mitarbeitende vom Naturkundemuseum in Karlsruhe wird die projekteigene Homepage (www.flip-wiesen.de) stetig aktualisiert und weiterentwickelt. Auf der Webseite werden auch die Produkte aus dem Projekt zum Download angeboten (https://www.flip-wiesen.de/download).
Durch die assoziierten Projektpartner beim Naturkundemuseum in Karlsruhe wurden außerdem die Inhalte für diverse Schautafeln ausgearbeitet. Die Tafeln werden 2025 angefertigt. Ab Sommer 2025 informieren sie standortbezogen an verschiedenen FLIP-Wiesen BürgerInnen über Wiesen-Themen wie Biodiversität, Pflege, Lebensraumbesonderheiten, Tier- und Pflanzenwelt der Wiese.

Zentrale Ergebnisse und Empfehlungen:

Im Ergebnis kann nach vier Jahren Projektlaufzeit festgehalten werden, dass die Anlage von Wiesen und die Umwandlung von artenarmen Mährasen in regionaltypische, artenreiche Wildpflanzen-Wiesen auch auf den nährstoffreichen Standorten erfolgreich war. Die Wiesenflächen haben sich gut bis sehr gut entwickelt. Auf allen Flächen hat sich die Wiese nach der Anlage etabliert und somit ein Zugewinn an Biodiversität in der Vegetation stattgefunden. Positive Effekte auf die Biodiversität bei der Gruppe der Insekten zeichnet sich zu diesem Zeitpunkt bei den blütenbesuchenden Schwebfliegen und Wildbienen ab. Auf einer der FLIP-Wiesenflächen, die Gegenstand des faunistischen Monitorings ist (die Wiese im Kurpark), hat sich bereits eine für artenreiche Wiesen typische Spinnenfauna eingestellt. Die Wiesen, die im FLIP-Projekt angelegt wurden, zählen geobotanisch zu den Glatthaferwiesen und damit zum sogenannten artenreichen Grünland. Für diese Biotop-Typen können folgende Ökosystemleistungen genannt werden:

- Wiesen können bei entsprechender Verteilung im Siedlungsraum für eine Durchgängigkeit in der Landschaft im Sinne von Trittstein-Biotopen für die Tierwelt sorgen.
- Wiesen sind Lebensraum einer Vielzahl an Tieren, „Hot Spot“ der faunistischen Biodiversität auch durch die Belebung des Bodens und damit der Förderung der Boden-Fauna.
- Die tiefe und diverse Durchwurzelung des Bodens sorgt zudem für eine verbesserte Wasserrückhaltung.
- Die oberirdische Biomasse von Wiesen verhindert die Austrocknung des Bodens und sorgt für eine deutlich stärkere Abkühlung der Luft in der Nacht im Vergleich zu Rasenflächen. Dieser Aspekt kommt vor allem im Siedlungsraum zum Tragen.
- Durch Wiesen findet eine höhere CO2-Fixierung statt als durch artenarme Scherrasen.

In den ersten Jahren der Wiesen-Etablierung (durch Einsaat oder Pflegeumstellung) verändert sich der Standort stetig solange, bis sich eine standortgerechte Pflanzenzusammensetzung eingefunden hat. Ab diesem Zeitpunkt stellt der Lebensraum Wiese bei entsprechender Pflege ein stabiles und dauerhaftes Biotop dar. Mit zunehmendem Alter gewinnt der Lebensraum also an Qualität in Bezug auf Biodiversität und Ökosystemleistungen.

Kosten der Wiesenpflege:

Die Pflege der Langgraswiesen erfolgt mit eigens im Projekt angeschafften Geräten durch eine ein- bis zweimalige Mahd pro Jahr mit anschließendem Entfernen des Mahdguts.

Der Aachener Stadtbetrieb hat die Kosten für die Pflege der Langgraswiesen erhoben. Sie beziehen sich auf das Jahr 2024. Die Pflegekosten belaufen sich im jährlichen Durchschnitt auf 0,35 Euro pro Quadratmeter. Hinzu kommen Entsorgungskosten je Pflegegang von durchschnittlich 0,01 Euro pro Quadratmeter. Diese Größe ist allerdings sehr variabel, da sie witterungsabhängig ist: in regenreichen Jahren mit viel Aufwuchs ist entsprechend viel Biomasse zu entsorgen, während in trockenen Jahren sehr viel weniger Grasschnitt zur Entsorgung anfällt.

Dem gegenüber steht die Rasenflächenpflege von Gebrauchsrasen in Parkanlagen. Für den Aachener Stadtbetrieb steht die für 2019 erhobene Kennzahl von 0,90 Euro pro Quadratmeter und Jahr zum Vergleich zur Verfügung.

Die Zahlen zeigen sehr deutlich, dass die Pflege von Langgraswiesen im Vergleich zu Scherrasen weniger als die Hälfte der Kosten verursacht.

Die Kosten für die einmalige Neuanlage einer Langgraswiese sind dabei nicht berücksichtigt. Die Möglichkeiten der Etablierung einer Langgraswiese erstrecken sich von einer Änderung des Mahd-Rhythmus und Nutzung des in der Fläche vorhandenen Artenpotenzials bis zum Abtragen oder Umfräsen des Oberbodens mit anschließender Neueinsaat mit regionalem Saatgut. Entsprechend unterschiedlich hoch sind die Kosten für eine Neuanlage einer Langgraswiese anzusetzen.

Empfehlung:

Das Team des Projekts FLIP empfiehlt aufgrund der positiven Erfahrungen im Projekt und der wissenschaftlichen Grundlagen, die zum jetzigen Zeitpunkt vorliegen, die Beibehaltung der im Projekt etablierten Wiesenstandorte und die weitere Ausdehnung derartiger Lebensräume im Siedlungsraum.

Anlage/n:

1 - 2024Frank-et-al_AcceptanceUrbanInsectfriendlyMeadows (öffentlich)

2 - 2025Bach-et-al_UrbanGraslandRestaurationSuccess_Spiders (öffentlich)

3 - FLIP-FlaechenStadtAachen_2024-11-11 (öffentlich)

Urban Forestry & Urban Greening 99 (2024) 128426

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

Bug city life: Public acceptance of urban insect-friendly meadows in Germany, Austria, and Switzerland

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ARTICLE INFO

Keywords:
Insect decline
Insect conservation
Insect-friendly meadows
Acceptance
Public perception
Urban green space management

ABSTRACT

Reports of continuing declines in some insect populations have raised concerns and calls for action to protect insects. The establishment of insect-friendly meadows in urban areas provides an opportunity to conserve both insect and plant diversity. However, public acceptance can be an obstacle to the implementation of such meadows, for example, due to competing land use interests and the perception that tall meadows are visually unattractive. To address these concerns and align urban green spaces with both public preferences and environmental needs, a systematic understanding of the factors influencing public acceptance of meadows is essential. To this end, a representative online survey was conducted in Germany, Austria, and Switzerland with 899 participants to assess the acceptance of insect-friendly meadows in urban areas. The study shows significant support for insect-friendly meadows across all subgroups and within each country-specific subgroup. The factor that most influences their acceptance is the recognition of the ecological benefits of these meadows. It is therefore highly recommended to prioritize public awareness campaigns that highlight the complex relationship between plant and insect diversity. Such efforts can contribute to a better understanding of the benefits of insect-friendly meadows for biodiversity, thereby increasing public support for these conservation measures. Additionally, considerations related to perceived aesthetics, appreciation of an increase in insect abundance, preference for public funding, and a general sense of safety around these meadows should inform the development and communication strategies for insect-friendly green spaces, as they significantly influence public acceptance. These design and perception aspects of meadows were shown to have a stronger influence on the acceptance of meadows than individual, attitudinal characteristics such as environmental attitudes or attitudes toward insect decline. While this study provides insights into the general public acceptance of insect-friendly meadows, more research is needed to understand the influence of the specific local context on meadow acceptance.

1. Introduction

Insects are important providers of a range of ecosystem services that contribute to the quality of human life (Schowalter et al., 2018). Plant diversity and quantity worldwide depend on the pollination services provided by insects (Ollerton et al., 2011). Additionally, insects serve as pest controllers and decompose excreta and dead biomass (Goulson, 2019). However, insects also have intrinsic value and provide benefits that cannot be economically assessed. For example, insects enhance the beauty of nature (Haslett, 2007; New, 2022), and observing and supporting insects can contribute to human well-being (Wignall et al., 2019).

The interdependencies between vegetation, humans, and insects are bidirectional: Many ecosystems are fragile, and the well-being of humans and insects depends on the well-being of the ecosystem (Schowalter et al., 2018); in turn, the stability of the ecosystem depends on the ecosystem service provided by insects and other contributors (Goulson, 2019; Sánchez-Bayo & Wyckhuys, 2019).

Taking all of this into account, it is alarming that the ongoing “anthrophocene defaunation” (Dirzo et al., 2014), which describes the loss of biodiversity due to anthropocene drivers, is also affecting insects, as shown by numerous reports on different species from different parts

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https://doi.org/10.1016/j.ufug.2024.128426
Received 30 January 2024; Received in revised form 27 June 2024; Accepted 1 July 2024
Available online 4 July 2024

of the world (Dirzo et al., 2014; Sánchez-Bayo & Wyckhuys, 2019). Despite geographical and taxonomic limitations in the availability of studies, there is sufficient evidence to conclude that conservation measures are needed for insects (Montgomery et al., 2020; Saunders et al., 2020).

Reasons for the decline in insect populations include the effects of climate change and related environmental changes, such as changes in temperature, extreme precipitation, or drought (Sánchez-Bayo & Wyckhuys, 2019), as well as the consequences of direct human impacts, such as stress from pesticides, loss of habitat, a lack of flowering plants, and parasites (Garbuzov & Ratnieks, 2014; Goulson et al., 2015). Urbanization and ground sealing are among the greatest threats to global biodiversity (Seto et al., 2012).

An effective way to conserve insects is to protect their habitats and food sources (Sánchez-Bayo & Wyckhuys, 2019). Well-designed urban green spaces (UGS), such as natural areas, brownfield sites, gardens, and engineered green infrastructure in urban areas, can provide such habitats and habor diverse insect populations (Daniels et al., 2020). While common UGS management practices, such as mowing and pruning, chemical applications, or the introduction of non-native plant species, threaten urban biodiversity (Aronson et al., 2017), reducing UGS maintenance and sustaining native vegetation can transform UGS into biodiverse habitats for insects at relatively low costs (Aronson et al., 2017).

Despite the ecological benefits of such meadows and the general openness of the public to biodiversity (Fischer et al., 2020; Unterweger et al., 2017), insect-friendly meadows are not universally accepted in urban areas (Stoll-Kleemann, 2001). Non-acceptance of such meadows can lead to vandalism and dumping (Turo and Gardiner, 2019), impeding their positive impacts on biodiversity and well-being. This demonstrates that the management of UGS is subject to a complex interplay of social, cultural, environmental, and economic factors (Aronson et al., 2017). A key challenge for the management of UGS is therefore to balance citizens' demands for UGS with the ecological imperatives of maintaining and enhancing biodiversity and with political and economic interests to ensure long-term support for these meadow types (Aronson et al., 2017; Collins et al., 2019; Hoyle et al., 2017). Therefore, this research aims to identify public perceptions of UGS and the factors that contribute to the acceptance of urban insect-friendly meadows. Using a quantitative online survey in Germany, Austria, and the German-speaking part of Switzerland, we derive a statistical model that explains the public acceptance of meadow conversions. The results allow us to provide empirically based recommendations for the implementation of and communication about urban insect-friendly meadows in line with societal requirements.

2. Public acceptance of insect-friendly meadows

The aim of the study is to identify factors relevant to acceptance of meadows. According to Lucke (1995), *acceptance* can be defined as the relationship between the object of acceptance, the subject of acceptance, and the context of acceptance. In line with the study's aim to understand what drives the general attitudes toward urban insect-friendly meadows and to arrive at findings and recommendations that are not only applicable to a specific project context but rather to a much wider audience, the study focuses on the acceptance object and the acceptance subject and how both contribute to overall meadow acceptance. *Acceptance* is thus understood here as acceptance "on the broadest, most general level", as opposed to (local) community acceptance (Wüstenhagen et al., 2007). Thus, the impact of a specific local context on acceptance is not the focus of the empirical study but is regarded in the Discussion. The *object of acceptance* in this study is the meadow, and it is operationalized as aspects related to the meadow itself, such as its appearance and its impact on biodiversity. In this study, we refer to these factors collectively as *meadow-related characteristics*. The *subject of acceptance* is defined as the general public in this study, and it is operationalized by the psychological characteristics of this general public (e.g., awareness of insect decline and environmental attitudes). They are collectively referred to as *individual, attitudinal characteristics*.

This theoretical research framework serves as the basis for our research model (cf. Fig. 2). To further explore which specific factors should be investigated for acceptance of urban insect-friendly meadows, an empirical and a theoretical approach were combined. First, an exploratory empirical prestudy (focus group) was conducted (cf. Fig. 1). By systematically analysing the focus group discussion, recurring themes could be extracted which could serve as possible influential factors for the acceptance of the meadow, such as the *perceived aesthetics* ("It doesn't bloom nicely") or *liking of changes in insect occurrence* ("When you are barbecuing, for example, people might be bothered by the fact that there are more insects on the grass"). As a next step, a literature review was carried out to check the relevance of these topics in the scientific literature on meadow acceptance to date and to identify additional influencing factors. This was necessary because the focus groups provided insightful results for the meadow-related characteristics, but less so for individual, attitudinal characteristics. The following section discusses the results of the literature review on public acceptance of insect-friendly meadows.

2.1. Influence of meadow-related characteristics on acceptance

2.1.1. Perceived ecological benefit, linking of changes in insect abundance, and perceived aesthetics

UGS can enhance people's psychological well-being by eliciting positive feelings and satisfying non-material needs (Chiesura, 2004). This is even more the case when biodiversity is perceived to be high (Fuller et al., 2007). Furthermore, acceptance of meadow transformation is higher when participants have knowledge about biodiversity (Fischer et al., 2020). However, it should be recognized that biodiversity as perceived by laypeople may differ from actual biodiversity, as perceived biodiversity seems to depend mainly on color diversity rather than plant species diversity (Hoyle et al., 2018; Lindemann-Matthies et al., 2010). It is therefore interesting to investigate both the effect of perceived biodiversity and aesthetics on the acceptance of meadows. Furthermore, it has been shown that the presence of valued animal species positively influences the perceived value of UGS (Obrist et al., 2012; Unterweger et al., 2017), even more than the flora (Unterweger et al., 2017). However, no studies were found that investigated the effect of increased insect abundance.

2.1.2. Perceived land use conflicts

Several studies have indicated that design preferences for UGS depend on preferences for the use of UGS (Lampinen et al., 2021). Participants tended to dislike tall-grown meadows when they felt restricted in their desired activities and valued UGS that were free from physical or social barriers (Lampinen et al., 2021; Obrist et al., 2012). However, activities related to nature and socializing were perceived as suitable for tallgrass meadows (Lampinen et al., 2021).

2.1.3. General feeling of safety

In their literature review, Turo and Gardiner (2019) suggested that

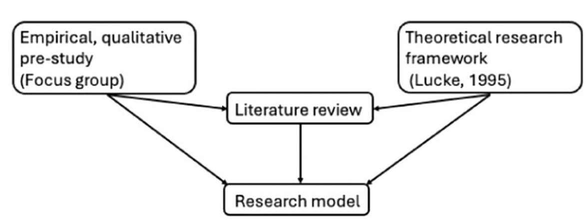

Fig. 1. Research approach combining an empirical prestudy, a theoretical acceptance framework (Lucke, 1995) and a literature review contributing to the design of the research model.

perceptions of safety may influence acceptance of meadows. They point out that the fear of insect bites is a major concern and even outweighs perceived conservation benefits, and that tall and dense vegetation increases both perceived and actual crime rates.

2.1.4. Preference for low costs and public funding

The relationship between perceived costs, funding sources, and acceptance of insect-friendly meadows remains largely unexplored. According to managers of UGS, reduced mowing offers an opportunity to save rather than requiring financial investment (Hoyle et al., 2017). However, implementing insect-friendly meadows may require initial investment. A study of a non-representative sample in Berlin showed a general willingness to pay for UGS (Fruth et al., 2019).

2.1.5. Perceived likelihood of abandonment

Finally, UGS that are not valued or are even actively rejected are at risk of being defiled (Turo & Gardiner, 2019). However, it is known that residents prefer UGS that look tidy and neat (Fischer et al., 2020; Obrist et al., 2012). Therefore, if urban tall-grown meadows are expected to be neglected or bedraggled, this may have a negative influence on their acceptance.

2.2. Influence of individual, attitudinal characteristics on acceptance

Research has extensively explored the correlation between meadow acceptance and various sociodemographic factors, including gender, age, culture, and experience (Gobster et al., 2007; Unterweger et al., 2017; Zobec et al., 2020). It is important to note that socio-demographic variables such as gender are known to be carriers of underlying individual, attitudinal traits. For example, women tend to be more accepting of meadows than men, but they also have a higher sensitivity to biodiversity and natural aesthetics (Unterweger et al., 2017; Zobec et al., 2020). Further investigation into these underlying individual, attitudinal characteristics is necessary, as they have received little attention in the context of pollinator declines (Knapp et al., 2021). The present study will therefore undertake a more detailed examination of the importance of psychological factors such as perception, knowledge, and attitude towards insects and the decline of insects to the acceptance of insect-friendly meadows as a means to conserve pollinators.

2.2.1. Perceived urgency of insect decline, perceived affectedness by insect decline, self-efficacy beliefs

Within the general framework of behavioral modeling, motivation and attitude toward a behavior are predicted by perceived urgency and self-efficacy beliefs (Ajzen, 1991; Rogers, 1975). Believing that one can achieve the desired change is a necessary condition for motivation (to act accordingly) (Ajzen, 1991; Rogers, 1975). Regarding meadow acceptance, it is thus likely that *self-efficacy beliefs*, i.e. being convinced that actions taken by individuals against insect decline can be effective, influence meadow acceptance. At the same time, it has been shown that the greater (more severe and likely) the perceived threat to the world at large and to oneself, the greater the motivation to take action (Rogers, 1975). Contrary to this, a previous study did not find a significant correlation between self-efficacy beliefs, perceived threat and biodiversity conservation intention (Wenzel et al., 2023). The relationship between these factors thus needs further investigation as it seems plausible that the more insect decline is perceived to be an urgent threat in general and to oneself, the higher the motivation to take action against this decline, i.e. in the form of transformed green spaces.

2.2.2. Knowledge about insect-ecosystem dependency and awareness of insect decline

It can be assumed that the perception of insect decline as a threat presupposes a certain knowledge of the interdependence of the ecosystem on insects and vice versa, as well as awareness for the decline of insects. Indeed, previous studies confirm the importance of awareness of insect decline on general pollinator conservation motivation (Wignall et al. 2019). However, the results on the influence of knowledge about insects on conservation motivation are ambiguous. Unterweger et al. (2017) discovered that individuals with a comprehensive understanding of entomology preferred meadows over lawns. Yet, in another study, the influence of knowledge on pollinator conservation behavior was minimal compared to the significance of perception- and identity-related factors (Knapp et al. 2021).

2.2.3. General environmental attitude, insect-friendliness and -aversion

In addition to the fear of personal harm caused by insect decline, an alternative, less egocentric explanation for insect-protective behavior is that people want to protect insects and the environment for their intrinsic beauty, i.e. for moral reasons. This potential explanation is corroborated by the findings that an appreciation and a sense of responsibility for biodiversity were associated with a higher affinity for nature and more positive attitudes toward insect-friendly meadows (Fischer et al., 2020; Unterweger et al., 2017).

Furthermore, it has been found that insects can evoke positive emotions in individuals (Wignall et al., 2019), and that positive attitudes toward insects increased meadow acceptance (Obrist et al., 2012). However, this effect is limited to certain flagship species. The presence of undesired insects, such as wasps (Sumner et al., 2018), may make insect abundance a factor in rejecting insect-friendly meadows. Therefore, attitudes towards insects, positive as well as negative, should be considered for the explanation of meadow acceptance.

Fig. 2 summarizes the factors that are hypothesized to influence meadow acceptance based on the literature review and empirical study presented previously.

In summary, meadow-related characteristics have received particular attention regarding their influence on meadow acceptance so far, especially aesthetic perception and its interplay with actual and perceived ecological benefits, the likelihood of abandonment, and land use conflicts, while other meadow-related and individual, attitudinal characteristics have also been considered, although less extensively. However, there is a gap in knowledge about the interplay of the individual, attitudinal characteristics and their relative importance for public acceptance compared to meadow-related characteristics. Therefore, this study aims to develop a holistic model to explain the

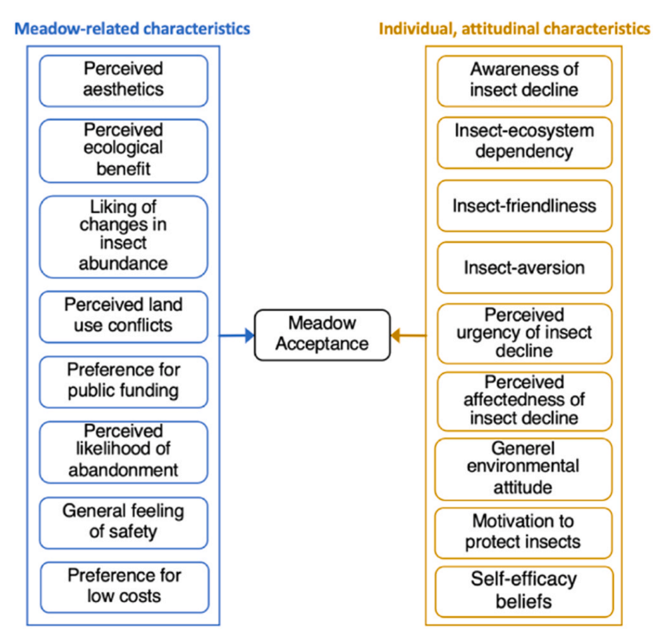

Fig. 2. Research model including both meadow-related and individual, attitudinal characteristics as hypothesized predictors of insect-friendly meadow acceptance.

acceptance of urban meadows that allows for the derivation of socially accepted insect-friendly UGS design and communication recommendations. In addition, the aim is to quantify and understand the interplay between meadow-related and individual, attitudinal characteristics. Therefore, the current study aims to answer the following research questions:

- **RQ1:** To what extent are insect-friendly meadows accepted in public spaces?
- **RQ2:** Which meadow-related and individual, attitudinal characteristics contribute to which extent to the acceptance of insect-friendly meadows?

3. Materials and methods

As described above, a combined empirical and theoretical approach was chosen (Fig. 1) to identify possible relevant factors for meadow acceptance (Fig. 2). Since at the time of the study there was no standardized instrument for measuring meadow acceptance that included all relevant dimensions, several quantitative prestudies were conducted to test the suitability of the newly developed instrument and the particular items used in the questionnaire.

3.1. Sampling procedure

The online survey was conducted in Germany, Austria, and (German-speaking) Switzerland, to test the generalizability of the results beyond a national context. These three German-speaking countries were chosen because it allowed the survey to be repeated in the same language, German, thus avoiding variations in the data due to translation inaccuracies. Also, it allowed for an interpretation of the results against a cultural background with which the authors are most familiar, thus allowing for a more accurate understanding of the results. Participants were recruited between 08.09.2022 and 14.09.2022 through panel sampling by a market research company. To ensure a balanced sample, quotas were set independently for the variables *country of residence*, *gender*, and *education*. In addition, data quality checks were applied. Participants received an incentive from the market research company for their participation. No formal ethical approval was required for the study.[2]

3.2. Outline of the online survey

Prior to the start of the survey, all participants were informed of the privacy standards of the study,[3] its content and its purpose, and that they were free to terminate their participation at any time.

At the beginning of the survey, participants were asked to provide demographic information such as age, gender, educational level, residence (urban/rural), nationality (DE/AT/CH), and private or professional involvement with ecological topics. Participants were then asked about their environmental attitudes (Geiger & Holzhauer, 2020).

Next, a description was provided explaining that the study aimed to assess opinions about the conversion of certain parts of lawns in urban parks into insect-friendly wildflower meadows. Two pictures were provided, one of a traditional lawn and one of a wildflower meadow, to illustrate the difference between the two types of green space management (Fig. 3).

In the following section, participants were asked to indicate their agreement with statements about meadow-related characteristics, such as perceived ecological benefits and perceived land use conflicts, which were hypothesized to influence meadow acceptance based on the preliminary study and the literature review (cf. Fig. 2 and Appendix, Table A.3, for specific items).

The next section focused on insects and insect decline (cf. Fig. 2 and Appendix, Table A.4, for specific items), examining perceptions of insects and their interdependency with the ecosystem, and perceptions of insect decline. Questions about actions to protect insects were also asked. Other questions about insects and insect decline followed (e.g., a quiz and questions about willingness to accept restrictions for insect conservation), but these were not part of the analysis and are therefore not described in detail.

All items were measured on a fully verbalized 6-point Likert scale (unless otherwise indicated), ranging from 1 (do not agree at all) to 6 (fully agree). To ensure reliability, only factors with a Cronbach's α value of.7 or higher were considered for further analysis (Blanz, 2015). For factors scoring lower values, factor analysis was performed for all individual, attitudinal characteristics and part-whole correction for all meadow-related characteristics to exclude items until reliability reached the desired level (Field, 2013). Item sources and reliability values for all items included in the analysis can be found in the Appendix (Table A.3 and A.4).

3.3. Participants

After data cleaning, a total of n = 899 data sets remained for analysis, with n = 299 participants from Germany and n = 300 each from Austria and Switzerland. In the total sample, approximately half of the participants were female (n = 450). Participants ranged in age from 18 to 75 years, with a mean age of 44.4 years (SD = 14.8). Regarding educational background, most participants had a secondary school degree (n = 371) or a general university entrance qualification (n = 357).[4] In terms of residency, n = 420 participants lived in urban areas, slightly fewer than those residing in rural areas (n = 477). Regarding ecological involvement, n = 431 participants reported no background in ecological issues, n = 436 participants reported private involvement with ecological

Fig. 3. Illustrationof a traditional lawn (top, ©JanyaSk/Shutterstock.com) and insect-friendly meadow (bottom, ©Jana Jedamski) as used in the survey.

[2] We did not seek an ethics committee approval because our study falls into a category that does not require such approval in Germany. This category includes all non-invasive, non-clinical research on human subjects, where the subjects are informed transparently about the purpose, aim and risks of the studies and where these risks are reasonably low.

[3] Because we do not have consent from the participants to share their data outside of the specific research project they were assessed for, the data cannot be made publicly available. Data can, however, be shared for reviewing purposes should this be required.

[4] For more details and a comparison of the sample to the German population, see Appendix Table A.2

issues, and n = 73 participants reported professional involvement in ecological issues.

3.4. Data analysis

The study aimed to include both meadow-related and individual, attitudinal characteristics in a holistic model with *acceptance of insect-friendly meadows* as the target variable. Therefore, correlations were first performed for all meadow-related and individual, attitudinal characteristics. Only those parameters that significantly correlated with the target variable were included in two separate exploratory backward regression analyses, one focusing on individual, attitudinal and one on meadow-related characteristics. Finally, a first approach to validate the model and to find out about nation-specific influences on the model was carried out. To this end, the meadow-related and individual, attitudinal characteristics that significantly predicted meadow acceptance in the individual models were first combined into an overall model for the entire sample using forced entry regression analysis. The same method was then used to create three models for the three national subsamples.

Statistical assumptions were checked prior to analysis (Bowerman & O'connell, 1990; Stevens, 2002). Cohen's guidelines (Cohen, 1988) were applied to interpret the amount of variance explained in regression and correlation analysis. Because there is a risk of overestimating regression significance with larger sample sizes (Field, 2013), a confidence cutoff of $\alpha \leq .001$ and $\beta(standardized) \geq 0.1$ was defined for all regression analyses. If values for any coefficients were found to be insufficient, they were excluded from the model, and the regression procedure was repeated until all values were within the desired ranges. For the benefit of readability, only the final models are reported in the Results section. A complete overview of all iterations can be found in Table A.6, A.8, A.9, and A.10 in the Appendix.

Tests for group differences were conducted to explore the influence of the national context on the descriptive results. As the assumption of normal distribution and homogeneity of variance was violated, the more robust Welch-ANOVA (instead of standard ANOVA) was applied for statistical analysis of the group differences. To address the issue of Type I errors (false positives) in multiple comparisons, we applied the Bonferroni correction to the ANOVA analysis to adjust the significance levels of individual tests. Pairwise comparisons were performed using the Tukey post-hoc procedure to identify statistically significant group differences.

All statistical analyses were performed using SPSS version 29.0.2.0.

4. Results

Subsequently, the results of the statistical investigation will be presented.

4.1. Analysis of influence of meadow-related characteristics on acceptance

Public acceptance of meadows was high (cf. Fig. 4), reaching a mean value of about 4.9 on the six-point scale. Similarly, *perceived ecological benefit* and a *liking of changes in insect abundance* were positively rated, and *preference for public funding* was also high. The *general feeling of safety* was reported to be positive. On average, participants rated the *perceived aesthetics*, the *perceived likelihood of abandonment* and the *preference for low costs* of the meadows as rather neutral. On average, participants disagreed with statements that dealt with *perceived land use conflicts* that could arise due to the meadow.

The results showed strong positive correlations between meadow *acceptance* and the *perceived ecological benefit* (r =.87), *liking of changes in insect abundance* (r =.82), *perceived aesthetics* (r =.79), *perceived land use conflicts* (r = −.66), a *general feeling of safety* (r =.75), and a *preference for public funding* (r =.68). A moderate correlation was found for the *perceived likelihood of abandonment* (r = −.35). *Preference for low costs*

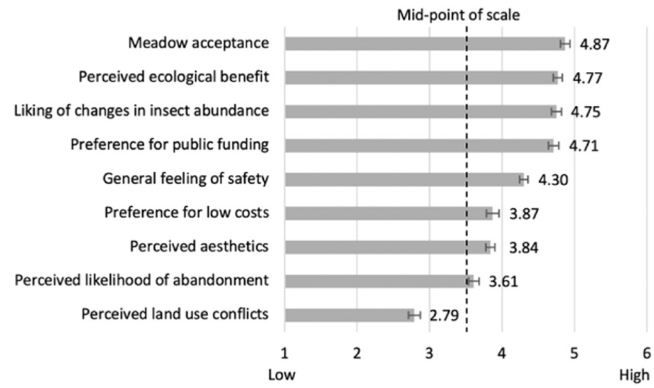

Fig. 4. Means with 95 % confidence intervals for the perception of meadow-related characteristics among the overall sample (n = 899, n = 1 data set missing for *general perception of safety*).

had only a weak but still significant correlation with *acceptance* of insect-friendly meadows (r = −.26). Inter-predictor correlations are documented in the Appendix A.5. Therefore, all variables were included in the regression modeling.

The resulting regression model (Fig. 5) was able to explain 83.8 % (R =.916, SE = 0.40) of the variance in meadow acceptance (F(5, 892) = 930.844, p <.001) and revealed that *perceived ecological benefit* was by far the strongest predictor, contributing approximately twice as much to the acceptance of insect-friendly meadows as *perceived aesthetics*, *liking of changes in insect abundance*, or *preference for public funding*. The *general feeling of safety* was the least explanatory factor. During the backward regression procedure, *perceived land use conflicts*, *perceived likelihood of abandonment*, and *preference for low costs* were excluded from the model because they did not contribute significantly to variance, or their explanatory power was too low for the defined threshold.

4.2. Analysis of influence of individual, attitudinal characteristics on acceptance

Overall, participants showed high awareness of *insects' interdependence with ecosystems*, and reported high *awareness* and *perceived urgency of a decline in insects*, and *perceived personal affectedness* (cf. Fig. 6). Their *general attitude toward the environment* was rather positive and *insect-friendliness* was high, and consequently, *insect-aversion* was low. Participants felt *efficacious* and *motivated to contribute to insect conservation.*

The results showed significant, positive, strong correlations between meadow *acceptance* and awareness of *insects' interdependence with*

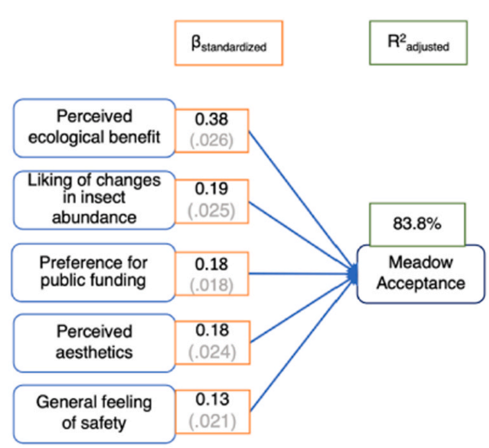

Fig. 5. Meadow-related characteristics predicting insect-friendly meadow acceptance (n = 898, $p \leq .001$) for all displayed predictors. Gray: standardized standard error.

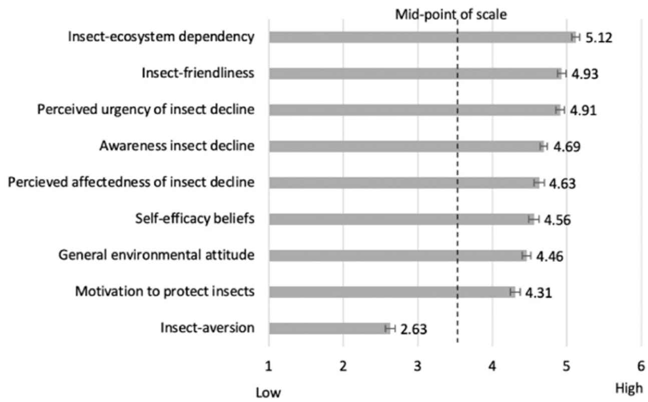

Fig. 6. Means and 95 % confidence intervals of the individual, attitudinal characteristics hypothesized to influence meadow acceptance among the overall sample (n = 899, (n = 899, with missing data for *perceived self-efficacy* and *motivation to protect insects* (n = 2), *perceived urgency of insect decline* (n = 3), *perceived affectedness of insect decline* (n = 10), and *perceived insect-ecosystem dependency* (n = 11)).

ecosystems (r =.65), *awareness of insect decline* (r =.61), *perceived urgency of insect decline* (r =.60), *motivation to protect insects* (r =.59), *insect-friendliness* (r =.60), *self-efficacy beliefs* (r =.50), and *insect-aversion* (r = −.50). A moderate correlation was found for *perceived affectedness of a decline in insects* (r =.48) and the *general environmental attitude* (r =.44). An overview of all inter-predictor correlations is provided in the Appendix A.7. As all variables showed significant correlations with *acceptance*, all were included in the regression model.

The model resulting from the regression analysis is displayed in Fig. 7. The model is able to explain 49.8 % of the total variance in meadow acceptance (R =.707, SE = 0.70, F(4, 881) = 220.628, p <.001). While both, the model including meadow-related characteristics and the one including individual, attitudinal characteristics, exhibit high levels of goodness of fit, the explanatory power of the model that considers individual, attitudinal characteristics is decisively lower than for the model including only meadow-related characteristics, indicating that meadow acceptance may be better predicted by meadow-related characteristics than by individual, attitudinal characteristics.

The model shows that among the individual, attitudinal characteristics, awareness of *insects' interdependence with ecosystems* is by far the strongest predictor of insect-friendly meadow acceptance, followed by the *motivation to protect insects*, the *awareness of insect decline*, and for the *general environmental attitude*. *Insect-friendliness* and *-aversion*, *perceived affectedness by a decline in insects*, *perceived urgency of a decline in insects*, and *self-efficacy beliefs* were excluded due to their low contribution and

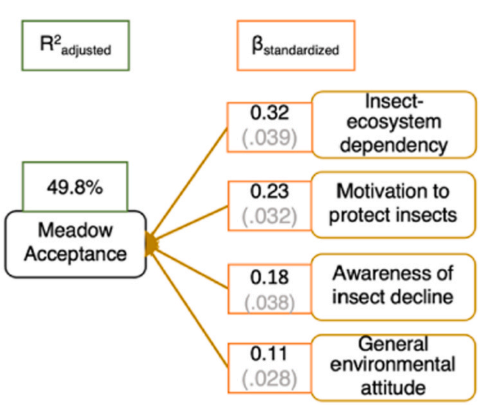

Fig. 7. Individual, attitudinal characteristics predicting insect-friendly meadow acceptance (n = 886, $p \leq .001$ for all coefficients. Gray: standardized standard error.).

low significance in explaining the variance in acceptance of insect-friendly meadows.

4.3. *Weighing the influence of meadow-related against individual, attitudinal characteristics*

To test the hypothesis that meadow acceptance is better predicted by meadow-related than by individual, attitudinal characteristics, meadow-related and individual, attitudinal characteristics were combined in one model. The regression analysis revealed that the influence of the meadow-related characteristics was indeed much higher than the influence of the individual, attitudinal characteristics, which were all excluded during the modeling process due to small effect sizes or becoming insignificant. Consequently, the overall model corresponds to Fig. 5. Taking all observed factors into account, the *perceived ecological benefit* was the strongest predictor for insect-friendly meadow acceptance.

4.4. *National differences in the model*

To identify general and specific predictors of acceptance of insect-friendly meadows, nation-specific differences between the model and its predictors were examined. Figs. 8 and 9 depict the means and 95 % confidence intervals for the factors of the final overall regression models for meadow-related and individual, attitudinal characteristics. Potential differences between the subsamples were calculated using Welch-ANOVAs for all factors.[5]

The level of overall *meadow acceptance* did not differ significantly between Germany, Austria, and Switzerland, nor did the subsamples differ significantly in the perception of any meadow-related characteristic. However, a statistically significant difference was observed for the *motivation to protect insects* (F(2, 595.62) = 9.97, p <.001, n = 897): Swiss participants showed significantly lower *motivation to protect insects* than German (-0.32, 99 % CI [-0.56, −0.08], p <.001, SE = 0.08) and Austrian (-0.31, 99 % CI [-0.55, −0.07], p <.001, SE = 0.08) participants. No significant differences were found between the national subsamples for any of the other individual, attitudinal characteristics.

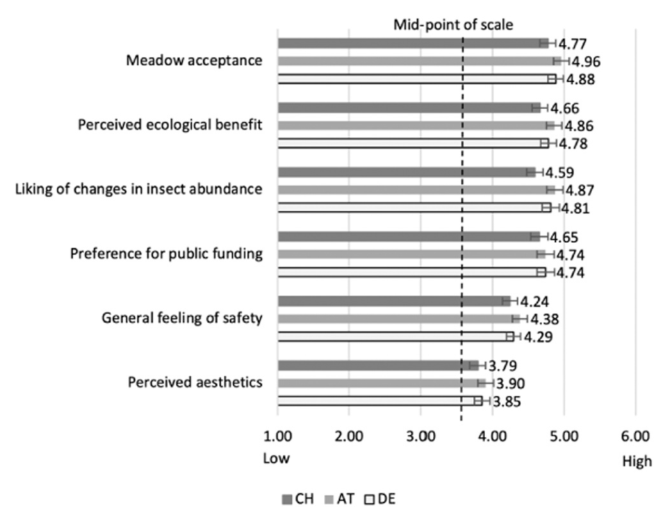

Fig. 8. Comparison of means and 95 % confidence intervals of the perception of meadow-related characteristics in Germany (DE, n = 299), Austria (AT, n = 300), and Switzerland (CH, n = 300).

[5] including any factors that were excluded from the regression models. Therefore, the Bonferroni correction of alpha values resulted in the new alpha threshold of p < 0.003

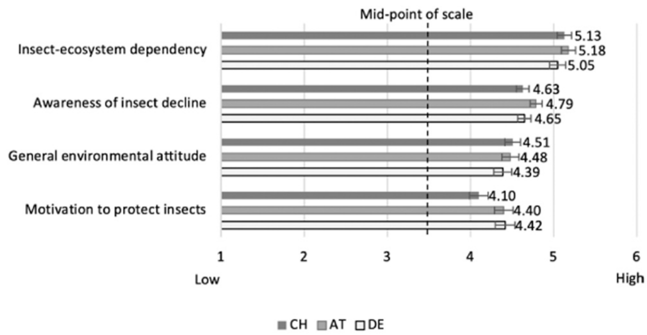

Fig. 9. Comparison of means and 95 % confidence intervals of individual, attitudinal characteristics for the samples from Germany (DE), Austria (AT), and Switzerland (CH). Missing data sets for *insect-ecosystem dependency* (DE: n = 5, AT: n = 4, CH: n = 2) and *motivation to protect insects* (DE: n = 1, CH: n = 1).

Testing the predictor model for *meadow acceptance* in different national contexts revealed which factors remained stable and which were context specific. Table 1 displays the regression results for the overall model and for each subsample. The model was significant for all subsamples and was able to explain a high proportion of the variance in *meadow acceptance* throughout. It was most explanatory for the Swiss context, explaining 85.6 % (R =.926, SE = 0.39) of the variance in *acceptance* (F(4, 295) = 443.685, p <.001, n = 300), 85.6 % (R =.921, SE = 0.37) for Germany (F(5, 293) = 329.55, p <.001, n = 299), and 81.6 % (R =.904, SE = 0.42) for Austria (F(3, 296) = 443.62, p <.001, n = 300).

In all three countries, *perceived ecological benefit* contributed the most to overall meadow acceptance. In the German and Austrian subsamples, the *liking of changes in insect abundance* was the second most relevant for acceptance, whereas in the Swiss subsample, the *preference for public funding* and the *perceived aesthetics* were stronger predictors. *Preference for public funding* and *perceived aesthetics* were significant predictors only in the German and Swiss models, although their proportion in predicting acceptance differed considerably between the samples, being almost twice as high in the Swiss as in the German sample. A *general feeling of safety* was relevant only in the German and Austrian models.

In summary, the developed model has high explanatory power to predict meadow acceptance, which was most strongly influenced by the perceived ecological benefits of the meadow, both overall and in the individual subsamples. More detailed investigations revealed that other influential factors differ in their relevance and strength in influencing acceptance depending on the particular subsamples.

5. Discussion

To the best of our knowledge, this study is the first to statistically compare factors related to the meadow itself and individual, attitudinal factors side-by-side in terms of their influence on overall meadow acceptance in a holistic model, allowing statements to be made about their relative importance. By conducting an empirical survey with three different national samples, we are able to derive findings that are stable across contexts. The model can inform implementation strategies for meadows in urban areas that align with social requirements. The results provide insights into the general acceptance of meadows and its specific contributing factors. However, the approach has limitations in explaining local attitudes.

5.1. Key results and responses to the research questions

5.1.1. Acceptance of insect-friendly meadows in public spaces

In general, a high level of acceptance of insect-friendly meadows was observed among the sample, and acceptance levels did not differ significantly between the German, Swiss, and Austrian subsamples. This confirms previous results showing a general openness to near-natural design of urban and rural green spaces (Fischer et al., 2020; Southon et al., 2017). These results can be considered an opportunity for the establishment of such meadows in urban areas which can serve conservation purposes and at the same time evoke a positive public response. No less important, the study shows that such meadows are perceived as an ecological benefit to urban areas and the expected increase in insect abundance is welcomed. However, it should be kept in mind that although participants expressed a willingness to accept insect-friendly meadows in general, this does not necessarily mean that they would unanimously support the conversion of lawns into meadows at the local level, especially if they are (too) close to their homes (Hoyle et al., 2017). Nevertheless, the results imply that the general idea of such meadows in urban areas appeals to a wide audience in the countries surveyed.

5.1.2. Relevance of meadow-related or individual, attitudinal characteristics for the acceptance of insect-friendly meadows

The results of the study showed that meadow-related characteristics outweighed individual, attitudinal characteristics in importance for meadow acceptance.

The *perceived ecological benefit* was identified as by far the most important factor for meadow acceptance, strongly correlated with *perceived aesthetics*. This reinforces the results of previous research on the interrelationships between acceptance of meadows, perceived biodiversity value and aesthetics (Hoyle et al., 2018; Lampinen et al., 2021; Lindemann-Matthies et al., 2010).

While the wilderness of biodiversity-rich meadows can evoke positive reactions and even be perceived as aesthetic by some (Lampinen et al., 2021), it can also provoke opposition (Hoyle et al., 2017). It should therefore be ensured that biodiversity-rich meadows appear neat and cared for, for example by implementing “mowing strips” to provide a formal framing for otherwise informal green spaces (Fischer et al., 2020). This could also enhance the general feeling of safety that is attributed to short-cut lawns rather than meadows (Garvin et al., 2012).

Given the interrelationship between perceived biodiversity, perceived aesthetics, and acceptance, it will be important to increase communication efforts, especially at times when their benefits for

Table 1
Regression models for the overall sample (n = 898), and for the national subsamples Germany (DE, n = 299), Austria (AT, n = 300), & Switzerland (CH, n = 299) ($p \leq .001$ for all coefficients).

Country	$R^2_{adjusted}$	$\beta_{standardized}$ (standardized standard error)				
		Perceived ecological benefit	Liking of changes in insect abundance	Preference for public funding	Perceived aesthetics	General feeling of safety
Overall	.838	0.38 (.026)	0.19 (.025)	0.18 (.018)	0.18 (.024)	0.13 (.021)
DE	.846	0.39 (.048)	0.21 (.044)	0.16 (.032)	0.13 (.039)	0.16 (.036)
AT	.816	0.46 (.045)	0.31 (.046)			0.22 (.036)
CH	.856	0.37 (.039)	0.14 (.037)	0.29 (.029)	0.26 (.037)	

biodiversity are not obvious and their perceived aesthetics is rather negative, for example in late summer when they are long and potentially dry (Hoyle et al., 2017). Accepting insect-friendly meadows will also require a change in urban dwellers' expectations about the aesthetics of urban green spaces, which could be supported by providing information about the ecological value of seemingly unaesthetic green spaces (Sikorski et al., 2021).

Indeed, providing information about the increased biodiversity value of meadows compared to short-cut lawns has been shown to effectively promote meadow acceptance (Fischer et al., 2020; Gobster et al., 2007; Southon et al., 2017; Unterweger et al., 2017). One way to further support this relationship is to actively communicate how biodiversity is increasing in those urban green areas that have been transformed into meadows, not only on a general level but also locally, for example by conducting scientific monitoring of plant and insect development on site over time and preparing the results for a non-scientific audience.

Regarding the influence of other factors, it was found that, contrary to our expectations, the *general environmental attitude* and *awareness* and *perceived urgency of insect decline* were outweighed by the meadow-related characteristics in terms of their importance for the acceptance of meadows, minimizing their impact to the extent that they were finally excluded from the explanatory model. The results suggest that insect-friendly meadows are accepted primarily because of their expected general ecological value, and that it is less decisive for their acceptance whether people have an environmentally friendly attitude per se or are aware of environmental issues (such as insect decline). However, it should be noted that the individual, attitudinal characteristics in this study were focused mainly on attitudes toward insects. If the meadows were not perceived as an insect conservation measure but rather as an aesthetic enhancement of urban areas or a general increase in biodiversity, this would explain why the individual, attitudinal characteristics played a lesser role in explaining the acceptance of the meadows. However, further research is needed, as this study did not investigate whether the meadows are perceived as a (suitable) insect conservation strategy.

Land use conflicts (Obrist et al., 2012; Stoll-Kleemann, 2001) and *cleanness/ likelihood of abandonment* (Fischer et al., 2020; Lampinen et al., 2021; Obrist et al., 2012) have been shown to influence the acceptance of insect-friendly meadows in previous studies. In this study, however, these factors did not have a significant impact when examined in combination with other, more influential factors. This discrepancy could be explained by the fact that in this study the general and abstract acceptance of insect-friendly meadows was measured, so that, e.g., specific land use conflicts were attributed to the meadow to a lesser extent. A local replication of the study could help to analyze the effect of possible land use conflicts on meadow acceptance more reliably.

Finally, while the *preference for low costs* seems to play a subordinate role, the *preferred source of funding* is clearly defined and relevant for acceptance: the meadows should be financed by public funds. Therefore, the communication strategy should disclose the source of funding for the meadow implementation and maintenance.

Regarding the similarities and differences of the explanatory models between the subsamples, it was shown that *perceived ecological benefit* and *liking of changes in insect abundance* influenced acceptance in the overall sample as well as in all subsamples. In contrast, the *perceived aesthetics*, a *preference for public funding*, and a *general feeling of safety*, while affecting *acceptance* in the overall model, differed in their relevance for meadow acceptance in the different subsamples. Welch-ANOVA analyses of possible differences between the subsamples revealed no significant differences that could account for the different models. Thus, we can only hypothesize that the country of origin served as a carrier variable for other underlying psychological, attitudinal, or contextual differences that we did not assess in the study. For example, we did not assess subjective or objective knowledge of biodiversity in general or insect decline in particular, which would be a useful addition to the model.

The variation in the explanatory models across the subsamples indicates that the acceptance of urban meadows is subject to contextual differences, although some patterns emerged that were stable across the subsamples. This calls for a holistic approach to urban meadow acceptance, which should not be limited to communicating biodiversity benefits, but should target a multitude of factors to reach diverse audiences. This means that it is necessary to incorporate non-ecological topics in the communication about urban meadows, such as discussing new aesthetics in the design of urban green spaces.

5.2. Limitations and future research

In our approach, we have focused on acceptance-relevant factors of insect-friendly meadows that are stable across contexts. This inevitably entails a definition of acceptance that is generalized and does not take into account specific local circumstances. It should be considered a first step toward a deeper understanding of the public's response to insect-friendly meadows. Future research should repeat the measurements at specific sites with meadow conversion projects that directly affect participants. This could validate the results in practice and allow for the identification of possible gaps between the general attitude toward insect-friendly meadows and a specific local project, a phenomenon well-known in other domains (Jones & Eiser, 2010). It would also allow to explore the possible variability of the perception of insect-friendly meadows depending on the local context. Furthermore, examining local acceptance on-site and before/after the implementation of insect-friendly meadows would allow for comparative studies, and interventions such as the communication strategies, as proposed here, could be evaluated for their effectiveness.

In addition, In the survey, we used a picture of a meadow with flowers in bloom to ensure that all participants shared the same idea of an insect-friendly meadow. The picture may have influenced the aesthetic perception and the relevance of this factor in the survey because it depicts the meadow in a rather attractive state. Different photographs depicting various states of meadows or field studies in different seasons could reduce this methodological bias.

Since no statistical differences were found between the national subsamples in the predictor variables using Welch-ANOVAs, it could be interesting to conduct analyses on group differences on moderating effects, considering that the composition and strength of the predictor variables still differed between the national contexts. Conducting more qualitative studies to examine the underlying factors contributing to the difference in the nation-specific samples and building structural equation models could be a next step to explore the context of insect-friendly meadow acceptance.

6. Conclusion

The study found a high acceptance of insect-friendly meadows in urban areas in the overall sample and in the subsamples for Germany, Austria, and Switzerland. In addition, potential predictors of acceptance were examined. The findings highlight the particular importance of the perceived ecological benefits and a positive attitude toward an increase in insect abundance for meadow acceptance. Educating citizens about the ecological benefits of urban insect-friendly meadows, such as an increase in local insect abundance, could therefore be a promising approach to further enhance the already positive attitudes toward insect-friendly meadows in urban areas. In this way, also non-experts can understand the use and benefits of seemingly neglected green spaces for urban biodiversity. The perceived aesthetics of such meadows also plays a central role and calls for a general discussion on how to find trade-offs between the requirements for the aesthetic appearance of urban green spaces and new, biodiversity-friendly maintenance practices. It is important to acknowledge that urban green space management, especially changes toward more biodiversity-friendly practices, should therefore not only be seen as an environmental management task, but must be accompanied by targeted communication strategies to engage citizens in a more biodiverse city. If communicated in an engaging way, urban insect-friendly meadows have great potential to win over not only insects but also urban dwellers.

Acknowledgments and funding statement

We would like to thank all study-participants for their contribution to our research. Thank you also to Benjamin Daniels and Jana Jedamski for fruitful discussions about insect-friendly meadows from an ecological perspective, and to Julian Hildebrandt for helpful discussions about statistical methods. This work has been inspired by the project FLIP (Funding Number 3519685A22), which was funded by the BMUV (The Federal Environment and Consumer Protection Ministry) and the BfN (Federal Agency for Nature Conservation).

CRediT authorship contribution statement

Mona Frank: Writing – review & editing, Writing – original draft, Visualization, Formal analysis, Data curation. **Barbara S. Zaunbrecher:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Simon Himmel:** Methodology, Investigation, Data curation, Conceptualization. **Martina Ziefle:** Supervision, Resources, Funding acquisition.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT August version 3 and DeepL Write β to translate and refine pieces of text from their native language into English. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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.

Data Availability

Because we do not have the participants' permission to publish individual data sets, they cannot be included with this research article.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ufug.2024.128426.

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Urban Ecosystems (2025) 28:0
https://doi.org/10.1007/s11252-024-01626-x

From lawns to meadows: spiders (Arachnida: Araneae) as indicators to measure urban grassland restoration success

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Accepted: 7 September 2024

Abstract
In the present study, we investigate how spiders can be used to assess the effectiveness of restoring mesic grasslands on former urban lawns. We compile and analyze a comprehensive dataset, including both past and current data, focusing on the Aachen region. By systematically examining this data, we identify various indicators using different analytical methods. This approach allows us to distinguish distinct species communities, making them useful as diagnostic tools at various stages of habitat development. Additionally, we identify further parameters that are essential for evaluating meadow restoration in urban settings. We highlight the crucial importance of understanding the local species repertoire, as this knowledge is vital for setting realistic benchmarks for restoration projects.

Keywords Spiders · Grassland restoration · Hay meadows · Germany

Introduction

Intensively managed urban lawns are probably the most widespread habitats in European cities (Hedblom et al. 2017). While they may provide recreational space for citizens and improve mental and physical health (de Vries et al. 2003; Nielsen and Hansen 2007; Ma et al. 2019), they are ecologically characterized by a lack of biodiversity (Shwartz et al. 2014; Unterweger et al. 2017; Lerman et al. 2018) and require regular maintenance through mulch mowing which is costly and time-consuming (Chollet et al. 2018; Sturm et al. 2018; Sehrt et al. 2020; Watson et al. 2020). It is important to name the disadvantages of maintaining these lawns precisely and explore alternative land-use type that can provide similar ecosystem services and habitats to promote biodiversity. The most obvious approach in this context is restoration toward an extensive, species-rich grassland (Klaus 2013). However, while biodiversity-rich greenspaces have been shown to have positive effects on human well-being (Taylor and Hochuli 2015; Lai et al. 2019; Fischer et al. 2020), they may not always be suitable for traditional public uses, such as sports and recreation (Nicol and Blake 2000; Peschardt et al. 2012). Balancing between the citizen and environmental needs (Palliwoda et al. 2017; Daniels et al. 2018; Fischer et al. 2020) is crucial to avoid conflicts over urban greenspace use and to highlight the benefits of extensifying lawns in planning and managing these spaces (Campbell 1996; Aronson et al. 2017). But recent findings indicate a high level of public acceptance for the conversion of lawns into extensive species-rich grasslands (Frank et al. 2024).

A simple adjustment to mowing concepts, such as reducing the mowing frequency to ones or twice a year, can often lead to a fast increase in plant biodiversity (Chollet et al. 2018; Sehrt et al. 2020). Of course, reseeding with appropriate seeds also leads to a fast increase of plant species richness (Norton et al. 2019; Daniels et al. 2020). Since extensification of lawns has only recently been recognized as an easy implementation tool to promote urban biodiversity (Chollet et al. 2018; Baldock 2020), knowledge about the effects and developments on arthropod biodiversity here is still scarce and often focusing on pollinating insects (e.g. Burr et al. 2018; Larson et al. 2014; Lerman et al. 2018; Wastian et al. 2016; Wintergerst et al. 2021). A reduction of mowing (and an eventual seeding) and, thus, an increase of flowering resources usually leads to a rapid increase of this highly mobile group, which was shown

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Published online: 15 October 2024

for example by Hofmann and Renner (2020) on annual flowering strips in Munich. This is also supported by a meta-analysis of Proske et al. (2022), who showed that highly mobile pollinating or phytophagous insect are the most benefitting taxa from a reduced management intensity of urban lawns. Despite a rapid increase of flowering plant and pollinating species it is challenging to determine whether the restored lawns can serve as a permanent habitat for arthropods. While the meadows may provide a valuable food resource, it remains unclear whether they are suitable for reproduction or overwintering of arthropods. However, it is important to have reliable observation and evaluation tools, as these are often required in funding programs like the Federal Program on Biological Diversity ("Bundesprogramm Biologische Vielfalt"), which is intended to implement the goals of the Convention on Biodiversity as part of the National Strategy on Biodiversity in Germany (Flinkerbusch and Nowack 2017).

At this point, epigeic spiders (Arachnida: Araneae), a group that is often neglected in projects dealing with the creation of flowering meadows in urban environments, should be proposed as an additional group, suitable for evaluation. Spiders have the advantage that they can run their complete life cycle in the same habitat (even if preferred microhabitats may differ during life-cycle (Hallander 1970)) and, at least partially, can reach new habitats faster than other wingless predators by spreading with the air plankton via ballooning (Bell et al. 2005). Several studies have already shown that spiders are effective indicators for grassland restoration or extensification efforts (Perner and Malt 2003; Déri et al. 2011; Buchholz et al. 2018; Smith DiCarlo and DeBano 2019; Solascasas et al. 2022) and also in heathland restoration spiders are commonly used as evaluation tools (Cristofoli et al. 2010; Schirmel and Buchholz 2011; Borchard et al. 2014; Hacala et al. 2020).

Since spiders are a widespread trigger of phobias and disgust (Frynta et al. 2021) their use as indicator species in urban environments can also be beneficial from a socio-economic perspective. Studies have shown, that the connection of biodiversity promoting approaches with involving further stakeholders like education and communication partners can lead to a greater acceptance and awareness of arthropods (Garbuzov et al. 2015; New 2018). It was also found, that factual knowledge reduces the level of fear towards animal species (Makashvili et al. 2014; Oražem et al. 2021).

In this case study we investigate which parameters and species of spider communities may be suitable for the evaluation of urban grassland restoration efforts using mesophilic meadows. Since one important aspect in habitat restoration is "What is ecologically feasible?", a good knowledge of regional species pool and species distribution is necessary to define realistic development goals (Bakker et al. 2000; Miller and Hobbs 2007).

Materials and methods

Investigation site

The study area focuses on Aachen, Germany's westernmost city with a size of 160 km^2 and approximate 250.000 residents, which borders on the Netherlands and Belgium and lies in a transitional area between the intensively used agricultural area Jülich-Zülpich Börde in the north and the northern margins of the Eifel mountains in the south and east. Although Aachen is not located near the coast, it has an oceanic climate with comparatively low temperatures in summer, mild winters and an annual precipitation with 908 mm between 1980—2009 (Buttstädt and Schneider 2014).

Dataset

For our study we compiled a regionalized dataset of published and unpublished spider community datasets and classified them along an urbanization gradient, starting with community data from urban ornamental lawns. We are aware that the source-sink model between rural and urban areas is a very simplified approach (Varet et al. 2013) and that habitats influenced by urbanization often form unique communities, differing from their natural and semi-natural equivalents (Sattler et al. 2011) due to different filters (Sattler et al. 2010; Van Nuland and Whitlow 2014). Therefore, we integrated data from urban extensive meadows as a reference point for spider communities in meadows influenced by urbanization. As a habitat that mediates the transition between urban and semi-natural meadows, we used data from species-poor meadows from the agricultural surrounding countryside, since these have the largest proportion of mesophilic grassland in the urban–rural boundary area of Aachen. We assume that species found in these meadows have also a high probability to colonize urban meadows on a short to mid-term time scale. As a reference point for ecologically valuable meadow habitats from a less fragmented and intensively used landscape, we integrated data from extensive used hay meadows, which we use to define target species for mesic grassland restoration in urban areas.

To generate a representative set of study sites, we used the ARAMOB data repository (ARAMOB 2023; Bach et al. 2023) to export all available datasets with spider communities collected with pitfall traps in habitats classified according to EUNIS (Davies et al. 2004) as mesic grassland (E2) in Aachen and the surrounding area and enriched it with further unpublished local project datasets. This allowed us to select a representative sample of mesic grassland communities from different scenarios (see S1

Table 1) that were well-suited for our study. To ensure that the community data was representative collected, all data sets were filtered out that were not collected with at least three pitfall traps and a sixty-day collection timespan within the vegetation period (April—October). After applying our selection criteria, we were left with 38 study sites (S1 Table 2). These plots were divided into four categories: intensively maintained urban ornamental lawns (UI, $n = 13$), urban extensive meadows (UE, $n = 3$), and species-poor agricultural meadows from the surrounding countryside (AM, $n = 7$). The selected urban extensive meadows were the only once available since extensive urban grassland in Aachen was rare. Only in recent years' efforts began to extensify large areas of inner-city ornamental lawns, so the small sample of these type of grasslands and the heterogeneous study design reflects the conditions at the study area to date. We augmented our dataset with spider community data from extensive species rich hay meadows from the neighboring rural Eifel region, with an approximate distance of 50 km from the city center Aachen. These meadows (HM, $n = 15$) served as reference values due to the lower fragmentation of the surrounding landscape matrix and the more semi-natural conditions (Fig. 1).

Sampling took place between 1996—2021 with 51,329 collected individuals from 149 species. Nomenclature was applied according to the World Spider Catalog (2024). Only adult spiders identified to the species level were included in the analyses. All members of species groups that were not split until after the earliest collection year, were named equally in our dataset as long as we could not confirm their identity on all plots (e.g., *Micaria pulicaria* and *Micaria micans* as *Micaria pulicaria* s.l. (Muster and Michalik 2020)).

We standardized the activity density data collected over different time spans and number of pitfall traps by calculating the catch per unit effort based on the approach by Saska et al. (2021). This method essentially measures activity density per trap per day. All calculations were done with this standardized measure of activity density. We will refer to it as "daily activity density" in the following. The term "activity" in this context highlights that the measure is influenced not just by how many spiders are present, but also by their

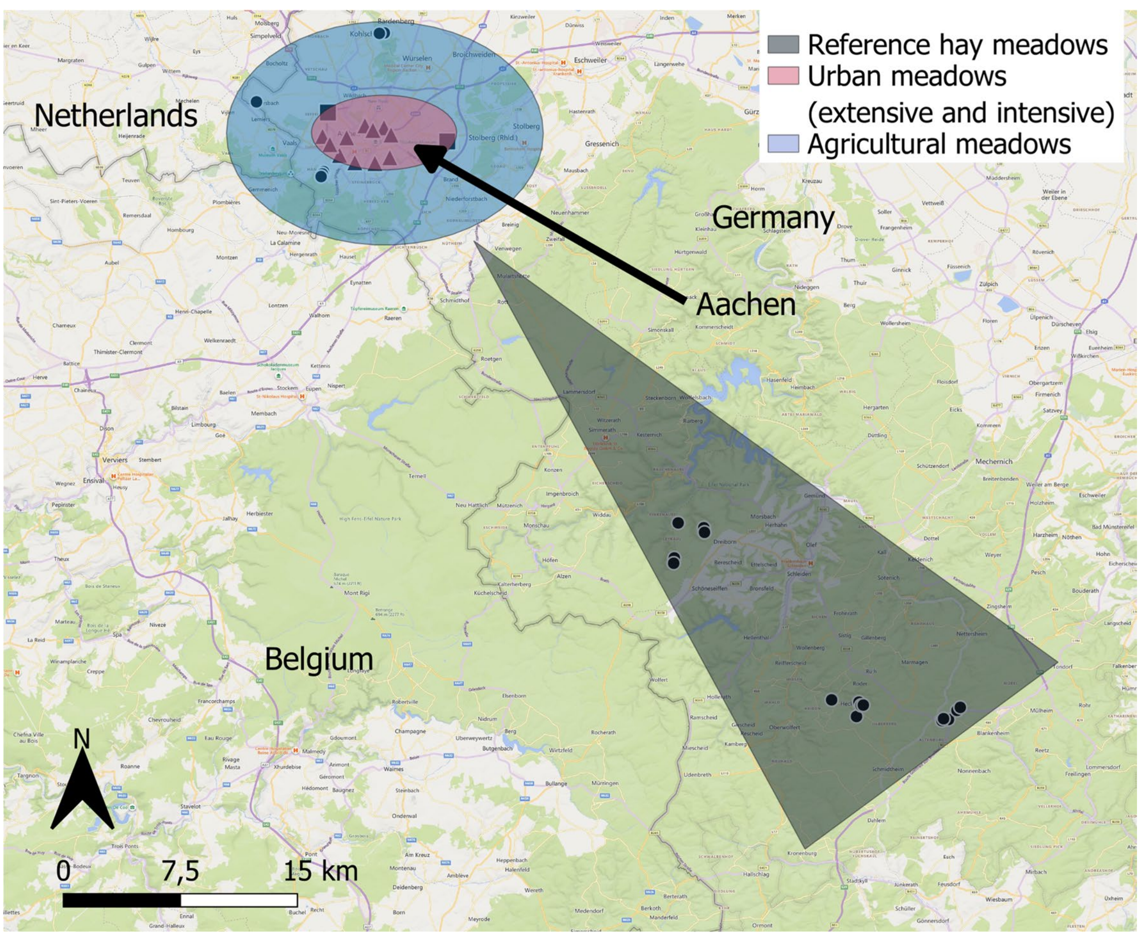


Fig. 1 Sampling sites located in and around Aachen. Black dot indicate exact locations, while colored shapes denote corresponding area categories. In the urban meadows, triangles represent intensive meadows, while squares represent extensive meadows

movement behavior, which affects their likelihood of being captured in pitfall traps (Woodcock 2005).

All spider species were characterized based on traits that are well-documented to reflect responses to urbanization (Buchholz et al. 2018; Lövei et al. 2019; Cabon et al. 2024a, b; Martínez-Núñez et al. 2024). These traits include median (female) body size based on minimum and maximum values (mm) from Nentwig et al. (2023), ballooning ability (Bonte et al. 2003, 2004; Bell et al. 2005; Simonneau et al. 2016), hunting mode (Cardoso et al. 2011), forest affinity as a measure of habitat specificity (Blick et al. 2019; Schneider et al. 2021) and their niche values for moisture and shading demands (Entling et al. 2007). (See also S1 Table 3).

Statistical analyses

All data preparation and analyzing steps were done using R version 4.2.2 with RStudio (2022.07.2 Build 576). We first calculated the Chao1 index to estimate species richness using the vegan package (Oksanen et al. 2018) and compared these estimates with the observed species counts to assess the completeness of the respective sampling effort. Afterwards we performed a Multi-Response Permutation Procedure (MRPP) to confirm the significance of differences in species composition among our predefined site groups (not shown in the "Result" section).

We then compared the daily activity density and species richness in the different site groups. In addition, we calculated the community weighted mean (CWM) trait values using package 'FD' (Laliberte et al. 2014) to find parameters suitable for evaluation efforts. These were tested using a one-way ANOVA to find significant differences ($p \leq 0.05$) in trait characteristics between our groups and Tukeys range test for multiple comparisons (adjusted $p \leq 0.05$). Furthermore, we investigated the size distribution within our four groups by performing a non-parametric density estimation using a Gaussian kernel. Density is weighted using the summed daily activity density data per body size. With the vegan package (Oksanen et al. 2018) we performed a correspondence analysis on the site-species matrix to investigate whether distinct communities emerge in the different groups. We identified species groups for future use to evaluate the restoration success with a three step nested indicator species analysis (ISA) using 'indicpsecies' package (De Cáceres and Legendre 2009). In this approach we did the first ISA with the complete dataset looking for exclusive indicators in all four groups (UI, UE, AM, HM). The calculated indicators ($p \leq 0.05$, Indicator Value ≥ 0.7) were then excluded from the dataset and a second ISA with combined site groups was performed to find indicators separating between urban and less to non-urbanized grasslands (UI + UE vs. AM + HM). Previous step with removing new indicator species was repeated and the third ISA was performed testing all meadows against the lawns to find species which are euryoecious in grassland but missing in lawns (UI vs UE + AM + HM). All indicator species were controlled for their prevalence for mesophilic grasslands using expert knowledge and literature to be considered as ecological meaningful. Only the exclusive indicators of extensive urban grassland were excluded from this process, as we consider these, regardless of their ecology, as species that supplement urban grassland communities through urban filtering and occupying niches that might otherwise remain unoccupied (Fournier et al. 2020).

Results

Species richness estimates, calculated using the Chao1 estimator, varied across the different groups studied (Table 1). The semi-natural hay meadows had the highest Chao1 estimates, suggesting a more comprehensive capture of the spider community. Urban extensive meadows and species-poor agricultural meadows displayed slightly lower Chao1 estimates, indicating fewer unseen species compared to hay meadows. Lawns exhibited the lowest species richness and Chao1 estimates, reflecting a more limited and less diverse spider community. Despite these differences, the relatively high Chao1 estimates across all groups suggest that our sampling captured a substantial portion of the species present.

Figure 2 illustrates that ornamental lawns had lower mean values in both biodiversity parameters than the compared groups. In contrast, extensive meadows in the urban environment showed significantly lower mean daily activity densities compared to meadows in the non-urban

Table 1 Overview of number of species richness, the total number of individuals collected (unstandardized), the estimated species richness (Chao1 Index) with associated standard error (SE), and the sampling completeness percentage across the groups on the urban-intensification gradient

Group	Species collected	Individuals collected (unstandardized)	Chao1 ± SE	Completeness
UI ($n=13$)	59	3550	67.67 ± 6,41	87.19%
UE ($n=3$)	64	2438	77.13 ± 9,01	82.98%
AM ($n=7$)	63	12,598	80.00 ± 10,65	78.75%
HM ($n=15$)	109	32,743	116.29 ± 4,71	93.73%

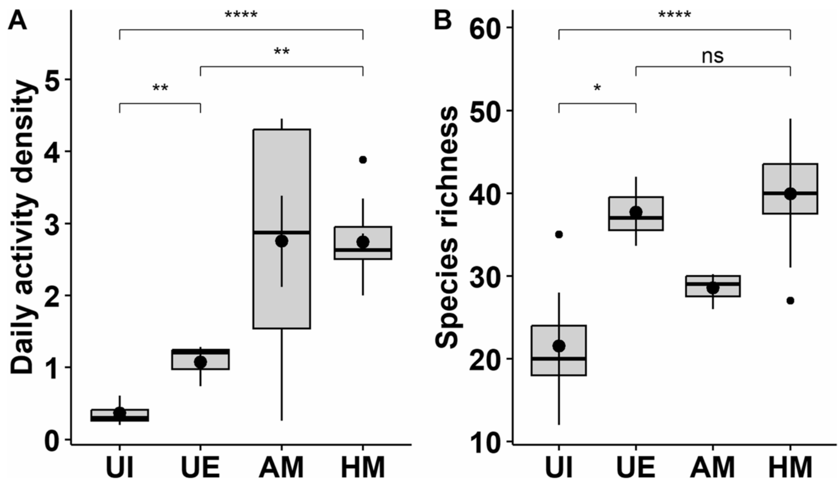


Fig. 2 Daily activity density (**A**) and species richness (**B**) of lawns resp. meadows in different fragmentation and intensity scenarios. Statistical significance was calculated using Kruskal–Wallis, pairwise comparison was done with Wilcoxon. (< 0.0001 = ****, < 0.001 = ***, < 0.01 = **, < 0.0 5 = *, > 0.05 = ns). UI = urban intensive, UE = urban extensive, AM = agricultural meadows, HM = hay meadows

environment, but no significant differences for species richness compared to the reference group of semi-natural hay meadows. However, the species activity densities of the urban meadows were still significantly higher than on the lawns.

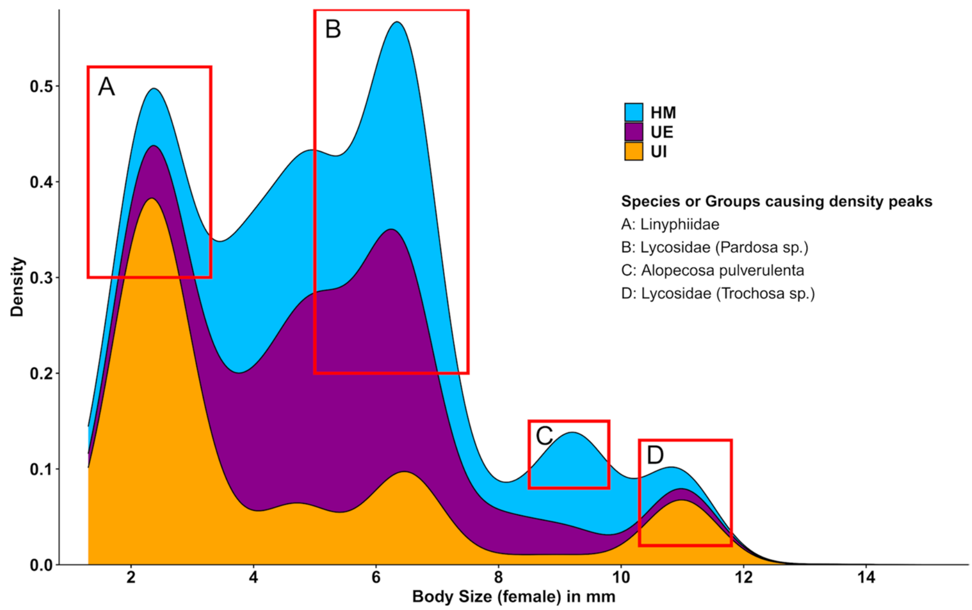
A comparison of the CWM of the different trait characteristics (Table 2) shows that the intensive lawns differ mainly in the structure of the hunting guilds, which is also reflected in the composition of the spider families. Ornamental lawns also have an increased proportion of species not strictly tied to open habitats, as well as a higher proportion of species with lower moisture demands compared to hay meadows. In contrast, urban meadows only had a higher proportion of species with a preference for light forests or forest edges compared to hay meadows, no other significant differences could be found in the values shown here.

Ecologically intact hay meadows show a broadly similar distribution between spiders of 2—8 mm body size, with spiders between 6—7 mm dominating, caused mainly by species of the wolf spider genus *Pardosa* (Fig. 3). After

Table 2 Results of one way ANOVA statistics and subsequent postHoc Tukey HSD tests of different traits and their (significant) characteristics (CWM) and proportions of the most dominant families between the groups on the urban-intensification gradient. Tukey only shows the results against the UI group. A + indicates a significantly ($p < 0.05$) higher value of the characteristic feature,—a significantly ($p < 0.05$) lower value compared to UI. Tests vs. UE are not presented since the only significance was a higher CWM of Forest affinity – forest light compared to HM, all other comparisons were not significant

		ANOVA		Tukey HSD (vs UI)		
		p (F)	F	HM	AM	UE
Body size		0.001	6.565	+	+	n.s
Forest affinity	Open	0.002	6.255	n.s	+	n.s
	Mixed open	< 0.001	9.595	-	-	n.s
	Forest light	0.018	3.863	n.s	n.s	+
Hunting mode	Ambush hunters	0.004	5.440	+	n.s	+
	Ground hunters	< 0.001	16.228	+	+	+
	Orb web hunters	< 0.001	17.624	+	n.s	+
	Other hunters	< 0.001	19.643	-	-	-
	Sheet web hunters	< 0.001	14.306	-	-	n.s
	Space web hunters	0.014	4.094	-	-	n.s
Niche values	Shading	0.011	4.331	n.s	n.s	n.s
	Moisture	0.003	5.801	+	n.s	n.s
Ballooning	Yes	0.029	3.391	n.s	+	n.s
	No	0.029	3.391	n.s	-	n.s
Family proportions	Gnaphosidae	0.034	3.245	+	n.s	n.s
	Hahniidae	0.001	6.645	-	-	n.s
	Linyphiidae	< 0.001	23.194	-	-	-
	Lycosidae	< 0.001	27.435	+	+	+
	Tetragnathidae	< 0.001	17.590	+	n.s	+
	Theridiidae	0.014	4.094	-	-	n.s
	Thomisidae	0.004	5.440	+	n.s	+

Fig. 3 Density plot showing the distribution of body sizes in spider communities of Group HM, UE and UI (AM has been excluded here for display reasons). UI = urban intensive, UE = urban extensive, HM = hay meadows



that, the proportion of larger spiders drops sharply and only smaller peaks appear, due to the larger lycosids *Alopecosa pulverulenta* and *Trochosa terricola*. The distribution pattern of extensive urban meadows equals that of hay meadows, with weaker or absent (*A. pulverulenta*) wolf spider peaks. The similarity also reflects the results of the analysis of the body size CWM values, which could not find a significant difference. However, lawns are quite different from this pattern; here, the first peak (< 3 mm) is followed by an almost equally severe decline, which does not recover. The wolf spider peaks are almost completely missing, only at the end *Trochosa ruricola* triggers another peak in a similar magnitude compared the other two groups.

The analysis of the spider communities (Fig. 4) shows that especially lawns and meadows in the urban environment and the hay meadows separate from each other and form distinct communities. Only the species-poor meadows from the agricultural surrounding area have a less distinct community and overlap with urban meadows and hay meadows. The calculated indicator species (see also Fig. 5) in the plot show a clear clustering around the hay meadows plots. Apart from exclusive urban lawns and meadows indicators, only *Erigone atra* and *Pardosa amentata* are located more distant.

A total of 17 indicator species were identified (Fig. 5, S1 Table 4), of which 3 indicated for ornamental lawns (curved arrow). Group A includes established meadow species in the urban environment, partially excluding those marked with asterisks, as these are exclusive indicators of urban extensive meadows and not necessarily occurring in mesic grassland but can also include species adapted to conditions in urban environment. Group B represents meadow species from the adjacent agrarian countryside, which in addition with group A are expected on a short to medium time scale on extensified ornamental lawns due to their spatial proximity. In contrast, bold species in Group C represent indicators of semi natural hay meadows and are therefore defined as regional long-term target species.

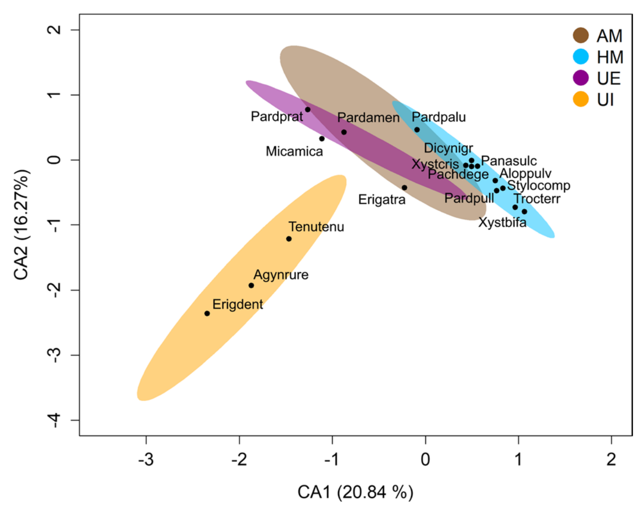


Fig. 4 Correspondence Analysis showing the mesic grassland plots from different urbanization and intensity scenarios. (Variance explained by CA1: 20.84%, CA1 + 2: 37.11%). Ellipses were used as envelopes to encounter all sites. Black dots refer to calculated indicator species. Agynrure = *Agyneta rurestris*, Aloppulv = *Alopecosa pulverulenta*, Dicynigr = *Dicymbium nigrum*, Erigatra = *Erigone atra*, Erigdent = *Erigone dentipalpis*, Micamica = *Micaria micans*, Panasulc = *Panamomops sulcifrons*, Pardamen = *Pardosa amentata*, Pardpalu = *Pardosa palustris*, Pardprat = *Pardosa prativaga*, Pardpull = *Pardosa pullata*, Pachdege = *Pachygnatha degeeri*, Stylcomp = *Styloctetor compar*, Tenutenu = *Tenuiphantes tenuis*, Trocterr = *Trochosa terricola*, Xystbifa = *Xysticus bifasciatus*, Xystcris = *Xysticus cristatus*; UI = urban intensive, UE = urban extensive, AM = agricultural meadows, HM = hay meadows

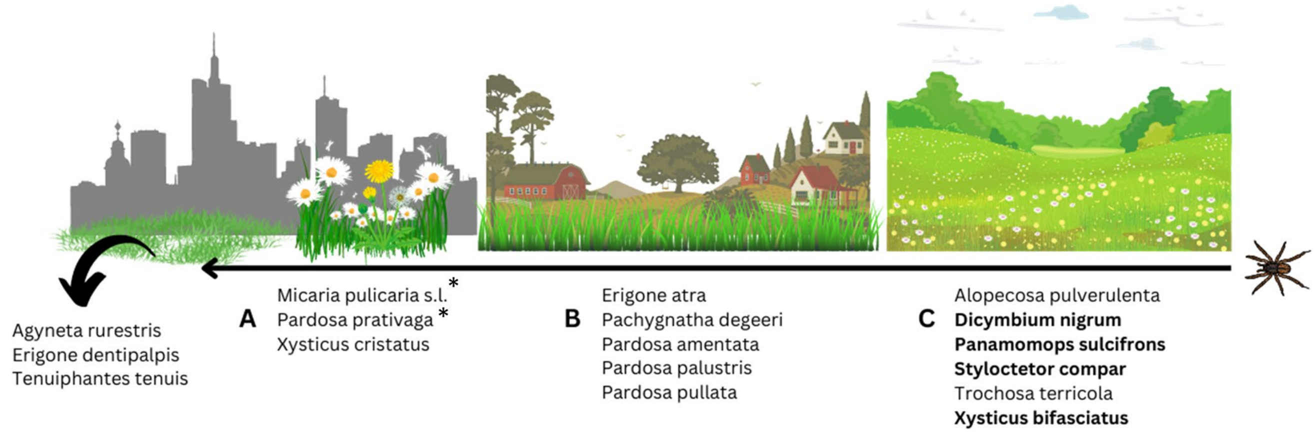


Fig. 5 Result of the nested Indicator species analyses. Species are ordered according to their spatial proximity to urban lawns. Detailed results of nested ISA see Supplement Table 4. Graphic was created with canva.com

Non-bold species in Group C were also exclusive indicators of hay meadows but were not defined as long-term target species due to their ecology and expectability in urban areas.

Discussion

Biodiversity parameters

The results of our study show that urban extensive meadows can have similar parameters regarding species richness and functional diversity compared to semi-natural hay meadows found in less urbanized landscape matrices. Of concern are the low abundance values, as low population sizes may pose an increasing risk of local extinction events (O'Grady et al. 2004). However, other studies found little differences on spider activity densities along urban gradients (Sattler et al. 2011; Philpott et al. 2014; Otoshi et al. 2015), so we attribute this to a combination of local conditions, small sample and a temporal bias in our dataset, as all urban meadows were sampled in the same year, while sampling on sites in all other groups took place in different years, and not to a general pattern. Spider population sizes are known to shift significantly, even between years (Workman 1977; Kobel-Lamparski and Gack 2020).

Species and trait composition

Another striking parameter in the evaluation of restoration or extensification efforts on urban lawns is the species composition of the spider community. While the correspondence analysis supports the hypothesis made at the beginning about agricultural meadows in the adjacent countryside as mediators between urban and semi natural meadows, the ornamental lawns form their own distinct communities. According to the results of Cockfield and Potter (1984), lycosid, thomisid and tetragnathid (here mainly *Pachygnatha degeeri* and *Pachygnatha clercki*) spiders as typical species of intact hay meadows (Nyffeler and Breene 1990) are strongly decreasing on ornamental lawns, also explaining significant differences in hunting guild structure and mean body size. This can of course be linked with the high management intensity and the resulting structural poverty of these habitats (Bell et al. 2001). The urban reference group demonstrates that family compositions (Table 2), equal to hay meadows, are possible in urban environments with an appropriate habitat quality. Especially wolf spiders (Lycosidae) usually known for the highest activity density in grassland compared to other spider families (Standen 2000) may be suitable for evaluation, as, at least an identification up to family level can be done even by less experienced researchers. Furthermore, a monitoring with pitfall traps is cost and time efficient (Work et al. 2002; Hohbein and Conway 2018). While their proportion to the total spider community on the studied lawns was on average around 25%, all other meadows in this study never had wolf spider proportions below 50% (not shown in the "Result" section). Since Lycosidae are known to dominate pitfall catches in grassland habitats (Duffey 1962; Samu et al. 1996; Lang 2000; Weeks Jr and Holtzer 2000; Jocqué and Alderweireldt 2005; Woodcock 2005; Jansen et al. 2013; Burkman and Gardiner 2015) and even urban gardens (Otoshi et al. 2015), a threshold value of a minimum of 50% of the total spider catch should belong to Lycosidae as a parameter for the positive evaluation of the extensification efforts on former lawns.

The spatial proximity, on the other hand, of spider communities on urban meadows compared to reference hay meadows demonstrates that similar communities can develop, but nevertheless form distinct communities probably caused by urban filtering (Fournier et al. 2020) and different disturbance intensities (Sattler et al. 2010). While the influence of different mowing techniques and regimes on spider communities in grassland ecosystems are well studied (Haskins and Shaddy 1986; Nyffeler and Breene 1990; Cizek et al. 2012; Pech et al. 2015; Buri et al. 2016; Berger et al. 2024), there is a lack of knowledge on the influence of low-threshold disturbances on arthropod communities in grasslands which occur daily in an urban context, like littering leading to new microhabitats (Kolenda et al. 2021). Furthermore Buchholz et al. (2021) demonstrated i.a. a negative correlation between spider diversity and a high dog presence resp. activity on urban dry grasslands in Berlin. Wu and Elias (2014) showed how anthropogenic caused vibratory noise limits sensory abilities in prey detection in spiders or Goßmann et al. (2022) who identified spider webs as sinks for microplastics like tire wear particles. Thus, the extent to which communities in urban habitats are or will be disturbed is difficult to predict, nor is the degree of disturbance in communities strictly correlated with urbanization (Niemelä and Kotze 2009; Nagy et al. 2018). However, the regional species pool has the greatest influence on the composition of urban communities (Fournier et al. 2020) and should therefore be considered as an ecological constraint of what is possible in restoration projects (Miller and Hobbs 2007).

Target species

By analyzing the regional species pool, we were able to identify three species groups that can be used to indicate habitat improvements of restored meadows at two different scales (Fig. 5). Group A consists of *Xysticus cristatus*, which indicated for all meadow types except ornamental lawns, and two indicator species exclusive for urban meadows, distinguishing them from less to non-urbanized meadows. Contrasting to *Pardosa prativaga,* which is together with *X. cristatus* associated with hay meadows (Nyffeler and Breene 1990), *Micaria pulicaria* s.l. (which is highly probably *M. micans* since only individuals belonging to this species are known to the authors from urban areas in Aachen) prefers warm and dry habitats (valid for *M. micans* (Muster and Michalik 2020)), appearing to be a species with favored traits for urban environments like thermophilia (Menke et al. 2011; Magura et al. 2013; Meineke et al. 2017; Piano et al. 2020). Apart from this, all three species are nevertheless generalists with a broad ecological amplitude.

This is also true for species in Group B, which are also euryoecious with a focus on mesic grassland ecosystems (Nyffeler and Breene 1990; Martin 2020). Of particular interest here is the separation of *Erigone dentipalpis* and *Erigone atra*. Although, as highly mobile pioneer species and r-strategists (Bell et al. 2001) both belong to the most common spiders on arable fields (Blick et al. 2000), ornamental lawns seem to be a tough place even for survivalists. Presumably, this confirms Wiehle's (1960) observation that *E. atra* has a slightly higher moisture requirement than *E. dentipalpis* since lawns have a constant risk of drying out in summer (Smagin et al. 2006). We expect Group A and B to be potential early colonizers for several reasons: 1) All species are highly mobile (except *M.* cf. *micans*) generalists. 2) All species occur in the city or the adjacent landscape. 3) All species have already been reported from urban environments by other authors (Rozwałka 2006; Keer et al. 2010; Sattler et al. 2011; Buchholz et al. 2018; Braschler et al. 2020). However, it is questionable in which time span a colonization is expectable. Although concrete studies are lacking for this specific question, studies from other urban habitat types concluded that for those generalists the decisive factor is primarily habitat quality and neither time nor habitat connectivity (Vergnes et al. 2012; Varet et al. 2013; Burkman and Gardiner 2015; Vähätalo et al. 2024). Equal results came from orthopteran assemblages where management is more important than landscape parameters (Huchler et al. 2023). Huhta et al. (1979) reported a low spider density in the first year after the creation of artificial soil plots in garden grassland with a rapidly increase in the following years. We expect two years as a rough guide to measure first changes in species composition, whereby this is of course also dependent on factors that are beyond one's control like weather (Shochat et al. 2008).

In contrast to the species just discussed, bold species from Group C are more specialized mesic grassland species even with national conservation concerns (*Styloctetor compar* (Blick et al. 2016)) or considered as rare on a national or regional scale (*Panamomops sulcifrons*, *Dicymbium nigrum* (Buchholz et al. 2010; Blick et al. 2016)) and are identified as valuable target species. Although literature usually describes *Xysticus bifasciatus* as a species of dry grass- and heathlands (Heimer and Nentwig 1991; Roberts 1995; Bee et al. 2017), several studies recorded *X. bifasciatus* in hay meadows (Nyffeler and Benz 1979; Prokopenko 2015; Szmatona-Túri et al. 2017), even co-occurring with *S. compar* (Řezáč and Heneberg 2018; Frenzel et al. 2022). Also Martin (2020) described wet and mesic meadows as the preferred habitat, so we consider the ecological relevance to be given here to name *X. bifasciatus* as a possible target species for mesic grassland restoration in this region. Except for *X. bifasciatus* (which was found by Buchholz et al. (2018) on urban grassland in Berlin) historical records from Aachen are known for these species (Arachnologische Gesellschaft 2023) emphasizing the possibility of a general occurrence of these species in suitable urban habitats. The hygrophilous species (Heimer and Nentwig 1991) *Styloctetor compar* should be highlighted: At the beginning of the twentieth century this species was described as "nicht selten bei Aachen" (not rare near Aachen, Bösenberg 1902). Since then no recent records from Aachen or the adjacent landscape were available, except for an individual specimen from an AM plot in our dataset, what may be linked to the large-scale drainage of wetlands and the canalization of urban streams to reduce malaria causing *Anopheles* sp. populations and to increase general urban hygiene (Kortenhaus 1928).

The two non-bold species are also exclusive indicators of hay meadows, but based on their ecology, occurrence in urban habitats and general frequency, they certainly belong to the groups discussed first. Notable is *Trochosa terricola*, which is not a classic meadow species since it has a higher demand for shading, thus prefers forests, forest edges or hedgerows (Hänggi et al. 1995; Martin 2020) and possibly benefitting from increasing vegetation height in semi-natural hay meadows (Bonte et al. 2000; Dennis et al. 2001). Being one of the largest local species, its amplitude is also clearly seen in the density distribution of the body sizes in the hay meadows (Fig. 4). Surprisingly, the ornamental lawns also peak in this area, caused by its sibling species *Trochosa ruricola* (with significant increased daily abundances compared to hay meadows where *T.ruricola* was nearly absent with singeltons only). This also led to a missing significance in analysis of body size CWM between urban lawns and urban meadows, as *T. ruricola* was the dominant species on some lawns, providing very high variance in this group. It seems contradictory that in a habitat that obviously filters large species, a species belonging to the largest lycosid spiders is one of the most captured (by ornamental lawn standards) species. In contrast to the otherwise diurnal wolf spiders, *T. ruricola* may benefit here from its nocturnal activity (Bayram 1995) to escape the increased predation pressure by birds on urban lawns (Mennechez and Clergeau 2001), to which it would be exposed as a large vagrant species (Gunnarsson 1996; Gunnarsson and Wiklander 2015). On the other hand, a methodological bias would also be conceivable, since a larger body size is associated with increased mobility and can provide a higher trapping probability (Luff 1975; Hancock and Legg 2012). Due to the different ecological demands of the two species, we did not exclude *T. terricola* from the list of indicator species and consider it a possible indicator of improvements in vegetation structure.

Apart from *T. terricola* and *Alopecosa pulverulenta*, which can be regularly detected in urban areas, it is impossible to speculate on when the defined target species will occur (if they ever do). Nevertheless, Bauer et al. (2024) have recently shown that urban grasslands are capable of supporting spider species of conservation concern. Our results therefore can provide important insights, for example, when trying to identify suitable donor grassland sites for translocation of arthropod communities during a restoration process (Helbing et al. 2020).

In summary, as a first step to measure improved habitat quality using epigeic spiders on former ornamental lawns in the short term, generalist grassland spiders should show increasing abundance and species richness. In Central Europe, a large part of the indicators discussed here can probably also be used, but an a priori overview of the regional species pool using publicly available sources like Atlas of the European Arachnids (https://atlas.arages.de) or the data portal of the arachnological society (www.aramob.de) should always be obtained. Research projects with low levels of funding could also measure an increase in wolf spider populations in general, as this family can be easily identified even by less experienced researchers and a monitoring with pitfall traps is cost (Morrill 1975) and time efficient (Hohbein and Conway 2018). This could be useful for research projects with a citizen science approach (Pocock et al. 2014; Zapponi et al. 2017). Nevertheless, species-level determination should always be preferred, as this is the only way to reliably track ecological and functional developments (Derraik et al. 2002). If no plot-specific initial surveys were done, which will presumably mostly be the case for ornamental lawns, a short- to medium-term target value of 50% wolf spider share of total pitfall trap catch can be used here with a sampling duration of at least two months within the vegetation period. On the long term, the focus should be on the detection of the grassland specialist target species as ecological indicators. For this purpose, adapted sampling by synchronizing collection time span with species phenological data or using semi-quantitative rapid assessment methods (e.g. Cardoso et al. (2008)), can take place in later phases to further reduce the workload. Using spiders as flagship species in urban restoration projects combined with public promotion such as area signage, local news coverage, or the creation of educational school materials can increase visibility for this species group. This heightened exposure stimuli, along with increased knowledge, may help reduce fear and disgust among local citizens (Smits et al. 2002; Abado et al. 2020), ultimately lowering the economic costs associated with these fears (DuPont et al. 1996; Pittig et al. 2014).

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11252-024-01626-x.

Acknowledgements We thank Freya Zäpernick and Lucas Stratemann who provided assistance in the ecological field work.

Author contributions All authors conceptualized the study and designed the methodology. A.B. and J.J. compiled and curated the dataset. M.R.-N. supervised the project and provided critical revisions. A.B. conducted the formal analysis and wrote the main manuscript text. A.B., J.J. and B.D. prepared the figures and tables. All authors reviewed and approved the final manuscript.

Funding Open Access funding enabled and organized by Projekt DEAL. This work was partly funded (Grant No. 3519685A22) by the Federal Agency for Nature Conservation (BfN) in the Federal Program on Biological Diversity with funding from the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV).

Data availability The data and the code of the analyses will be made available on GitHub (https://github.com/alexander-bach/lawns_to_meadows) following its publication. Data is also available in the ARAMOB data repository.

Declarations

Competing interests The authors declare no competing interests.

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Artenreiche FLIP-Wiesen auf öffentlichen Flächen im Stadtgebiet Aachen Stand November 2024

	Nutzung -Bezeichnung	Grünflächen-Name	Flächein qm	Produkt-verantwortlicher	Anlage Jahr
1	Straßenbegleitgrün	Blücherplatz Parkplatz	745,91	FB36 (Strassengruen)	FLIP- Einsaat Herbst 2021
1	Spielplatz	Bolzplatz Tute Patt	1156,20	FB36 (öff. Spielplätze)	FLIP-Einsaat Herbst 2023
1	Grün- und Parkanlage	Breitbenden	160,83	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2020
1	Grün- und Parkanlage	Breitbenden	367,85	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2021
1	Grün- und Parkanlage	Farwickpark	753,96	FB36 (Grünanlagen)	FLIP- Anlage Herbst 2024
1	Friedhof	Friedhof Schildchenweg	884,44	E18 (Friedhof)	FLIP- Anlage Herbst 2023
1	Grün- und Parkanlage	Gillesbachtal	63,34	FB36 (Grünanlagen)	FLIP- Anlage Herbst 2024, Patenschaft
1	Grün- und Parkanlage	Gillesbachtal	260,95	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2021
1	Grün- und Parkanlage	Gillesbachtal	119,05	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2021
1	Grün- und Parkanlage	Gillesbachtal	276,91	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2021
1	Grün- und Parkanlage	Grünzug Kronenberg	282,53	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2020
1	Grün- und Parkanlage	Grünzug Kronenberg	562,74	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2020
1	Straßenbegleitgrün	Hanbrucher Straße	314,73	FB36 (Strassengruen)	FLIP- Einsaat Herbst 2021
1	Straßenbegleitgrün	Hanbrucher Straße	224,87	FB36 (Strassengruen)	FLIP- Einsaat Herbst 2021
1	Straßenbegleitgrün	Hanbrucher Straße	399,52	FB36 (Strassengruen)	FLIP- Einsaat Herbst 2021
1	Straßenbegleitgrün	Hermann-Löns-Allee X Limburger Straße	284,65	FB36 (Strassengruen)	FLIP- Einsaat Herbst 2023
1	Grün- und Parkanlage	Hollandwiese	3149,71	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2022
1	Grün- und Parkanlage	Kaletzbenden	6161,04	FB36 (Grünanlagen)	FLIP-Einsaat Herbst 2021
1	Grün- und Parkanlage	Kennedypark	550,12	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2021
1	Grün- und Parkanlage	Kohlgasse GF	338,18	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2021
1	Grün- und Parkanlage	Kurpark Monheimsallee	1078,83	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2020
1	Grün- und Parkanlage	Lammertzpark	463,64	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2021
1	Grün- und Parkanlage	Lammertzpark	917,50	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2021
1	Grün- und Parkanlage	Nelson-Mandela-Park	452,28	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2020
1	Grün- und Parkanlage	Nelson-Mandela-Park	207,81	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2023
1	Grün- und Parkanlage	Nelson-Mandela-Park	122,31	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2023
1	Grün- und Parkanlage	Nelson-Mandela-Park	103,69	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2023
1	Grün- und Parkanlage	Nelson-Mandela-Park	194,47	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2023
1	Grün- und Parkanlage	Nelson-Mandela-Park	149,20	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2023
1	Grün- und Parkanlage	Nelson-Mandela-Park	206,55	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2023
1	Grün- und Parkanlage	Nelson-Mandela-Park	92,01	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2023
1	Grün- und Parkanlage	Nelson-Mandela-Park	467,94	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2020
1	Grün- und Parkanlage	Nelson-Mandela-Park	332,63	FB36 (Grünanlagen)	FLIP-Einsaat Herbst 2023
1	Grün- und Parkanlage	Nordbahnhof	439,76	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2021
1	Grün- und Parkanlage	Park am alten Friedhof (Haarener Allee)	272,46	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2022
1	Grün- und Parkanlage	Prämienstraße/Hasbach	421,80	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2022
1	Straßenbegleitgrün	Rathausplatz	37,15	FB36 (Strassengruen)	FLIP- Einsaat Herbst 2023
1	Straßenbegleitgrün	Schlangenweg	872,38	FB36 (Strassengruen)	FLIP- Einsaat Herbst 2021
1	Straßenbegleitgrün	Schlangenweg	1227,57	FB36 (Strassengruen)	FLIP- Einsaat Herbst 2021
1	Spielplatz	Spiel-/Bolzplatz Parkstraße	239,55	FB36 (öff. Spielplätze)	FLIP- Einsaat Herbst 2022
1	Schule	Städt.G G S Driescher Hof	305,29	FB45/400 (Schulen)	FLIP- Anlage Herbst 2024
1	Schule	Städt.Schule f. Erziehungshilfe Martin-Luther-King	157,75	FB45/400 (Schulen)	FLIP- Anlage Herbst 2024
1	Schule	Städt.Schule f. Erziehungshilfe Martin-Luther-King	78,60	FB45/400 (Schulen)	FLIP- Anlage Herbst 2024
1	Grün- und Parkanlage	Vennbahnstraße GF	286,25	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2022
1	Grün- und Parkanlage	Viehhofstraße GF	549,85	FB36 (Grünanlagen)	FLIP- Einsaat Herbst 2020
1	Grün- und Parkanlage	Von-Halfern-Park	48,61	FB36 (Grünanlagen)	FLIP-Anlage Herbst 2024
1	Öffentliches Gebäudegrün	Welsche Mühle mit Parkplatz (Am Mühlenteich)	285,81	E26 (öff. Gebäude)	FLIP- Einsaat Herbst 2022
47	**Summe**		**27.069,22**		