



Wildlife-friendly garden practices increase butterfly abundance and species richness in urban and arable landscapes

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<https://doi.org/10.1016/j.scitotenv.2024.171503> 

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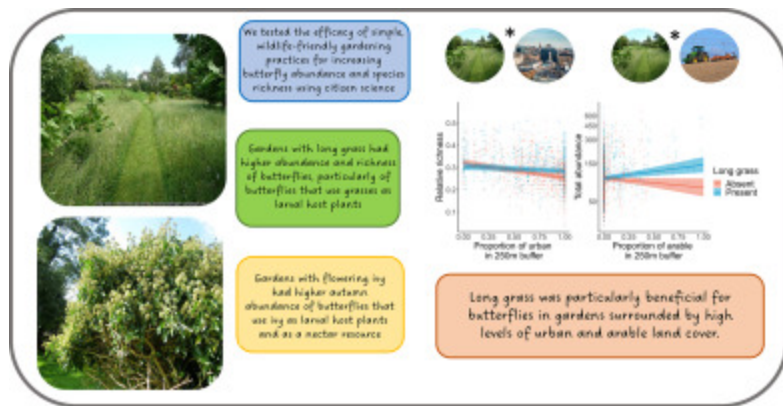
- Residential gardens could provide refugia for insects declining due to habitat loss.
- We use 5 years of citizen science butterfly data from >600 gardens in Great Britain.
- Long grass and flowering ivy *Hedera* spp. increase butterfly abundance and richness.
- Gardens with long grass benefit butterflies most in highly urban and arable areas.

- This provides the public with meaningful ways to increase butterflies in gardens.

Abstract

Insect declines are being reported worldwide and private, residential gardens could provide refugia for these species under increasing land use change. Interest in wildlife-friendly gardening has increased, but many management recommendations lack a scientific evidence-base. We used a large citizen science scheme, the Garden Butterfly Survey (GBS), with data from over 600 gardens across Great Britain (2016–2021) to determine how the surrounding landscape influences the abundance and species richness of butterflies in gardens and whether wildlife-friendly gardening practices, such as having long grass and providing nectar plants, benefit butterflies. First, we show that GBS provides reliable estimates of species abundances by comparing with results from standardised, long-term monitoring data. Garden size and surrounding land use had significant effects on butterfly abundance and richness in gardens, including positive relationships with garden size, woodland and arable farmland and negative relationships with urbanisation. Both the presence and area of long grass in gardens were positively related to higher butterfly richness and abundance, with the latter being driven by butterflies that use grasses as larval host plants. These effects differed depending on the surrounding landscape, such that long grass resulted in higher garden butterfly abundance in landscapes dominated by arable farming, and higher abundance and richness in highly urbanised areas. The presence of flowering ivy (*Hedera* spp.) in gardens resulted in higher abundance of *Celastrina argiolus* holly blue which uses ivy as a larval host, and of *Vanessa atalanta* red admiral and *Polygonia c-album* comma, which favour it as a nectar source. Our work provides evidence that undertaking simple wildlife-friendly garden practices can be beneficial for attracting butterflies, particularly in heavily modified areas. With over 728,000ha of gardens in Great Britain, the cumulative effect of leaving areas of lawn uncut and providing nectar and larval host plants could be key for helping biodiversity.

Graphical abstract



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Introduction

Insect declines have been documented globally over recent decades (Dirzo et al., 2014; Wagner et al., 2021), posing a risk to insect-mediated ecosystem functions and services that humans rely upon (Ameixa et al., 2018). Loss of insect populations has been linked to land use change, particularly agricultural intensification and increased urbanisation, and climate change (Fenoglio et al., 2021; Outhwaite et al., 2022; Vaz et al., 2023). In response, there has been extensive media coverage (Saunders et al., 2020), raising public awareness and encouraging action to help stem and reverse declines (Forister et al., 2019; Habel et al., 2019). Private, residential gardens offer opportunities for the public to take action and could provide refugia for biodiversity, helping to alleviate some of the negative pressures faced by insects in other heavily modified landscapes. An understanding of how the public could manage their gardens to become more attractive to insects could provide meaningful ways for people to help reverse insect declines.

Private outdoor space makes up over 728,000ha in Great Britain (GB), and it's estimated that 62% of this area is vegetated (Office for National Statistics, 2020). Taken individually, gardens may not appear to be of great significance to insect biodiversity, but collectively, they can represent important refuges, provide stepping stones across hostile landscapes, offer significant resources and contribute to landscape-scale species richness (Baldock et al., 2019; Goddard et al., 2010; Hill et al., 2021; Plummer et al., 2023; Tew et al., 2022). Particular features of gardens, such as the presence of trees, hedges and ponds, have been shown to increase abundance and richness of insects and birds (Bates et al., 2014; Tassin De Montaigu and Goulson, 2024; Tassin De Montaigu and Goulson, 2023). Undertaking wildlife-friendly management actions in private gardens, such as growing particular

flowering plants for nectar and pollen or the provision of artificial nest sites, can also benefit insects (Garbuzov and Ratnieks, 2014a; Gaston et al., 2005; Griffiths-Lee et al., 2022; Salisbury et al., 2015). The presence and abundance of nectar plants, for example, can increase the number of insect species recorded in gardens (Fontaine et al., 2016; Majewska et al., 2018; Pendl et al., 2022; Quistberg et al., 2016), despite a lack of scientific evidence underpinning many of the recommended 'wildlife-friendly' plant choices (Delahay et al., 2023; Garbuzov and Ratnieks, 2014b; Rollings and Goulson, 2019). Other garden management actions endorsed as wildlife-friendly have not proved effective for insects when tested (Gaston et al., 2005) or are yet to be assessed. For example, while reducing mowing intensity of urban greenspace results in greater insect abundance and species richness (Proske et al., 2022; Watson et al., 2020; Wintergerst et al., 2021), there is little evidence whether uncut parts of lawn benefit insect communities in private, residential gardens (but see Helden et al., 2018 and Lerman et al., 2018). Some recommended gardening practices for butterflies, such as planting nectar plants, may only lead to butterflies visiting gardens, while others such as leaving patches of uncut vegetation throughout the year, may provide suitable habitats and larval hostplants for some butterfly species to breed in the garden. Given the recent increased promotion of long grass in gardens for biodiversity, partly due to campaigns such as No Mow May (<https://www.plantlife.org.uk/campaigns/nomowmay/> ↗), it is important to establish the benefits of wildlife-friendly garden interventions.

The effectiveness of wildlife-friendly management actions in private gardens may be moderated by the nature of the surrounding landscape, which is likely to play a significant role in determining local insect community composition. In highly urbanised areas, for example, many taxonomic groups have reduced abundance and species richness compared with more rural areas (Clergeau et al., 2006; Fenoglio et al., 2021; Taylor et al., 2013), although some urban green spaces can support high insect diversity and the floral resources they require (Hall et al., 2017; Lynch et al., 2021). Urban gardens often harbour lower insect diversity (Bates et al., 2014; Di Mauro et al., 2007; Fontaine et al., 2016), while gardens surrounded by higher quality habitat, such as woodland and water bodies, have increased bird and butterfly species richness (i.e. positive edge effects) (Pendl et al., 2022; Tassin De Montaigu and Goulson, 2024; Tassin De Montaigu and Goulson, 2023). There is contrasting evidence as to the relative importance of site-level characteristics or the surrounding landscape in explaining species richness and abundance. Some studies suggest that changes made within gardens, for example more flowering plants, less bare ground and a greater number of trees, influence the richness and abundance of insects more than the make-up of the surrounding landscape (Otoshi et al., 2015; Quistberg et al., 2016; Tassin De Montaigu and Goulson, 2024). However, other research has demonstrated that the surrounding

landscape was more important than garden characteristics in influencing bird occurrence (Chamberlain et al., 2004) and moth assemblages (Ellis and Wilkinson, 2021). The importance of the surrounding landscape may also be moderated by site-level characteristics (i.e. the interactions between the site and the landscape, such as edge effects). Better understanding of the determinants of insect biodiversity in domestic gardens, particularly the contributions of and interactions between the surrounding landscape and garden features and management, are key to providing effective wildlife gardening advice to the public.

Here, we use data from a citizen science scheme, the Garden Butterfly Survey (GBS), to understand which factors influence the abundance and richness of butterflies recorded in gardens in GB. Citizen science, the involvement of volunteers in scientific research, has proved highly effective in biodiversity monitoring and ecological research, but can also have limitations due to data quality issues such as incorrect species identification (Brown and Williams, 2019; Dickinson et al., 2010). Thus, we first check that GBS data provide reliable estimates of species abundance, by comparison with long-term, standardised monitoring data from the UK Butterfly Monitoring Scheme (UKBMS). Then, we investigate how the landscape surrounding gardens affects butterfly abundance and richness. Next, we assess the effects of two recommended wildlife gardening practices, providing long grass and flowering ivy (*Hedera* spp.), on butterfly abundance and richness. To our knowledge, the efficacy of these practices for butterflies has not previously been investigated in private gardens. We hypothesise that having long grass, having a larger area of long grass, and having flowering ivy present, all of which potentially provide larval resources and nectar for adult insects, will result in higher butterfly abundance and richness. We also hypothesise that having long grass will increase the abundance of butterfly species that use grasses as larval host plants, and having flowering ivy will both increase the abundance of *Celastrina argiolus* holly blue, which uses ivy as a larval host plant, and the abundance of *Vanessa atalanta* red admiral and *Polygonia c-album* comma, which frequently feed on ivy nectar (Steel, 2003; Vickery, 1998). Finally, we explore the interactions between the surrounding landscape and the wildlife gardening practices to understand the situations in which such management can increase garden butterfly abundance and richness. Our overall aim is to identify how wildlife gardening practices and the surrounding landscape influence butterflies recorded in gardens so as to provide evidence-based advice for the public and other land managers to help increase populations of widespread butterflies.

Section snippets

Garden Butterfly Survey data

For this study, we used data from the Garden Butterfly Survey (GBS; www.gardenbutterflysurvey.org ↗), a citizen science project run by Butterfly Conservation. There is only a very basic survey protocol for GBS; participants simply record the maximum number of each butterfly species that they see on each date that they choose to survey their garden throughout the year. We used records from 2016 to 2021 from gardens in GB.

As participants can record butterflies at any time, the level of recording...

Comparison of change in species' collated indices between GBS and UKBMS datasets

Across all species and year combinations, the difference in annual collated index change derived from GBS and UKBMS datasets was non-significant ($t_{114} = -1.26$, $p = 0.21$) providing evidence that annual butterfly population growth rates were similar when derived from structured and unstructured datasets (Fig. 1). When a regular migrant species, *V. cardui*, was removed, the difference in annual collated index change was still non-significant (Fig. S3; Table S2). Looking into annual collated index...

Discussion

Using a citizen science approach, we set out to understand what determines the abundance and species richness of butterflies recorded in GB gardens, and to explore the efficacy of two commonly recommended wildlife gardening practices for butterflies. We found that the land use of the surrounding landscape and garden size were important in determining abundance and richness of butterflies in gardens. However, we also show that undertaking two simple wildlife-friendly garden practices, leaving...

CRedit authorship contribution statement

Lisbeth A. Hordley: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization. **Richard Fox:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization....

Declaration of competing interest

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

Acknowledgements

We are very grateful to all of the participants in Butterfly Conservation's Garden Butterfly Survey and to colleagues who helped to create, publicise and run the project. In particular, many thanks are due to Peter Eeles, who created and maintained the GBS website through which all of the data used in this study were captured. The GBS is funded by Butterfly Conservation and this study was funded by the Heather Corrie Fund from Butterfly Conservation. We thank Emily Dennis for statistical...

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