

BIOLOGICAL RECORDS CENTRE

Science Review



Foreword

Since JNCC was formed in 1991, we have supported and worked in partnership with the Biological Records Centre. The broad suite of species records gathered by citizen scientists and collated by the Biological Records Centre adds additional insight and richness to JNCC's structured species monitoring schemes.

With increasing focus on ecosystems and the crucial services they support, species continue to provide an important and measurable signal of the health of our natural environment. Data from the BRC helps us disentangle the complex changes in species abundance and distribution, providing a better understanding of the environmental pressures behind these. This evidence links species to habitats and ecosystems, uncovering traits that can explain why these changes are occurring.

Through the evidence and research enabled by the BRC, we are gaining deeper insight into the effects of climate change, habitat restoration, invasive species, and shifting ecological relationships. These data are helping to distinguish local management outcomes from broader environmental trends and are supporting the development of predictive approaches that will guide conservation action and investment in the natural environment for decades to come.



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Introduction

The 2015 [special issue](#) of the *Biological Journal of the Linnean Society* (Volume 115, Part 3) marked a celebration of 50 years of the Biological Records Centre. The issue provided a showcase of the importance of biological recording for understanding the dynamics of species distributions in the UK. In the ten years since then, the use of species occurrence records has expanded even further, with innovative methods for analysis and emerging questions about biodiversity change. This report aims to summarise some of these latest developments. Our format is inspired by the science reviews that GBIF have undertaken to highlight the global use of occurrence records. In this report, we describe the overall trends in data use of UK species occurrence records and the dominant themes of questions that they are used to address. We also highlight recent atlases, policy-relevant indicators and scientific case studies that are underpinned by the data.

To our readers – whether involved in data collection, analysis or application of findings – we hope this report inspires your future work and provides convincing evidence of the importance of continued support of the recording community to understand how biodiversity is changing in the UK.

How to cite

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About the Biological Records Centre

The Biological Records Centre (BRC) is a national hub for wildlife recording in the UK, operating as part of the UK Centre for Ecology & Hydrology (UKCEH) since 1964. The BRC's core mission is to support the collection, management and use of species occurrence records. The BRC works closely with 110 national recording schemes and societies and maintains essential infrastructure for storing occurrence records for a wide range of plant, fungi and animal groups. For more details on individual recording schemes, we recommend exploring the information on our [website](#).

A key part of BRC's work is fostering citizen science and technological innovation to make biological recording more effective and accessible. Our contribution is the [iRecord](#) platform, and the Indicia software that underlies it, which allows people throughout the UK to submit wildlife sightings, and also enables biodiversity data from a variety of other websites and apps to be collated and shared. Another app we support, [Record Cleaner](#), assists in the verification process by allowing records from any source to be checked for plausibility to maintain the quality of the data. BRC is supported by the Joint Nature Conservation Committee (JNCC), UKCEH and the National Capability for UK Challenges (NC-UK) programme.

The occurrence records feed into broader data aggregators such as the National Biodiversity Network (NBN) and the Global Biodiversity Information Facility (GBIF) that can be downloaded for use. The data are used in the publication of species' atlases and enable researchers, government bodies and conservation organisations to ask diverse basic and applied research questions. The work of the BRC ensures that a broad suite of taxonomic and functional groups contribute to the evidence-base to tackle biodiversity loss, alongside data from structured monitoring schemes that target select taxa.



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👤 = 100 users

Values are thousands

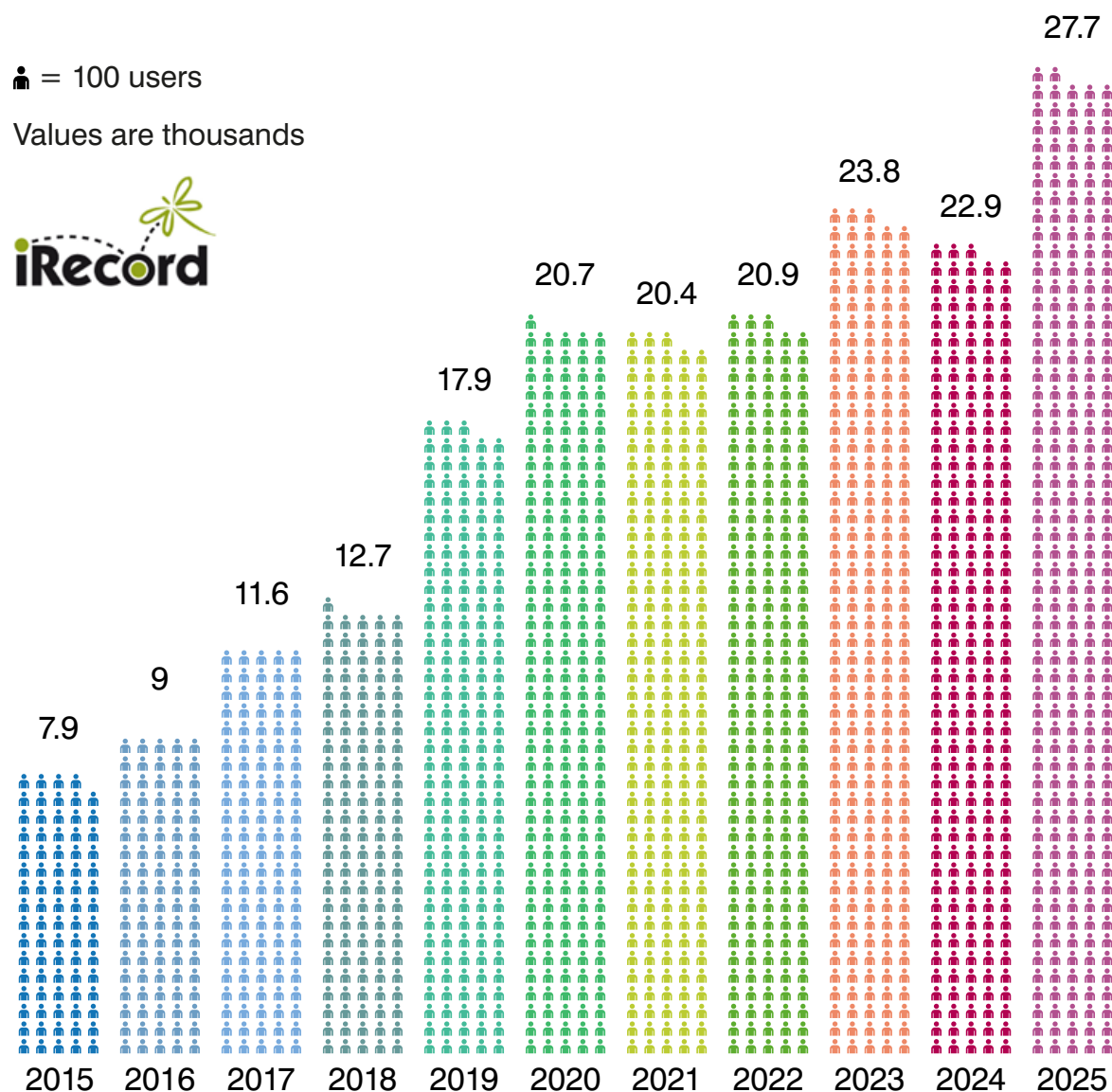


Fig. 1
The number of users sharing species occurrence records using iRecord has rapidly increased over the last decade.

Note: Calculated as the total number of Indicia users sharing records with iRecord for reporting, based on year of entry.

Why are species occurrence records an essential data source?

The power of species occurrence records is largely due to their simplicity – a date-stamped and georeferenced observation of a species, which collectively provide information on the spatial and temporal distribution of species. Species occurrence records have several further common features that make them invaluable for research and conservation:

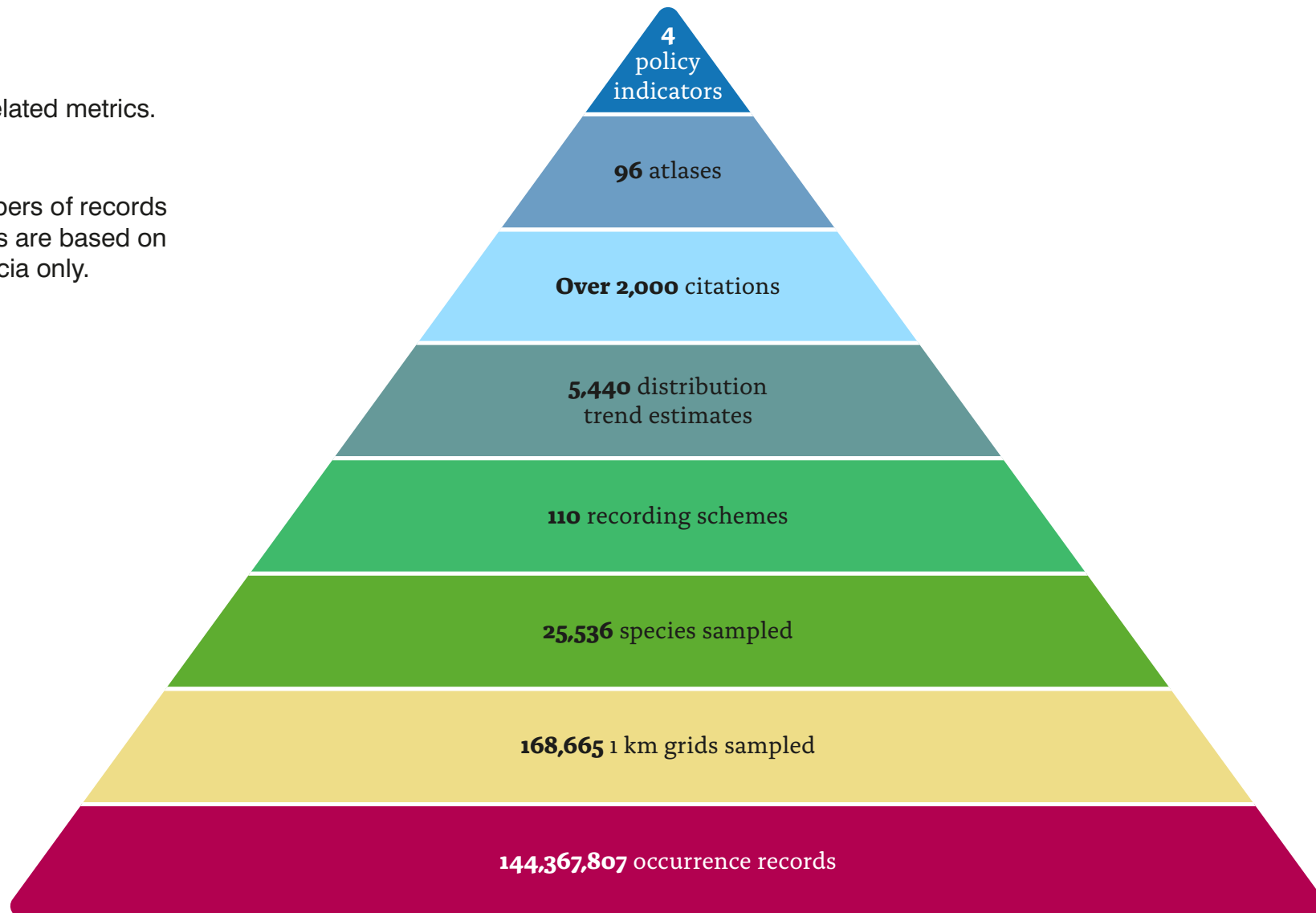
1. *Long-time scale:* Species occurrence records provide information over much longer sampling periods than most other monitoring data streams. While apps such as iRecord are relatively new (launched in 2012), species occurrence records were compiled from other, older, forms of monitoring including punch and record cards, and from offline data management software such as Recorder 6 and MapMate.
2. *Large spatial extent:* By pooling the efforts of different recorders across the country, species occurrence records cover a large spatial scale. Lower densities of records are found in remote areas that are less often visited by recorders.
3. *Broad taxonomic coverage:* The simplicity of occurrence records means that they can be compiled for diverse species in the same format and often by the same reporting platform. This makes them especially valuable for comparative analyses that compare the dynamics of different taxonomic groups.



BRC's impact in numbers

Fig. 2
Key BRC-related metrics.

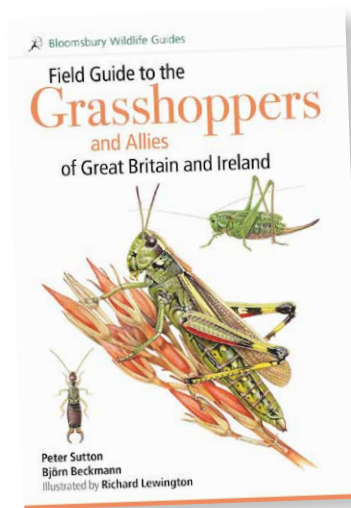
Note: Numbers of records and species are based on data in Indicia only.



Recent atlases based on occurrence records

Species atlases aggregate occurrence records into standardised spatial units, providing authoritative accounts of where species occur. By comparing records across multiple survey periods, atlases can also reveal long-term trends in range expansion, contraction or stability. Atlases typically present detailed grid-based distribution maps for hundreds to thousands of taxa in a taxonomic group, complemented by expert text summarising species' habitat preferences, life histories and patterns of change. This fundamental knowledge underpins a broad range of subsequent research questions and informs conservation priorities and Red Lists.

In the last 10 years, atlases have been produced for centipedes, mammals, vascular plants and charophytes fish, several groups of beetles including water beetles and click-beetles, butterflies, earthworms, soldierflies and allies, moths, and aculeate Hymenoptera. The three most recent atlases have been for grasshoppers and allies (Sutton et al., 2026), click-beetles (Mendel, 2024) and plants (Stroh et al., 2023).



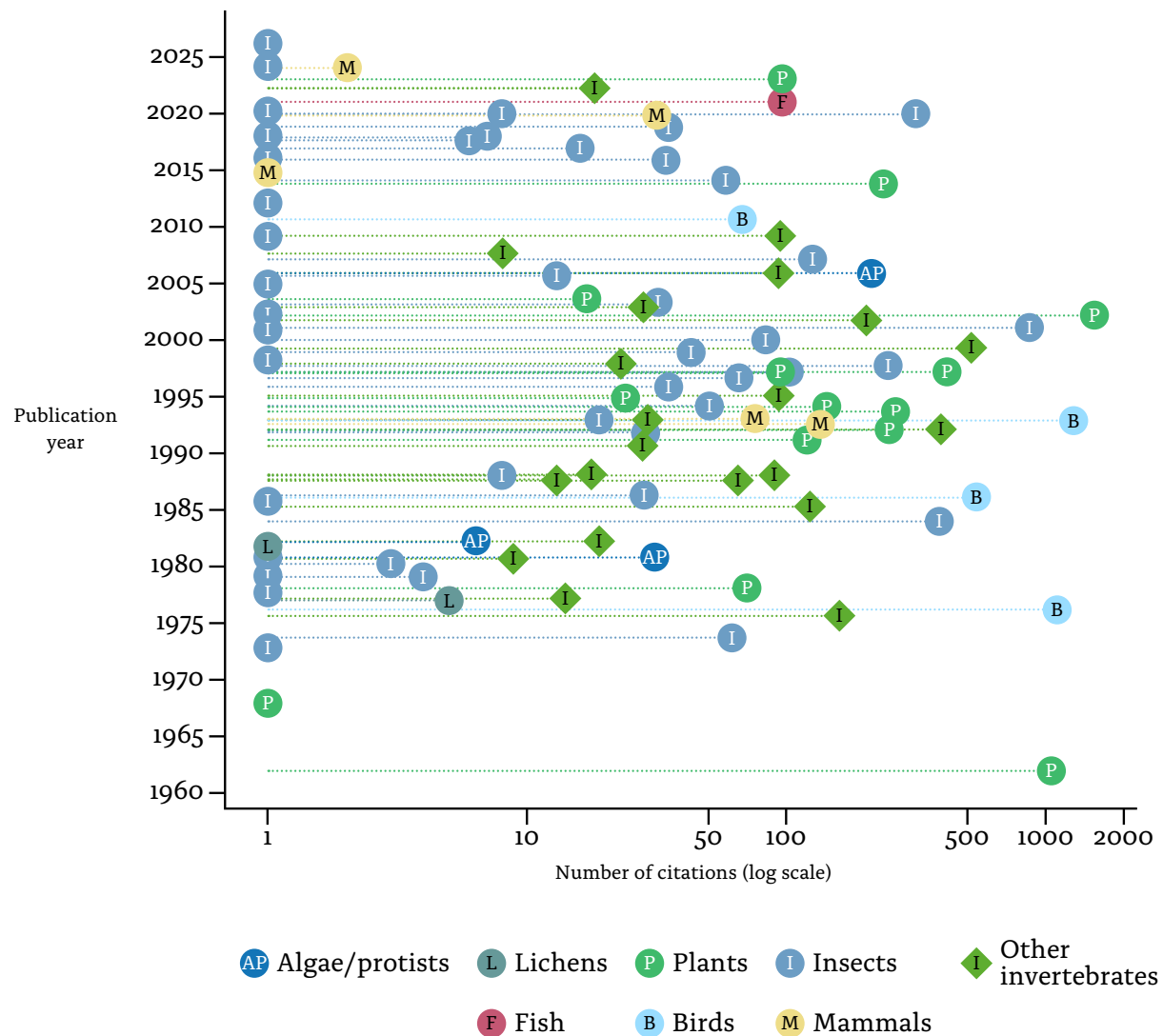


Fig. 3
Each point is a national atlas that was produced using species occurrence records. Citations are based on number of times they are cited by a paper or report based on Google Scholar.

Trends in data use

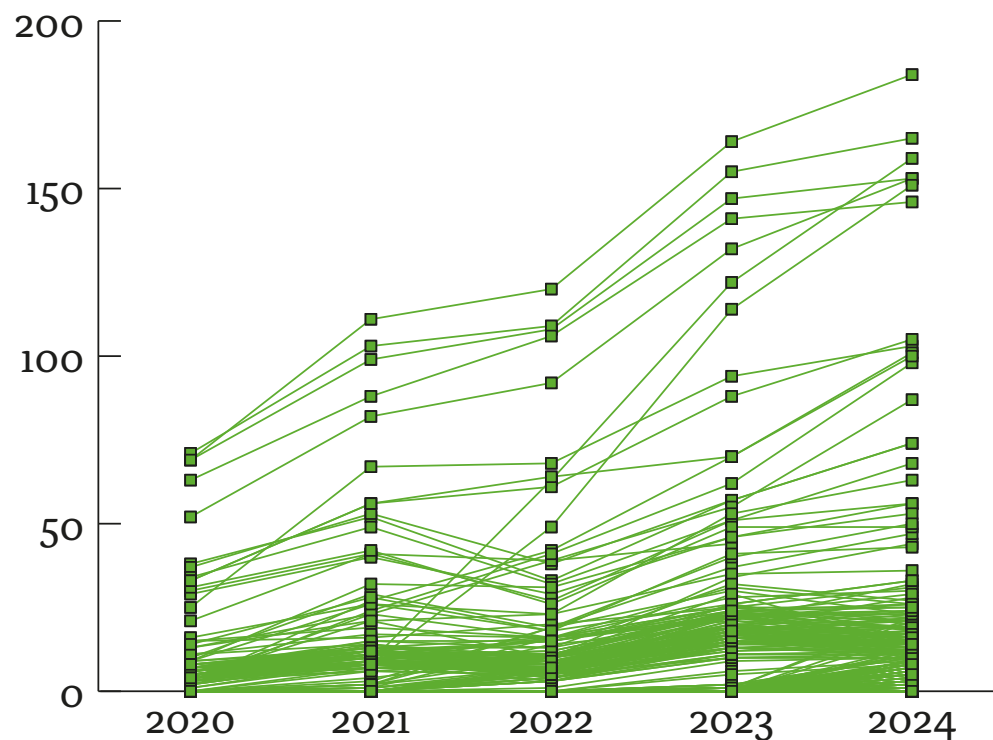
Tracking data use of species occurrence records is difficult since the data can be accessed by different routes and not all routes are associated with a specific digital object identifier (DOI). When available, a DOI can be cited by a data user to associate a specific dataset with a specific publication that uses the data.

Since 2015, data downloaded by GBIF do have DOIs, and data downloaded from the NBN Atlas are recommended to be cited with the GBIF DOI. This is helping our ability to track how the data are being used.

Data streams in GBIF can also be separated according to the organisation publishing the data. The BRC publishes some occurrence records direct to NBN Atlas/GBIF, while other data that are supported by BRC – through infrastructure, apps and other activity – are published by the recording schemes themselves. There are currently 29 publishers in GBIF that include data supported by the BRC (see list in Fig. 4 on the following page). The number of citations is growing across all data streams (Fig. 4).



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GBIF data publishers that include BRC-supported data

1. Amphibian and Reptile Conservation
2. Aquatic Heteroptera Recording Scheme
3. Balfour-Browne Club
4. Biological Records Centre
5. Botanical Society of Britain & Ireland
6. British Bryological Society
7. British Dragonfly Society Recording Scheme
8. British Lichen Society
9. Chrysomelidae Recording Scheme
10. Conchological Society of Great Britain & Ireland
11. Dipterists Forum
12. Freshwater Fish Recording Scheme
13. Grasshopper Recording Scheme
14. National Plant Monitoring Scheme
15. Oil Beetle Recording Scheme
16. Pseudoscorpion Recording Scheme
17. Riverfly Recording Scheme
18. Silphidae Recording Scheme
19. Siphonaptera and Phthiraptera Recording Scheme
20. Terrestrial Heteroptera Recording Scheme (Plantbugs and allied species)
21. Soldier Beetles and Allies Recording Scheme
22. Soldierflies and Allies Recording Scheme
23. Terrestrial Heteroptera Recording Scheme (Shieldbugs and allied species)
24. The Mammal Society
25. The National Longhorn Beetle Recording Scheme
26. UK Butterfly Recording Scheme
27. UK Cranefly Recording Scheme
28. Weevil and Bark Beetle Recording Scheme
29. Butterfly Conservation

Fig. 4
Citation numbers - according to GBIF DOIs – for species occurrence records. The list of GBIF publishers is shown. The different lines reflect different collections. The five top cited streams all derive from plant schemes.

Global research themes

Based on the GBIF citations, we clustered the topics of the studies into broad research themes to identify the dominant application areas of the data (Fig. 5).

Climate change and biological invasions emerge as top research themes. This highlights the importance of aggregations of species occurrence records for emergent patterns on species' distributions at large scales, and how these are shifting over time due to either warming temperatures or species introductions.

Occurrence records are also used for broader understanding of species distributions/biogeographies. Occurrence records are the core data source for species distribution modelling, which aim to predict areas of suitable habitat for species based on environmental factors such as land cover, land use and climate.

Species occurrence records are not only vital for terrestrial ecology. The dominant research themes also highlight the ecosystem breadth of the data since marine and freshwater ecological studies also take advantage of this data source.

As the use of species occurrence records has grown, so has methodological research about how they should be used. This is reflected by popular research themes on citizen science, statistics and data quality.



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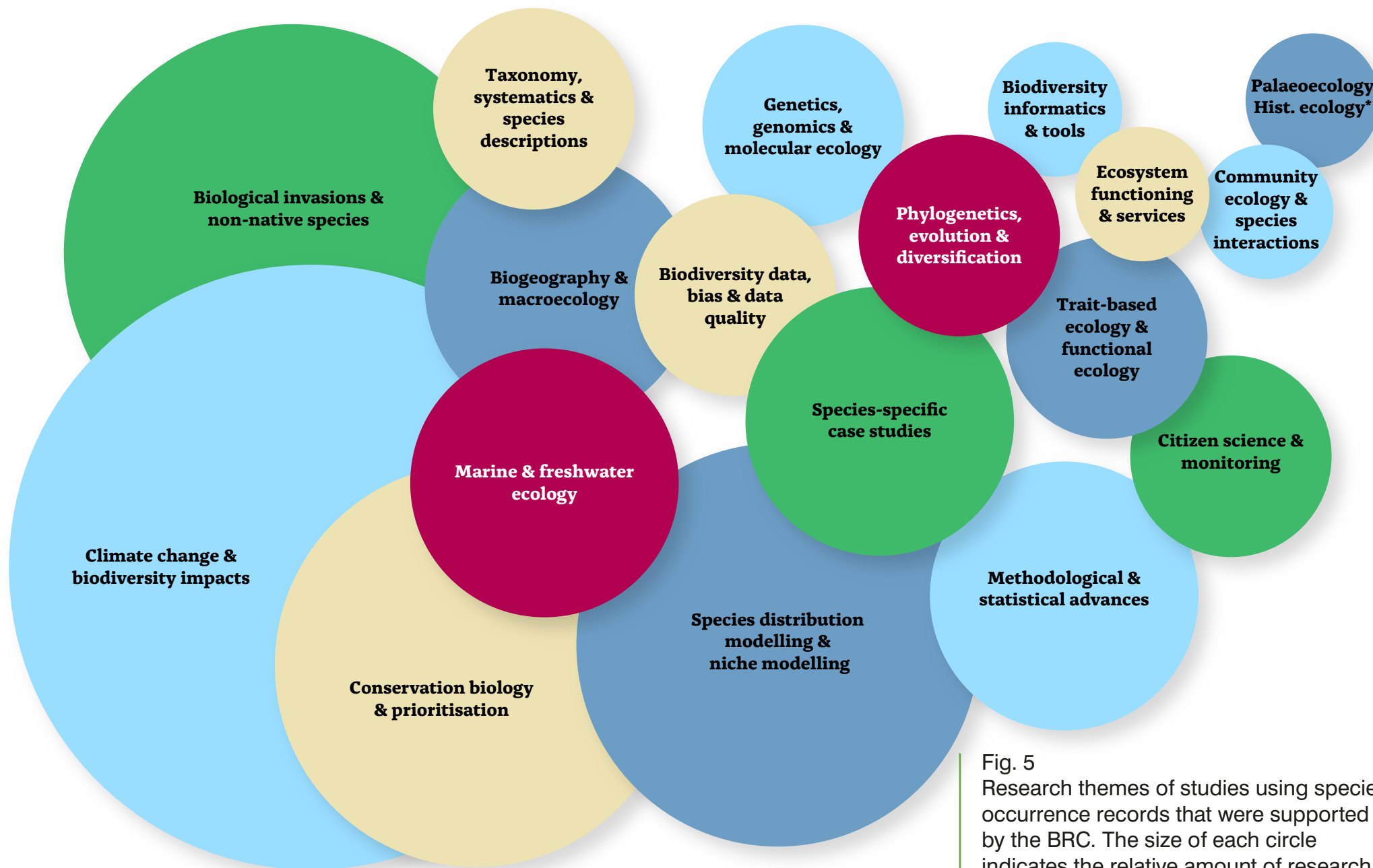


Fig. 5
Research themes of studies using species occurrence records that were supported by the BRC. The size of each circle indicates the relative amount of research dedicated to each theme.

*Historical ecology

UK Studies

BRC data have been used within projects led by the BRC or UKCEH, or within projects led by other institutions, addressing diverse topics across a wide range of organisms. In the following section, we primarily focus on UK studies for a more detailed analysis of the topics that have been addressed with the data since 2015. We selected studies that cover different topics and taxa. These UK studies are largely only possible through the occurrence records since they are the only large-scale data source for the focal taxon groups. The review was conducted using a combination of Web of Science and Google Scholar search platforms.

We identified 66 studies using invertebrate data. Some studies focus on data for a single species, while others use the taxonomic breadth of the data to compare the dynamics of different species across very different taxonomic groups. Popular datasets include bees and other Hymenoptera and butterflies and moths, but studies have used data on dragonflies, ladybirds, ground beetles, hoverflies, myriapods, ants, spiders and grasshoppers, amongst others.

For plants, bryophytes, and lichens, we identified 125 UK-focused studies. The occurrence records are particularly essential for species

descriptions included in the British Ecological Society's Database for Biological Flora. Studies focused on topics such as the interactions between plants and insects, indicator species of pollution or climate change, invasive species, and long-term change.

Most studies were conducted at the scale of Great Britain or the UK and take advantage of the long timespan of the data to understand how UK biodiversity is changing through time.

A broad range of statistical approaches has been used to analyse the data including Bayesian occupancy-detection models and Frescalo (to account for variation in detectability), convolutional neural networks (for image analysis), spatial clustering (to identify similar geographic regions), dynamic mixture models (to estimate proportions of bees in different social castes) as well as classic species distribution modelling approaches, including MAXENT and generalised additive models.

On the following pages, we provide short overviews of example studies.

Species trends

Complex long-term biodiversity change among invertebrates, bryophytes and lichens

Background: Broad longitudinal biodiversity trends remain understudied for most invertebrate and other challenging groups, weakening the evidence-based for developing appropriate conservation actions.

Main question: How have long-term biodiversity trends (1970–2015) varied across under-studied taxa (invertebrates, bryophytes, lichens) in the UK?

Data: Over 5,000 species occurrence records collected between 1970 and 2015.

Methods: Bayesian occupancy models were used to estimate changes in distribution over time within four aggregate taxonomic and habitat-based groups: freshwater and terrestrial (terrestrial insects, terrestrial non-insect invertebrates and bryophytes and lichens).

Main findings: Terrestrial non-insect invertebrates were the only group that reflected the declining trend reported for vertebrates and butterflies. Terrestrial insects and bryophytes and lichens taxonomic groups showed an increase in average occupancy. Freshwater species initially declined in average occupancy before having a notable increase from the mid-1990s.

Implications: Although, for most taxonomic groups, range size has been stable or increasing, there has been substantial changes in community composition. These results highlight the complexity in the responses of different taxonomic groups to drivers of change within the UK which should be considered when developing appropriate conservation action plans.

Reference

Outhwaite, C. L., Gregory, R. D., Chandler, R. E., Collen, B., & Isaac, N. J. (2020). Complex long-term biodiversity change among invertebrates, bryophytes and lichens. *Nature ecology & evolution*, 4(3), 384-392.

DOI

[10.1038/s41559-020-1111-z](https://doi.org/10.1038/s41559-020-1111-z)

Number of citations

242

Inferring current and Last Glacial Maximum distributions are improved by physiology-relevant climatic variables in cold-adapted ectotherms

Background: Mechanistic processes are frequently ignored in ecological niche-based models, with bioclimatic variables solely used to create biogeographic scenarios for species.

Main question: Do physiological (hydric/thermal) variables improve ecological niche model predictions of species distributions compared to standard bioclimatic variables?

Data: Occurrence data from the Global Biodiversity Information Facility and National Biodiversity Network up to September 2021 for *Vipera berus* and *Zootoca vivipara*.

Methods: Multi-algorithm ecological niche models were used to compare physiologically meaningful variables vs standard bioclimatic variables, including Last Glacial Maximum (LGM) reconstructions and permafrost constraints.

Main findings: Physiologically relevant variables better predict current distributions. They also improve inference of LGM refugia.

Implications: Mechanistic (physiology-informed) models outperform correlative ENMs, which will be useful for identifying refugia and climate vulnerability.



Reference

Guillon, M., Martínez-Freiría, F., Lucchini, N., Ursenbacher, S., Surget-Groba, Y., Kageyama, M., ... & Lourdais, O. (2024). Inferring current and Last Glacial Maximum distributions are improved by physiology-relevant climatic variables in cold-adapted ectotherms. *Journal of Biogeography*, 51(8), 1400-1415.

DOI

[10.1111/jbi.14828](https://doi.org/10.1111/jbi.14828)

Number of citations

6

Trait mediation explains decadal distributional shifts for a wide range of insect taxa

Background: Global shifts in insect distributions have been documented, but there is considerable variation among species.

Main question: How do species traits mediate insect distribution changes across Great Britain under climate and land-use change?

Data: Occurrence data for over 1200 species from nine insect groups within Great Britain from the National Biodiversity Network (odonates, orthopterans, carabids, ladybirds, bees, wasps and hoverflies) and other schemes (butterflies and moths) between 1990 and 2020.

Methods: Artificial neural networks were used to predict trends in insect occupancy, which were subsequently matched with trait data.

Main findings: Across the insect taxa, there was no consistent decline in occupancy across Great Britain since 1990, however, there was evidence of localised declines and alterations in community composition. Key drivers were suspected to relate to urbanisation and landscape simplification. Habitat breadth affected species resilience to landscape change while voltinism affected response to warming.

Implications: Trait-based approaches help predict species responses, which means that conservation should consider functional traits, not just species identity.

Reference

Bourhis, Y., Milne, A. E., Shortall, C. R., Beckman, B., Blumgart, D., Edwards, R., ... & Bell, J. R. (2025). Trait mediation explains decadal distributional shifts for a wide range of insect taxa. *Nature Communications*, 16(1), 8131.

DOI

[10.1038/s41467-025-63093-y](https://doi.org/10.1038/s41467-025-63093-y)

Number of citations

7

State of Dragonflies 2021

Background: Few studies have investigated how climate change and habitat quality and quantity impact dragonfly populations.

Main question: This report examines fifty years of dragonfly and damselfly trends in Britain and Ireland.

Data: Dragonfly occupancy data (~1.4 million biological records) between 1970 and 2019.

Methods: Bayesian occupancy-detection models were used to estimate species distribution trends.

Main findings: The findings showed that occupancy has significantly increased for 19 resident or regular migrant species (41%) since 1970, whereas five species (11%) had significantly declined.

Implications: Although trends appear positive, the changes reflect strong climate-driven reshuffling of communities, with potential risks for cold-adapted species and wetland ecosystems.



Reference

Taylor, P., Smallshire, D., Parr, A., Brooks, S., Cham, S., Colver, E., & Roy, D. (2021). State of Dragonflies 2021. British Dragonfly Society, UK.

Link

<https://british-dragonflies.org.uk/recording/state-of-dragonflies-2021/>

Number of citations

2

Climate change

Associations between a range-shifting damselfly (*Erythromma viridulum*) and the UK's resident Odonata suggest habitat sharing is more important than antagonism

Background: An approach is needed to rapidly assess species which shift their ranges in response to climate change to better understand if they have harmful effects on the biodiversity in their new ecosystems. The small red-eyed damselfly (*Erythromma viridulum*) is an example of a range-shifting species and its presence has been recorded within the United Kingdom since 1999.

Main question: Does the arrival of a range-shifting damselfly (*Erythromma viridulum*) negatively affect resident UK Odonata species?

Data: Occurrence records collected between 2000 and 2015.

Methods: Dynamic species occupancy models accounting for recording effort and climate were used to test whether the arrival of *E. viridulum* was associated with a decline of 17 resident UK Odonata.

Main findings: They found no strong evidence that *E. viridulum* causes declines in resident species. Instead, species respond similarly to shared environmental drivers. Habitat quality explained patterns more than interspecific interactions.

Implications: Range-shifting species may not necessarily harm resident biodiversity. Monitoring frameworks should distinguish shared environmental responses from biotic interactions

Reference

Cranston, J., Isaac, N. J., & Early, R. (2023). Associations between a range-shifting damselfly (*Erythromma viridulum*) and the UK's resident Odonata suggest habitat sharing is more important than antagonism. *Insect Conservation and Diversity*, 16(3), 416-426.

DOI

[10.1111/icad.12630](https://doi.org/10.1111/icad.12630)

Number of citations

6

Climate driven shifts in the synchrony of apple (*Malus × domestica* Borkh.) flowering and pollinating bee flight phenology

Background: Climate change is causing the phenology of many globally important crops and pollinators to shift, which increases the likelihood of asynchrony, potentially reducing the quality and quantity of crop production.

Main question: Are climate-driven phenological shifts causing mismatches between apple flowering and pollinator activity?

Data: Pollinator data from the Bees, Wasps, and Ants Recording Society (BWARS) between 1970 and 2017.

Methods: Generalised additive and generalised linear models were used to investigate temporal mismatch between apple flowering and pollinator activity.

Main findings: Early spring temperatures and rainfall seem to be the primary drivers for the shifts in flowering onset and peak flowering dates of Bramley apples. Bee phenology shifted in a non-linear pattern, advancing from 1970 to 1985 before stabilising through to 2017.

Implications: This study highlights the potential phenological asynchrony between apple flowering and bee pollinator timings and how citizen science can be utilised to help detect these trends and interactions.

Reference

Wyver, C., Potts, S. G., Edwards, R., Edwards, M., & Senapathi, D. (2023). Climate driven shifts in the synchrony of apple (*Malus × domestica* Borkh.) flowering and pollinating bee flight phenology. *Agricultural and Forest Meteorology*, 329, 109281.

DOI

[10.1016/j.agrformet.2022.109281](https://doi.org/10.1016/j.agrformet.2022.109281)

Number of citations

32

Linking climate warming and land conversion to species' range changes across Great Britain

Background: There is limited evidence on the synergistic or cumulative effects of increased temperature and habitat destruction on biological assemblages at local and regional scales.

Main question: What are the independent and interactive effects of climate warming and land-use change on species persistence and extirpation?

Data: Distribution data for ~1,192 species (plants, birds, butterfly and macromoths) from two time periods, 1930–1960 and 2005–2009.

Methods: Mixed-effects models were used to assess how their distribution has changed over time.

Main findings: Climate change and land use changes both influenced species' changes, increasing the probability of persistence for 40% of species and decreasing it for 12%. Fewer than 1 in 5 species showed interactive effects.

Implications: These individualistic responses to climate and land use change show the importance of incorporating species-level data within biodiversity and climate adaptation policies.



Reference

Suggitt, A. J., Wheatley, C. J., Aucott, P., Beale, C. M., Fox, R., Hill, J. K., ... & Auffret, A. G. (2023). Linking climate warming and land conversion to species' range changes across Great Britain. *Nature Communications*, 14(1), 6759.

DOI

[10.1038/s41467-023-42475-0](https://doi.org/10.1038/s41467-023-42475-0)

Number of citations

45

Phenological variation in biotic interactions shapes population dynamics and distribution in a range-shifting insect herbivore

Background: Few studies have examined the role of trophic phenological synchrony in determining species' distributions through its effects on population dynamics.

Main question: How does phenological synchrony with host plants influence population dynamics and range expansion in a range-shifting butterfly?

Data: Occurrence data from the Global Biodiversity Information Facility and National Biodiversity Network (including UK Biological Records Centre records) between 1970 and 2018.

Methods: General linear models and species distribution modelling

Main findings: Butterflies emerging later in the season had higher productivity in the annual second brood, particularly on novel annual hosts, due to improved synchronicity with plant germination. This was associated with accelerated range expansion, especially in areas exclusively occupied by novel hosts.

Implications: Phenological asynchrony can constrain local population growth, influencing consumer resource allocation, evolutionary adaptation and range expansion.

Reference

Stewart, J. E., Maclean, I., Botham, M., Dennis, E. B., Bridle, J., & Wilson, R. J. (2024). Phenological variation in biotic interactions shapes population dynamics and distribution in a range-shifting insect herbivore. *Proceedings of the Royal Society B: Biological Sciences*, 291(2036).

DOI

[10.1098/rspb.2024.0529](https://doi.org/10.1098/rspb.2024.0529)

Number of citations

3

Extinction risk from climate change is reduced by microclimatic buffering

Background: While climate change is associated with range-shifts and changes in phenology, species response may be buffered by local microclimate refugia.

Main question: Does microclimatic variation buffer species against climate-driven declines?

Data: Over five million distribution records for 430 climate-threatened and range-declining species.

Methods: Analysis of extinction patterns in relation to topographic heterogeneity.

Main findings: Microclimatic heterogeneity has strongly buffered species against regional extirpations linked to recent climate change. Population losses across England are found to be reduced in areas where topography generated greater variation in the microclimate.

Implications: Microhabitat heterogeneity is critical for climate resilience and should be considered in conservation efforts.

Reference

Suggitt, A. J., Wilson, R. J., Isaac, N. J., Beale, C. M., Auffret, A. G., August, T., ... & Maclean, I. M. (2018). Extinction risk from climate change is reduced by microclimatic buffering. *Nature Climate Change*, 8(8), 713-717.

DOI

[10.1038/s41558-018-0231-9](https://doi.org/10.1038/s41558-018-0231-9)

Number of citations

513

A national-scale assessment of climate change impacts on species: Assessing the balance of risks and opportunities for multiple taxa

Background: Decision-makers need evidence on the risks that climate change poses to species for planning conservation.

Main question: What is the balance of climate-driven risks and opportunities for UK species?

Data: Data for British terrestrial and wetland species across taxonomic groups.

Methods: Species distribution projections and a risk classification framework.

Main findings: 21% of species were classified as being at high risk and 6% at medium risk of range loss under a B1 climate change scenario. However, some species may gain suitable climate space.

Implications: Climate change produces winners and losers, so a risk-based prioritisation is needed to direct conservation efforts.



Reference

Pearce-Higgins, J. W., Beale, C. M., Oliver, T. H., August, T. A., Carroll, M., Massimino, D., ... & Crick, H. Q. (2017). A national-scale assessment of climate change impacts on species: Assessing the balance of risks and opportunities for multiple taxa. *Biological Conservation*, 213, 124-134.

DOI

[10.1016/j.biocon.2017.06.035](https://doi.org/10.1016/j.biocon.2017.06.035)

Number of citations

68

Invasive species and disease

Blackflies (Diptera: Simuliidae) of the United Kingdom with comments on species of public health and veterinary importance, their parasites and predators

Background: The biting habits of blackflies (Diptera: Simuliidae) are associated with the transmission of a variety of pathogens to humans, livestock and wildlife. However, they are deemed important in river and stream ecosystems, where they form part of the diet of various aquatic and terrestrial vertebrates.

Main question: To document the species composition, ecology, and distribution of UK blackflies and assess their public health, veterinary, and ecological significance.

Data: Occurrence data from the National Biodiversity Network Atlas pre-2023 of known British blackfly species.

Methods: Spatial distribution maps that show where these species are currently present across the UK.

Main findings: Blackflies are widespread. They include medically and veterinarily-important species that can transmit pathogens, cause biting nuisance and allergic reactions, while also playing key trophic roles in freshwater ecosystems.

Implications: Effective monitoring and management are needed to balance their ecological importance with risks to human and animal health, particularly in areas with high blackfly activity.

Reference

López-Peña, D., & Cheke, R. (2023). Blackflies (Diptera: Simuliidae) of the United Kingdom with comments on species of public health and veterinary importance, their parasites and predators. *The Simuliid Bulletin*, 60, 18-51. (10).

Link

<https://hdl.handle.net/10550/89103>

Number of citations

4

Niche analyses and the potential distribution of four invasive bumblebees worldwide

Background: Several *Bombus* species with invasive potential have been reported to have spread to various regions worldwide, generating ecological and economic losses.

Main question: What is the potential global distribution of invasive *Bombus* species?

Data: Occurrence data from the Global Biodiversity Information Facility and National Biodiversity Network until 2023 for four *Bombus* species.

Methods: Species distribution models (MAXENT, Support vector machines, Random forest and Boosted regression tree methods) were used to compare their native and invaded ranges under current climatic conditions.

Main findings: The distribution models reflected documented ranges of the *Bombus* species and found that niche overlap was observed in the regions of highest potential distribution suitability for *B. ruderatus*, *B. subterraneus*, and *B. terrestris*, with *B. impatiens* reflecting this to a lesser extent.

Implications: The *Bombus* species studied have the potential to establish in environments similar to their native ranges and demonstrate the capacity to adapt to temperature and humidity shifts, allowing them to spread into new climatic areas.

Reference

López-Aguilar, T. P., Montalva, J., Vilela, B., Arbetman, M. P., Aizen, M. A., Morales, C. L., & Silva, D. D. P. (2024). Niche analyses and the potential distribution of four invasive bumblebees worldwide. *Ecology and Evolution*, 14(4), e11200.

DOI

[10.1002/ece3.11200](https://doi.org/10.1002/ece3.11200)

Number of citations

8

Predicting the spatio-temporal dynamics of biological invasions: Have rapid responses in Europe limited the spread of the yellow-legged hornet (*Vespa velutina nigrithorax*)?

Background: Risk assessment frameworks are vital for guiding invasive alien species management, yet their effectiveness is often constrained by insufficient knowledge of invasion dynamics following species initial introduction into new regions.

Main question: The yellow-legged hornet (*Vespa velutina nigrithorax*) serves as a case study to illustrate a generalisable mechanistic framework for species distribution modelling, using observed spread in other invaded areas to forecast invasion dynamics in the absence of management interventions.

Data: Yellow-legged hornet occurrence data collected between 1993 and 2020.

Methods: An ensemble Ecological Niche Model and MIGCLIM model, for dispersal, were used to predict its current and future projected distribution.

Main findings: Implemented measures have been effective in restricting its spread when comparing the forecasted potential range of the yellow-legged hornet in the absence of control measures against its current European distribution.

Implications: This model framework may be useful to inform the identification of high-risk areas for surveillance measures to be prioritised for rapid detection and early management.

Reference

Hassall, R. M., Purse, B. V., Barwell, L., Booy, O., Lioy, S., Rorke, S., ... & Roy, H. E. (2025). Predicting the spatio-temporal dynamics of biological invasions: Have rapid responses in Europe limited the spread of the yellow-legged hornet (*Vespa velutina nigrithorax*)? *Journal of Applied Ecology*, 62(1), 106-118.

DOI

[10.1111/1365-2664.14829](https://doi.org/10.1111/1365-2664.14829)

Number of citations

10

Many plants naturalized as aliens abroad have also become more common within their native regions

Background: Plant species might differ in trends between their native and invasive parts of their range.

Main question: Do plant species that become naturalised in regions outside their native range also show increasing occupancy within their native regions?

Data: Data for 3,900 native European plant species across 10 regions.

Methods: A test of occupancy changes across regions in relation to global naturalisation success.

Main findings: Species that are widespread and increasing in their native ranges are significantly more likely to become naturalised globally, indicating parallel expansion at home and abroad.

Implications: Traits promoting invasiveness also drive native expansion. Incorporating native-range dynamics into invasion risk assessments could improve predictions of which species are likely to become invasive in new regions.



Reference

Paudel, R., Fristoe, T. S., Kinlock, N. L., Davis, A. J., Zhao, W., Van Calster, H., ... & van Kleunen, M. (2025). Many plants naturalized as aliens abroad have also become more common within their native regions. *Nature communications*, 16(1), 8227.

DOI

[10.1038/s41467-025-63293-6](https://doi.org/10.1038/s41467-025-63293-6)

Number of citations

8

Land use and pollution

Brownfield sites promote biodiversity at a landscape scale

Background: The practice of repurposing brownfield sites is often promoted due to the perception that they are ecologically important, representing habitats with limited disturbance.

Main question: What is the difference in species richness and assemblage rarity between ex-landfill sites and the surrounding area and the role of area of the ex-landfill site and time since its closure?

Data: Data on selected invertebrate species (moths, dragonflies, damselflies) as well as birds and plants, recorded in England between 2006 and 2019.

Methods: Generalised linear mixed effects models.

Main findings: Species richness was positively associated with both the presence and increasing area of ex-landfill sites for several insect taxa, however, this effect declined over time.

Implications: Brownfield sites are valuable but transient habitats. Further research is needed to examine the proportion of full landscape-scale assemblages that can be supported by brownfield sites and which features of the ex-landfill sites or surrounding landscape contributes to the increase and longevity of species richness.

Reference

Macgregor, C. J., Bunting, M. J., Deutz, P., Bourn, N. A., Roy, D. B., & Mayes, W. M. (2022). Brownfield sites promote biodiversity at a landscape scale. *Science of the Total Environment*, 804, 150162.

DOI

[10.1016/j.scitotenv.2021.150162](https://doi.org/10.1016/j.scitotenv.2021.150162)

Number of citations

40

Potential for positive biodiversity outcomes under diet-driven land use change in Great Britain

Background: A shift toward human diets that include more fruit and vegetables, and less meat likely means that there will be future changes in land use such as the conversion of grazing land into horticulture.

Main question: How might diet-driven land-use change affect biodiversity?

Data: Occurrence records for pollinator and invertebrate species collected between 1970 and 2022.

Methods: Ensemble species distribution models using BIOCLIM, generalised linear models, random forest methods.

Main findings: Across land use scenarios reflecting domestic fruit and vegetable production and imports, the findings suggest net positive effects on biodiversity, with a greater number of species projected to gain rather than lose suitable habitat.

Implications: Land use changes associated with dietary shifts could mitigate some biodiversity losses expected under climate change. This means that food system change can support biodiversity.

Reference

Ferguson-Gow, H., Nicholas, O., Outhwaite, C., Green, R., Scheelbeek, P., Colombo, P. E., ... & Pearson, R. G. (2024). Potential for positive biodiversity outcomes under diet-driven land use change in Great Britain. *Wellcome Open Research*, 7, 147.

DOI

[10.12688/wellcomeopenres](https://doi.org/10.12688/wellcomeopenres.1012688.1)

Number of citations

5

Potential landscape-scale pollinator networks across Great Britain: Structure, stability and influence of agricultural land cover

Background: Understanding plant-pollinator networks is crucial to predict the risks anthropogenic factors pose to pollinators, yet constructing comprehensive networks to examine these geographical patterns remains challenging.

Main question: To better understand these pollination dynamics, plant–pollinator networks were modelled across Great Britain at a 10 km scale, based on observed floral visits and species co-occurrence.

Data: Occurrence data for bees, hoverflies and butterflies, as well as plant data, collected between 1985 and 2015.

Methods: Occupancy, network analysis and linear mixed effect models.

Main findings: Agricultural land cover was positively correlated with both network generality and robustness to extinctions under multiple extinction scenarios. Enhanced robustness was linked to shifts in plant community composition (a reduction in extinction-prone species) and a network structure characterised by higher pollinator generality.

Implications: Traits that support species persistence in intensively farmed landscapes may enhance the robustness of plant–pollinator networks to future environmental changes. Simplified communities may be more robust but less diverse.

Reference

Redhead, J. W., Woodcock, B. A., Pocock, M. J. O., Pywell, R. F., Vanbergen, A. J., & Oliver, T. H. (2018). Potential landscape-scale pollinator networks across Great Britain: Structure, stability and influence of agricultural land cover. *Ecology Letters*, 21(12), 1821-1832.

DOI

[10.1111/ele.13157](https://doi.org/10.1111/ele.13157)

Number of citations

88

Air pollution and its effects on lichens, bryophytes, and lichen-feeding Lepidoptera: review and evidence from biological records

Background: Air pollution can have broad effects on organisms, but evidence is scattered.

Main question: To synthesise evidence on how air pollution affects lichens, bryophytes, and lichen-feeding Lepidoptera, and to evaluate how biological records can reveal these impacts.

Data: Biological recording data.

Methods: Literature review with analyses of long-term biological recording data.

Main findings: Air pollution, particularly sulphur dioxide and nitrogen deposition, has driven major declines and subsequent recoveries in lichens and bryophytes, with indirect positive effects observed in lichen-feeding moths as pollution levels decreased.

Implications: The study demonstrates that biological records are a powerful tool for detecting ecological responses to environmental change and highlights both direct and cascading ecosystem effects of air pollution.



Reference

Pescott, O. L., Simkin, J. M., August, T. A., Randle, Z., Dore, A. J., & Botham, M. S. (2015). Air pollution and its effects on lichens, bryophytes, and lichen-feeding Lepidoptera: review and evidence from biological records. *Biological journal of the Linnean Society*, 115(3), 611-635.

DOI

[10.1111/bij.12541](https://doi.org/10.1111/bij.12541)

Number of citations

136

Conservation

Building the Freshwater Network: A new approach to the identification of freshwater biodiversity hotspots and restoration opportunities in England and Wales

Background: Current water environment policy has failed to protect and restore freshwater biodiversity in England and Wales. A new approach is required to address the deficiencies of current policy and direct conservation work.

Main question: This paper presents a conceptual framework and analytical tool, the Freshwater Network, to help inform freshwater conservation management strategies in the restoration and improvement of freshwater biodiversity in England and Wales.

Data: Occurrence data collected between 1988 and 2024 for macroinvertebrates, plants and other taxa classified as species of conservation concern.

Methods: Each 1km square was assessed based on the number of species of conservation concern, the length of rivers and streams classified as WFD high-status for freshwater invertebrates and the presence of legally designated freshwater habitats.

Main findings/Implications: This assessment can be used within the Freshwater Network to identify freshwater biodiversity hotspots at both the regional and national scale, aiding land managers, organisations and policymakers in the development of effective conservation management efforts.

Reference

Biggs, J., Ewald, N., Nicolet, P., Case, P., Williams, P., & Tasker, S. (2025). Building the Freshwater Network: A new approach to the identification of freshwater biodiversity hotspots and restoration opportunities in England and Wales. *Ecological Solutions and Evidence*, 6(3), e70089.

DOI

[10.1002/2688-8319.70089](https://doi.org/10.1002/2688-8319.70089)

Number of citations

1

Multi-taxa spatial conservation planning reveals similar priorities between taxa and improved protected area representation with climate change

Background: Historically, protected area (PA) networks have been designed to represent all major habitats, with a focus on a small number of indicator taxa, limited spatial coverage and minimal consideration of future climate change projections.

Main question: Do conservation priorities align across taxa under climate change?

Data: Occurrence data on a wide range of taxonomic groups between 1970 and 1989.

Methods: Bayesian hierarchical and Core-area Zonation models were used to determine priority conservation areas. Spatial prioritisation results across 18 taxa were compared against future (2080) climate change projections to assess the potential impacts of climate on the PA network efficacy.

Main findings: Priority conservation areas were similar among multiple taxa, despite varying spatial species richness patterns, suggesting that systematic prioritisations based on indicator taxa are still appropriate for conservation planning. However, increasing the number of protected hectads by 2% was found to increase the occurrence of certain taxa by up to 17%, highlighting the disproportionate ecological value small-scale additions can have to PA networks.

Implications: Small expansions of protected areas can be highly effective and indicator taxa are potentially useful.

Reference

Critchlow, R., Cunningham, C. A., Crick, H. Q., Macgregor, N. A., Morecroft, M. D., Pearce-Higgins, J. W., ... & Beale, C. M. (2022). Multi-taxa spatial conservation planning reveals similar priorities between taxa and improved protected area representation with climate change. *Biodiversity and Conservation*, 31 (2), 683-702.

DOI

[10.1007/s10531-022-02357-1](https://doi.org/10.1007/s10531-022-02357-1)

Number of citations

47

Are existing biodiversity conservation strategies appropriate in a changing climate?

Background: Existing biodiversity conservation strategies were largely developed without accounting for climate change, raising concerns about their long-term effectiveness as species distributions and habitat suitability shift.

Main question: Do current national conservation strategies for priority species remain appropriate under climate change, or do they require revision?

Data: Occurrence records for 30 NERC Act priority species.

Methods: The Frescalo method was used to assess recorder effort. Occupancy data were then modelled using a generalised additive model.

Main findings: Existing conservation actions frequently diverged from those identified by the climate-adaptive decision framework, suggesting that many current strategies may be misaligned with the actions needed to support species persistence under future climate conditions.

Implications: National conservation strategies for priority species may need systematic re-evaluation through a climate change lens.

Reference

Oliver, T. H., Smithers, R. J., Beale, C. M., & Watts, K. (2016). Are existing biodiversity conservation strategies appropriate in a changing climate? *Biological Conservation*, 193, 17-26.

DOI

[10.1016/j.biocon.2015.10.024](https://doi.org/10.1016/j.biocon.2015.10.024)

Number of citations

55

A new vascular plant Red List for Great Britain

Background: Red Lists underpin nature conservation and help to prioritise future action.

Main question: This report presents a comprehensive revision of the Great Britain (GB) Red List for all native and archaeophyte vascular plants.

Data: 1,720 plant taxa from verified datasets published by the Botanical Society of Britain and Ireland (BSBI) covering three distribution atlas time periods (1930-1969; 1987-1999; 2000-2019).

Methods: IUCN Red List Guidelines to classify threat status.

Main findings: About 25% of vascular plant species in Great Britain are threatened with extinction, with additional species classified as regionally extinct or near threatened and many declines linked to habitat degradation and land-use change.

Implications: The Red List provides strong evidence of widespread decline in Britain's flora and serves as a key tool for prioritising conservation actions and guiding biodiversity policy.

Reference

Stroh, P. A., Pescott, O. L., Bateman, R. M., Cooke, E. L., Cousins, M., Fay, M. F., ... & Walker, K. J. (2025). A new vascular plant Red List for Great Britain. *British & Irish Botany*, 7(3), 148-216.

DOI

[10.33928/bib.2025.07.148](https://doi.org/10.33928/bib.2025.07.148)

Number of citations

5

A new IUCN Red List of the bryophytes of Britain, 2023

Background: Britain supports one of the richest bryophyte floras in Europe. Following previous assessments in 2001 and 2011, the aim of this study was to provide a new IUCN Red List of the bryophytes of Britain.

Main question: To update the conservation status of all bryophyte species in Britain using IUCN Red List criteria and assess changes since previous assessments.

Data: Data for 1,097 bryophyte species recorded since 1500.

Methods: A synthesis of available distribution, population, and ecological data following IUCN Red List guidelines.

Main findings: Approximately 19% of assessed bryophyte species are threatened with extinction, with 59 classified as critically endangered, and at least four already regionally extinct.

Implications: The Red List highlights substantial extinction risk and provides a critical evidence base for prioritising conservation actions and monitoring biodiversity change in Britain.

Reference

Callaghan, D. A. (2022). A new IUCN Red List of the bryophytes of Britain, 2023. *Journal of Bryology*, 44(4), 271-389.

DOI

[10.1080/03736687.2023.2185393](https://doi.org/10.1080/03736687.2023.2185393)

Number of citations

28

Monitoring and methods

Data-derived metrics describing the behaviour of field-based citizen scientists provide insights for project design and modelling bias

Background: Citizen science data holds great potential for monitoring biodiversity, although variance in recorder behaviour can lead to bias in the data collected.

Main question: Can we quantify the behavioural variation of citizen scientists using a range of temporal, spatial and data content metrics?

Data: Occurrence data from iRecord Butterflies for the period January 2014 to September 2017.

Methods: Kernel density estimation, k-means clustering analysis, principal components analysis models.

Main findings: The principal components analysis revealed that participants fell along four continuous axes that describe variation in participants' behaviour: recording intensity, spatial extent, recording potential and rarity recording, rather than distinct behaviour clusters.

Implications: Understanding recorder behaviour in terms of these axes could better support the use of the citizen science data by accounting for biases in the data collection process.



Reference

August, T., Fox, R., Roy, D. B., & Pocock, M. J. O. (2020). Data-derived metrics describing the behaviour of field-based citizen scientists provide insights for project design and modelling bias. *Scientific Reports*, 10(1), 11009.

DOI

[10.1038/s41598-020-67658-3](https://doi.org/10.1038/s41598-020-67658-3)

Number of citations

86

First national survey of terrestrial biodiversity using airborne eDNA

Background: Biodiversity data suffers from limited temporal and spatial coverage due to the high sampling needed to obtain a comprehensive understanding. Airborne environmental DNA (eDNA) presents an opportunity to counter these limitations and facilitate the rapid assessment of terrestrial species on a global scale.

Main question: The first national-scale assessment of terrestrial biodiversity using a metabarcoding technique, which was applied to airborne eDNA sourced from a national ambient air quality monitoring network.

Data: Invertebrate occurrence data from the National Biodiversity Network Atlas (NBN Atlas).

Methods: Spatial distribution maps to identify where these genera were present across the UK.

Main findings: Citizen science data and eDNA detections were comparable, with eDNA outperforming citizen science data in detecting elusive and less charismatic species.

Implications: While eDNA signals were local, the findings suggest that incorporating eDNA protocols into existing air quality monitoring networks could offer a cost-effective way of standardising biodiversity monitoring.

Reference

Tournayre, O., Littlefair, J. E., Garrett, N. R., Allerton, J. J., Brown, A. S., Cristescu, M. E., & Clare, E. L. (2025). First national survey of terrestrial biodiversity using airborne eDNA. *Scientific Reports*, 15(1), 19247.

DOI

[10.1038/s41598-025-03650-z](https://doi.org/10.1038/s41598-025-03650-z)

Number of citations

26

Modelling the distribution of rare invertebrates by correcting class imbalance and spatial bias

Background: Soil invertebrates represent a taxonomic group with scarce opportunistic observational data, suffering from a relatively high number of non-detections.

Main question: A test of the spatially stratified under-sampling method of Robinson et al. (Diversity and Distributions, 24, 460) to improve modelling of rare species.

Data: Occurrence records from the Global Biodiversity Information Facility and the British Myriapod and Isopod Group recording scheme from 1971 to 2020 for six rare millipedes in Ireland.

Methods: Random forests to estimate species distributions.

Main findings: Spatially stratified under-sampling methods improved the predictive performance of species distribution models particularly on rarer millipede species, although unstratified under-sampling methods were occasionally more effective.

Implications: These improved modelling approaches present a promising methodology for predicting the distribution of understudied or rare species.

Reference

Gaul, W., Sadykova, D., White, H. J., León-Sánchez, L., Caplat, P., Emmerson, M. C., & Yearsley, J. M. (2022). Modelling the distribution of rare invertebrates by correcting class imbalance and spatial bias. *Diversity and Distributions*, 28(10), 2171-2186.

DOI

[10.1111/ddi.13619](https://doi.org/10.1111/ddi.13619)

Number of citations

7

Thinking like a naturalist: Enhancing computer vision of citizen science images by harnessing contextual data

Background: Machine learning tools have the ability to provide efficient and reproducible species identification in ecology; however, most approaches are constrained by their reliance on raw image pixels for classification.

Main question: Does adding contextual data improve automated species ID?

Data: Occurrence data for 18 species of ladybird from the UK Ladybird Survey between 2013 and 2018.

Methods: Multi-input neural network models to automatically identify the records to species level.

Main findings: The multi-input model achieved a 9.1 percentage-point improvement in top-1 accuracy in comparison to the image-only baseline (48.2%), while the image-plus-metadata ensemble offered a more modest 3.6-point improvement.

Implications: Machine learning models could be effectively harnessing contextual information to improve the interpretation of images. Incorporating contextual data within machine learning models improves image classification accuracy and performance.



Reference

Terry, J. C. D., Roy, H. E., & August, T. A. (2020). Thinking like a naturalist: Enhancing computer vision of citizen science images by harnessing contextual data. *Methods in Ecology and Evolution*, 11 (2), 303-315.

DOI

[10.1111/2041-210X.13335](https://doi.org/10.1111/2041-210X.13335)

Number of citations

107

Patterns of contribution to citizen science biodiversity projects increase understanding of volunteers' recording behaviour

Background: Citizen science makes great contributions to monitoring, but its diversity creates challenges in using the data.

Main question: How do patterns of participation in citizen science biodiversity projects vary across volunteers, and how do these patterns contribute to spatial, temporal, and taxonomic biases in biological recording?

Data: Data from Greater London CIC, iSpot and iRecord.

Methods: Analysis of recorder patterns and biases with respect to taxonomy, space and time.

Main findings: There was highly uneven participation, with most volunteers contributing very few records. Each scheme showed distinct spatial and taxonomic biases, suggesting volunteers self-select into platforms based on interests. Bias arises both from observer preferences and ecological/detectability factors.

Implications: Citizen science data are systematically biased, but these biases are informative. Understanding recorder behaviour can improve statistical correction of bias and help design better citizen science schemes to align volunteer motivations with scientific needs.

Reference

Boakes, E. H., Gliozzo, G., Seymour, V., Harvey, M., Smith, C., Roy, D. B., & Haklay, M. (2016). Patterns of contribution to citizen science biodiversity projects increase understanding of volunteers' recording behaviour. *Scientific Reports*, 6(1), 33051.

DOI

[10.1038/srep33051](https://doi.org/10.1038/srep33051)

Number of citations

189

Policy use

BRC data underpin several official biodiversity indicators used to track change and inform policy in the UK. These include the UK indicator “Status of pollinating insects” and both UK and England indicators on the “Status of priority species: distribution”, alongside the recently developed England indicator “Status of all species: distribution”.

The pollinating insects indicator tracks long-term changes in the distribution of wild bees and hoverflies across the UK since 1980. It draws on extensive biological records contributed through national recording schemes, including the Bees, Wasps and Ants Recording Society and the Hoverfly Recording Scheme.

The priority species indicators measure changes in the distribution of species of conservation concern since 1970. These include species listed on national biodiversity priority lists across the UK, and, for England, those identified under Section 41 of the Natural Environment and Rural Communities Act (2006). The UK indicator currently integrates trends for more than 500 species across 22 taxonomic groups, spanning a wide range of invertebrates and plants.

Building on this approach, the “Status of all species: distribution” indicator for England, first produced in 2025, expands coverage to 5,440 species across 30 taxonomic groups. By including a broader representation of biodiversity, this indicator provides a more comprehensive assessment of change across taxa and complements the focus on priority species.

Most of the records that underpin these indicators are contributed by volunteer observers and are therefore opportunistic in nature,

with uneven sampling in space and time (Isaac et al., 2014a and b). To address these challenges, trends are estimated using Bayesian occupancy models, which attempt to account for variation in recording effort and detection probability (van Strien et al., 2013). This approach provides annual estimates of species’ occupancy, allowing robust inference from complex, heterogeneous datasets.

Together, these indicators demonstrate how BRC data translate into policy-relevant evidence, enabling long-term monitoring of biodiversity change, informing conservation priorities, and supporting national and international reporting commitments.

Moreover, beyond indicators, BRC data are used for a range of other policy-relevant applications, including assessing the effectiveness of conservation interventions, quantifying the impacts of environmental pressures, spatial planning, and building scenarios of the future. Collectively, the work enabled by the BRC provides vital evidence for conservation decision-making.



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