Planning Rebuttal Evidence.

Evidence of Paul Burrell.

In respect of Land at Grove Farm and land East of the Railway Line, Bentley, Suffolk.

Construction of a Solar Farm (up to 40MW export capacity) with ancillary infrastructure and cabling, DNO substation, customer substation and construction of new and altered accesses.

On behalf of Green Switch Capital Ltd

Date: January 2026 | Pegasus Ref: P25-0480

Appeal Ref: APP/D3505/W/25/3370515 | LPA Ref: DC/23/056656

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Appendices.

1. Introduction

1.1. My name is Paul Burrell. I hold a BSC (Soc Sci) Hons in Geography and a Diploma in Urban Planning. My particulars are set out in my earlier Proof of Evidence.

1.2. This Rebuttal Evidence has been prepared having reviewed the various Parties Proofs of Evidence, and I respond to several matters raised by Mr Steven Stroud on behalf of the LPA, and Mr Ian Poole on behalf of the Rule 6 Parties. This Rebuttal naturally does not cover every point raised by the above parties, and my not referencing each point should not be taken to necessarily indicate my agreement with the approach, analysis or findings presented in their evidence and statements.

1.3. The evidence that I have prepared and provide for this Section 78 appeal is true and has been prepared and is given in accordance with the guidance of my professional institution. I can confirm that the opinions expressed are my true and professional opinions.

2. Alternative Site Assessment

2.1. A number of comments are made by Mr Stroud concerning the updated Alternative Site Assessment (*ASA, Core Document C24*) in his evidence. Whilst I do not intend to rebut each and every point in evidence in this Note, I have sought to clarify the grid connection process and timescales in bringing forward a solar farm scheme in my evidence already. I would note that there is no prescribed methodology for undertaking such an ASA exercise at either the national level or at the Local level; this reaffirms my position that one is not required. Such studies where provided will be reliant on matters of professional judgement. Even if an alternative site were to be identified as potentially appropriate, without an available grid connection and/or secured land control, it would in my opinion be no more than a "phantom alternative" and not a genuine prospect to be able to deliver a solar project to the grid.

2.2. Specifically with regard to alternative Areas C1 and C2, Mr Stroud seeks to suggest that highways access is not an 'insurmountable issue' in paragraphs 5.29 to 5.30. However, the ASA considers whether or not development is preferable at C1 or C2, not whether development is achievable *per se*. The point is that whilst access to the Appeal Site is via Station Road, which is not a single track road (and then via upgraded farm tracks, not public highways, within the Appeal Site itself), access to C1 and C2 would be via single track adopted highway from its junction with the A137 to where it would access sites C1 and C2, which is a minimum distance of approximately 1.3km and which would therefore likely require upgrades and traffic management along this length of the public highway.

2.3. It should also be noted that sites C1 and C2 were also discounted in the ASA due to impacts upon ProWs that are not reflected at the Appeal Site, which is not mentioned by Mr Stroud.

3. Residential Amenity

3.1. In respect of noise matters, Mr Poole in his evidence makes a number of points in respect of noise and residential amenity. I attach at **Appendix R1** Rebuttal evidence by Mr Kettlewell in respect of noise matters and Mr Poole's evidence, in particular at paragraphs 4.34 and 7.3 whereby it would appear that some confusion has arisen from the lower level of noise generated by the use of string inverters as proposed as part of the Appeal scheme, and the use of centralised inverter stations at the Boxsted site which generated higher levels of noise. In summary, Mr Kettlewell concludes that noise generated by the proposed development can be effectively controlled by means of condition.

3.2. In respect of Glint and Glare, Mr Poole in his evidence at paragraphs 7.5 and 7.6 alleges that the screening available would not be effective in winter effects. Acknowledging that times vary by receptor due to the different locations, in response I would note that Table 4 of the Glint and Glare report (*Core Document A18*) does not identify a reflection during the winter months of November, December, January and February, with most occurrences in the spring and summer when hedgerows would be in leaf.

4. Biodiversity

4.1. With regard to the matter raised by Mr Poole with regard to ground nesting birds and Local Plan Policy LP16 at paragraphs 4.20 to 4.23 of his evidence, I attach a response prepared by Howard Fearn of Avian Ecology which addresses this matter as **Appendix R2**.

4.2. I note that Mr Fearn concludes that whilst single pair of each of yellow wagtail and skylark may be displaced from breeding within the Appeal Site, it is his view that the Proposed Development will not lead to any measurable reduction in the conservation of either species. Also, the conversion of arable to grassland/grazing pasture is likely to be beneficial to nearby breeding pairs of the same species.

4.3. Further, Mr Fearn concludes that the Proposed Development would deliver a substantial biodiversity net gain, retain and enhance higher-value habitats, and introduce long-term, low-intensity land management that represents an ecological improvement over the existing intensively managed arable baseline. He concludes too that effects on farmland birds, including skylark and yellow wagtail, have been considered appropriately.

5. Public benefits and level of significance

5.1. With regard to the matter raised by Mr Stroud in respect of the four renewable energy benefits, I note he relies upon the *Botteford* decision by the Secretary of State in his evidence at paragraph 5.10 *inter alia* that these benefits should collectively be given significant weight, and further that this approach by the Secretary of State departed from the approach adopted by the Inspector who had recommended substantial weight should be given . I make the following four points in response.

5.2. First, a Inspector is entitled to reach their own view on the weight to be afforded to renewable & low energy generation, in light of NPPF paragraph 168. This is because renewable energy generation and Net Zero are Government <u>objectives</u>, rather than solely <u>benefits</u>.

5.3. This distinction is important when the applying the judgment in *Bewley Homes PLC v SSLUHC [2024] EWHC 1166* and the Court's interpretation of the similar instruction in paragraph 81 (now in paragraph 85) to give "significant weight" to the need to support economic growth and productivity. Holgate J (as he then was) made clear that the "*need to support economic growth and productivity*" was an objective identified by Government and that the local policies and benefits associated with it may vary.

5.4. Applying that principle to this Appeal, it is clear that renewable energy generation and Net Zero are <u>objectives and</u> <u>targets</u> that Government has set out in various national policy documents, and that the <u>benefits</u> associated with them will require consideration in the specific circumstances of making a decision on any particular scheme. The reference in the NPPF at paragraph 168a to the benefits "*associated with*" those targets is both broad and open-ended. It cannot be right that the Government was at once introducing a remarkable new presumption that there is a need for renewable and low carbon energy, and that significant weight must be given to its benefits, whilst also proscribing a closed list of the benefits to be considered.

5.5. Second, I do not consider that the requirement to give "*significant weight*" to the benefits of renewable energy generation and the contribution to Net Zero should be taken as a ceiling. In *Bewley Homes* at paragraphs 48-53, Holgate J was clear that paragraph 81 of the NPPF did not compel a decision-maker to attribute the same level of weight ("significant") to any economic benefit flowing from any proposal irrespective of the merits of the economic case and the local or regional circumstances. The same is true of paragraph 168(a). Indeed, "*substantial weight*" is often given to the benefit associated with renewable and low carbon schemes, as I have already identified in my earlier evidence.

5.6. Third, I disagree with the Secretary of State's approach to applying paragraph 168a as expressed in the paragraph cited in Mr Stroud's evidence at paragraph 5.10. The interpretation notably involved the reading of the word "*collectively*" into a paragraph of the NPPF where it does simply does not exist. I believe the correct approach should be to carefully consider each of the 'associated benefits' and to ascribe an appropriate weight to each.

5.7. Fourth, the consultation draft NPPF now indicates in Policy W3 that "*substantial weight*" should be given to "*the benefits for improving energy security, supporting economic development and moving to a net zero future*". This are clearly identified individual benefits, noted separately, and with the enhanced level of weight attached to them. As stated in my evidence, I accept that is a consultation draft, but is a clear direction of travel, and is consistent with the significance accorded to NSIP scale projects in the very recently updated NPS.

6. Grid connection

6.1. There is reference by Mr Stroud to the EA register in his evidence at paragraph 3.6. To clarify, my understanding is that this date relates to the NESO (transmission network) connection date. UKPN (distribution network) offered a connection date, which Green Switch Capital accepted, for March 2028. The DNO / customer contracts are not listed on the NESO register, as NESO are not a party to those contracts.

Appendix R1

NVC
Noise &
Vibration
Consultants Ltd.

APPEAL AGAINST REFUSAL OF PLANNING PERMISSION FOR

PROPOSED DEVELOPMENT OF A PHOTOVOLTAIC SOLAR ARRAY ON LAND AT

GROVE FARM, BENTLEY

PINS Ref: APP/D3505/W/25/3370515
LPA Ref: DC/23/056656

NOISE

REBUTTAL EVIDENCE OF

DEAN ROBERT KETTLEWELL MSc MAE MIOA I.Eng

Ref: DRK/260102/0

Date: 8th January 2026

1 INTRODUCTION

1.1 This rebuttal evidence is provided in response to the proof of evidence of Ian Poole of Places4People Planning Consultancy for the Public Inquiry acting on behalf of Bentley Parish Council and Stop Grove Farm Solar (referred to hereafter as `P4PPC').

1.1.2 This evidence addresses each point raised by P4PPC and where appropriate, refers to evidence already covered in the Noise Impact Assessment (ref. R23.0708/DRK dated 31st August 2023). This report is provided as an appendix to the Planning Design and Access Statement (PDAS Appendix G – Noise and Vibration Assessment (Core Document: A14).

2 P4PPC SECTION 4: GROUND 1 PLANNING POLICY & SECTION 7: GROUND 4 RESIDENTIAL AMENITY

2.1 Reference P4PPC Paragraph 4.34 and paragraph 7.3:

"The Noise Assessment that accompanied the application as an appendix to the Planning Design and Access Statement (PDAS Appendix G – Noise and Vibration Assessment) (Core Document A14) stated that the inverters would "produce a noise level not exceeding 62dB LAeq15mins @ 1m (based on measured levels with maximum load)". However, the Acoustic Impact Assessment accompanying a current planning application being considered by Babergh District Council at Boxted, (DC/23/05127) suggests that the inverters will create a sound power level of 93 dB(A)."

2.2 My Noise Impact Assessment report (ref. R23.0708/DRK dated 31st August 2023) at paragraph 6.2.3, states:

"The following example of mitigation measures is based on typical plant noise from similar sites in the UK. It is important to note that there is more than one method to control noise levels (e.g. plant selection or design) that can achieve similar levels at NSRs. The mitigation strategy would be confirmed as part of any planning consent condition as proposed by the Environmental Health Protection Officer.
a) Transformer noise level of 70dB LAeq15mins @ 1m sound pressure level.
b) Solar plant string inverters produce a noise level not exceeding 62dB LAeq15mins @ 1m (based on measured levels with maximum load).

c) Substation switchgear noise level of 65dB LAeq15mins @ 1m sound pressure level.
d) Acoustic screen mounted around 2 of the transformers closest to R4 (Potash Lane). Refer to Figure 3 for location. The screen should 0.5m higher than the height of the transformer enclosure (e.g. height of container 2.9m, screen height would be 3.4m) and formed by a solid material of minimum 12kg/m2 mass e.g. close boarded fencing to appropriate thickness with no gaps between boards or between boards
and supports or ground."

2.3 As explained in the above paragraph, the proposed design for the solar panel inverters is based on **`string inverters'** and as such these are relatively small plant and normally located at the end of panel rows behind the panel. I provided a Technical Note in response to queries raised by the BMSDC Senior Environmental Health Protection Officer dated 2nd January 2024 (reference Core Document A39). This Technical Note is referenced in core document 14c. The examples in Appendix 2 of the Technical Note show that these do not produce any significant noise, with levels of <55dB and <62dB sound power level provided. This level of noise is similar to that I have experienced when undertaking commissioning solar plant field noise tests in the past.

2.4 The P4PPC evidence refers to the Boxted Solar Farm application (DC/23/05127), which is a completely different site, and indicates the inverters will create a sound power level of 93dB(A). The noise impact assessment submitted by RES in support of the Boxted application (Ref. RES 04806-6612352, Rev: 1 dated 17 October 2023) refers to the inverter level at section 5.1 of the RES report, which is shown as 6 **centralised inverter stations** in Appendix B4 noise mapping results. This is a completely different method of plant design to the Grove Farm Solar development, whereby numerous inverters are grouped together in the 6 containers across the site as opposed to `string inverters' which are located generally at the end of certain panel rows as being proposed for Grove Farm Solar. Also, the noise levels with the centralised inverter approach will be higher as the containers require fan cooling systems, due to them being enclosed, and therefore the reason why there is a differential in levels between the two systems. Additionally, even if the two sites were using a similar plant design, the noise levels commercially vary considerably depending on the Technology Provider and therefore the point raised in evidence is **completely misleading and inappropriate** as it refers to another solar site application's evidence using a different technology.

2.5 The P4PPC evidence at paragraph 4.35 continues on, to state:

"Given this conflicting evidence, although I am not a noise expert, I am doubtful whether the Noise Assessment submitted is reliable to determine the potential impacts on the residential amenity of nearby residents. I have also spent time close to solar farms in the summer months, when power is being generated and the noise emanating from them is most clearly audible. It seems highly likely that the residents living closest to the site would experience these negative impacts."

2.6 We therefore conclude that this statement is completely incorrect and a misleading use of information and shows a lack of understanding of how solar array plant designs work. As an expert, it is my experience over 40 years' experience, that with appropriate design and mitigation solar farms do not produce any significant noise impacts and audibility is subjective and depends on numerous factors including separation distance from plant and site-specific characteristics. The results of my Noise Impact Assessment show a **low impact** and therefore conclude the noise to be **not significant**.

2.7 Reference P4PPC Paragraph 4.41 Planning Policy BEN 3 Development Design states:
"b) do not materially harm the amenities nearby residents by reason of noise, smell, vibration, overshadowing, loss of light and outlook, other pollution (including light pollution), or volume or type of vehicular activity generated, and/or residential amenity unless adequate and appropriate mitigation can be implemented;
I have demonstrated above that residential amenity could be negatively impacted though noise."

2.8 P4PPC suggest they have demonstrated that residential amenity would be impacted. The Noise Impact Assessment has shown that with appropriate design and mitigation the impact would be **low** and **not significant**. The P4PPC evidence presented simply relies on the assumption that plant noise source levels would be much higher than the example of plant levels indicated in the NVC report, which we have clarified in paragraph 2.2 to 2.6 above.

3 P4PPC SECTION 3: RULE 6 PARTY'S CASE & SECTION 7: GROUND 4 RESIDENTIAL AMENITY

3.1 Reference P4PPC paragraph 3.1 sub-section 4 case includes:

"4. The proposal would have significant impact on residents' amenities by reason of noise, glint and glare and visual impact."

3.2 The claim that a significant impact on residential amenity in respect of noise would occur has been shown in section 2.0 of this rebuttal and analysis in the Noise Impact Assessment to be unfounded and misleading.

3.3 Reference P4PPC paragraph 7.7 states:

"I am therefore of the opinion that insufficient consideration has been given to the impacts on residential amenity arising from noise, outlook and glint and glare and that the proposal is contrary to Local Plan Policy LP25 and Planning Practice Guidance. As I note above, local residents will also be giving their own evidence under this head."

3.4 The opinion, which is non-expert, provided by P4PPC in respect of noise does not present any evidence to support the case that noise would result in an adverse or significant impact and the results of the analysis and conclusions provided within the relevant Noise Impact Assessment are valid.

4 CONCLUSIONS

4.1 All the matters raised in the proof of P4PPC in respect of noise have been addressed in the points set out above. Noise generated by the proposed development can be effectively controlled by condition.

4.2 As such it is the appellant's case that there is nothing in the evidence of P4PPC that would amount to basis for refusal on the grounds of noise for the proposed development in this case.

Appendix R2

Client Name: **Green Switch Capital Ltd**

Site Name: **Grove Farm, Bentley, Ipswich**

Date: **8th January 2026**

Appeal reference: APP/D3505/W/25/3370515

1.1 Introduction

1.1.1 This statement has been prepared on behalf of the Appellant and relates to a planning appeal submitted pursuant to Section 78 of the Town and Country Planning Act 1990, concerning the proposed construction of a solar farm and battery storage together with all associated works, landscaping, equipment and necessary infrastructure ('the Proposed Development') on land at Grove Farm and Land East of the Railway Line, Bentley ('the Appeal Site').

1.1.2 This statement is prepared in response to the Rule 6 Party Case, submitted by Places4People Planning Consultancy and authored by Mr Ian Poole. My statement addresses matters raised with regards to ground nesting birds and specifically Local Policy LP16 (Biodiversity and Geodiversity) and paragraphs 4.20 to 4.23 of the Rule 6 party submission.

2.1 Qualifications and Relevant Experience

1.2.1 My name is Howard Fearn. I am the Director of Avian Ecology Ltd. ('AEL'), an ecological consultancy which currently employs thirty-two professional ecologists. I have been a practicing professional ecologist for twenty-three years.

1.2.2 I hold a Master's degree in Ecology and Environmental Management, and I am a full member of the Chartered Institute of Environmental Management ('CIEEM'). I am required by CIEEM to abide by the Code of Professional Conduct which includes exercising sound professional judgement in my work, identifying clearly the limitations and applying objectivity, relevance, accuracy, proportionality and impartiality to the information and professional advice I provide.

1.2.3 My professional experience is primarily in renewable energy developments, in particular onshore wind and solar energy projects of all scales across the UK. This includes all aspects of terrestrial ecology; however, my primary specialism is in ornithology. This includes involvement in many solar farm applications across the whole of England, including Development Consent Orders (DCO). I have authored numerous mitigation strategies for farmland birds, in particular skylarks, in relation to solar farms.

1.2.4 AEL personnel were involved in the original planning application for the Appeal Site, having produced the ecological assessment, biodiversity net gain (BNG) metric and biodiversity management plan for the proposals.

1.2.5 The evidence which I have prepared and provide for this appeal in this Appeal Statement is true and I confirm that the opinions expressed are my true and professional opinions. My professional fees in respect of this project do not depend upon the outcome of this Inquiry.

3.1 Rule 6 Party Case

1.3.1 The Rule 6 party contends that the application does not accord with Policy LP16 on the basis that the site supports a single pair of each of two ground-nesting bird species; skylark and yellow wagtail. Policy LP16 states:

Development which would have an adverse impact on species protected by legislation, or subsequent legislation, will not be permitted unless there is no alternative and the LPA is satisfied that suitable measures have been taken to:

a. Reduce disturbance to a minimum;

b. Maintain the population identified on site; and

c. Provide adequate alternative habitats to sustain at least the current levels of population.

4.1 Case for the Appellant

1.4.1 The breeding bird assemblage using the Site is typical of similar habitats in the region and is of no more than local value.

1.4.2 Recent research by the RSPB and the University of Cambridge (Copping et al 2025, Appendix 1), supports the benefits of solar farm landscape schemes within arable landscapes. They found that mixed habitat solar farms in an agricultural landscape, designed with biodiversity in mind and managed for nature supported nearly three times as many birds and a greater variety of species than nearby arable farmland. Furthermore, well managed solar farms "*could provide relief from the effects of agricultural intensification on biodiversity in the surrounding landscape*".

1.4.3 The landscape scheme outlined in drawing ref 3223-01-13 Rev A (CD:C4 and C5), with species diverse grassland planting around the edges, species rich hedgerow with trees around the solar perimeter fencing is considered to represent a mixed habitat solar farm in terms of the research categories and should greatly enhance the Site for a variety of bird species, in addition to other species groups such as bats and invertebrates. This is due to the increased heterogeneity of flora, providing increased food sources such as seeds and invertebrate species.

1.4.4 It is therefore appropriate to conclude that the Site will be improved for breeding birds overall, including multiple species with identical conservation status and protections to skylark and yellow wagtail. I therefore do not agree with Mr Poole (his paragraph 4.2.3) that the conclusions of the submitted ecological impact assessment are 'sweeping'; it is quite clear from the evidence that solar farms are typically beneficial for breeding birds.

Skylarks

1.4.5 Once abundant across Britain's open farmland, Skylarks have experienced significant population declines since the 1970s, primarily due to agricultural intensification and changes in cropping patterns. This decline led to the species' listing on the UK 'Red List' of Birds of Conservation Concern (Stanbury *et al*., 2021, Appendix 2), and categorising as a species of principal importance under the NERC Act (2006). Despite declines, skylarks remain a familiar feature of the UK countryside, with an estimated 1.6 million breeding pairs in 2016 (Woodward *et al.,* 2020, Appendix 3). According to the most recently available BTO report

(Heywood *et al*., 2025, Appendix 4), numbers have increased by 9% during the past decade and nearly 20% in the last five years in south-east England and the East Midlands, suggesting at least some level of stabilisation has occurred in recent years and that this is likely to be the case around the Appeal site also. It is therefore reasonable to consider that the potential displacement of a single pair of skylarks from the Site will be insignificant beyond site level, and negligible at a district or county level.

1.4.6 Further, research highlighted within the planning application EAR (Montag *et al.,* 2016, Appendix 5) and Fox (2022, Appendix 6) notes there was no statistical difference in the number of skylark territories between solar and control plots, and that skylarks were frequently observed foraging in, and around, solar farms, including with recently fledged young. These findings indicate that solar farms should not be viewed as absolute habitat losses for skylarks. Instead, they represent a functional shift in habitat use, from nesting to foraging (for other pairs in the vicinity), with potential population-level benefits when well managed.

1.4.7 It is also relevant that land management practices strongly influence local and regional populations. Within arable landscapes, different crop-types support varying densities of Skylarks, meaning that abundance and breeding productivity are heavily dependent on crop variation and populations are forced to adapt to local agricultural rotation. There is some evidence that breeding pairs will relocate during a breeding season where crops have grown and rendered their early-season location unsuitable for later breeding attempts (Donald, *et al*., 2001). Consequently, Skylark populations cannot be meaningfully measured at an individual site level.

1.4.8 It is considered that the landscaping enhancements across the Site will result in increased breeding success opportunities for nearby skylarks, with the conversion of arable land to permanent meadow grassland. The cessation of farming activities (which can disturb and destroy ground nesting bird nests), including removal of crop cycles, ploughing activities and pesticide/herbicide use will likely lead to an increase in breeding season prey (invertebrate) abundance, which in turn should allow retained local pairs to breed more successfully (i.e., raise more young).

1.4.9 As such, whilst a single skylark territory may be displaced, this is not considered a significant impact and the quality of land created post development is far more beneficial for a range of protected bird species, including several species with identical protected status as skylarks.

Yellow Wagtail

1.4.10 Yellow Wagtails are summer visitors to UK farmland, favouring damp pastures, marshes, and arable fields where they follow livestock or forage in sparse vegetation for insects. They nest on the ground in long grass or crops like beans and potatoes, but their numbers have declined due to habitat changes. This species is also a species of principal importance under the NERC Act and is a Red List (Birds of Conservation Concern) species. According to the British Trust for Ornithology 'Birdfacts' website (Appendix 7), yellow wagtails have been in decline since the early 1980s. The most recent population figure available is approximately 20,000 pairs in 2016 and is likely to have declined further since. Range contraction has occurred towards a core area in central England, especially in the west and south and in parts of East Anglia. As with skylark, breeding yellow wagtails feed on invertebrates and these are subsequently vital for rearing young. Population declines in arable landscapes are attributed to reductions in insect availability and changes in farming practice, i.e., the same as skylark.

1.4.11 Unlike skylark, there is little or no specific research in to the impacts of solar farm developments on breeding yellow wagtails. However, given that both species typically nest in open spaces away, it can reasonably be assumed that impacts are similar; i.e., birds probably do not breed within solar farms but will still use the solar farm area as a foraging resource. This view is supported by the annual 'Solar Habitat Reports', commissioned by Solar Energy UK (2023, 2024, 2025, Appendix 8), which show regular presence of yellow wagtails at operational solar farms. For example, the most recent (2025) report noted yellow wagtails were recorded at around 15% of sites surveyed. I consider this to be a high proportion given the much smaller number of yellow wagtails present in the UK than skylarks.

1.4.12 Consequently, as with skylark, it is highly likely that the appeal site will provide an enhanced foraging resource for yellow wagtails in the surrounding area and may well lead to an increase in breeding productivity. As such, whilst a single territory may be displaced, I do not consider this significant impact at any measurable population level.

Legislation and Policy Consideration

1.4.13 Skylark in particular, has been afforded significant weight when it comes to the impact of developments on the species. Skylarks and yellow wagtails have the same legal protection under the Wildlife and Countryside Act 1981 afforded to all species of nesting birds concerning deliberate disturbance and damage/ destruction of nests and eggs, rather than the loss of breeding habitat.

1.4.14 The legal position on breeding birds is set out in the NERC Act 2006 and the Wildlife and Countryside Act 1981. NERC designates both species as of principal importance for the purpose of conserving or enhancing biodiversity in England under s.41. Under s.41(3) the Secretary of State must–

> *"(a) take such steps as appear to the Secretary of State to be reasonably practicable to further the conservation of the living organisms and types of habitats included in any list published under this section, or*
>
> *(b) promote the taking by others of such steps."*

1.4.15 NERC also provides for a general biodiversity objective under s.40 as follows (and so far as relevant):

> *"40 Duty to conserve and enhance biodiversity (A1) For the purposes of this section 'the general biodiversity objective' is the conservation and enhancement of biodiversity in England through the exercise of functions in relation to England.*
>
> *(1) A public authority which has any functions exercisable in relation to England must from time to time consider what action the authority can properly take, consistently with the proper exercise of its functions, to further the general biodiversity objective."*

Specific protection for nesting birds is found in the WCA, which protects them from deliberate disturbance and their nests and eggs from destruction ***in precisely the same way as all wild birds under s.1. To breach this section is a criminal offence.***

1.4.16 Natural England has provided standing advice on protected species (which the Skylark is, falling under NERC). This provides, so far as relevant:

"If avoidance or mitigation measures are not possible, as a last resort you should agree compensation measures with the developer and put these in place as part of the planning permission. These should:

(a) make sure that no more habitat is lost than is replaced ('no net loss') and aim to provide a better alternative in terms of quality or area compared to the habitat that would be lost
(b) provide like-for-like habitat replacements next to or near existing species populations and in a safe position to provide a long-term habitat
(c) provide alternative habitats further away from the impacted population if the natural range of the species is not going to be adversely affected."

References to "no net loss" / "like-for-like" within the guidance do not refer to individual members of a species and represent aspirations in relation to habitat loss set out in generic advice. This is not a legal or policy obligation.

1.4.17 Nowhere within the legislative or policy framework is a pair-for-pair / like-for-like replacement of individual members of a sub-species population required. Even in the case of Great Crested Newts or bats, which are protected by Annex 1 of the Habitats Directive and therefore given the highest level of international legal protection available, there is no obligation for individual animal-for-animal replacement.

1.4.18 As such, whilst it is acknowledged that Local Policy LP16 requires a development to 'maintain the population identified on site', this sets a higher bar than is required under either the NPPF or Natural England standing advice. Further, should this approach be applied to all species of principal importance, which includes numerous widespread birds and other animals (such as hedgehog, brown hare and common toad), it would be prohibitive to any form of development to apply this requirement.

5.1 Conclusion

1.5.1 Whilst I accept that a single pair of each of yellow wagtail and skylark may be displaced from breeding within the Appeal site, it is my view that the Proposed Development will not lead to any measurable reduction in the conservation of either species, and in fact the conversion of arable to permanent grassland/ grazing pasture is likely to be beneficial to nearby breeding pairs of these same species.

1.5.2 The Proposed Development would deliver a substantial biodiversity net gain, retain and enhance higher-value habitats, and introduce long-term, low-intensity land management that represents an ecological improvement over the existing intensively managed arable baseline. Effects on farmland birds, including skylark and yellow wagtail, have been considered appropriately.

1.5.3 In my view, there is nothing to indicate that the Proposed Development would result in significant biodiversity loss or harm to protected/priority species. As outlined, evidence in fact indicates that well-managed solar farms in arable landscapes can deliver positive biodiversity outcomes. Consequently, it is my view that the Proposed Development will deliver a positive contribution to local and national targets to the restoration of biodiversity.

6.1 Appendices

- Appendix 1 – Copping et al (2025). Solar farm management influences breeding bird responses in an arable dominated landscape. Accessed via: https://www.tandfonline.com/doi/epdf/10.1080/00063657.2025.2450392?needAccess=true [22/04/2025)
- Appendix 2 – Stanbury, A., Eaton, M., Aebischer, N., Balmer, D., Brown, A., Douse, A., Lindley, P., McCulloch, N., Noble, D., and Win I. 2021. "The status of our bird populations: the fifth Birds of Conservation Concern in the United Kingdom, Channel Islands and Isle of Man and second IUCN Red List assessment of extinction risk for Great Britain". British Birds 114: 723-747. Available online at https://britishbirds.co.uk/content/status-our-bird-populations.
- Appendix 3 – Woodward, I., Aebischer, N., Burnell, D., Eaton, M., Frost, T., Hall, C., Stroud, D.A. & Noble, D. (2020). Population estimates of birds in Great Britain and the United Kingdom. British Birds 113: 69–104.
- Appendix 4 – Heywood, J. J. N., Massimino, D., Baker, L., Balmer, D. E., Brighton, C. H., Gillings, S., Kelly, L., Noble, D. G., Pearce-Higgins, J. W., White, D. M., Woodcock, P., Workman, E. and Wotton, S., The Breeding Bird Survey 2024: Population trends of the UK's breeding birds (BTO Research Report 787, Thetford: British Trust for Ornithology, Joint Nature Conservation Committee & Royal Society for the Protection of Birds, 2025), https://www.bto.org/sites/default/files/BBS-Report-2024.pdf.
- Appendix 5 – Montag H, Parker G & Clarkson T. (2016). The effects of solar farms on local biodiversity. A comparative study. Clarkson and Woods & Wychwood.
- Appendix 6 – Fox, H. (2022). Blithe spirit: Are skylarks being overlooked in impact assessment? CIEEM – In Practice, 117: pp47-51.
- Appendix 7 – https://www.bto.org/learn/about-birds/birdfacts/yellow-wagtail [accessed January 2025]
- Appendix 8 - Solar Energy UK (2023, 2024, 2025) Solar Habitat: Ecological Trends on UK Solar Farms. London: Solar Energy UK.

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Solar farm management influences breeding bird responses in an arable-dominated landscape

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ABSTRACT
Solar farms are increasing in Britain, but their biodiversity impact is under-studied. We explored bird populations on six solar farms in the East Anglian Fens, using an adapted Breeding Bird Survey across 23.2 km of transects, recording birds seen or heard within 100 m of transects (4 ha survey area). Solar farms were divided by management styles: simple habitat solar (10 transects) and mixed habitat solar (13 transects). We also surveyed 15.2 km of transects in arable farmland. Solar farms contained a greater bird abundance and species richness than arable farmland, but this varied with solar farm management (predicted abundance ±SE per 4 ha: solar with mixed habitat = 31.5 ± 6.4, solar with simple habitat = 17 ± 4.9, arable = 11.9 ± 2.6; predicted species richness ± SE per 4 ha: solar with mixed habitat = 13.5 ± 1.1, solar with simple habitat = 5.3 ± 0.6, arable = 5.5 ± 0.6). Our findings suggest that solar farms can benefit biodiversity in arable-dominated landscapes, especially when managed with biodiversity in mind.

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Addressing the climate emergency without exacerbating the extinction crisis requires information on how efforts to limit greenhouse gas emissions impact biodiversity. Solar energy production offers a sustainable power solution, but understanding the potential impact of solar production on biodiversity is critical. Solar energy capacity has grown rapidly in the UK, from 1.7 GW in 2012 to 15.7 GW by the end of 2023 (DESNZ 2024), and the UK Government (2023) aims to increase solar generation capacity to 70 GW by 2035. The Climate Change Committee's Sixth Carbon Budget scenarios estimate that 75–90 GW of solar may be needed by 2050 (CCC 2020). There is little remaining time to develop the solar capacity thought to be necessary to support a net zero 2035 power system, and the Climate Change Committee's scenarios clearly indicate that more solar development will be required. As solar power facilities continue to expand, there is increasing concern about their impact on bird populations.

To date, surprisingly little research has examined the impact of solar farms on birds. It has been theorized that waterbirds could mistake large arrays of solar panels for water bodies, colliding and dying as they attempt to land (Kagan *et al.* 2014), although there is little evidence to confirm or contradict this theory (Walston *et al.* 2016, Kosciuch *et al.* 2021). Perhaps the greatest impact on birds could be through land use change and habitat loss for breeding and foraging, as shown in the wider land use change research (Wilson *et al.* 2009, Rigal *et al.* 2023).

The few studies investigating bird use of solar farms have provided mixed results; Visser *et al.* (2019) found that bird species abundance and richness were lower inside a solar farm than on adjacent grassland, whereas DeVault *et al.* (2014) reported lower species richness but greater abundance in solar farms than on grassland on adjacent airfields. Furthermore, an ecological monitoring report found (non-significant) higher abundance of birds in solar farms than on surrounding land, associated with greater floral diversity (Montag *et al.* 2016). Meanwhile, Jarcuska *et al.* (2024) found solar farms supported higher bird species richness and diversity, and a higher abundance of invertebrate-eaters,

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possibly by increasing the structural diversity of bird habitats in farmland. Similarly, a monitoring report by a solar industry body reported high abundance and richness of birds in solar farms managed for conservation via a diverse mix of habitats and infrequent grass cutting, compared to intensively managed solar farms (Solar Energy UK 2023).

Much of the new UK solar capacity is likely to be sited on lowland agricultural land in southern and eastern England, where solar irradiance is highest (Palmer *et al.* 2019). However, such areas also contain relatively high densities of farmland birds (Balmer *et al.* 2013), many of which are already under pressure and have declining populations due to agricultural intensification and changing land management practices (Newton 2004, Wilson *et al.* 2009, Rigal *et al.* 2023).

Research to date has typically been based on single sites, often without comparison to the wider landscape, and has not considered differences in solar farm management or composition. Here, we compare the usage by bird species of solar farms and nearby areas of otherwise similar arable land in The Fens, an intensively agricultural region of eastern England that is dominated by arable and horticulture, in order to understand: (i) whether there were differences in abundance and species richness between solar farms and agricultural land uses; and (ii) whether these differences were moderated by solar farm management.

Methods

We searched the UK Government's Renewable Energy Planning Database (DESNZ 2023) to identify utility scale photovoltaic (PV) solar farms in The Fens. We contacted the solar farm owners and operators where contact details were available, and gained permission to survey six sites. All sites fell within an area stretching from Cambridge in the south to Peterborough in the west, and Lakenheath in the east (Figure S1). Sites varied in age, size, generation capacity and management methods.

We split the solar farms into two categories based on their management: 'simple habitat solar' farms were intensively managed, with the grass around solar panels cut or grazed and sward height remaining short throughout the summer, and no woody boundary features or other habitats present. In contrast, 'mixed habitat solar' farms contained more complex habitat as a result of infrequent cutting or grazing of the grass around the solar panels, which allowed greater sward height and the presence of wildflowers; there were also woody features along the boundary fence, such as hedgerows or trees. For comparison, we also surveyed arable land located between 0.95 and 1.6 km from each solar site, typically in an adjacent field, where access permission was granted.

We used the BTO/JNCC/RSPB Breeding Bird Survey (BBS; BTO 2024) methodology to survey bird populations. We carried out two visits per site, one in the early breeding season (April to mid-May 2023) and one in the late breeding season (mid-May to the end of June). Bird counts were performed early in the morning to coincide with peak bird activity, recording the number of individuals of each species detected by sight or sound up to 100 m either side of our 200 m transect sections, giving a survey area of 4 ha (= 0.04 km^2, or 4 ha) per transect section. We did not record individuals greater than 100 m away or flying overhead, with the exception of displaying Skylarks *Alauda arvensis*. This was because at such a distance birds could not be reliably associated with the land-use categories being surveyed. Juvenile and immature birds were omitted, so that the survey focused on breeding habitat associations. We did not carry out surveys in heavy rain, poor visibility, or strong winds due to reduced bird activity and detection.

The number of transect sections per site was dependent upon the site's size, i.e. how many continuous sections could be fitted within it. This allowed a representative sample that was directly comparable between sites. The number of transect sections on arable sites ranged from two to five, compared to three to seven on solar sites. In total, we surveyed 15 (3 km) transect sections on arable land, 10 (2 km) on simple habitat solar and 13 (2.6 km) on mixed habitat solar.

We estimated the total number of individuals per species for each transect section as the maximum number recorded from the two counts, as is standard for BBS. Where relevant, species were assigned to groups: (i) farmland birds or woodland birds according to the categories used in Defra's wild bird indicators (Eaton & Noble 2023); and (ii) Birds of Conservation Concern (BoCC) status based on Stanbury *et al.* (2021); see Table S1 for a full list of species and groups. For each site we then calculated total abundance across all species and per group.

Each group's response to land-use was modelled using a generalized linear mixed model. The response variable was summed abundance, with land-use category as a three-level fixed effect (arable, simple habitat solar, mixed habitat solar), and site as a random effect. Models were fitted with a negative binomial distribution and fitted abundance values were estimated for each land-use category at the transect section level (4 ha). Models were run per group (all species, BoCC Red-/Amber-listed, farmland birds and woodland birds). This was repeated for species richness, where the response variable was the total number of species recorded on each transect across both visits combined. We evaluated spatial autocorrelation by using the Moran's I statistic. The test revealed no significant spatial autocorrelation (all species abundance: Moran's I = –0.05, $P = 0.62$; all species richness: Moran's I = 0.04, $P = 0.22$; for details see Table S2). Individual species were not modelled, but we report their mean abundance for comparison across the three different land-use classifications.

Results

In total, we recorded 830 individuals from 44 species. Wood Pigeon *Columba palumbus* was the most common, with 152 counted across arable and solar farms, accounting for 18% of all individuals. Across all counts, 15.9% of species (24.5% of individuals) were BoCC Red-listed and 25% of species (38.6% of individuals) were BoCC Amber-listed (see Table S1 for full list of species recorded, their habitat association and BoCC status).

Mean abundance was highest in mixed habitat solar for 34 of the total 44 species, compared to arable and simple habitat solar where the mean abundance was highest for 5.5 and 4.5 species, respectively (scoring ties as 0.5). This overall pattern was statistically significant (Chi-square: $\chi^2 = 38.23$, df = 2, $P < 0.001$; Figure 1). Summed across all species, model-fitted predicted abundance was considerably higher in mixed habitat solar (Figure 2; mean = 35.1 birds per 4 ha; SE ± 6.4) compared to simple habitat solar (mean = 17 ± 4.9) and arable land (mean = 11.9 ± 2.6).

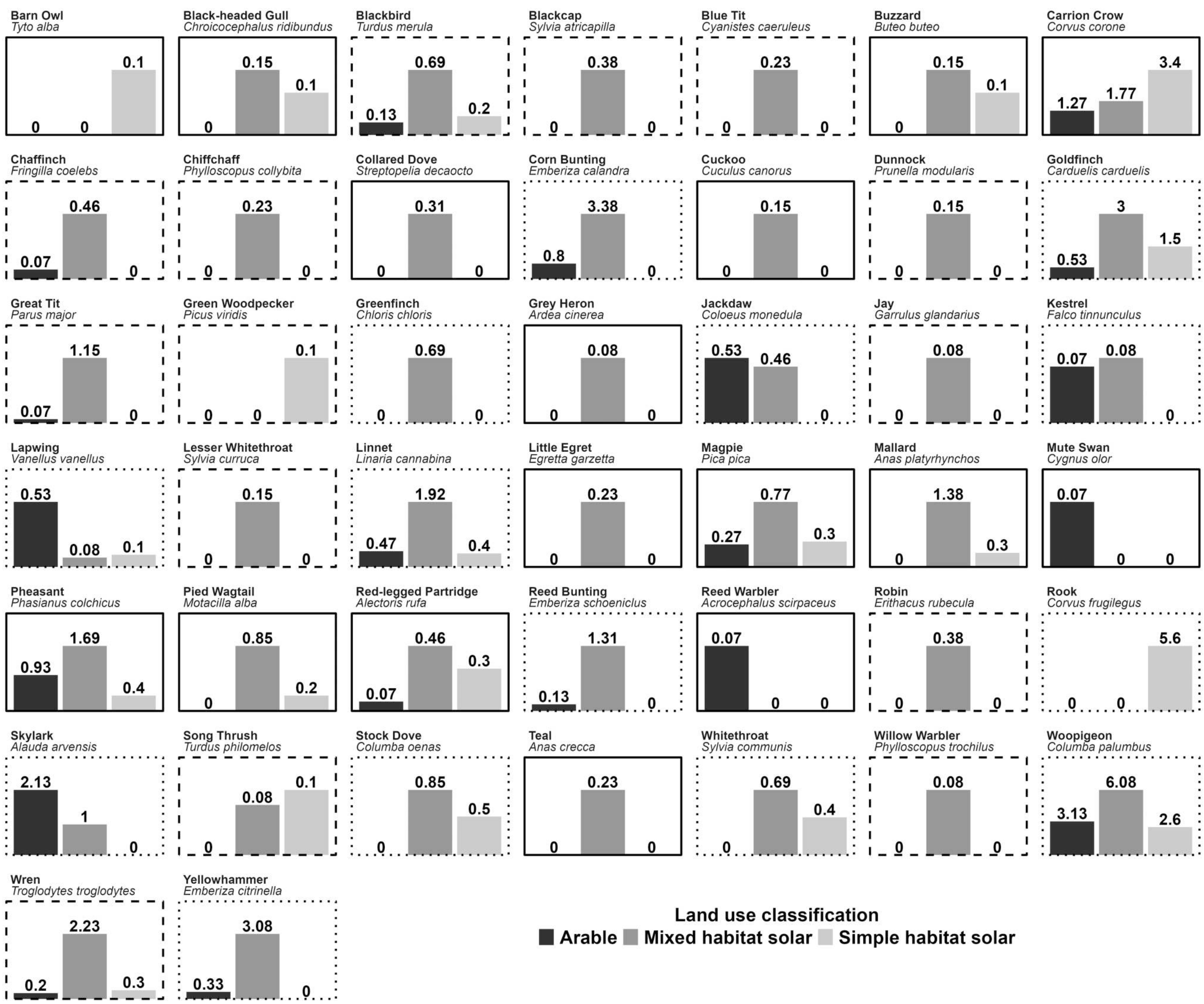

Figure 1. Mean bird abundance per transect section (4 ha) for each individual species recorded across the three different land-use classifications. Dashed border lines indicate woodland birds, while dotted border lines indicate farmland birds, according to Defra's wild bird indicators (Eaton & Noble 2023).

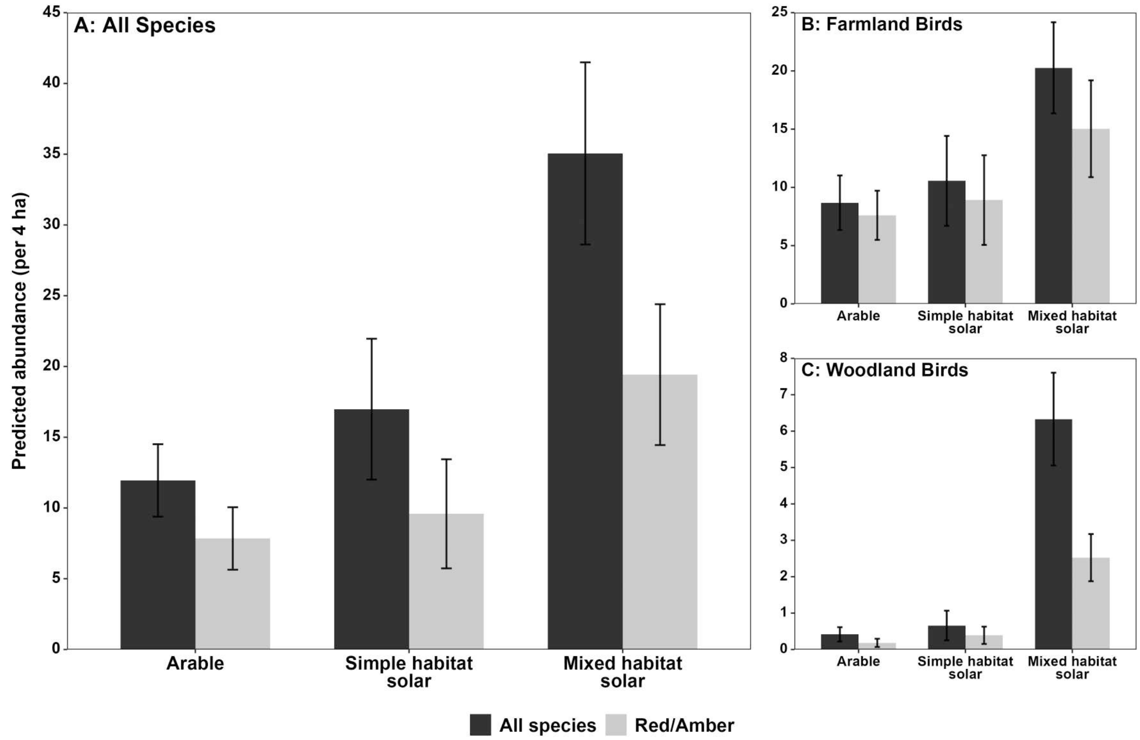

Figure 2. Predicted bird abundance and ± SE per 4 ha for (A) all species; (B) farmland birds; and (C) woodland birds across the three different land-use classifications. Dark bars represent all species and light bars represent Red- and Amber-listed Birds of Conservation Concern, per group.

This trend was also reflected within the farmland and woodland indicator groups, with greater predicted abundance in mixed habitat solar (Table S3; see also Table S4 for a summary of model statistics and Table S5 for model performance).

Differences in abundance of BoCC species between land uses largely mirrored the differences observed for all species. The highest abundance of BoCC species was in mixed habitat solar (mean = 19.4 ± 5; Table S3) and was significantly higher than in arable (mean = 7.8 ± 2.2) and simple habitat solar (mean = 9.6 ± 3.9; $P < 0.001$; Table S4).

Predicted species richness showed a similar response to predicted bird abundance, being highest in mixed habitat solar (Figure S2, mean = 13.5 ± 1.1 species per 4 ha) compared to simple habitat solar (mean = 5.3 ± 0.6) and arable land (mean = 5.5 ± 0.6). This trend was also observed in the farmland and, particularly, woodland indicator groups (Table S3; see Table S6 for a summary of model statistics and Table S5 for model performance).

Discussion

Our findings largely support the work of Montag *et al.* (2016), who observed greater abundance and species richness of multiple taxa, including birds, within solar farms compared to control plots within nearby arable land. Montag *et al.* (2016) suggested this was likely due to solar farms contributing to landscape heterogeneity of diverse flora with structures for cover and perching. Jarcuska *et al.* (2024) and Solar Energy UK (2023) also observed a relationship between solar farm management and bird diversity, likely due to increased floral diversity providing food via seeds and invertebrate prey.

In our results, mixed habitat solar farms appeared to offer greater structural heterogeneity than nearby arable land, and had more individual birds and bird species; on the other hand, simple habitat solar farms apparently offered only marginally greater structural diversity than arable fields, having a similar abundance and richness of birds. In addition to diverse habitat and greater sward length, the mixed habitat solar farms also contained woody features, such as hedgerows or boundary trees, which were the likely cause of the greater abundance of woodland generalists compared to arable and simple habitat solar.

Where our results differ from previous research this is likely due to differences in study design. For example, whilst DeVault *et al.* (2014) examined bird use of solar facilities and found fewer birds in solar farms, only species of a certain biomass were considered due to the study's focus on the risk to aviation. Additionally, their comparator was natural grassland, as was the case in Visser *et al.* (2019), rather than the arable land used in this study, which is the most common land-use context for solar development in the UK. The addition of new grassland habitat in the form of mixed habitat solar, as well as the structural complexity provided by the panels, is likely to be more beneficial in an arable-dominated context than if sites were located in an already grassland-dominated landscape (Hovick *et al.* 2015).

Variation in management across different solar farms also appears to be important for other taxa. Solar farms have been shown to negatively affect the activity of bats (Barré *et al.* 2023, Tinsley *et al.* 2023). However, both these studies focused on solar sites that were situated on grassland that was grazed or mown, or on cut arable crops. Conversely, as we have demonstrated for birds, Blaydes *et al.* (2021, 2022) and Walston *et al.* (2023) demonstrated the importance of mixed habitat management for pollinators. Bumblebee (*Bombus* spp.) foraging and nest density was doubled inside solar farms managed as wildflower meadows compared to those with wildflower margins only (Blaydes *et al.* 2022), and systematically reviewing relevant land management practices reveals that a range of interventions applied to solar farms could increase their ability to enhance pollinator biodiversity (Blaydes *et al.* 2021).

Our results indicate the beneficial effect that solar farm management can have on bird abundance and diversity. This should be considered in the planning and development of new solar energy projects, and in the management of existing solar farms, further outlined by Carvalho *et al.* (2024). Including biodiversity considerations in solar farm planning would allow for complementary generation of electricity and provision of habitat to support bird communities and other wildlife. In this way, we can enhance multifunctionality by stacking multiple benefits together in a system that combines human needs for energy and biodiversity needs for complex habitats.

Our results do not reduce the need to ensure that solar farms are developed away from nature-sensitive areas that are locally, nationally, or internationally important for wildlife. Solar farm proposals should be informed by national and local policy documents, such as local nature recovery strategies in England, the Nature Recovery Plan in Wales and Scotland's forthcoming Biodiversity Strategy to 2045. Whilst field-scale solar is generally incompatible with continued crop production (though see agrivoltaics: Dinesh & Pearce 2016), and care should be taken when siting solar farms on high grade farmland, given potential leakage effects (Don *et al.* 2024), modelling at the national scale suggests that the total land-take of solar farms under future climate mitigation scenarios is likely to be small (Copping *et al.* 2024).

Considering biodiversity needs in solar farm planning would also help address public concerns; Roddis *et al.* (2020) found that the most common concern raised by the public regarding solar farms was the impact on wildlife and habitats. Our findings show that in nature depleted landscapes, like arable farmland, solar farms managed for mixed habitat can increase bird abundance and diversity; this effect has also been observed with other taxa (Blaydes *et al.* 2021, Walston *et al.* 2023). Whilst careful planning is needed to ensure solar farms are sited in suitable areas, if managed with biodiversity in mind then their impact can be beneficial and could provide relief from the effects of agricultural intensification on biodiversity in the surrounding landscape.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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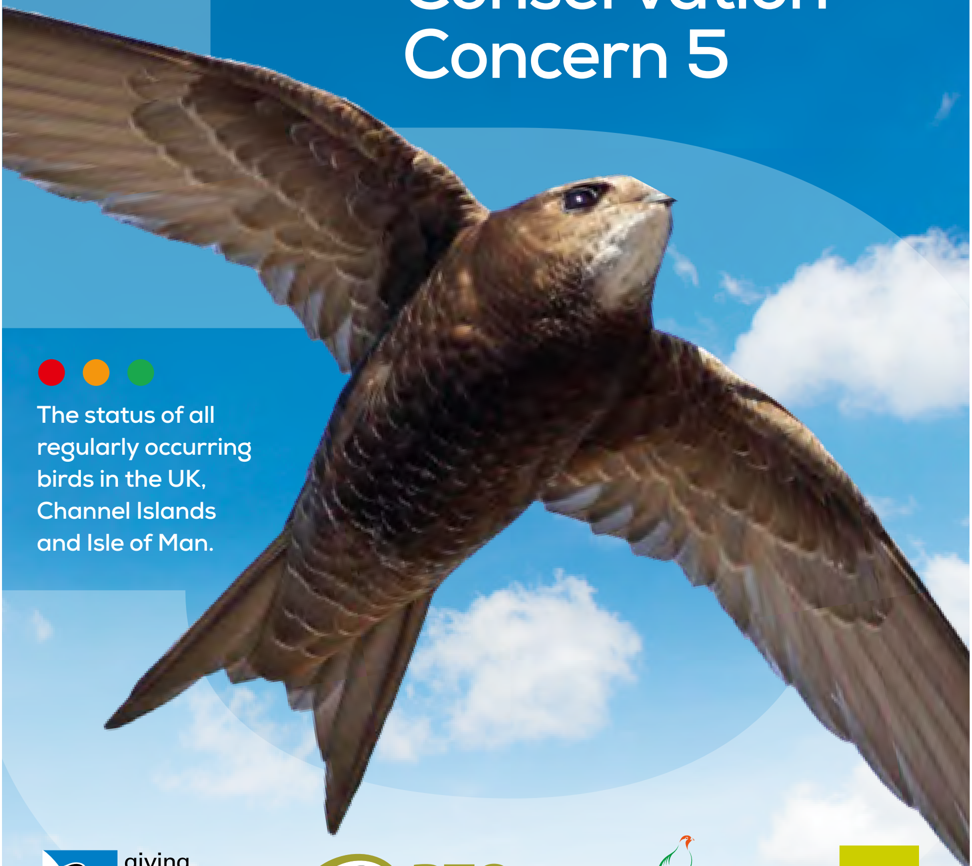
Birds of Conservation Concern 5



The status of all regularly occurring birds in the UK, Channel Islands and Isle of Man.

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NIEA Northern Ireland Environment Agency www.daera-ni.gov.uk

***Birds of Conservation Concern* is compiled by a coalition of the UK's leading bird conservation and monitoring organisations and reviews the status of all regularly occurring birds in the UK, Channel Islands and Isle of Man.**

This is the 5th Birds of Conservation Concern review, with the first published in 1996. The bird species that breed or overwinter here have been assessed against a set of objective criteria and placed on the Green, Amber or Red lists to indicate an increasing level of conservation concern. Data delays prevented an assessment of breeding seabirds (apart from Leach's storm-petrel), so their status was carried over from *Birds of Conservation Concern 4*.

The quantitative criteria assessed the historical decline, recent trends in population and range, population size, localisation and international importance of each species, as well as its global and European threat status.

The assessments show that the status of UK bird populations continues to decline. Since the last review in 2015, the golden oriole has been lost as a breeding species. In addition, the length of the Red list has grown by three; 11 species have been added, but six have moved to Amber and two are now no longer assessed as they have either ceased breeding in the UK or were excluded from the process for other reasons. The length of the Amber list has also grown by seven species.

The Birds of Conservation Concern 5 Red list

Grey partridge	Lapwing	Grasshopper warbler
Ptarmigan [g]	Whimbrel	House martin [a]
Capercaillie	Curlew	Wood warbler
Black grouse	Black-tailed godwit	Starling
Bewick's swan [a]	Ruff	Mistle thrush
White-fronted goose	Dunlin [a]	Fieldfare
Long-tailed duck	Purple sandpiper [a]	Ring ouzel
Velvet scoter	Woodcock	Spotted flycatcher
Common scoter	Red-necked phalarope	Nightingale
Goldeneye [a]	Kittiwake	Whinchat
Smew [a]	Herring gull	House sparrow
Pochard	Roseate tern	Tree sparrow
Scaup	Arctic skua	Tree pipit
Red-necked grebe	Puffin	Yellow wagtail
Slavonian grebe	Hen harrier	Hawfinch
Turtle dove	Montagu's harrier [a]	Greenfinch [g]
Swift [a]	Lesser spotted woodpecker	Twite
Cuckoo	Merlin	Linnet
Corncrake	Red-backed shrike	Redpoll
Leach's storm-petrel [a]	Marsh tit	Corn bunting
Balearic shearwater	Willow tit	Cirl bunting
Shag	Skylark	Yellowhammer
Dotterel	Marsh warbler	
Ringed plover	Savi's warbler	

a - species on the Amber list previously, g - species on the Green list previously

The Birds of Conservation Concern 5 Amber list

Quail	Stone-curlew	Tawny owl
Whooper swan	Oystercatcher	Osprey
Brent goose	Avocet	Honey-buzzard
Barnacle goose	Black-winged stilt [na]	Marsh harrier
Greylag goose	Grey plover	Sparrowhawk [g]
Bean goose	Bar-tailed godwit	White-tailed eagle [r]
Pink-footed goose	Turnstone	Kestrel
Eider	Knot	Rook [g]
Red-breasted merganser [g]	Curlew sandpiper	Shorelark
Shelduck	Sanderling	Sedge warbler [g]
Garganey	Snipe	Yellow-browed warbler [na]
Shoveler	Common sandpiper	Willow warbler
Gadwall	Green sandpiper	Common whitethroat [g]
Wigeon	Spotted redshank	Dartford warbler
Mallard	Greenshank	Short-toed treecreeper
Pintail	Redshank	Wren [g]
Teal	Wood sandpiper	Dipper
Black-necked grebe	Black-headed gull	Song thrush [r]
Stock dove	Mediterranean gull	Redwing [r]
Woodpigeon [g]	Common gull	Pied flycatcher [r]
Nightjar	Lesser black-backed gull	Black redstart [r]
Spotted crake	Yellow-legged gull	Common redstart
Moorhen [g]	Caspian gull	Wheatear [g]
Crane	Iceland gull	Dunnock
Black-throated diver	Glaucous gull	Meadow pipit
Great northern diver	Great black-backed gull	Water pipit
European storm-petrel	Little tern	Grey wagtail [r]
Northern fulmar	Common tern	Bullfinch
Manx shearwater	Arctic tern	Parrot crossbill
Spoonbill	Sandwich tern	Scottish crossbill
Bittern	Great skua	Lapland bunting
Little bittern [na]	Black guillemot	Snow bunting
Cattle egret [na]	Razorbill	Reed bunting
Great white egret [na]	Guillemot	
Gannet	Short-eared owl	

r - species on the Red list previously, g - species on the Green list previously, na - not assessed previously

Birds of Conservation Concern 5 Former breeding species

Great bustard	Black tern	Wryneck
Kentish plover	Great auk	Golden oriole [r]
Temminck's stint	Snowy owl	Serin

r - species on the Red list previously

Themes from Birds of Conservation Concern 5

This assessment adds to a wealth of existing evidence that shows many of our bird populations are in trouble. At 70 species, the Red list is now longer than ever before, and is almost double the length of that in the first review in 1996. New Red-listed species include swift, house martin, ptarmigan, purple sandpiper, Montagu's harrier and greenfinch.

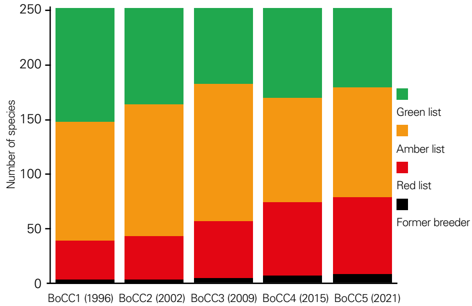
Previous reviews have highlighted the worrying plight of farmland, woodland and upland birds. There has been no improvement in the overall status of species associated with farmland and upland; indeed, more species have been Red-listed.

The status of long-distance Afro-Palearctic migrants that spend the non-breeding season in sub-Saharan Africa, particularly the humid tropics, continues to decline.

We also raise concerns over the status of our wintering wildfowl and wader populations, with Bewick's swan, goldeneye, smew and dunlin also joining the Red list. Pressures are wide-ranging and are complicated by 'short-stopping', whereby species have shifted their wintering grounds north-eastwards in response to increased temperatures caused by climate change.

There is also a worrying trend towards more of the UK's regularly occurring species being classed as threatened with global extinction; with the addition of Leach's storm-petrel and kittiwake, this increases the list to nine bird species.

It is not all bad news. Thanks to successful reintroduction projects, the white-tailed eagle



moves from the Red to Amber list. Song thrush, pied flycatcher, grey wagtail, redwing and black redstart also moved off the Red list to Amber, but the first three species remain close to the Red list threshold.

The UK has seen continued colonisation by new bird species, and we added four new breeding species (great white egret, cattle egret, little bittern and black-winged stilt) and one non-breeding species (yellow-browed warbler) to this review. While we welcome these additions to our wildlife, we should simultaneously recognise that the arrival of new species here owes much to man-induced climate change.

The full details of this assessment, including the Green list, can be found at Stanbury, A., Eaton, M., Aebischer, N., Balmer, D., Brown, A., Douse, A., Lindley, P., McCulloch, N., Noble, D., and Win I. 2021. The status of our bird populations: the fifth Birds of Conservation Concern in the United Kingdom, Channel Islands and Isle of Man and second IUCN Red List assessment of extinction risk for Great Britain. British Birds 114: 723-747. Available online at **https://britishbirds.co.uk/content/status-our-bird-populations**.

Endorsed by:

BirdLife International · BOU · British Birds · National Trust · RBBP Rare Breeding Birds Panel · the Seabird Group · SOC · WOS CAC · The Wildlife Trusts · WWT

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APEP 4

Population estimates of birds in Great Britain and the United Kingdom

BTO · Game & Wildlife Conservation Trust · JNCC · rspb giving nature a home · WWT

INTRODUCTION & APPROACH

Population estimates of birds have many applications in conservation and ecological research, as well as being of significant public interest. This is a summary of the fourth report by the Avian Population Estimates Panel, following those in 1997, 2006 and 2013, presenting population estimates of birds in Great Britain and the United Kingdom.

INTRODUCTION

Knowing the absolute number of birds in a population is of particular importance to those who make decisions about conservation policy and engage in site management. It can be difficult to produce robust estimates of population size; firstly because numbers fluctuate from year to year – or even from month to month – as individuals breed, die and migrate; and secondly, because for all but the scarcest species it is usually impossible to carry out a full census (i.e. count every individual) and we have to rely on surveys from which estimates of population size can be derived.

Estimates of population size are a key conservation tool, used alongside population trend information and that on other aspects of bird ecology (such as survival and productivity rates). Although trends over time are particularly valuable for assessing the status of species and biodiversity for many conservation purposes, knowledge of the absolute size of an animal population is also needed to fully understand threats to that species, to evaluate the risk of extinction and to make decisions about how to protect it.

The European Union (EU) Directive on the conservation of wild birds requires Member States to report on the status of native bird species every six years. This report includes an assessment of species population status (population sizes and distributions, and changes in these parameters over time).

The Avian Population Estimates Panel (APEP) is a collaboration between the UK statutory conservation agencies and relevant non-governmental organisations. Three previous APEP assessments have been published APEP 1 (Stone *et al.* 1997), APEP 2 (Baker *et al.* 2006) and APEP 3 (Musgrove *et al.* 2013).

This report (APEP 4) presents the most recent estimates for both Great Britain and the United Kingdom. Most of these estimates were submitted, together with other data and information, as part of the UK's Article 12 report to the EU in September 2019 (JNCC 2019).

APPROACH

The role of APEP is to collate the best estimates of breeding and non-breeding bird population size and present a consensus view on the most appropriate estimates for relevant conservation applications, such as defining thresholds for statutory site designations. Most estimates are for the breeding season. Breeding estimates are presented for all species included in APEP 3 and for additional species (including non-natives) with at least one case of proven breeding from 2011 onwards.

Non-breeding season estimates for winter visitors are included only for waterbirds and a small number of other species included in APEP 3. In general, non-breeding estimates have been omitted for largely resident species, even where resident populations are supplemented in winter by large-scale arrivals, except for waterbirds where statutory site protection and reporting is based around non-breeding estimates. Estimates of passage numbers have been excluded, with the exception of the globally threatened Aquatic Warbler.

The table that makes up the bulk of this summary reports the population estimates of full species listed in categories A–C of the British List. Each estimate is accompanied by the following information:

- **Season**: B = Breeding; P = Passage; W = Wintering.
- **Unit** (of measurement): AOS = Apparently Occupied Sites; F = females; I = individuals; M = males; N = nests; P = pairs; T = territories.
- The **estimate** may be presented as a single figure or a range is given; in some cases a mean with 95% confidence intervals in parentheses is shown. Estimates tagged '+' or '-' are known to be larger (+) or smaller (-) than the estimate listed, but no better estimate is available.
- **Date** is the date/period to which the UK estimate relates.

Dipper, by Edmund Fellowes / BTO. Dipper population size was based on the 1988–91 Bird Atlas estimate, extrapolated using the Waterways Breeding Bird Surveys.

Species name	Season	Unit	GB Estimate	UK Estimate	UK Date
Capercaillie	W	I	1,100	1,100	2015/16
Black Grouse	B	M	4,850	4,850	2016
Ptarmigan	B	P	(2,000–15,000)	(2000–15,000)	2007
Red Grouse	B	P	265,000	265,000	2016
Red-legged Partridge	B	T	72,500	72,500	2016
Grey Partridge	B	T	37,000	37,000	2016
Quail	B	M	350	355	2013–17
Pheasant	B	F	2,300,000	2,350,000	2016
Golden Pheasant	B	M	15	15	2010–14
Lady Amherst's Pheasant	B	M	0	0	2016
Brent Goose	W	I	105,000	135,000	2012/13–2016/17
Canada Goose	B	P	54,000	54,500	2013–17
	W	I	160,000	165,000	2012/13–2016/17
Barnacle Goose	B	P	1,450	1,550	2012–15
	W	I	105,000	105,000	–
Snow Goose	B	P	2^{+}	2^{+}	2010–14
	W	I	75	75	2011/12–2015/16
Greylag Goose	B	P	47,000	47,000	2013–17
	W	I	230,000	230,000	2012/13–2016/17
Taiga Bean Goose	W	I	230	230	2016/17–2017/18
Pink-footed Goose	W	I	510,000^{-}	510,000^{-}	2015–16
Tundra Bean Goose	W	I	300	300	2011/12–2014/15
White-fronted Goose	B	P	(0–1)	(0–1)	2013–17
	W	I	13500	14,000	–
Mute Swan	B	P	6,500 (5,850–7,100)	7,000 (6,300–7,600)	2016
	W	I	50,500	52,500	2012/13–2016/17
Bewick's Swan	W	I	4,350	4350	2015
Whooper Swan	B	P	24	28	2013–17
	W	I	16,000	19,500	2015
Egyptian Goose	B	P	1,850	1,850	2013–17
	W	I	5,600	5,600	2012/13–2016/17
Shelduck	B	P	7,600^{+}	7,850^{+}	2016
	W	I	47,000	51,000	2012/13–2016/17
Mandarin Duck	B	P	4,400^{+}	4,400^{+}	2007–11
	W	I	13,500	13,500	2007–11
Garganey	B	P	105	105	2013–17
Shoveler	B	P	1,100	1,100	2013–17
	W	I	19,000	19,500	2012/13–2016/17
Gadwall	B	P	(1,250–3,150)$^{+}$	(1,250–3,200)$^{+}$	2016
	W	I	31,000	31,000	2012/13–2016/17
Wigeon	B	P	200^{+}	200^{+}	2013–17
	W	I	445,000	450,000	2012/13–2016/17
American Wigeon	W	I	17	18	2012/13–2016/17
Mallard	B	P	(59,000–140,000)$^{+}$	(61,000–145,000)$^{+}$	2016
	W	I	665,000	675,000	2012/13–2016/17
Pintail	B	P	27	27	2013–17
	W	I	19,500	20,000	2012/13–2016/17
Teal	B	P	(2,700–4,750)	(2,700–4,750)	2016
	W	I	430,000	435,000	2012/13–2016/17
Green-winged Teal	W	I	32	34	2012/13–2016/17
Red-crested Pochard	B	P	39 (20–47)$^{+}$	39 (20–47)$^{+}$	2010–14
	W	I	570	570	2012/13–2016/17

Species name	Season	Unit	GB Estimate	UK Estimate	UK Date
Pochard	B	P	695	720	2013–17
	W	I	23,000	29,000	2012/13–2016/17
Ferruginous Duck	W	I	8	9	2012/13–2016/17
Ring-necked Duck	W	I	16	18	2012/13–2016/17
Tufted Duck	B	P	(16,000–18,000)	(16,500–19,000)	2016
	W	I	130,000	140,000	2012/13–2016/17
Scaup	B	P	(0–1)	(0–1)	2013–17
	W	I	3,900^{+}	6,400^{+}	2011/12–2014/15
Eider	B	P	36,000	37,000	2012–15
	W	I	81,500	86,000	2011/12–2014/15
Surf Scoter	W	I	23	24	2012/13–2016/17
Velvet Scoter	W	I	3,350^{+}	3,350^{+}	2011/12–2014/15
Common Scoter	B	P	52	52	2007
	W	I	135,000^{+}	135,000^{+}	2011/12–2014/15
Long-tailed Duck	W	I	13,500^{+}	13,500^{+}	2011/12–2014/15
Goldeneye	B	F	200	200	2006 – 2010
	W	I	18,500	21,000	2012/13–2016/17
Smew	W	I	125	125	2012/13–2016/17
Goosander	B	P	4,800 (4,250–5,250)$^{+}$	4,800 (4,250–5,250)$^{+}$	2016
	W	I	14,500	14,500	2012/13–2016/17
Red-breasted Merganser	B	P	1,550 (1,350–1,750)$^{+}$	1,650^{+}	2008–11
	W	I	10,500	11,000	2012/13–2016/17
Ruddy Duck	B	P	(2–3)	(2–3)	2017
	W	I	23	23	2016
Nightjar	B	M	4,600 (3,700–5,500)	4,600 (3,700–5,500)	2004
Swift	B	P	59,000 (43,000–75,000)$^{+}$	59,000 (43,000–75,000)$^{+}$	2016
Great Bustard	B	P	4	4	2013–17
Cuckoo	B	P	17,000 (8,950–24,500)$^{+}$	18,000 (9,800–26,000)$^{+}$	2016
Rock Dove	B	P	460,000 (375,000–545,000)	465,000 (380,000–550,000)	2016
Stock Dove	B	T	320,000	320,000	2016
Woodpigeon	B	P	5,050,000 (4,750,000–5,350,000)	5,150,000 (4,850,000–5,450,000)	2016
Turtle Dove	B	T	3,600	3,600	2016
Collared Dove	B	P	795,000 (715,000–875,000)	810,000 (730,000–890,000)	2016
Water Rail	B	T	3,900^{+}	3,900^{+}	2016-17
Corncrake	B	M	1,100	1,100	2013–17
Baillon's Crake	B	M	(0–6)	(0–6)	2012
Spotted Crake	B	M	27	27	2013–17
Moorhen	B	T	200,000	210,000	2016
	W	I	300,000	305,000	2012/13–2016/17
Coot	B	P	25,500^{+}	26,000^{+}	2016
	W	I	200,000	205,000	2012/13–2016/17
Crane	B	P	31	31	2013–17
	W	I	175	175	2017/18
Little Grebe	B	P	(3,300–6,650)	(3,650–7,300)	2016
	W	I	15,000	15,500	2012/13–2016/17
Red-necked Grebe	B	P	(0–1)	(0–1)	2013–17
	W	I	59	60	2011/12–2014/15
Great Crested Grebe	B	P	4,300^{+}	4,900^{+}	2016
	W	I	16,500	18,000	2012/13–2016/17
Slavonian Grebe	B	P	28	28	2013–17
	W	I	920	995	2011/12–2014/15

Species name	Season	Unit	GB Estimate	UK Estimate	UK Date
Black-necked Grebe	B	P	55	55	2013–17
	W	I	115	115	2012/13–2016/17
Stone-curlew	B	P	365+	365+	2013–17
Oystercatcher	B	P	92,500	95,500	2016
	W	I	285,000	305,000	2012/13–2016/17
Black-winged Stilt	B	P	3 (0–6)	3 (0–6)	2013–17
Avocet	B	P	1,950	1,950	2013–17
	W	I	8,700	8,700	2012/13–2016/17
Lapwing	B	P	96,500	97,500	2016
	W	I	620,000	635,000	2006/07
Golden Plover	B	P	(32,500–50,500)	(32,500–50,500)	2016
	W	I	400,000	410,000	2006/07
Grey Plover	W	I	33,500	33,500	2012/13–2016/17
Ringed Plover	B	P	5,300 (5,100–5,500)	5,450 (5,250–5,600)	2007
	W	I	41,500	42,500	2012/13–2016/17
Little Ringed Plover	B	P	1,250 (1,200–1,300)	1,250 (1,200–1,300)	2007
Dotterel	B	M	425 (280–645)	425 (280–645)	2011
Whimbrel	B	P	310	310	2009
	W	I	38	41	2012/13–2016/17
Curlew	B	P	58,000	58,500	2016
	W	I	120,000	125,000	2012/13–2016/17
Bar-tailed Godwit	W	I	50,500	53,500	2012/13–2016/17
Black-tailed Godwit	B	P	53	53	2013–17
	W	I	39,000	41,000	2012/13–2016/17
Turnstone	W	I	40,000	43,000	2012/13–2016/17
Knot	W	I	265,000	265,000	2012/13–2016/17
Ruff	B	F	13	13	2013–17
	W	I	895	920	2012/13–2016/17
Temminck's Stint	B	P	0	0	2013–17
Sanderling	W	I	20,000	20,500	2012/13–2016/17
Dunlin	B	P	(8,600–10,500)	(8,600–10,500)	2005–07
	W	I	345,000	350,000	2012/13–2016/17
Purple Sandpiper	B	P	1	1	2013–17
	W	I	9,700	9,900	2012/13–2016/17
Little Stint	W	I	8	8	2012/13–2016/17
Woodcock	B	M	55,000 (42,000–69,000)	57,000 (43,000–71,000)	2016
	W	I	1,400,000	1,400,000	2003/04
Jack Snipe	W	I	100,000	110,000	2004/5
Snipe	B	P	64,500	66,500	2016
	W	I	1,000,000	1,100,000	2004/5
Red-necked Phalarope	B	M	64	64	2013–17
Common Sandpiper	B	P	13,000	13,000	2016
	W	I	52	52	2012/13–2016/17
Green Sandpiper	B	P	2	2	2013–17
	W	I	290	290	2011/12–2014/15
Redshank	B	P	22,000	22,000	2016
	W	I	94,500	100,000	2012/13–2016/17
Wood Sandpiper	B	P	30	30	2013–17
Spotted Redshank	W	I	67	68	2012/13–2016/17
Greenshank	B	P	1,100+	1,100+	1995
	W	I	810	920	2012/13–2016/17
Kittiwake	B	P	195,000 (170,000–250,000)	205,000 (175,000–255,000)	2015

Species name	Season	Unit	GB Estimate	UK Estimate	UK Date
Black-headed Gull	B	P	130,000^{+}	140,000^{+}	1998–2002
	W	I	2,200,000 (2,100,000–2,200,000)$^{+}$	2,200,000 (2,100,000–2,300,000)$^{+}$	2003/04–2005/06
Mediterranean Gull	B	P	1200^{+}	1,200^{+}	2013–17
	W	I	4,000	4,000	2011/12–2014/15
Common Gull	B	P	48,000	48,500	1998–2002
	W	I	700,000 (670,000–720,000)$^{+}$	710,000 (680,000–730,000)$^{+}$	2003/04–2005/06
Ring-billed Gull	W	I	17	21	2012/13–2016/17
Great Black-backed Gull	B	P	15,000 (7,200–19,000)$^{-}$	15,000 (7,200–19,000)$^{-}$	2015
	W	I	76,000 (71,000–81,000)$^{+}$	77,000 (72,000–82,000)$^{+}$	2003/04–2005/06
Glaucous Gull	W	I	155^{+}	165^{+}	2011/12–2015/16
Iceland Gull	W	I	330^{+}	355^{+}	2011/12–2015/16
Herring Gull	B	P	130,000^{-}	130,000^{-}	1998–2002
	W	I	730,000 (700,000–760,000)$^{+}$	740,000 (710,000–780,000)$^{+}$	2003/04–2005/06
Caspian Gull	W	I	125	125	2011/12–2014/15
Yellow-legged Gull	B	P	2	2	2013–17
	W	I	840	840	2011/12–2014/15
Lesser Black-backed Gull	B	P	110,000^{-}	110,000^{-}	1998–2002
	W	I	120,000 (120,000–130,000)$^{+}$	130,000 (120,000–130,000)$^{+}$	2003/04–2005/06
Sandwich Tern	B	P	12,500 (11,500–14,000)	14,000 (13,000–15,000)	2015
	W	I	53	65	2011/12–2014/15
Little Tern	B	P	1,450	14,50	2013–17
Roseate Tern	B	P	100	100	2013–17
Common Tern	B	P	9,600 (7,550–11,500)	11,000 (8,900–13,500)	2015
Arctic Tern	B	P	52,500	53,500	2000
Great Skua	B	P	9,650^{+}	9,650^{+}	1998–2002
Arctic Skua	B	P	785 (535–1550)	785 (535–1550)	2015
Common Guillemot	B	P	885,000	950,000	1998–2002
Razorbill	B	P	140,000 (93,000–215,000)	165,000 (100,000–250,000)	2015
Black Guillemot	B	P	19,000	19,500	1998–2003
Puffin	B	P	580,000^{-}	580,000^{-}	1998–2002
Red-throated Diver	B	P	1,250 (1,000–1,550)	1,250 (1,000–1,550)	2006
	W	I	21,500^{+}	21,500^{+}	2011/12–2014/15
Black-throated Diver	B	P	215 (190–250)	215 (190–250)	2006
	W	I	560^{+}	560^{+}	2004/05 – 2008/09
Great Northern Diver	W	I	4,350^{+}	4,400^{+}	2015/16
White-billed Diver	W	I	80^{+}	80^{+}	2010-12
Storm Petrel	B	AOS	25,500 (21,000–33,500)	25,500 (21,000–33,500)	1998–2002
Leach's Petrel	B	P	48,000 (36,500–65,000)	48,000 (36,500–65,000)	1998–2002
Fulmar	B	P	350,000 (195,000–680,000)	350,000 (195,000–680,000)	2015
Manx Shearwater	B	P	295,000 (280,000–315,000)	300,000 (280,000–320,000)	1998–2002
Gannet	B	N	295,000	295,000	2013–14
Shag	B	P	17,500 (13,500–20,500)	17,500 (13,500–20,500)	2015
	W	I	110,000^{+}	110,000^{+}	1998–2002
Cormorant	B	P	8,200	8,900	1998–2002
	W	I	62,000^{+}	64,500^{+}	2012/13–2016/17
Glossy Ibis	W	I	27	27	2011/12–2014/15
Spoonbill	B	P	29	29	2017
	W	I	105	105	2011/12–2014/15
Bittern	B	M	191^{+}	191^{+}	2017
	W	I	795	795	2017/18
Little Bittern	B	M	5	5	2013–17
Night-heron	B	P	(0–1)	(0–1)	2013–17

Species name	Season	Unit	GB Estimate	UK Estimate	UK Date
Cattle Egret	B	P	(10–15)	(10–15)	2017
	W	I	65	66	2011/12–2014/15
Grey Heron	B	P	9,950	10,500 (10,000–11,000)	2013–17
	W	I	45,000	45,500	2012/13–2016/17
Purple Heron	B	P	0	0	2013–17
Great White Egret	B	P	(8–12)	(8–12)	2017
	W	I	72	72	2011/12–2014/15
Little Egret	B	P	1,100+	1,100+	2013–17
	W	I	11,500	11,500	2012/13–2016/17
Osprey	B	P	240+	240+	2013–17
Honey-buzzard	B	P	(33–69)	(33–69)	2000
Golden Eagle	B	P	510	510	2015
Sparrowhawk	B	P	28,500	30,500	2016
Goshawk	B	P	620+	620+	2013–17
Marsh Harrier	B	P	(590–695)	(590–695)	2016
Hen Harrier	B	P	500	545	2016
Montagu's Harrier	B	P	8	8	2013–17
Red Kite	B	P	4,350	4,400	2016
White-tailed Eagle	B	P	122+	123+	2017
Rough-legged Buzzard	W	I	29	29	2012/13–2016/17
Buzzard	B	P	(61,500–85,000)	(63,000–87,500)	2016
Barn Owl	B	P	(4,000–14,000)	(4,000–14,000)	2016
Tawny Owl	B	P	50,000	50,000	2005
Little Owl	B	P	3,600 (2,350–4,900)	3,600 (2,350–4,900)	2016
Long-eared Owl	B	P	(1,600–5,300)	(1,800–6,000)	2007–11
Short-eared Owl	B	P	(610–2,150)	(620–2,200)	2007–11
Kingfisher	B	P	(3,650–6,100)	(3,850–6,400)	2016
Bee-eater	B	P	1 (0–3)	1 (0–3)	2013–17
Wryneck	B	P	0	0	2013–17
Lesser Spotted Woodpecker	B	P	(600–1,000)	(600–1,000)	2015
Great Spotted Woodpecker	B	P	130,000 (120,000–145,000)	130,000 (120,000–145,000)	2016
Green Woodpecker	B	P	45,500 (40,500–50,500)	45,500 (40,500–50,500)	2016
Kestrel	B	P	30,000	31,000	2016
Merlin	B	P	1,150 (850–1,450)	1,150 (890–1,450)	2008
Hobby	B	P	2,050	2,050	2016
Peregrine	B	P	1,650 (1,500–1,800)	1,750 (1,600–1,900)	2014
Rose-ringed Parakeet	B	P	12,000	12,000	2016
Red-backed Shrike	B	P	3	3	2013–17
Great Grey Shrike	W	I	98	98	2012/13–2016/17
Golden Oriole	B	M	0 (0–2)	0 (0–2)	2013–17
Jay	B	T	16,5000	170,000	2016
Magpie	B	T	550,000	610,000	2016
Chough	B	P	330	335	2014–15
	W	I	1,250	1250	2014/15
Jackdaw	B	P	1,450,000 (1,300,000–1,650,000)	1,550,000 (1,350,000–1,750,000)	2016
Rook	B	P	885,000 (775,000–1,000,000)	980,000 (865,000–1,100,000)	2016
Carrion Crow	B	T	1,050,000	1,050,000	2016
Hooded Crow	B	T	185,000	285,000	2016
Raven	B	P	9,500+	10,000+	2016
Waxwing	W	I	9,750	10,000	2012/13–2016/17
Coal Tit	B	T	590,000	660,000	2016
Crested Tit	B	P	(1,000–2,000)	(1,000–2,000)	2007

Species name	Season	Unit	GB Estimate	UK Estimate	UK Date
Marsh Tit	B	T	28,500	28,500	2016
Willow Tit	B	P	$2,750^{-}$	$2,750^{-}$	2016
Blue Tit	B	T	3,250,000	3,400,000	2016
Great Tit	B	T	2,200,000	2,350,000	2016
Bearded Tit	B	P	695	695	2013–17
Woodlark	B	P	2,300 (1,850–2,750)	2,300 (1,850–2,750)	2016
Skylark	B	T	1,500,000	1,550,000	2016
Shore Lark	W	I	110	110	2012/13–2016/17
Sand Martin	B	N	(64,500–210,000)	(70,500–225,000)	2016
Swallow	B	T	625,000	705,000	2016
House Martin	B	P	470,000 (330,000–610,000)	480,000 (335,000–620,000)	2016
Cetti's Warbler	B	M	$3,450^{+}$	$3,450^{+}$	2016
Long-tailed Tit	B	T	370,000	380,000	2016
Wood Warbler	B	M	6,500 (6,000–7,050)	6,500 (6,000–7,050)	2016
Yellow-browed Warbler	W	I	25	25	2012/13–2016/17
Willow Warbler	B	T	2,050,000	2,300,000	2016
Chiffchaff	B	T	1,650,000	1,750,000	2016
Iberian Chiffchaff	B	P	(0–1)	(0–1)	2013–17
Aquatic Warbler	A	I	3^{+}	3^{+}	2013–17
Sedge Warbler	B	T	220,000	240,000	2016
Reed Warbler	B	P	$130,000 (100,000–155,000)^{+}$	$130,000 (100,000–155,000)^{+}$	2016
Marsh Warbler	B	P	8	8	2013–17
Icterine Warbler	B	P	(0–2)	(0–2)	2013–17
Grasshopper Warbler	B	T	9,750	12,000	2016
Savi's Warbler	B	P	5	5	2013–17
Blackcap	B	T	1,600,000	1,650,000	2016
Garden Warbler	B	T	145,000	145,000	2016
Lesser Whitethroat	B	T	79,000	79,000	2016
Whitethroat	B	T	1,100,000	1,100,000	2016
Dartford Warbler	B	P	2,200	2,200	2017
Firecrest	B	T	$2,000^{+}$	$2,000^{+}$	2017
Goldcrest	B	T	675,000	790,000	2016
Wren	B	T	9,750,000	11,000,000	2016
Nuthatch	B	T	250,000	250,000	2016
Treecreeper	B	T	210,000	225,000	2016
Starling	B	P	1,650,000 (1,450,000–1,800,000)	1,750,000 (1,550,000–1,950,000)	2016
Ring Ouzel	B	P	7,300 (5,550–9,400)	7,300 (5,550–9,400)	2016
Blackbird	B	P	4,850,000 (4,600,000–5,050,000)	5,050,000 (4,800,000–5,250,000)	2016
Fieldfare	B	P	(0–1)	(0–1)	2013–17
	W	I	680,000	720,000	1981–84
Redwing	B	P	24	24	2013–17
	W	I	650,000	690,000	1981–84
Song Thrush	B	T	1,200,000	1,300,000	2016
Mistle Thrush	B	T	150,000	165,000	2016
Spotted Flycatcher	B	T	38,500	41,500	2016
Robin	B	T	6,650,000	7,350,000	2016
Bluethroat	B	P	(0–1)	(0–1)	2013–17
Nightingale	B	M	5,550 (5,100–6,000)	5,550 (5,100–6,000)	2012
Pied Flycatcher	B	P	(22,000–25,000)	(22,000–25,000)	2016
Black Redstart	B	P	58	58	2013–17
	W	I	400	400	1981–84
Redstart	B	P	135,000 (97,000–170,000)	135,000 (97,000–170,000)	2016

Species name	Season	Unit	GB Estimate	UK Estimate	UK Date
Whinchat	B	P	49,500 (19,500–79,000)	49,500 (19,500–79,000)	2016
Stonechat	B	P	61,000 (39,500–83,000)	65,000 (43,000–87,000)	2016
Wheatear	B	P	165,000 (115,000–220,000)	170,000 (120,000–220,000)	2016
Dipper	B	P	(6,350–19,000)	(6,900–20,500)	2016
House Sparrow	B	P	5,150,000 (4,650,000–5,650,000)	5,300,000 (4,800,000–5,750,000)	2016
Tree Sparrow	B	T	225,000	245,000	2016
Dunnock	B	T	2,350,000	2,500,000	2016
Yellow Wagtail	B	T	19,500	19,500	2016
Grey Wagtail	B	P	33,500	37,000	2016
Pied Wagtail	B	P	495,000 (435,000–560,000)	505,000 (445,000–570,000)	2016
Meadow Pipit	B	P	2,250,000 (1,950,000–2,550,000)	2,450,000 (2,100,000–2,750,000)	2016
Tree Pipit	B	P	105,000 (66,000–145,000)	105,000 (66,000–145,000)	2016
Water Pipit	W	I	205	205	2012/13–2016/17
Rock Pipit	B	P	34,000	36,000	1988–1991
Chaffinch	B	T	4,800,000	5,050,000	2016
Brambling	B	P	(0–1)	(0–1)	2013–17
	W	I	(45,000–1,800,000)	(45,000–1,800,000)	1981–84
Hawfinch	B	P	(500–1000)	(500–1,000)	2011
Bullfinch	B	T	225,000	265,000	2016
Greenfinch	B	P	760,000 (710,000–810,000)	785,000 (735,000–835,000)	2016
Twite	B	P	7,800 (5,800–10,000)	7,850 (5,850–10,000)	2013
Linnet	B	T	530,000	560,000	2016
Common Redpoll	B	P	12	12	2013–17
	W	I	335	335	2012/13–2016/17
Lesser Redpoll	B	P	220,000	260,000	2016
Arctic Redpoll	W	I	9	11	2012/13–2016/17
Parrot Crossbill	B	P	65	65	2008
Scottish Crossbill	B	P	6,800 (4,050–11,500)	6,800 (4,050–11,500)	2008
Crossbill	B	P	25,000 (19,000–33,000)	26,000 (19,500–34,000)	2016
Goldfinch	B	P	1,600,000 (1,400,000–1,750,000)	1,650,000 (1,450,000–1,800,000)	2016
Serin	B	P	0	0	2013–17
Siskin	B	P	430,000	445,000	2016
Lapland Bunting	B	P	(0–1)	(0–1)	2013–17
	W	I	310	310	2012/13–2016/17
Snow Bunting	B	T	60 (48–83)	60 (48–83)	2011
	W	I	(9,000–13,500)	(10,000–15,000)	1981–84
Corn Bunting	B	T	11,000 (9,050–13,000)	1,1000 (9,050–13,000)	2016
Yellowhammer	B	T	685,000	700,000	2016
Cirl Bunting	B	T	1,100	1,100	2016
Reed Bunting	B	T	255,000	275,000	2016

CONCLUSIONS

APEP 4 has a range of important uses, and it is essential to understand the detail of the information presented in the full paper, published in *British Birds*, in order to interpret these data correctly. The function of APEP needs to continue after the UK has left the EU, enabling the status of our bird populations to be viewed in a wider context.

KEY FINDINGS

The population estimates presented here indicate that there are now thought to be about 85 million breeding pairs of birds in the UK, similar to the number estimated by APEP 3. The Wren continues to be the most common species and has increased slightly since APEP 3, with the current estimate of 11 million pairs making up about one in eight of our breeding birds.

Out of a total of 249 breeding species, 21 species have estimates exceeding one million pairs (compared with 23 species in APEP 3) and these 21 contribute almost 80% of the total, with 58% provided by the 10 commonest species alone.

Although the total number of breeding pairs is similar to that reported by APEP 3, the changes for individual species have been mixed: slightly more species increased than decreased. The vast majority of these increases and decreases relate to genuine population changes measured by long-term monitoring schemes such as BBS for many of the commoner species, or by single-species surveys or RBBP data for scarcer species. However, some changes to estimates are the result of new species surveys or a change in the estimation method, particularly for wintering estimates, while some increases or decreases since APEP 3 may represent better understanding of a species' abundance rather than genuine population change.

Analysing the APEP 4 breeding population estimates by taxonomic group shows that the vast majority of species with populations greater than 100,000 breeding pairs are passerines. This partly reflects the fact that most species found in the UK are passerines, and that this group includes many ecological 'generalists' able to make use of widespread habitats across the UK, including woodland and gardens. Also, most passerines are small-bodied and exhibit particular ecological traits such as smaller territories and higher densities.

The UK's coastline is important for breeding seabirds, with populations of international importance for some species. The seabirds include a notable proportion of species with a breeding population estimate of greater than 100,000 pairs, with a population estimate for Common Guillemot of just under a million pairs (950,000). Many of seabird estimates used have not been updated since APEP 3, though updates will be available shortly.

Among the other groups, it is unsurprising that the breeding population estimates for raptors and owls are all below 100,000 pairs, since these species are apex predators and occur naturally in much lower numbers than their prey species. The UK is important for many wintering waders and wildfowl, the majority of which breed farther north, meaning that UK breeding populations for this group are less significant. However, for some species the UK breeding populations are important and are also in decline: although the current breeding population estimates for all wader species are below 100,000, those for Lapwing and Oystercatcher were both above this threshold in APEP 3, as was that for Curlew in APEP 2.

Although some international requirements for reporting avian population sizes may not apply in the future, for example when the UK leaves the EU, it will remain necessary to understand the status of UK populations to inform national conservation policy and to prioritise any necessary conservation actions. This will ensure that the UK can continue to meet other international obligations and continue to feed into BirdLife International's six-year assessment of the state of Europe's birds (which incorporates data from non-EU as well as EU countries).

It is also anticipated that some EU Birds Directive obligations will be translated into country-level environmental reports, with a coordinating role by JNCC to evaluate the implications of any future changes in reporting protocols. We thus anticipate that APEP updates on avian population size estimates will continue on a six-year cycle.

The full report, for which this is a summary, was published in the journal *British Birds* in February 2020.

Woodward, I., Aebischer, N., Burnell, D., Eaton, M., Frost, T., Hall, C., Stroud, D.A. & Noble, D. (2020). Population estimates of birds in Great Britain and the United Kingdom. *British Birds* 113: 69–104.

https://britishbirds.co.uk

Wren population size was calculated by combining a historical territory-mapping based estimate in the 1998–91 Bird Atlas with a change measure from the BTO/JNCC/RSPB Breeding Bird Survey.

WREN, BY CHRIS KNIGHTS / BTO

Cover: Snow Bunting, by Liz Cutting / BTO. Snow Bunting population size was based on an RSPB survey, carried out in 2011.

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Looking out for birds

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The Breeding Bird Survey 2024 *incorporating the Waterways Breeding Bird Survey*

Population trends of the UK's breeding birds

THE 2024 BBS REPORT

THE BBS PARTNERSHIP

The BTO/JNCC/RSPB Breeding Bird Survey is a partnership jointly funded by the BTO, JNCC and RSPB, with fieldwork conducted by volunteers. The Breeding Bird Survey (BBS) now incorporates the Waterways Breeding Bird Survey (WBBS).

The members of the BBS Steering Committee in 2024 were James Pearce-Higgins (Chair), Dawn Balmer, Simon Gillings, Dario Massimino, David Noble (all BTO), Simon Wotton, Leah Kelly (both RSPB), Ethan Workman, Lucy Baker and Paul Woodcock (all JNCC).

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THE BBS TEAM AT BTO

James Heywood is the BBS National Organiser and first point of contact for BBS or WBBS queries. James is responsible for the day-to-day running of these surveys, liaising with BTO Regional Organisers and volunteers, maintaining the databases, promoting the schemes, and producing the annual report. David White, Engagement & Surveys Officer for England, supports the National Organiser, primarily with the volunteer coordination of these surveys.

Caroline Brighton, Research Ecologist and Dario Massimino, Senior Data Scientist, both in the Bioacoustics and Data Science Team, produced the bird and mammal population trends for 2024. David Noble is the Principal Ecologist for Monitoring, responsible for strategic developments in biodiversity monitoring. Dawn Balmer is Head of Surveys, which includes both BBS and WBBS among other surveys. Maria Knight, Secretary in the Science Department, works closely with James and David assisting with the running of the surveys. Simon Gillings oversees the BBS and WBBS research programmes, and James Pearce-Higgins is the Director of Science.

Contact the BBS National Organiser:

James Heywood, British Trust for Ornithology
Email: **bbs@bto.org** Tel: **01842 750050**

ONLINE RESOURCES

The Official Statistics for BBS are formally published at: https://jncc.gov.uk/our-work/bbs-official-statistics

Further information, including graphs of population change, can be found at www.bto.org/bbs and www.bto.org/wbbs. A full species-by-species discussion of these results, and those from other surveys, can be found on the BirdFacts website at: www.bto.org/birdfacts.

This report can be downloaded from: www.bto.org/bbs-report

ACKNOWLEDGEMENTS

We would firstly like to thank all the volunteers who spend many hours in the field collecting the data for this report. Without their efforts, this scheme would not be possible. We are also grateful to the following people for their help in 2024: Lee Carnihan, Ben Darvill, Jemma Davies, Mark Hammond, Gethin Jenkins-Jones, Andrew Joys, Sorrel Lyall, Drew Lyness, Justin Walker and Steve Willis. Many people have contributed to both the BBS and WBBS schemes' development and organisation, including Nicholas Aebischer, Mandy Andrews, Mark Avery, Stephen Baillie, Ian Bainbridge, Helen Baker, Richard Bashford, Jessa Battersby, George Boobyer, Andy Brown, Steve Buckland, Nick Carter, Steve Carter, Dan Chamberlain, Rachel Coombes, Humphrey Crick, Sarah Davis, Iain Downie, Mark Eaton, Sarah Eglington, Steve Freeman, Colin Galbraith, David Gibbons, John Goss-Custard, Rhys Green, Jeremy Greenwood, Richard Gregory, Sarah Harris, Rob Keen, John Marchant, Ian McLean, Mike Meharg, Richard Minter, Ian Mitchell, David Morris, Dorian Moss, Stuart Newson, Nancy Ockendon, Will Peach, Ken Perry, Mike Raven, Brenda Read, Warren Read, Angela Rickard, Kate Risely, Anna Robinson, William Skellorn, Ken Smith, Sandra Sparkes, David Stroud, Pierre Tellier, Chris Thaxter, Richard Thewlis, Derek Thomas, Mike Toms, Lawrence Way, Richard Weyl, Andy Wilson (BBS and WBBS logos), Mark Wilson, Karen Wright and Lucy Wright.

We acknowledge the support of the Northern Ireland Environment Agency, who fund professional fieldworkers to cover squares in Northern Ireland. Natural England, NatureScot and Forestry Commission Scotland (now Scottish Forestry) have contributed to additional surveys on Upland BBS and Scottish Woodland BBS squares in previous years. We are very grateful to the RSPB for funding the initial development of BBS Online, and to the BTO Information Systems Team who have continued to develop the system and provide technical support.

The founder sponsors of the 1998 WBBS pilot year were Thames Water, British Waterways, Severn Trent, Hyder (Welsh Water) and Anglian Water. Since then surveys have been funded by the Environment Agency, BTO, JNCC and RSPB, and sponsored by Severn Trent, Anglian Water and by Essex & Suffolk Water. The WBBS was adopted into the BBS Partnership in 2017.

The report was produced by James Heywood. The cover photo of a Raven was kindly supplied by Edmund Fellowes/BTO images and the report was printed by Swallowtail Print, Norwich, using carbon-balanced paper from responsible sources.

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INSIDE ...

This is the 30th annual report of the BTO/JNCC/RSPB Breeding Bird Survey (BBS) and Waterways Breeding Bird Survey (WBBS), documenting the population trends of widespread UK breeding bird species during the periods 1994–2024 and 1998–2024 respectively. These are the main schemes for monitoring the population changes of the UK's widespread breeding birds, providing an important indicator of the health of the countryside. Trends are produced each year for 119 species based on BBS data, and for 28 waterway specialist species based on WBBS data. Population trends are published as Official Statistics and have been produced to the high professional standards set out in the Code of Practice for Statistics. The results are used widely to set priorities and to inform conservation action.

BULLFINCH: ALAN DREWITT/BTO

CITATION

Heywood, J.J.N., Massimino, D., Baker, L., Balmer, D.E., Brighton, C.H., Gillings, S., Kelly, L., Noble, D.G., Pearce-Higgins, J.W., White, D.M., Woodcock, P., Workman, E. & Wotton, S. 2025. *The Breeding Bird Survey 2024*. BTO Research Report **787**. British Trust for Ornithology, Thetford.

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Latest News

Below is a round up of the latest news for BBS and its partner projects.

BBS ON BLUESKY

In January of this year, BBS expanded its social media presence and is now posting both on BlueSky and X (formerly Twitter). Whist BTO has decided to move exclusively to BlueSky, our partnership survey accounts – including SMP and WeBS – will continue on both for the time being. BBS will stay on @BBS_birds on X and is now posting on @bbs-birds.bsky.social.

GOLDEN PLOVER

For this year's report, we have updated the methods for calculating trends for **Golden Plover**. Golden Plover, along with five other species of wader, have always been subject to count filters; any count greater than 10 birds on an individual 200 m sector is assumed to be a late-wintering or passage flock and is excluded. For Golden Plover, data are also excluded if they fall within 18 100-km squares in the south and east of Britain. This approach was simple and computationally undemanding – a necessary requirement when processing millions of records annually to quickly generate and update official statistics (see the *2019 BBS report*). However, with continual improvements in computational performance, we can now consider a more tailored approach. A number of scenarios were compared by BTO Research Ecologist, Caroline Brighton, and the best – first employed in this report – involved a spatial filter based on the combined 1988–91 and 2007–11 Bird Atlas breeding distributions, plus a 10 km buffer (Figure 1). Importantly, the increased spatial resolution of the filter means more squares contribute to population trends, with an all-time trend now available for England and an increase in precision of the five- and 10-year change estimates (p20).

Could other species benefit from this approach? Caroline also ran a similar spatial filter for **Whinchat** and **Wheatear**, migrants that are seen on BBS squares in both breeding and non-breeding areas. A spatial filter based on Atlas distributions for these species made no difference – the inclusion of relatively small numbers of passage birds in south-east Britain has no impact on population trends. This more tailored approach is therefore likely to have more of an impact for flocking species, so waterfowl is a likely target for more research. Equally, this method won't be effective for species with fast-expanding distributions; Atlases are conducted periodically, with the next BTO-led atlas to start in winter 2027! Importantly, there is always a balance between ever more fine-grained modelling and greater precision versus the need to produce answers quickly to inform conservation decision making.

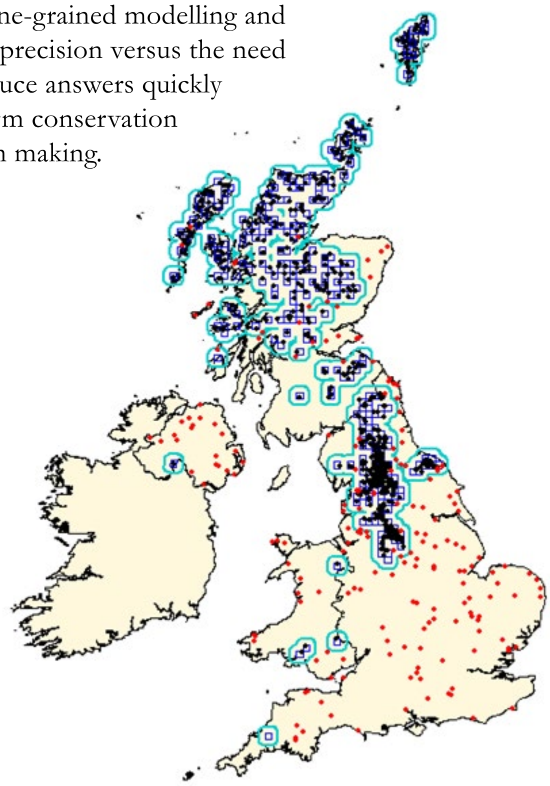


Figure 1: The distribution of 10-km squares with breeding Golden Plover from the second and third Bird Atlases combined (dark blue), plus the 10-km buffer around this range (light blue). Points show the locations of Golden Plover 1-km BBS squares (1994–2023) within (black) or outside (red) its combined Atlas range. Note this is after applying the 10-bird-rule (i.e. a count threshold of >10 in the same section and distance band).

GOLDEN PLOVER: LIZ CUTTING/BTO

BY THE SOUND OF THINGS

Readers of our end-of-year newsletter will recall the blog article '**From landscape to soundscape**' by William Gough of the University of East Anglia (UEA), where he describes his PhD research within UEA's wider 'Economics of Biodiversity' programme.

At the time of writing, 58 volunteers have sound recorders deployed on 61 BBS squares to help William gather enough data for the project. Thank you to everyone who is taking part. ▶

▲ One of the 61 acoustic recorders collecting data as part of the UEA study.

◀ Continuing on the topic of sound, we were delighted when Cathy Shaw, a BBS volunteer in the Yorkshire Dales, got in touch to advertise an episode of '**Nature Tripping**', a podcast published by Cathy's partner, Jo Kennedy, on our interaction with sound in nature. Cathy spoke about her experiences of 14 years of BBS surveying in the Dales and the evocative sound of the Curlew (**episode 27** – tinyurl.com/bdf7mjuy).

WCBS & UKBMS – 50th YEAR

Last year was a really poor year for butterflies, with Butterfly Conservation declaring a Butterfly Emergency on the back of results from the Big Butterfly Count. Data from The UK Butterfly Monitoring Scheme (UKBMS) have subsequently confirmed that 2024 was one of the worst years on record for UK butterflies; 51 out of the UK's 59 species declined between 2023 and 2024.

For the Wider Countryside Butterfly Survey (WCBS), coverage on BBS squares was up to 316, an increase of 10% compared with 2023 and the highest coverage for a decade. Thirty-eight butterfly species were recorded on BBS squares as part of WCBS, with seven seen on just the one square. A highlight is a colony of Marsh Fritillary on the island of Islay, west Scotland. Islay supports one of the strongest populations of this species in the UK.

50 YEARS UKBMS

2025 will be the 50th year of fieldwork for the UKBMS, one of the longest running insect monitoring schemes in the world. WCBS forms an important part of this scheme; whilst the long-standing and traditional Pollard Walks (or 'Transects') are on self-selected sites, WCBS provides an important representative picture of the wider countryside. To celebrate this landmark for UKBMS, a series of events will be held throughout the year. Local Branches up and down the country will be hosting events in their area. BTO, who are part of the UKBMS partnership by virtue of the link with WCBS, will also be hosting an event at the Nunnery in July or August, with more details to come in due course. The year will culminate in a 50th anniversary conference on 11 October at Nottingham University. For more details on the year's events, including the end of year conference, please visit: https://ukbms.org.

◀ Small Tortoiseshell already had a poor year in 2023, with overall UKBMS figures showing a one-year decline of 50%. But 2024 was the worst year ever for this species and it is in significant long-term decline in all four countries of the UK.

SMALL TORTOISESHELL: LIZ CUTTING/BTO; CURLEW: ADRIAN LEE; SOUND RECORDER: WILLIAM GOUGH

Coverage and sightings in 2024

Many BTO regions saw record coverage to go alongside some very impressive individual contributions.

2024 was the best year for BBS coverage this decade and the fourth best of all time (Table 1). As usual, there was fluctuation in coverage; whilst there was only a relatively small increase of 31 squares covered overall, there were more obvious gains in some areas and losses in others. Of particular note was the terrific increase in coverage in the Merseyside region from 10 to 18 squares, and tripling in the space of two years. There is currently no Regional Organiser (RO) for Merseyside and this increase followed a successful series of BBS-focused training events in the north-west of England in the spring of 2024 (see p8–9).

RECORD REGIONS

It was also a record year for many regions. Sussex became the first ever region to reach 200 squares, and the Scottish Borders the first mainland region to achieve 100% coverage – all 68 squares – in 2024, many of them in some very remote places indeed. In all, 17 regions achieved their best or joint best coverage in 2024: Argyll (Mull, Coll, Tiree & Morvern); Arran; Ayrshire & Cumbrae; Borders; Buckinghamshire; Cornwall; Dorset; Essex (north-east); Glamorgan (south); Gwent; Islay, Jura & Colonsay; Isle of Wight; Lothian; Moray & Nairn; Oxfordshire (south); Sussex and York.

As well as these superb collective efforts, there were some very impressive individual contributions. Two volunteers achieved some staggering personal coverage, with Steve Davies (RO West Midlands & Worcestershire) completing 50 visits for BBS and WBBS, and Neil Stratton (RO for the Scottish Borders) completing 38 visits.

The boost given to coverage in Scotland by Upland Rovers continues; 2024 was the third best year north of the border and 84 Upland Rover squares were covered in what was a particularly challenging year for weather. In Wales, there are some encouraging signs, with an additional nine squares covered since 2023, and follows the first year of a new full-time engagement post in Wales. On the other side of the Irish Sea and also benefiting from a new Engagement Coordinator, Northern Ireland achieved its second highest coverage. This was aided by the coverage of 52 squares by three professional surveyors, largely in the west of the country, and in the first year of a new funding agreement which sees DAERA support for professional surveyors as well as mentoring of new volunteers.

Table 1: The number of BBS squares with data received to date and the number of volunteers participating by year.

	England	Scotland	Wales	Northern Ireland	Channel Islands	Isle of Man	UK total	No. of volunteers
1994	1,172	245	122	25	1	4	1,569	*838*
1995	1,321	283	121	17	1	4	1,747	*1,014*
1996	1,420	308	116	65	7	4	1,920	*1,199*
1997	1,657	313	138	75	6	6	2,195	*1,523*
1998	1,712	309	192	85	7	6	2,311	*1,830*
1999	1,791	275	223	95	7	5	2,396	*1,918*
2000	1,749	246	213	83	7	3	2,301	*1,858*
2001*	532	78	22	0	7	0	639	*542*
2002	1,652	231	215	97	7	3	2,205	*1,778*
2003	1,738	255	214	109	7	4	2,327	*1,872*
2004	1,884	273	253	102	11	6	2,529	*2,022*
2005	2,180	305	271	120	13	3	2,892	*2,332*
2006	2,569	336	272	107	19	5	3,308	*2,661*
2007	2,822	486	269	129	16	4	3,726	*2,959*
2008	2,556	404	242	121	15	1	3,339	*2,639*
2009	2,569	396	235	116	17	0	3,333	*2,570*
2010	2,566	331	246	115	16	0	3,274	*2,553*
2011	2,538	358	223	110	15	0	3,244	*2,489*
2012	2,671	383	275	117	21	4	3,471	*2,628*
2013	2,729	471	332	127	26	0	3,685	*2,775*
2014	2,734	482	340	120	27	0	3,703	*2,734*
2015	2,832	476	343	78	23	3	3,755	*2,793*
2016	2,875	490	334	127	24	2	3,852	*2,797*
2017	2,948	523	340	131	28	3	3,973	*2,836*
2018	2,992	581	332	119	20	4	4,048	*2,835*
2019	2,939	608	325	119	21	8	4,020	*2,774*
2020†	1,762	157	61	28	17	9	2,034	*1,453*
2021	2,841	628	301	152	19	10	3,951	*2,714*
2022	2,836	633	315	126	16	10	3,936	*2,749*
2023	2,854	624	300	129	19	10	3,936	*2,756*
2024	2,863	626	309	139	22	8	3,967	*2,779*

** 2001: foot-and-mouth disease, † 2020: COVID-19*

SIGHTINGS AND HEATHLAND BIRDS

A total of **236** species were seen across all 3,967 squares. The square with the most species recorded was, once again, in the Cotswold Water Park in Wiltshire (71 species), followed closely by a Cambridgeshire square at the head of the Ouse Washes (68 species). Both were particularly noteworthy for their herons, with six species recorded between them – **Grey Heron**, **Little Egret**, **Great White Egret**, **Cattle Egret**, **Bittern** and **Purple Heron**! It was a record year for Bittern on BBS, being heard (and occasionally seen) on nine squares in 2024, 50% more than the previous record in 2019. At the other end of the scale, nine upland squares held two or fewer species (though some of these squares had just a single visit). Thankfully no one had the ignominy of having no birds, though nine visits – again, all in the uplands – recorded only Meadow Pipit. Whether it is one or 71 species you observe, **data from all squares are equally valuable!**

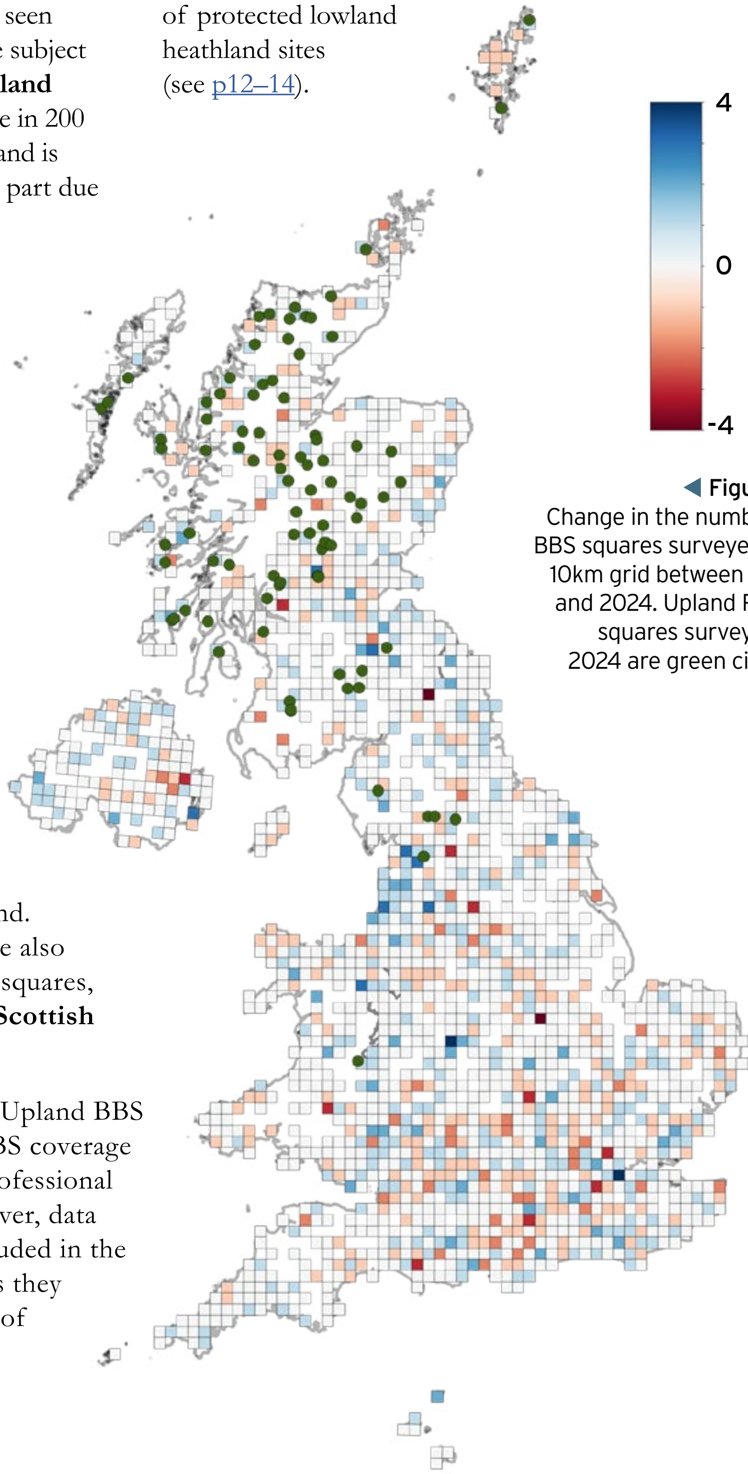
Twenty-seven species were seen on just one square and included the Purple Heron above, along with **Marsh Warbler**, **Little Gull** and **Garganey**. Three species seen rarely on BBS squares – at least in the past – are the subject of this year's BTO/RSPB/Natural England **Heathland Birds Survey**. **Woodlark**, formerly seen on just one in 200 BBS squares, now has a five-year trend in England and is seen on one in 85 squares across the UK, thanks in part due to growth in coverage in counties of southern England, but also due to its recent expansion into farmland from its more traditional wooded heath habitat. By the time this report is published, national survey visits for Woodlark will be complete. **Dartford Warbler** was seen on 26 squares in 2024 and – as in BBS – visits for the Heathland Birds Survey will go on to the end of June. The third focal species is **Nightjar**, with visits to survey this crepuscular migrant being in June and July. If you would like some evening bird surveying to go with your early morning BBS, then please visit the taking-part pages of the survey's website www.bto.org/heathland-birds-survey. The survey aims to provide updated population estimates for these three species – all of which are reliant to a large degree on the UK's network of protected lowland heathland sites (see p12–14).

◀ BBS data shows that Woodlark has increased by 75% in England in the last five years and is one of the subjects of this years Heathland Birds Survey

COVERAGE CHANGE MAP

The map (Figure 2) illustrates where coverage changed between 2023 and 2024 within 10-km squares. Whilst there was only an increase of 31 squares overall, there are more localised changes with some gains and losses. As well as Merseyside and Lancashire, there were local gains in south-east Wales, southern Scotland and across the west of Northern Ireland. The **84 Upland Rover** squares from 2024 ● are also shown. Alongside these were **3,755 'core' BBS** squares, **89 'add-on' Upland Adjacent** squares and **36 Scottish Woodland (SWBBS)** squares.

Other squares from separate 'add-on' schemes (Upland BBS and SWBBS-Adjacent) no longer included in BBS coverage (having been surveyed from 2006 to 2013 by professional fieldworkers) are not included in Table 1. However, data from these squares in the years covered are included in the data analysis and trend calculations for the years they were surveyed. Ongoing, professional coverage of squares in Northern Ireland is included in the map and table. Please see pages 16 and 17 for more information on these surveys and square types.



◀ **Figure 2:** Change in the number of BBS squares surveyed per 10km grid between 2023 and 2024. Upland Rover squares surveyed in 2024 are green circles.

WOODLARK: CHRIS KNIGHTS/BTO

Saying Yes to Engagement

BTO is blessed with a skilled and dedicated Engagement Team, directed by Ieuan Evans. Here, we hear how one arm of this unit – the Country Operations Engagement Team – tackles the perennial challenge of recruiting, training and retaining survey volunteers.

David White, Engagement & Surveys Officer, BTO

BTO is often asked what we are doing as an organisation to increase participation in surveys like BBS and WBBS across the UK. One priority of the Country Operations Engagement Team is just that. So, how do we do it?

FACE TO FACE

BTO has an established record in providing a range of training resources and options for people of all abilities and motivations. The use of online training has really grown in the last few years and the Engagement Team run various events, ranging from courses on identification, to more informal 'Meet the BTO' evening sessions, where supporters can learn more about BTO's surveys.

As well as doing their fair share of engagement activities virtually, the County Operations (CO) Engagement Team – led by Ben Darvill – prioritises leading face-to-face sessions about BTO surveys for small groups of people. These sessions are limited to around a dozen participants each, and offer the opportunity to 'learn by doing' in a supportive environment.

The fundamental aim of BBS training sessions is to demonstrate to participants that taking part in the survey isn't as complicated as it may initially seem, and it allows them to try out the survey with others. Where possible, the sessions are held entirely in the field. The team sends attendees off to survey mock transect sections and as they go, talk about the nuts and bolts of the survey methodology that surveyors need to know.

As I am sure you can appreciate, surveying a BBS square in an upland area is a vastly different experience to surveying a square in lowland farmland! As a result, the team delivers these sessions at a wide variety of venues in a range of habitats, with those in more upland environments taking account of the additional challenges of navigation with a nod towards potential Upland Rover volunteers.

WHERE TO GO?

An important question to address at this point is how the team prioritises where in the UK to deliver these sessions? A large part of this is based upon analysing BBS coverage across the 130 UK 'BTO regions'. If it looks like BBS coverage could benefit from a boost, the team will focus on those areas.

NETWORKING

An absolutely crucial part of maintaining BBS coverage across the UK is the Regional Network and specifically the 100 or so BBS Regional Organisers who coordinate the survey on behalf of BTO in their respective regions (see back cover). They are all volunteers, and without them, the survey would cease to operate very quickly. We also often find that if a region is without a BBS Regional Organiser or a Regional Representative (RR), BBS coverage tends to drop. The team therefore spends a lot of time focusing on these so-called 'vacant' regions, in an effort to boost BBS coverage in them.

We also work with both new and existing Regional Organisers to deliver these types of sessions in their regions. This not only serves to get to know potential and existing surveyors, it also allows them to meet members of the team in person. This helps to build relationships between our volunteers and BTO staff. This is especially important, and it definitely helps with volunteer retention going forward.

Please read on to find out what some of the members of the team did during 2024 to try to increase participation in BBS in their respective countries across the UK.

▲ David White works across both the Country Operations Engagement and Surveys Teams and is ideally placed to provide survey-specific training and support. Here he is (second from right) in action in Merseyside, alongside Drew Lyness (left) and Gethin Jenkins-Jones (second from left).

TRAINING EVENT: DREW LYNESS

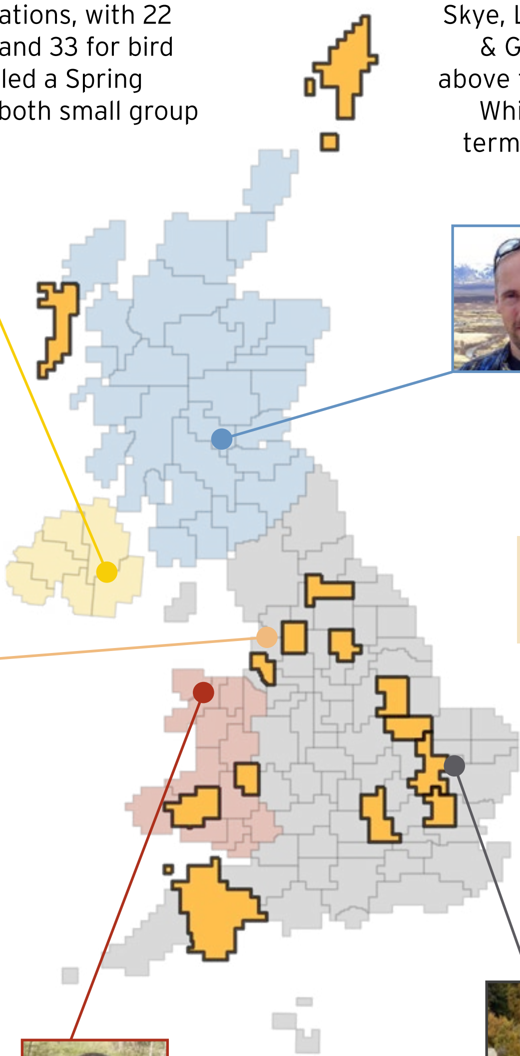
With dedicated engagement staff focusing on all four UK nations, BTO can reach and better support volunteers – be they surveyors or Regional Organisers – and provide training and help that is tailored to the individual needs of those countries. The Upland Rover and upland-themed training is a great example. Below, each of the four BTO Country Operation Engagement Coordinators give a snippet of the work they have been doing for BBS.

Northern Ireland: **Jemma Davies & Sorrel Lyall**

We offered two options for spring training in 2024 – specific BBS training and more relaxed bird identification training walks to build confidence in song and call identification for those who didn't yet feel ready to take the plunge into BBS surveying. We offered both options in four locations, with 22 people signing up for BBS training and 33 for bird identification training. We also trialled a Spring Birding Support scheme, involving both small group sessions where participants worked together on identification and mock BBS transects, and one-to-one support for new BBS surveyors. These approaches helped 2024 to be the second best year ever for BBS coverage in Northern Ireland.

Scotland: **Steve Willis**

Upland habitats cover a huge proportion of Scotland and we have known for a long time that they are under-recorded. 2024 saw BTO Scotland continue to offer upland-specific training, and we spent time with existing and prospective volunteers in Skye, Lochaber, Aberdeenshire, Dumfries & Galloway and even in the Ochils just above the BTO Scotland Office in Stirling. Whilst there are obvious challenges in terms of terrain in the uplands, a major benefit of carrying out BBS in upland areas is that there are fewer species of birds, lower numbers overall, and birds are more likely to be visible. Upland surveys make for a great starting point in a volunteer's BBS journey.



If you are interested in helping out, especially in one of the VACANT regions in orange (see back cover), then please get in touch!

For all the latest in-person or online BTO events and training please visit: www.bto.org/events

▶ **Figure 3:** As well as promoting BBS to potential new surveyors, the CO Engagement Team also support members of the Regional Network and work to fill vacancies. BBS ROs are critical to the successful running of the survey.

Wales: **Gethin Jenkins-Jones**

Being my first spring working for BTO, I was very excited to engage with new people about BBS. I organised four training events across Wales, often with BTO Regional Representatives. It was great meeting the attendees whilst discussing and practising the survey, before finishing with some nice refreshment of hot drinks and cookies! We had a growth in BBS coverage in Wales in 2024, with 309 squares covered across the country. Now slightly more confident, for 2025 I plan on doing nine training events, tweaking things slightly to make the sessions even more enjoyable for those wishing to join us in 2025, and years beyond.

England: **Drew Lyness**

In similar style to other UK countries, we've offered separate face-to-face sessions in the spring focusing on 'Demystifying BBS' and 'Birdsong ID practice' – delivering four of each sessions in north-west England and Devon respectively. In the face of challenges and unforeseen distractions delivered by gale-force winds, medieval battle re-enactments and parkruns, we had 24 people sign up across the very enjoyable BBS engagement sessions, and 38 people for the bird songs and calls practice events, which was fantastic to see. These sessions resulted in a spike in BBS uptake in north-west England especially, with a few BBS squares and a also WBBS stretch being allocated to participants in Devon.

Opening up BBS data

Regular readers of the BBS report will realise just how valuable BBS data is and how much it is used. Now, accessing and using these data has just got a lot easier.

Dario Massimino, Senior Data Scientist, BTO, **Simon Gillings**, Head of Data Science & Bioacoustics, BTO and **James Heywood**, BBS National Organiser, BTO

BBS and WBBS data form an invaluable dataset that is often used for national and international scientific research. Up until now, scientists and other groups interested in using BBS and WBBS data have had to request these data. This approach – whilst enabling the BBS partners to monitor and easily describe how the data are used, as well as be involved in collaborations – has its drawbacks. But since December 2024, BBS data have become more accessible, via the publication of the BBS data paper.

BBS – 30 YEARS IN THE MAKING

Every year, BBS reports on the population trends of the UK's common terrestrial birds with 119 species currently reported (p18–19). The trends produced – which are official government statistics – can be combined with those from the BBS's predecessor, the Common Birds Census (CBC). The resulting composite trends stretch from the 1960s and are a major contributor to the annual Wild Bird Indicators (also official statistics), which have highlighted the long-term declines of our farmland birds and more recent declines of woodland species. BBS data are widely used in research, including work on the value of protected areas for birds (p12–14).

The 2023 BBS Report marked the 30th year of BBS fieldwork, with over 100 volunteers contributing data – all collected from randomly selected 1-km squares across the UK – in each year of the scheme. Together, nearly 9,000 people from across the UK surveyed over 7,000 different squares over the course of those 30 years. Typically, each square demands two visits per year and, following the 2024 field season, 15 of those volunteers each amassed over 180 visits. That is the equivalent of surveying three squares a year for 30 years! In total, the BBS dataset represents well over 300,000 hours of recording by a committed and skilled set of volunteers and in a given year, approximately 15,000 km are trodden (and occasionally waded) by volunteers on their transects.

▲ The Goldfinch is synonymous with BBS, being the scheme's logo – designed by Andy Wilson – since the very beginning. The new published dataset sees 146,766 records of Goldfinch, which puts it in 19th place in terms of number of records. Woodpigeon, Blackbird and Carrion Crow have the greatest number of records in the new dataset with over one million between them.

GOLDFINCH: SARAH KELMAN/BTO

DATA PAPER – "THE BREEDING BIRD SURVEY OF THE UNITED KINGDOM"

Over time, these volunteers have generated over eight million biological records (birds, mammals and habitat). However, although these data have formed the backbone of over 180 peer-reviewed papers by researchers far and wide over the decades, until now they have not been readily accessible to everyone, available only on request. These requests place a significant time constraint on the staff that support them. Working with our colleagues at BTO and BBS partner organisations, we decided to address this. Now, for the first time, the raw data generated over the 30 years of BBS have been published. This move makes BBS one of the only structured national bird recording schemes which makes the data collected by the tremendous efforts of its volunteers available in this way.

The published dataset contains 7,070,577 records of 26,375,773 individual birds of 217 species. Aside from a small number of passage migrants, the majority (158 species, 73%) are regular UK breeding bird species and account for 64% of the UK breeding birds (Figure 4). Some restrictions or constraints apply; for example, over 39,000 records of 78 sensitive species – as defined by the National Biodiversity Network – were not included for welfare reasons.

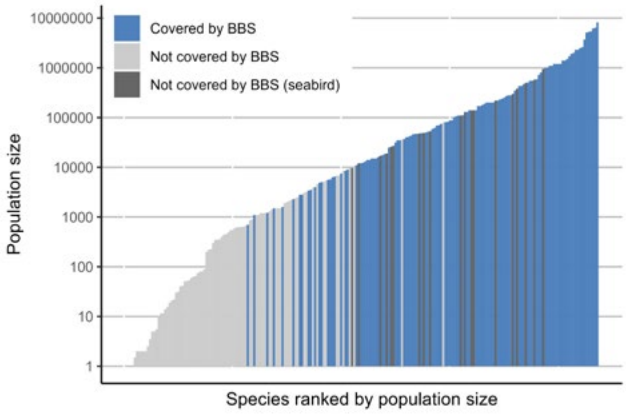


Figure 4: Which species does BBS monitor effectively? Bars show the UK population size of all breeding species; the blue bars show the 119 species with BBS trends, the dark grey bars show seabirds (not covered by the BBS which is a terrestrial survey), and the light grey bars show the species for which there are not enough BBS data to reliably estimate population trends. Population size is on a logarithmic scale.

The published data are available at a relatively fine spatial scale; volunteers submit data on up to 10 200 m 'transect sections' and record over one of three distance bands, plus in-flight birds, and it is at this level that the data have been published. In addition to the data, our paper describes the development of the survey, the analytical methods we use to calculate population trends, and information on how these are used. This publication now becomes the single, citable reference point for all aspects of the survey, including its field protocol, sampling design and analytical methods.

THE IMPORTANCE & IMPACT OF BBS DATA

Data from BBS have been used to support a number of important developments. As well as the annual production of official statistics, BBS data are pivotal to the production of periodic assessments of bird populations, via the Avian Population Estimates Panel (APEP), and for setting conservation priorities via Birds of Conservation Concern. In addition to the recent work on protected areas, BBS data have a long association with research into our farmed land and land management via assessments into the effectiveness of agri-environment schemes, as well as threats to woodland birds and assessing the effects of climate change. By opening up this rich seam of information, we hope and expect BBS data to be put to yet more impactful use.

DELIVERING DATA

Whilst the North American Breeding Birds Survey has already been releasing site-level data, to the best of our knowledge, the publication of the BBS dataset is the first breeding season dataset to be made available in this way in Europe.

To publish the entire dataset, down to the 200 m transect section level is another step entirely, and a decision that was not straightforward and came with some challenges. For example, some of the running costs of BBS are supported by income from data services and contract work that we are well suited to do, having first-hand experience of these data. It may also reduce the degree to which the BBS partners – BTO, JNCC and RSPB – can collaborate with other organisations, now they no longer have to request these data. But, making the data more widely available of course gives them much added potential; the range of applications for BBS data is large. The data will act as a rich source for those interested in analytical considerations – the advancement of statistical techniques, and integration of other taxa to study species interactions. Above all, we expect that the publication of BBS data will pave the way for more impactful science by a greater range of people to provide better futures for birds and other wildlife.

▲ BBS volunteers record every species they see or hear when completing their surveys, including Dotterel, which are seen on around two to three squares per year. Records for rarer species like this one are not included in the published dataset for welfare reasons. Dotterel – alongside Ptarmigan and Snow Bunting – are the subject of the 2025 Montane Bird Survey, run by RSPB and NatureScot.

DOTTEREL: EDMUND FELLOWES/BTO

FURTHER READING

Massimino, D. ***et al.*** 2024. The Breeding Bird Survey of the United Kingdom. *Global Ecology and Biogeography* **34**: e13943. doi.org/10.1111/geb.13943

Pearce-Higgins, J.W. ***et al.*** 2018. Overcoming the challenges of public data archiving for citizen science biodiversity recording and monitoring schemes. *Journal of Applied Ecology* **55**: 2544–2551. doi.org/10.1111/1365-2664.13180

Protected area condition and birds

The 2022 Breeding Bird Survey report highlighted the work of BTO and RSPB on assessing the effectiveness of the UK's network of protected sites for bird conservation. Here we report on a follow up to this work.

Caroline Brighton, Research Ecologist, BTO

The results of the work published at the start of 2023 were encouraging; protected area extent was positively related to bird occurrence and abundance. But does the quality of these protected areas matter as well?

30 by 30

As recently as December 2022, a landmark agreement called the Kunming-Montreal Global Biodiversity Framework was established by world leaders from 196 nations to halt nature loss and prevent ecosystem collapse. Among the key ambitions of the Framework were global targets to protect 30% of land, coastal waters and ocean by 2030 (known as '30 by 30'). As a result, this has led to a rapid expansion of land and sea globally being designated as protected. But how effective are protected areas (PAs; see Box 1) at reducing biodiversity loss?

This question was the premise for previous BTO- and RSPB-led research using BBS data, which assessed how the size of PAs affects biodiversity metrics, using UK birds on terrestrial sites as a case study. The study found strong evidence that PA extent was associated with increases in the occurrence and abundance of bird species, with benefits being greatest for species of highest conservation concern. However, to achieve the greatest possible benefits for wildlife, we also need to understand the relationship between biodiversity metrics and the *quality* of the protected areas. Hence, it is not just the size and quantity of PAs that is likely to be important in meeting the biodiversity targets, but also their management and condition. Therefore, as a BTO follow-on study, we used BBS data to explore the relationship between PA condition and bird biodiversity.

Box 1: Protected Sites in the UK – a recap.

- **Special Protection Areas (SPA):** These are selected to protect one or more rare, threatened or vulnerable bird species listed in Annex I of the Birds Directive, or certain regularly occurring migratory species.
- **Special Areas of Conservation (SAC):** These protect one or more special habitats and/or non-avian species – terrestrial or marine – listed in the Habitats Directive.
- **Site/Area of Special Scientific Interest (SSSI/ASSI):** These are a GB-/NI-based designation and may be based on particular flora, fauna, habitats or geology.

OUR APPROACH

We tested whether improving site condition (a current policy target) would also improve species counts (abundance) and changes in abundance through time (population trends) within UK PAs. We used BBS population data combined with condition data provided by the Statutory Nature Conservation Bodies (SNCBs – Natural England, Natural Resources Wales, Northern Ireland Environment Agency and NatureScot), as the best indicator of changes in PA quality. The SNCBs monitor the status of PAs on a six-year reporting cycle by evaluating condition with respect to standardised ecological interest features (habitats, species or geology) for which the PAs have been designated (i.e. in accordance with SSSI/ASSI selection guidelines). For example, for habitats, they might be heathland or woodland; for species, they might be butterflies or breeding birds; and geological features, might be fossils or landforms. For each feature, performance indicators are developed by identifying the key attributes which describe its condition (e.g. habitat extent or quality, species population size or distribution).

◀ An example Protected Area is the Breckland SPA in East Anglia – close to the BTO Head Office – designated for Woodlark, Stone-curlew and Nightjar. The reliance on protected sites by Woodlark and Nightjar – as well as Dartford Warbler – provides a major motivation for this year's Heathland Birds Survey.

NIGHTJAR: CHRIS KNIGHTS/BTO

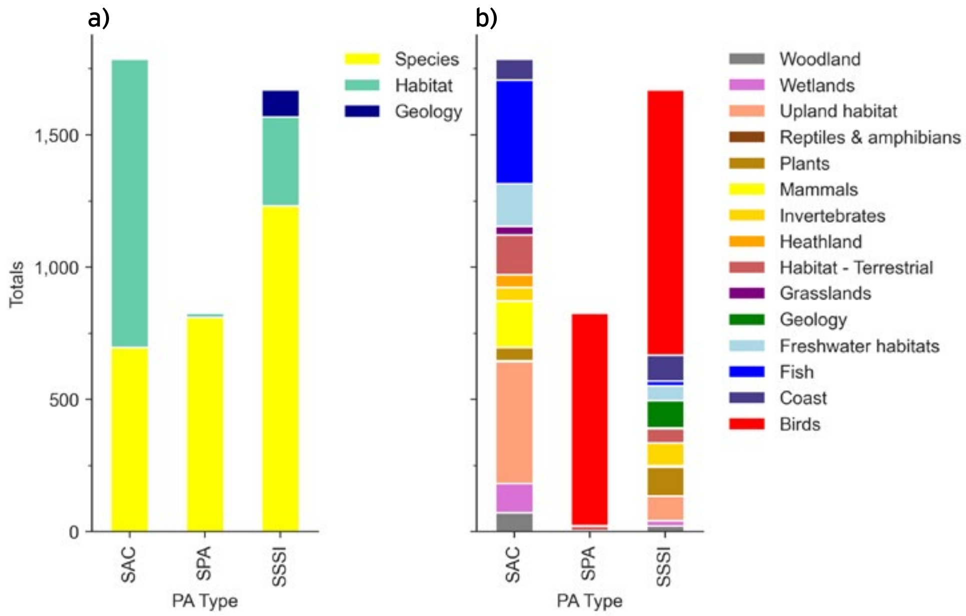


Figure 5: Two different breakdowns of the number of feature types which were assessed for condition, per protected area (PA) designation: By (a) broad classification of Habitat- or Species-based (and also Geology, which is unique to SSSIs), or (b) by the type of habitat or species. SPAs are designated only for birds, and there is a dominance of bird designation for SSSIs. Upland habitats form a significant proportion of SAC feature designation.

PAs may have multiple features of interest, and Figure 5 shows how the assessments are divided between the various feature types. For Northern Ireland, Wales and Scotland, data are provided for the condition of each individual whole feature within the PA, whereas for England, condition is summarised across PA units (PA is subdivided by historical tenure) and data is provided for the combined condition of each unit. This is an important consideration which impacts the results, since the England condition assessments are less likely to reflect overall condition of the protected site as they are measured across multiple features. The results of the latest condition monitoring indicate that many PAs are in poor condition, with certain land cover types being more adversely affected (e.g. moors and heathland, peat bogs, estuaries; Figure 6).

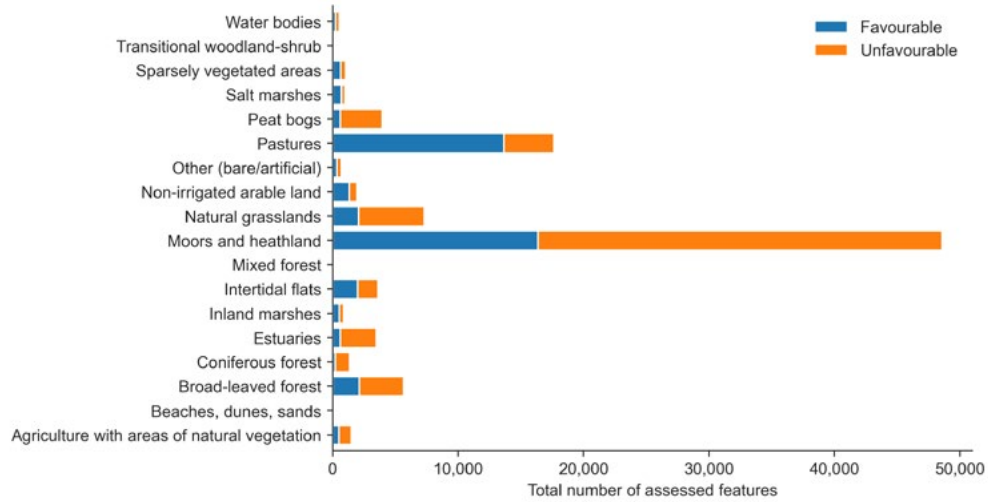
LINKING BBS AND CONDITION DATA

The condition data are referenced to the whole PA (or PA unit in England), while the BBS data is per 1-km grid square, so we had to spatially match the two datasets. Due to the multiplicity of feature assessments, we created variables that reflected the average condition of each PA (the proportion of favourable and proportion of unfavourable condition assessments) that contained an overlapping BBS square. We then tested whether favourable site condition was associated with an increase in species' abundance and/or a more positive trend, while controlling for differences in climate, land cover, and elevation. Due to the different methods of assessing PA condition across countries, we separately analysed i) the UK, ii) Northern Ireland, Wales and Scotland combined (NI/WA/SC) and iii) England only (ENG).

EFFECTS OF FAVOURABLE AND UNFAVOURABLE PAS ON BIRDS

Our analysis used statistical modelling (mathematical representation of observed data) to determine the relationship between bird abundance/trend and the proportion of the PA in favourable condition in a BBS square. This allowed us to test whether PAs in favourable condition have better species' abundance and/or trends, on average, than unfavourable sites (Figure 7). Overall, we found some evidence that protected sites in favourable condition were associated with greater bird abundances than PAs in unfavourable condition in Wales, Scotland and Northern Ireland combined. We also found evidence that PAs in favourable condition were associated with increased population trends compared to unfavourable PAs in Wales,

Figure 6: Total number of favourable and unfavourable land cover related condition assessments. Land cover data were derived from the CORINE Land Cover inventory, using the dominant land cover type per PA with an intersecting BBS square from our analysis. A protected area is counted more than once if it intersects more than one BBS square.



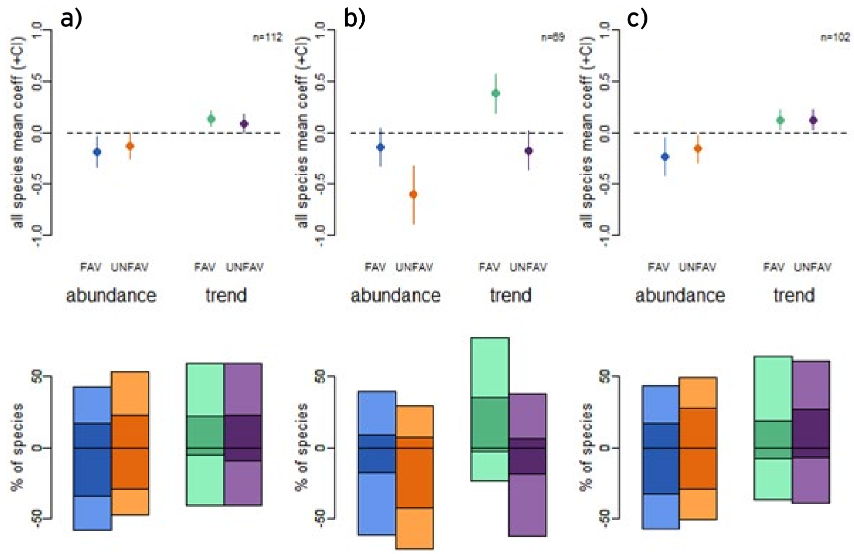


Figure 7: Summarising the effect of PA condition on abundance and trend dynamics of UK breeding bird species. The point plots represent the means (±95% CIs) of all modelled species with negative and positive associations for each population measure (abundance and trend in abundance) and favourable or unfavourable PA condition (weighted by area that intersects the monitored 1-km square). The bar graphs represent the percentage of species with a significant (bold colours) or non-significant (pale colours) positive or negative relationship with PA condition. (a) For the whole UK; (b) for Northern Ireland, Wales and Scotland combined; and (c) England only.

Scotland and Northern Ireland combined (Figure 7b). These results were not apparent in England – which represented the bulk of the data – or consequently, the UK, likely due to the different assessment method.

We also tested the hypothesis that favourable PA condition will benefit the same species that were found to benefit from PAs in general in the previous study (i.e. rare, specialist and cold-adapted species, those of high conservation concern and those of certain habitats). We found that the abundance trends of Red-listed species in the UK and English data were more positive within PAs (regardless of the extent to which these were in favourable or unfavourable condition) than outside PAs. This suggests that species of conservation concern benefit from PAs whatever their condition. There was also some evidence that favourable PA condition was more beneficial for habitat specialists and cold-adapted species than for generalists. This makes sense given that the rare habitats on which the specialists depend are likely to be found only within PAs.

FIND OUT MORE ABOUT PAS...

Brighton, C.H. *et al.* 2024. Protected areas in good condition have a positive effect on bird population trends. *Biological Conservation* **292:** 110553. doi.org/10.1016/j.biocon.2024.110553

PROVIDING NEW EVIDENCE

Our findings suggest that improving protected areas in unfavourable condition can deliver benefits to global species recovery and biodiversity, and highlights the importance for policy actions to include effective conservation management. Considering the Global Biodiversity Framework's ambition of '30 by 30', simply achieving coverage – without ensuring those areas are of sufficient quality – may not be sufficient to restore biodiversity. Therefore, this study provides new knowledge to inform policy objectives, both with respect to the Convention on Biological Diversity (CBD) framework and for UK governments. It is important to note that while the creation of PAs is the main way the biodiversity targets are being realised in Europe, other effective area-based conservation measures also play a crucial role - including set-aside within agriculture areas, military areas or watersheds. Designating and managing protected areas must be addressed in combination with anthropogenic activities outside of these areas, otherwise, we run the risk of exacerbating unsustainable land management and undermining the benefit of the protected areas.

FURTHER READING ON CUCKOOS (SEE BELOW)

Davies, J.G. *et al.* 2023. Spring arrival of the common cuckoo at breeding grounds is strongly determined by environmental conditions in tropical Africa. *Proceedings of the Royal Society B*. **290**: 20230580. doi.org/10.1098/rspb.2023.0580

Denerley, C. *et al.* 2019. Breeding ground correlates of the distribution and decline of the Common Cuckoo *Cuculus canorus* at two spatial scales. *Ibis* **161**: 346–358. doi.org/10.1111/ibi.12612

Douglas D.J.T. *et al.* 2010. How important are climate-induced changes in host availability for population processes in an obligate brood parasite, the European cuckoo? *Oikos* **119**: 1834–1840 doi.org/10.1111/j.1600-0706.2010.18388.x

Hewson, C.M. *et al.* 2016. Population decline is linked to migration route in the Common Cuckoo? *Nature Communications* **7**: 12296 doi.org/10.1038/ncomms12296

Mills, L.J. *et al.* 2020. Using molecular and crowd-sourcing methods to assess breeding ground diet of a migratory brood parasite of conservation concern. *Journal of Avian Biology* **51:** e02474 doi.org/10.1111/jav.02474

Species focus: Cuckoo

Cuckoo numbers are changing in different ways in different parts of the UK. Studies both at home and abroad shed light on how and why this variation exists.

Chris Hewson, Senior Research Ecologist, BTO

This focus on Cuckoo reviews more than a decade of work undertaken by BTO and RSPB on UK Cuckoo population changes, and looks at some of the most recent trends.

Until around 2010, the declines seen in **Cuckoo** were one of the many stories of UK bird decline. Since then, Cuckoos have been on the up in parts of the UK, increasing by 20% in the last 10 years and 7% in the last five. Looking within Great Britain, there is substantial difference between different countries, with Cuckoo in Scotland having increased by two-thirds since 1995 and 40% in the last 10 years. In Wales, a decline of 34% between 1995 and 2010 has been reversed in the subsequent decade, with a 44% increase seen between 2012 and 2022. Only in England has the decline continued, where Cuckoo numbers are now a third of what they were in the mid 1990s and less than a quarter compared to the mid 1960s (Figure 8).

A programme of tagging studies has revealed that this geographical pattern correlates to differences in mortality seen during migration back to the non-breeding grounds south of the Sahara (Hewson *et al.* 2016). During post-breeding migration, tracked Cuckoos in the uplands of Scotland and Wales migrated via a south-easterly route, whereas in England varying proportions of birds take either this route or a south-westerly route. It has been shown that there is a significantly increased mortality on the southern-westerly route and that its use correlates with the degree of local population decline. It is known that Cuckoos have not advanced their date of arrival in the UK, contrary to other species, and these tracking studies show that environmental

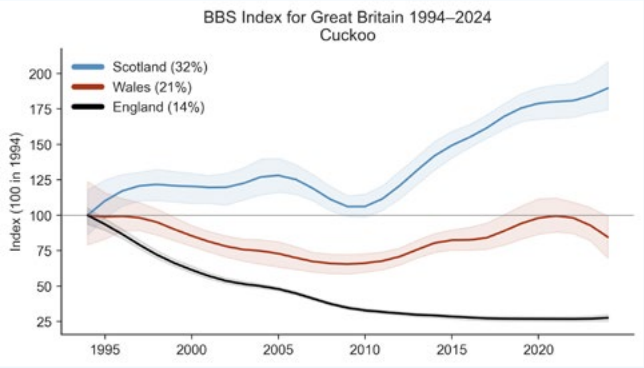


Figure 8: Cuckoo population indices in Scotland, Wales and England. Cuckoos have increased in both the north and west of Great Britain, especially since 2010.
See p17 for details on interpreting graphs.

CUCKOO & MEADOW PIPIT: EDMUND FELLOWES/BTO

conditions on stopover locations in West Africa limit their ability to do so. This timing constraint appears to increase mortality risk at multiple stages of the annual cycle as the birds attempt to compensate (Davies *et al.* 2023).

As well as variation in migratory behaviour, there is also variation in habitat preference, diet, and host species. A study investigating both local and national scale variation in Cuckoo abundance found that Cuckoos were now more likely to occur in semi-natural habitats with more **Meadow Pipits** and fewer **Dunnocks**, compared with intensively farmed landscape with fewer Meadow Pipits and more Dunnocks (Denerley *et al.* 2019). Cuckoos are also increasingly associated with wetlands, specifically reedbeds (or reed-lined waterways) where **Reed Warbler** is the main host species. Whilst Cuckoo in lowland Britain/England is still in decline, one region of England where Cuckoos are increasing is in the East of England (17% increase in the last five-years). This region also has both 10- and five-year increases in Reed Warbler populations, though previous work published prior to this more recent increase in Cuckoos has shown that host populations are not a limiting factor (Douglas *et al.* 2010).

There is also an impact of Cuckoo prey availability. The moth species favoured by Cuckoo have declined faster than other moth species (Denerley, *et al.* 2019) and are the species most vulnerable to intensive land management (Mills *et al.* 2020). These moths are becoming increasingly confined to areas of semi-natural habitat and wetland, as well as – for example, the Garden Tiger – shifting range northwards.

These studies cover a wide range of aspects of Cuckoo life-history, from diet, host population, habitat preference and migratory strategy. Together, they paint a complex picture, and indicate that conditions in the UK and on migration contribute to Cuckoo population changes.

Background and methods

The BBS was launched in 1994 to provide more representative habitat and geographical coverage than the main survey running at the time, the CBC. The CBC ended in 2000, and the overlap period between 1994 and 2000 allowed BTO to develop methods for calculating long-term trends (from the 1960s to the present) using data from both schemes. The BBS National Organiser, based at BTO HQ, is responsible for the overall running of the scheme, and is the main point of contact for the network of volunteer Regional Organisers (ROs). ROs are responsible for finding new volunteers and allocating squares to observers in their region. At the end of the season they validate submissions made online, and collect paper submissions for inputting.

The BBS is a line-transect survey based on randomly located 1-km squares. Squares are chosen through stratified random sampling, with more squares in areas with more potential volunteers. The difference in sampling densities is taken into account when calculating trends. BBS volunteers make two early-morning visits to their square during the April–June survey period, recording all adult birds encountered while walking two 1-km transects across their square. Each transect is divided into five 200-m sections for ease of recording. Birds are recorded in three distance categories, or as 'in flight', in order to assess detectability and estimate species density. To assess further the detectability of species the option of recording how birds were first detected (by song, call or visually) was introduced in 2014. Observers also record the habitat along the transects, and may record any mammals seen during the survey. Surveying a BBS square involves around six hours of fieldwork per year, and the aim is for each volunteer to survey the same square (or squares) every year.

As BBS squares are selected randomly, they can turn up within any kind of habitat. Some squares can never be surveyed, and these truly 'uncoverable' sites are removed from the system. However, squares that are temporarily inaccessible, or which are not taken up due to their remote location, are retained in order to maintain the integrity of the sampling design.

The BBS provides reliable population trends for a large proportion of our breeding species. Trends can also be produced for specific countries, regions or habitats. For these analyses, we take the higher count from the two visits for each species, summed over all four distance categories and 10 transect sections. Only squares that have been surveyed in at least two years are included in the analyses. Population changes are estimated using a log-linear model with Poisson error terms. Counts are modelled as a function of year and site effects, weighted to account for differences in sampling densities across the UK.

Since 2009, data from additional randomly selected 1-km squares surveyed as part of the Scottish Woodland BBS and the Upland BBS have been included in the BBS sample. These squares were surveyed using the same methodology as standard BBS squares, and results were incorporated into the trends, accounting for additional sampling effort. Since 2010, the option of adding an Upland Adjacent square to an existing 'Eligible Upland' BBS square has been encouraged, with the aim of increasing coverage in upland areas. These data are treated separately during analysis.

The 'Upland Rovers' initiative was introduced in 2017, with the aim of further increasing coverage in remote areas. Carefully selected squares are available to be surveyed just once by 'roving' volunteers. These are 'core' BBS squares with poor to no previous coverage, upland in habitat type and remote as identified by a combination of distance from road and local human population.

Work has been carried out to assess the reliability of BBS trends, to ensure that reported trends are based on reliable data and sufficient sample sizes. This work has resulted in the following exclusions and caveats:

- We do not report population trends for six species of gull (Black-headed, Mediterranean, Common, Great Black-backed, Herring and Lesser Black-backed), as a large proportion of the records are of non-breeding, wintering or migratory individuals.
- Trends for rare breeding species with substantial wintering populations (e.g. Fieldfare) are excluded.
- Trends for Common Tern, Cormorant, Grey Heron and Little Egret are reported with the caveat that counts may contain a high proportion of birds away from breeding sites.
- Trends for Barn Owl and Tawny Owl are reported with the caveat that the BBS monitors nocturnal species poorly.
- Counts for six wader species (Oystercatcher, Lapwing, Golden Plover, Curlew, Snipe and Redshank) are corrected to exclude transient and other non-breeding individuals or flocks. Spatial filters (based on Bird Atlas distributions) are also applied to observations of Golden Plover to exclude birds outside of suitable breeding areas (see p4 for further details).

As for reports since 2021, we use the standard methods and omit all data from 2001 and 2020 to prevent the coverage biases in those years from affecting the trends we produce (see the *2021 BBS Report*). Although we omit the underlying data, we can estimate trend values for 2001 and 2020 by interpolating the smoothed trend line over the remaining years.

Interpreting the results

Pages 18–31 contain the annual bird and mammal population trend statistics for BBS, and pages 34–35 cover WBBS results. Some guidance on reading and interpreting these tables and graphs is provided below.

THRESHOLDS FOR TRENDS

To ensure robust results, we produce trends only for species with sufficient data. To judge this, we look at the average number of squares on which a species has been recorded per year during the trend period. For UK BBS trends, we consider species above a reporting threshold of 40 squares. For countries within the UK, English Regions and UK WBBS trends, the threshold is an average of 30 squares during the trend period. The one-year change for 2023–24 is shown where the sample size reaches the reporting threshold for one of the longer trend periods. Therefore, if there is a 10-year or 'all-time' (28-year) trend, a one-year change is presented.

BBS 'ADD-ON' SQUARES

'Add-on' squares surveyed during the lifetime of the BBS, using BBS methodologies, have been included in these trends. These include Upland BBS, Upland Adjacent and Scottish Woodland squares. Upland BBS and Scottish Woodland squares were originally surveyed by professional fieldworkers: Scottish Woodland squares are now surveyed by volunteers. Upland Adjacent squares are also covered by volunteers during visits to survey their core BBS square: these were introduced as an option to increase coverage in remote upland areas.

TRENDS AND TABLES EXPLAINED

Species	Min. sample	1-year (23-24)	10-year (13-23)	28-year (95-23)	LCL	UCL
(Little Egret)	74	33 *	68 *	2,726 *	867	inf
Sparrowhawk	354	-15	-18 *	-25 *	-35	-13

- Trends for species in brackets are reported with caveats (explanation on pages 16, 31 and 34).
- For bird trends, **Red-listed** and **Amber-listed** species from *Birds of Conservation Concern 5* (BoCC5) are shown in the relevant colour. The exception to this is in the Wales Population trends, where the *Birds of Conservation Concern 4 Wales* (BoCC4 Wales) assessments are used.
- The sample size refers to the mean number of squares per year on which the species was recorded during BBS or WBBS. The figure shown in the tables, 'Min. Sample', is the smaller of these sample size figures for the 10-year and all-time trends, per species, per region.
- Trends are presented as the percentage change over three periods: one-year, 10-year and all-time.
- The short-term change covers the most recent years of the survey, i.e. for BBS and WBBS: 2023 to 2024.
- The long-term changes for both BBS and WBBS, cover the lifetime of the survey (BBS birds: 1994–2024, BBS mammals: 1995–2024, WBBS: 1998–2024). The 10-year trends cover 2013–23 for both surveys. All-time and 10-year periods have been smoothed, and the end years truncated.
- Trends with statistically significant changes are marked with an asterisk (*), where the 95% confidence limits of the change do not overlap zero.
- LCL and UCL are the lower and upper 95% confidence limits for the longest BBS bird trend: 1995–2023, BBS mammal trend: 1996–2023 and WBBS bird trend 1999–2023. Any confidence limit greater than 10,000 is displayed as 'inf'.

INTERPRETING GRAPHS

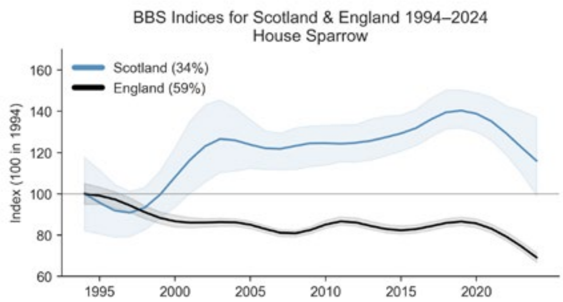
All BBS and WBBS graphs are displayed in the same way throughout the report. Beware, however, that the index and time period axes do vary in scale.

Single region BBS and WBBS index graphs show:

- smoothed trend – dark line
- confidence interval (85%) – pale shading
- annual index values – dots

In addition to these, we produce plots of multiple countries or regions for the same species on the same graph. This is used to illustrate where trends differ among geographical areas, either in their direction, or in the timing of particular changes. Care should be taken interpreting these; higher or lower indices for one region compared to another do not necessarily mean higher or lower abundance or prevalence.

In the example below, House Sparrow have – until recently – been increasing in Scotland and are decreasing in England. However, occupancy (number of squares observed as a percentage of the number surveyed) is still higher in England (59%) compared with Scotland (34%). For comparisons of countries and some regions, occupancy rates from 2024 are presented in the figure legend for reference. For clarity, annual index values are not shown in multi-region plots.



ONLINE RESOURCES

BBS BIRD TREND GRAPHS ONLINE: www.bto.org/bbs-graphs
BBS BIRD TREND TABLES ONLINE: www.bto.org/bbs-tables
BBS MAMMAL TRENDS ONLINE: www.bto.org/bbs-mammals
WBBS RESULTS ONLINE: www.bto.org/wbbs-results

United Kingdom: population trends

This report and online tables document the population trends of 119 UK species, and are calculated from BBS squares in England, Scotland, Wales, Northern Ireland, the Channel Islands and the Isle of Man. The non-native Egyptian Goose reaches the UK reporting threshold of an all-time average of 40 squares, whereas Firecrest now has a 10-year trend.

STATISTICALLY SIGNIFICANT RESULTS

Period	No. species	Greatest change in UK trends	
Long-term (95–23) increases	36	(Little Egret)	2,726%
Long-term (95–23) decreases	43	Turtle Dove	-98%
Short-term (23–24) increases	15	Pied Flycatcher	52%
Short-term (23–24) decreases	21	Teal	-68%

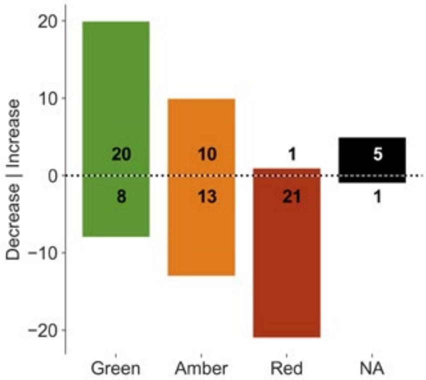


Figure 9: The number of birds with significant long-term declines and increases by BoCC5 assessment status (NA=Not assessed).

YELLOW WARNING

The declines of farmland species are regularly reported in the BBS report and this year is no exception. Species in this assemblage have experienced some of the largest declines of any UK species dating back to the 1960s when monitored by the CBC. Several farmland species have significant 28- and 10-year declines, but have either experienced little change in the last five years (e.g., **Grey Partridge**) or have even increased (**Skylark**).

However, **Yellow Wagtail** and **Yellowhammer** have shown a relatively steep and worrying decline over the last five years, with 2024 being the third consecutive drop in the annual index. For Yellow Wagtail, this comes after a period of relative stability in the 2010s, following a steep decline starting in the 1970s. In the case of Yellowhammer, this is the latest episode in a long decline dating back to at least the 1960s. Whereas Yellow Wagtail is a migratory species seen mostly in England, Yellowhammer is a resident in all parts of the UK. As reported last year, it has dropped below the normal threshold for reporting in Wales – evidence of steep decline there – and it is also now in decline in Scotland as well as England. This follows on from a period of population growth in Scotland between 2002 and 2012.

Following decades of decline in the UK and in Europe, another farmland bird – **Turtle Dove** – is showing signs of recovery along the Western European Flyway as a result of hunting moratoria (Carboneras, *et al.* 2024). There appears to be no signs of recovery in the UK, at least not yet.

YELLOW WAGTAIL: SARAH KELMAN/BTO

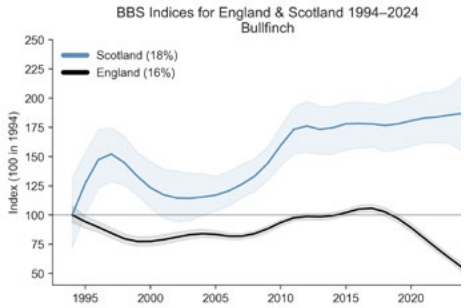


Figure 10: Bullfinch have experienced a decline of nearly 40% in the last five years in England.

FINCHES

There is a mixed picture for the UK's finches. **Chaffinch** declines have been reported in these pages previously in the context of the epidemic of Trichomonosis that had first hit **Greenfinch** and then Chaffinch (*2019 BBS Report*), the five-year decline 2013–18 being reported at 24%. Chaffinch numbers have continued to decrease since then, with the latest five-year decline reported at 20%. Meanwhile, this report is the first where there has not been a five-year decline for Greenfinch since 2017, when five- and 10-year trends were first reported.

Another finch in decline is **Bullfinch**; the overall UK trend 1995–2023 shows a decline of 15%. The population has fluctuated over that time, with the last five years showing a decline of nearly a quarter following a period of increase between 2000 and 2015. In England, the decline is even more obvious, with Bullfinch down by nearly 40% since 2018 and 2024 seeing the fourth successive drop in the unsmoothed annual index. Meanwhile, in Scotland, Bullfinch are faring rather better, with numbers having increased by 46% since the start of BBS (Figure 10).

FIND OUT MORE...

Carboneras, C., *et al.* 2024. Rapid population response to a hunting ban in a previously overharvested, threatened landbird. *Conservation Letters* **17**: e13057. doi.org/10.1111/conl.1305

Table 2: UK population trends during 2023–24, 2013–23 and 1995–2023.

Species	Min. sample	1-year (23-24)	10-year (13-23)	28-year (95-23)	LCL	UCL
Canada Goose	588	0	32 *	129 *	75	208
Greylag Goose	324	31	24	240 *	67	718
Mute Swan	281	23 *	1	25	-5	68
Egyptian Goose	40	6	59 *	1,972 *	690	inf
Shelduck	160	5	-16 *	-22	-54	15
Mandarin Duck	42	-6	66 *	580 *	278	1,558
Gadwall	54	-16	69 *	217 *	87	502
Mallard	1,466	2	-8 *	5	-6	14
Teal	51	-68 *	49	–	–	–
Tufted Duck	165	10	-19	7	-26	50
Goosander	48	25	-6	-17	-40	47
Red Grouse	160	1	-27 *	-20 *	-33	0
Grey Partridge	193	-3	-18 *	-64 *	-69	-57
Pheasant	2,094	7 *	-9 *	18 *	10	27
Indian Peafowl	46	-22	-36 *	–	–	–
Red-legged Partridge	611	31 *	-12 *	-3	-14	10
Swift	1,007	12	-45 *	-68 *	-71	-64
Cuckoo	671	5	20 *	-33 *	-39	-25
Feral Pigeon	762	-2	11 *	-11	-23	3
Stock Dove	981	7	41 *	51 *	33	75
Woodpigeon	2,859	2	-2	36 *	28	43
Turtle Dove	24	-15	-75 *	-98 *	-99	-97
Collared Dove	1,476	-10 *	-28 *	-21 *	-28	-11
Moorhen	671	8	-12 *	-25 *	-33	-14
Coot	286	2	-32 *	-19	-36	1
Little Grebe	77	8	-5	11	-18	61
Great Crested Grebe	76	-18	-22 *	-18	-46	10
Oystercatcher	397	2	-2	-21 *	-31	-10
Lapwing	643	-5	-15 *	-53 *	-60	-48
Golden Plover	106	-31 *	-8	-19	-39	4
Curlew	530	-2	-10 *	-51 *	-57	-44
Snipe	185	-16	8	17	-3	47
Common Sandpiper	79	10	-4	-21 *	-36	-4
Redshank	88	7	2	-45 *	-62	-15
(Common Tern)	67	7	-20	-4	-54	51
(Cormorant)	279	20	13	36	-3	88
(Grey Heron)	701	0	-3	-13 *	-25	-2
(Little Egret)	74	33 *	68 *	2,726 *	867	inf
Sparrowhawk	354	-15	-18 *	-25 *	-35	-13
Marsh Harrier	33	9	-5	244 *	126	448
Red Kite	276	7	136 *	2,464 *	1,458	4,542
Buzzard	1,322	7 *	-1	78 *	63	99
(Barn Owl)	56	-9	4	231 *	124	461
Little Owl	59	-24	-53 *	-79 *	-84	-72
(Tawny Owl)	96	32	-25 *	-43 *	-56	-29
Kingfisher	58	36	10	-15	-44	37
Gt Spotted Woodpecker	1,294	-2	-4 *	127 *	108	143
Green Woodpecker	883	-12 *	-32 *	-10	-17	0
Kestrel	683	1	-4	-37 *	-43	-30
Hobby	46	-38 *	-8	-16	-41	24
Peregrine	56	-23	-35 *	-48 *	-64	-22
Ring-necked Parakeet	109	8	95 *	2,406 *	1,009	inf
Jay	896	-8	-9 *	15 *	5	29
Magpie	2,157	3	2	1	-5	5
Jackdaw	2,071	0	7 *	62 *	47	76
Rook	1,460	-4	-5	-25 *	-32	-17
Carrion Crow	2,717	-6 *	-1	17 *	9	25
Hooded Crow	153	-5	8	20	-10	62
Raven	423	-11	24	42	-8	123

Species	Min. sample	1-year (23-24)	10-year (13-23)	28-year (95-23)	LCL	UCL
Coal Tit	967	-5	-8 *	0	-13	14
Marsh Tit	149	6	-25 *	-48 *	-59	-35
Willow Tit	25	10	-50 *	-90 *	-94	-83
Blue Tit	2,646	-6 *	-8 *	-4	-7	0
Great Tit	2,532	-4 *	-14 *	22 *	16	28
Skylark	1,937	0	18 *	-9 *	-14	-4
Sand Martin	153	-14	-3	16	-36	117
Swallow	2,167	-18 *	-42 *	-25 *	-30	-19
House Martin	968	7	-37 *	-42 *	-48	-34
Cetti's Warbler	50	30 *	388 *	1,122 *	544	inf
Long-tailed Tit	1,128	-13 *	-3	12 *	3	25
Wood Warbler	44	9	-55 *	-81 *	-88	-71
Willow Warbler	1,465	10 *	-3	-7	-15	1
Chiffchaff	1,930	10 *	44 *	190 *	174	206
Sedge Warbler	320	-16 *	-13 *	-13	-30	5
Reed Warbler	151	-3	22 *	45 *	12	82
Grasshopper Warbler	92	-5	13	8	-21	57
Blackcap	1,994	13 *	22 *	193 *	174	214
Garden Warbler	470	-18 *	-15 *	-30 *	-39	-19
Lesser Whitethroat	312	44 *	3	-1	-15	14
Whitethroat	1,557	-11 *	-16 *	15 *	7	27
Firecrest	46	38 *	242 *	–	–	–
Goldcrest	940	1	7	8	-10	27
Wren	2,825	8 *	24 *	36 *	29	42
Nuthatch	644	-1	10 *	110 *	85	138
Treecreeper	412	-3	-2	9	-8	26
Starling	1,845	-16 *	-14 *	-57 *	-61	-53
Song Thrush	2,321	9 *	22 *	34 *	28	42
Mistle Thrush	1,208	-10	-11 *	-38 *	-44	-32
Blackbird	2,829	1	-4 *	17 *	12	21
Ring Ouzel	44	-29	-12	–	–	–
Spotted Flycatcher	169	-2	-37 *	-67 *	-73	-57
Robin	2,729	7 *	14 *	29 *	25	34
Nightingale	34	-1	-3	-41 *	-65	-7
Pied Flycatcher	39	52 *	–	-56 *	-76	-29
Redstart	201	-5	-22 *	8	-6	24
Whinchat	77	3	-17	-60 *	-71	-46
Stonechat	209	-8	184 *	258 *	182	381
Wheatear	371	-4	-27 *	-32 *	-43	-17
Dipper	67	0	-39 *	-52 *	-69	-33
Tree Sparrow	206	-19 *	-37 *	39 *	1	83
House Sparrow	1,818	-9 *	-7 *	-11 *	-18	-5
Dunnock	2,367	-4 *	-12 *	6 *	1	12
Yellow Wagtail	169	-13	-20 *	-53 *	-63	-40
Grey Wagtail	243	16	8	-13	-26	2
Pied Wagtail	1,387	-4	-15 *	-22 *	-28	-15
Meadow Pipit	887	-12 *	-4	-16 *	-23	-8
Tree Pipit	156	21	-16	-8	-29	24
Chaffinch	2,789	-3 *	-39 *	-34 *	-37	-31
Bullfinch	706	-8	-21 *	-15 *	-22	-6
Greenfinch	1,753	3	-50 *	-66 *	-68	-63
Linnet	1,337	0	5	-22 *	-28	-15
Redpoll	189	-5	-19 *	12	-20	51
Common Crossbill	65	-9	-30 *	2	-32	56
Goldfinch	2,064	-1	17 *	152 *	135	171
Siskin	240	8	-12 *	44 *	15	77
Corn Bunting	152	13	38 *	-16	-38	10
Yellowhammer	1,258	-11 *	-23 *	-35 *	-41	-29
Reed Bunting	568	-17 *	-1	22 *	6	38

INTERPRETING THE RESULTS: see page 17

TREND TABLES ONLINE: www.bto.org/bbs-tables

England: population trends

The population trends for 116 species are reported for England. Whilst several species are in decline in England, many – particular woodland birds – are increasing farther north in Britain.

STATISTICALLY SIGNIFICANT RESULTS

Period	No. species	Greatest change in English trends	
Long-term (95–23) increases	35	Red Kite	24,725%
Long-term (95–23) decreases	41	Turtle Dove	-98%
Short-term (23–24) increases	16	Kingfisher	82%
Short-term (23–24) decreases	20	Hobby	-37%

NEW TRENDS

Two new all-time trends for species in England are published in this report for **Golden Plover** and **Marsh Harrier**. They arise for very different reasons. Golden Plover is afforded an all-time trend in England due to a change in analytical methods (see p4). The change in spatial filtering rules means that many important breeding areas – including the North York Moors and Pennines – are now included in calculating population trends and boost sample sizes. The new trends reveal a significant decline of Golden Plover in England over the last 10 years. Previously, there had been more uncertainty around these estimates.

Meanwhile, Marsh Harrier can rightly be considered one of the UK's recent conservation success stories. Down to just a single pair in 1971 (RBBP, 2023), the species has increased to such an extent that it is now seen on 47 English squares per year. Since the start of BBS, numbers have trebled across England, with the majority of that increase seen between 1994 and 2015. Like **Bittern**, which is detected rarely on BBS, Marsh Harrier has benefitted from the creation, expansion and restoration of reedbeds and can be seen foraging over adjacent farmland.

WOODLAND WOES

Bullfinch and **Chaffinch** (see 'UK Population Trends', p18) are two species on the UK and England Woodland Indicators. As well as the long-term declines of farmland species, the most recent set of indicators again highlighted a shorter-term (five-year) decline in woodland birds. As ever, the picture is not uniform – some woodland species are doing well, like **Blackcap** and **Chiffchaff**, but others, like Bullfinch and Chaffinch are in decline. Many of the woodland species in decline include specialists like **Spotted Flycatcher**, **Pied Flycatcher**, **Wood Warbler**, **Willow Tit**, **Marsh Tit** and **Tree Pipit**. Several of these are long-distance migrants. Even then, some generalists, including the almost ubiquitous **Dunnock** are showing more recent declines, down by 12% in the last five years (Figure 11).

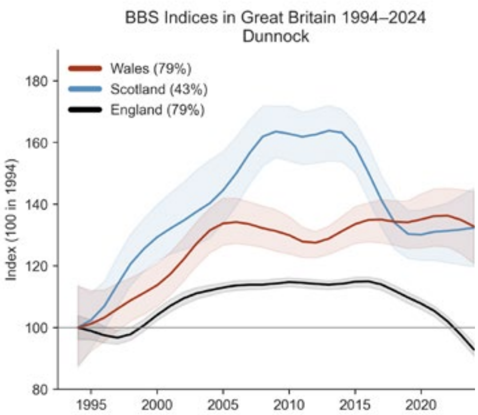


Figure 11: Dunnock, one of our most familiar generalist species is experiencing a decline in England.

NIGHTINGALE

Nightingale, another woodland edge/scrub species, has declined by 90% since 1967, as reported by combined CBC and BBS trends. A new study has shown that the UK and continental populations – the latter being relatively stable – have two separate wintering areas, with UK birds wintering in a very restricted area of West Africa centred on the Gambia. Continental breeders, meanwhile, winter in a much larger area of West Africa (Kirkland *et al.* 2025).

The non-breeding area used by UK Nightingale, as well as being smaller, was also found to be of lower habitat suitability compared to the areas used by continental populations. Together, this makes UK Nightingales much more vulnerable. This builds on previous work which had identified that Nightingale declines were also linked to breeding season habitat changes (e.g., Holt *et al.* 2010). Whilst the small recent upturn in Nightingale in England – up by 32% in the last five years – might indicate that local conservation efforts are being effective, conditions in the non-breeding grounds are clearly a major factor influencing population trends.

FIND OUT MORE...

Eaton, M.A. & The RBBP 2023. Rare Breeding Birds in the UK in 2021. *British Birds* **116:** 609–684.

Holt, C.A. *et al.* 2010. Experimental evidence that deer browsing reduces habitat suitability for breeding Common Nightingales *Luscinia megarhynchos*. *Ibis* **152**: 335–346. doi.org/10.1111/j.1474-919X.2010.01012.x

Kirkland, M. *et al.* 2025. Extreme migratory connectivity and apparent mirroring of non-breeding grounds conditions in a severely declining breeding population of an Afro-Palearctic migratory bird. *Scientific Reports* **15**:330. doi.org/10.1038/s41598-025-86484-z

NIGHTINGALE: EDMUND FELLOWES/BTO

Table 3: Trends in England during 2023–24, 2013–23 and 1995–2023.

Species	Min. sample	1-year (23-24)	10-year (13-23)	28-year (95-23)	LCL	UCL
Canada Goose	532	**14**	**26 ***	**92 ***	42	167
Greylag Goose	261	**32 ***	**22 ***	**342 ***	181	657
Mute Swan	238	**25**	**13**	**26**	-7	94
Egyptian Goose	40	**6**	**58 ***	**1,965 ***	648	inf
Shelduck	128	**0**	**-15**	**0**	-42	29
Mandarin Duck	40	**-15**	**61 ***	**592 ***	295	1,641
Gadwall	50	**-17**	**63 ***	**197 ***	76	511
Mallard	1,215	**6**	**-10 ***	**10 ***	1	20
Teal	30	**-57**	**124 ***	**–**	–	–
Tufted Duck	141	**11**	**-24 ***	**-4**	-33	33
Red Grouse	88	**1**	**-19 ***	**-5**	-33	55
Grey Partridge	165	**-2**	**-21 ***	**-63 ***	-69	-55
Pheasant	1,744	**5**	**-7 ***	**20 ***	12	29
Indian Peafowl	43	**-9**	**-34**	**–**	–	–
Red-legged Partridge	588	**36 ***	**-11 ***	**-7**	-20	6
Swift	856	**14**	**-47 ***	**-69 ***	-73	-65
Cuckoo	419	**16 ***	**-9 ***	**-71 ***	-75	-67
Feral Pigeon	615	**-4**	**18 ***	**-15 ***	-25	-1
Stock Dove	903	**5**	**47 ***	**52 ***	34	74
Woodpigeon	2,264	**1**	**-3 ***	**38 ***	29	46
Turtle Dove	23	**-15**	**-75 ***	**-98 ***	-99	-97
Collared Dove	1,271	**-11 ***	**-33 ***	**-28 ***	-34	-23
Moorhen	618	**7**	**-16 ***	**-29 ***	-37	-19
Coot	257	**4**	**-28 ***	**-15**	-35	14
Little Grebe	59	**10**	**-2**	**-1**	-37	71
Great Crested Grebe	68	**-9**	**-24 ***	**-29 ***	-47	-2
Oystercatcher	225	**1**	**6**	**61 ***	30	101
Lapwing	539	**-5**	**-21 ***	**-43 ***	-49	-36
Golden Plover	62	**-24 ***	**-35 ***	**-21**	-43	11
Curlew	343	**7**	**-2**	**-32 ***	-44	-21
Snipe	96	**-2**	**12**	**1**	-23	36
Common Sandpiper	33	**26**	**5**	**-30**	-54	4
Redshank	62	**9**	**-18**	**-44 ***	-63	-18
(Common Tern)	61	**-19**	**-15**	**10**	-43	70
(Cormorant)	233	**-16 ***	**15**	**31 ***	5	74
(Grey Heron)	570	**6**	**-2**	**-21 ***	-31	-9
(Little Egret)	68	**35 ***	**62 ***	**2,479 ***	906	inf
Sparrowhawk	289	**-17 ***	**-21 ***	**-33 ***	-40	-23
Marsh Harrier	30	**3**	**-8**	**231 ***	132	436
Red Kite	222	**16 ***	**166 ***	**24,725 ***	inf	inf
Buzzard	939	**9 ***	**7 ***	**200 ***	164	251
(Barn Owl)	53	**-11**	**4**	**242 ***	140	516
Little Owl	57	**-24**	**-52 ***	**-78 ***	-83	-71
(Tawny Owl)	83	**9**	**-24 ***	**-38 ***	-54	-20
Kingfisher	51	**83 ***	**-17**	**-27**	-49	11
Gt Spotted Woodpecker	1,107	**-2**	**-12 ***	**88 ***	74	104
Green Woodpecker	828	**-11 ***	**-34 ***	**-4**	-11	5
Kestrel	606	**-1**	**-4**	**-24 ***	-31	-17
Hobby	44	**-37 ***	**-13**	**-17**	-48	20
Peregrine	35	**31**	**-21**	**15**	-26	103
Ring-necked Parakeet	109	**7**	**94 ***	**2,397 ***	875	inf
Jay	763	**-10**	**-15 ***	**-5**	-12	3
Magpie	1,793	**4**	**3**	**2**	-3	8
Jackdaw	1,667	**1**	**12 ***	**78 ***	65	92
Rook	1,166	**-2**	**-4**	**-16 ***	-25	-5
Carrion Crow	2,217	**-3**	**2**	**27 ***	15	35
Raven	214	**-14**	**4**	**25**	-34	290

Species	Min. sample	1-year (23-24)	10-year (13-23)	28-year (95-23)	LCL	UCL
Coal Tit	645	**-3**	**-8**	**12**	-3	27
Marsh Tit	136	**4**	**-25 ***	**-50 ***	-60	-39
Willow Tit	21	**-10**	**-53 ***	**-91 ***	-94	-84
Blue Tit	2,134	**-5 ***	**-7 ***	**-4 ***	-8	-1
Great Tit	2,034	**-5 ***	**-14 ***	**14 ***	9	18
Skylark	1,531	**0**	**14 ***	**-12 ***	-17	-7
Sand Martin	90	**-23 ***	**-2**	**-6**	-36	55
Swallow	1,647	**-15 ***	**-48 ***	**-34 ***	-37	-28
House Martin	734	**7**	**-44 ***	**-59 ***	-63	-52
Cetti's Warbler	47	**35 ***	**400 ***	**932 ***	428	inf
Long-tailed Tit	990	**-4**	**-9 ***	**3**	-7	15
Willow Warbler	922	**7**	**-17 ***	**-47 ***	-54	-41
Chiffchaff	1,600	**8 ***	**39 ***	**181 ***	163	199
Sedge Warbler	199	**-11**	**-7**	**-18**	-34	6
Reed Warbler	143	**-4**	**21 ***	**42 ***	13	85
Grasshopper Warbler	42	**-10**	**11**	**-23**	-51	22
Blackcap	1,669	**12 ***	**17 ***	**148 ***	134	165
Garden Warbler	378	**-18 ***	**-19 ***	**-42 ***	-48	-33
Lesser Whitethroat	298	**41 ***	**3**	**-1**	-15	12
Whitethroat	1,327	**-12 ***	**-18 ***	**9 ***	3	16
Firecrest	43	**39 ***	**226 ***	**–**	–	–
Goldcrest	676	**4**	**7**	**32 ***	15	54
Wren	2,187	**12 ***	**23 ***	**30 ***	25	35
Nuthatch	550	**2**	**9 ***	**111 ***	86	139
Treecreeper	307	**-1**	**-5**	**-2**	-20	14
Starling	1,485	**-11 ***	**-15 ***	**-66 ***	-68	-63
Song Thrush	1,800	**8 ***	**13 ***	**25 ***	18	31
Mistle Thrush	934	**-11 ***	**-21 ***	**-53 ***	-56	-49
Blackbird	2,237	**-2**	**-10 ***	**7 ***	4	11
Ring Ouzel	23	**26**	**12**	**–**	–	–
Spotted Flycatcher	106	**4**	**-25 ***	**-71 ***	-77	-63
Robin	2,144	**8 ***	**15 ***	**36 ***	31	42
Nightingale	34	**-4**	**-3**	**-40**	-61	3
Redstart	111	**4**	**-14**	**1**	-22	27
Whinchat	25	**-15**	**-53 ***	**-70 ***	-85	-56
Stonechat	86	**-1**	**233 ***	**308 ***	180	561
Wheatear	199	**-15**	**-40 ***	**-30 ***	-50	-1
Dipper	31	**-25**	**-41 ***	**-61 ***	-80	-11
Tree Sparrow	153	**-4**	**-48 ***	**-9**	-30	15
House Sparrow	1,460	**-11 ***	**-12 ***	**-25 ***	-31	-19
Dunnock	1,913	**-6 ***	**-14 ***	**-1**	-6	4
Yellow Wagtail	165	**-12**	**-19 ***	**-53 ***	-61	-43
Grey Wagtail	164	**15**	**11**	**3**	-17	26
Pied Wagtail	1,035	**-3**	**-8 ***	**-20 ***	-27	-14
Meadow Pipit	450	**-13 ***	**-16 ***	**-24 ***	-35	-14
Tree Pipit	69	**22**	**-37 ***	**-67 ***	-81	-51
Chaffinch	2,151	**-4 ***	**-48 ***	**-45 ***	-48	-42
Bullfinch	534	**-14**	**-36 ***	**-33 ***	-41	-25
Greenfinch	1,499	**5**	**-48 ***	**-63 ***	-66	-60
Linnet	1,075	**-7**	**-3**	**-27 ***	-34	-18
Redpoll	68	**42**	**-33 ***	**-27**	-58	21
Crossbill	30	**22**	**-45 ***	**–**	–	–
Goldfinch	1,687	**3**	**15 ***	**141 ***	124	157
Siskin	92	**4**	**12**	**85**	-7	438
Corn Bunting	144	**14 ***	**38 ***	**-13**	-33	20
Yellowhammer	1,086	**-12 ***	**-22 ***	**-42 ***	-47	-37
Reed Bunting	423	**-19 ***	**-9 ***	**23 ***	5	43

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INTERPRETING THE RESULTS: see page 17

Scotland: population trends

There are four new species trends for Scotland published in this report. Five-year trends are now available online for Nuthatch and Grey Partridge, with Canada Goose and Red Kite graduating to ten-year trends. This takes the total number of species monitored by BBS in Scotland to 77.

STATISTICALLY SIGNIFICANT RESULTS

Period	No. species	Greatest change in Scottish trends	
Long-term (95–23) increases	22	Chiffchaff	1,219%
Long-term (95–23) decreases	14	Greenfinch	-70%
Short-term (23–24) increases	5	Grey Wagtail	55%
Short-term (23–24) decreases	8	Long-tailed Tit	-43%

UPLAND DOWN

The latest Scottish Terrestrial Wild Bird Indicators, published in February, show that the Scottish Upland Indicator has declined the most since 1994, with an overall decline of 20%. The Scottish indicators are based largely – as is the case for UK and English indicators – on BBS data. The production of the upland indicator is especially reliant on the Upland Rover scheme and we extend our thanks to those trekking great heights and/or long distances, often without seeing many birds.

One species that will be familiar to almost all Upland Rover volunteers is the **Meadow Pipit.** Whilst the population has fluctuated considerably over time, Meadow Pipit has been in decline for many years in parts of its UK range, particularly in England where it has declined by 24% since 1995. This decline seems to be driven by losses in lowland areas; in upland areas of England, there has been relatively little change (Figure 12). In Scotland, there has been a 14% decline overall since 1994, with a significant decline of 32% between 1994 and 2010.

One of the species for which Upland Rovers has made a positive impact on our ability to produce population trends is **Whinchat**, which we reported last year as having a new 10-year trend for Scotland. RSPB-led research, published in 2021 and 2023 revealed that Whinchat declines were greatest in areas near woodland, but least severe in unenclosed grassland habitats which are common in upland areas. Another study, whilst conducted many miles away on Dartmoor in south-west England, also shows that Whinchat territory persistence was more likely to occur in steeper sided valleys with more Bracken (especially with heathland vegetation), areas with fewer trees and away from enclosed, intensively managed grasslands. (Hawkes, *et al.* 2024).

Wheatear, another species of chat familiar to many in upland areas, has also declined across the UK, including in Scotland where it is down by 31% over the period 1995–2023 (Figure 13).

WADER WATCH

Waders were a major focus of the results reported in the 2021 BBS report. The UK's uplands, especially in Scotland, support many of the UK's breeding waders. Some species use sites in both upland and lowland settings, whereas others like **Golden Plover** are almost entirely reliant on upland sites for nesting. The declines of **Curlew** have been reported in both the popular and scientific press. In England, there are signs that Curlew are stable in some northern regions (see p28, English Regions). In Scotland, there is a decline of 62%, compared with 32% overall in England. In Wales, the situation is worse, where a decline of three-quarters has been seen since 1995. Other waders in England and Scotland are struggling too, with **Lapwing** having declined by 43% in England and 62% in Scotland.

Meanwhile, the **Oystercatcher** increase in England continues, up by 61% in the last 28 years, compared with a 38% decline in Scotland. No overall change in numbers have been detected for **Snipe** since 1995 in either England or Scotland.

◀ Wheatear abundance has fluctuated over the course of BBS, with the last peak around 2010. It has declined since, with most of this concentrated between 2010 and 2018.

WHEATEAR: LIZ CUTTING/BTO; LAPWING: CHRIS KNIGHTS/BTO

FIND OUT MORE...

Hawkes, R.W. *et al.* 2024. Environmental correlates of Whinchat *Saxicola rubetra* breeding territory retention in a declining upland population. *Bird Study* **71**: 241–255. doi.org/10.1080/00063657.2024.2375383

Table 4: Trends in Scotland during 2023–24, 2013–23 and 1995–2023.

Species	Min. sample	1-year (23-24)	10-year (13-23)	28-year (95-23)	LCL	UCL
Canada Goose	31	**-46**	**41**	**–**	–	–
Greylag Goose	45	**35**	**20**	**165**	-30	846
Mute Swan	32	**15**	**-34**	**–**	–	–
Mallard	129	**-7**	**-10**	**-23 ***	-36	-3
Red Grouse	66	**0**	**-29 ***	**-28 ***	-41	-8
Pheasant	177	**17**	**-15 ***	**2**	-17	23
Swift	58	**6**	**-16**	**-63 ***	-74	-49
Cuckoo	102	**6**	**40 ***	**67 ***	37	110
Feral Pigeon	80	**9**	**-7**	**4**	-34	59
Stock Dove	36	**68**	**-11**	**–**	–	–
Woodpigeon	265	**11**	**-4**	**10**	-10	34
Collared Dove	65	**-1**	**5**	**18**	-34	128
Oystercatcher	149	**0**	**-8**	**-38 ***	-51	-26
Lapwing	86	**-6**	**-6**	**-62 ***	-73	-51
Golden Plover	43	**-30**	**9**	**-16**	-39	17
Curlew	135	**-15**	**-15 ***	**-62 ***	-70	-54
Snipe	73	**-20**	**10**	**23**	-5	63
Common Sandpiper	41	**8**	**-4**	**-21**	-36	5
(Grey Heron)	61	**-13**	**2**	**6**	-18	41
Sparrowhawk	31	**-21**	**-17**	**–**	–	–
Red Kite	31	**52 ***	**128 ***	**–**	–	–
Buzzard	180	**1**	**-12 ***	**8**	-9	31
Gt Spotted Woodpecker	78	**-3**	**10**	**456 ***	329	698
Kestrel	38	**14**	**5**	**-61 ***	-74	-39
Jay	34	**3**	**12**	**472 ***	259	1,097
Magpie	74	**14**	**50 ***	**101 ***	50	176
Jackdaw	155	**12**	**20**	**56 ***	18	115
Rook	131	**-21**	**0**	**-39 ***	-55	-13
Carrion Crow	246	**-19 ***	**-7**	**-7**	-23	12
Hooded Crow	59	**-12**	**0**	**-24**	-50	19
Raven	72	**-9**	**70**	**59**	-9	154
Coal Tit	167	**-6**	**-2**	**-2**	-22	28
Blue Tit	209	**-3**	**-3**	**4**	-8	21
Great Tit	202	**-1**	**-11 ***	**47 ***	25	81
Skylark	258	**-1**	**28 ***	**-3**	-14	11
Sand Martin	43	**-2**	**3**	**51**	-42	426
Swallow	220	**-15 ***	**-32 ***	**-3**	-20	16
House Martin	86	**18**	**-23 ***	**52 ***	5	140
Long-tailed Tit	45	**-43 ***	**65 ***	**103 ***	38	210
Willow Warbler	266	**12 ***	**7**	**34 ***	17	56
Chiffchaff	104	**10**	**135 ***	**1,219 ***	762	2,031
Sedge Warbler	67	**-20**	**-17**	**12**	-23	63
Blackcap	105	**14 ***	**60 ***	**714 ***	471	1,256
Garden Warbler	38	**9**	**-1**	**–**	–	–
Whitethroat	111	**0**	**1**	**134 ***	61	216
Goldcrest	111	**-28 ***	**-14**	**-6**	-28	22
Wren	290	**-5**	**29 ***	**68 ***	49	87
Treecreeper	48	**11**	**15**	**32**	-16	90
Starling	177	**-25 ***	**-9**	**-32 ***	-48	-14
Song Thrush	229	**0**	**26 ***	**36 ***	16	56
Mistle Thrush	96	**-29 ***	**-1**	**2**	-26	47
Blackbird	251	**0**	**-2**	**30 ***	15	54
Spotted Flycatcher	33	**-11**	**-58 ***	**–**	–	–
Robin	250	**-2**	**-6**	**12**	-2	27
Whinchat	27	**-7**	**3**	**-64 ***	-79	-40
Stonechat	54	**-17**	**169 ***	**191 ***	102	363
Wheatear	97	**-8**	**-17**	**-31 ***	-46	-12
Tree Sparrow	40	**-25 ***	**12**	**400 ***	98	1,390
House Sparrow	130	**1**	**-3**	**28**	-4	81
Dunnock	177	**-1**	**-20 ***	**29 ***	6	52
Grey Wagtail	36	**55 ***	**-3**	**-26**	-49	13
Pied Wagtail	162	**-5**	**-26 ***	**-33 ***	-46	-18
Meadow Pipit	263	**-13 ***	**4**	**-14 ***	-23	-6
Tree Pipit	46	**31 ***	**-4**	**88 ***	34	162
Chaffinch	299	**-5**	**-23 ***	**-11**	-22	1
Bullfinch	60	**-5**	**7**	**46 ***	3	106
Greenfinch	107	**-6**	**-49 ***	**-70 ***	-79	-58
Linnet	108	**11**	**46 ***	**3**	-19	34
Redpoll	65	**-5**	**-3**	**33**	**-11**	**135**
Crossbill	34	**-18**	**-24**	**–**	–	–
Goldfinch	142	**-11**	**34 ***	**236 ***	167	356
Siskin	99	**11**	**-23 ***	**24**	-9	66
Yellowhammer	133	**-7**	**-22 ***	**7**	-15	32
Reed Bunting	80	**-10**	**29 ***	**55 ***	22	111

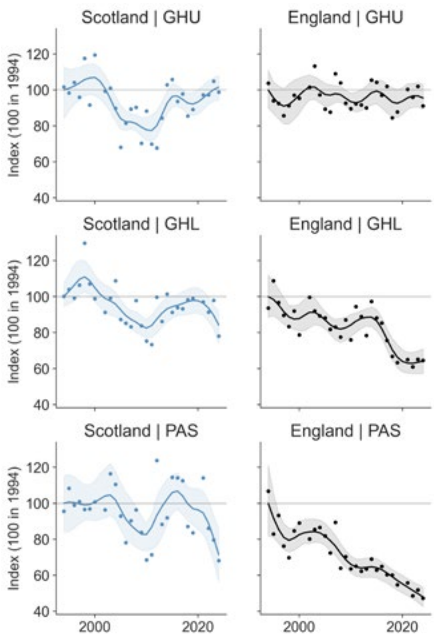

Figure 12: Meadow Pipit habitat specific trends in Scotland (left) and England (right) in its three most associated habitats: GHU = Upland grass- or heathland; GHL = Lowland grass- or heathland; PAS = Pastoral habitat. Uplands are defined as those higher than 300 m above sea-level.

Habitat specific trends are calculated using the method of Sullivan *et al.* (2015).

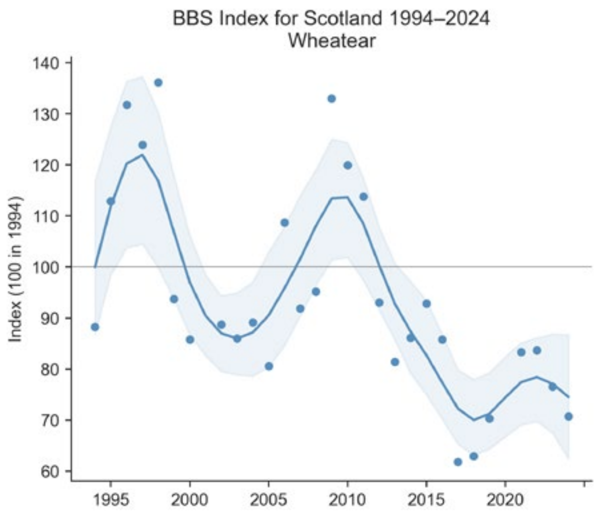

Figure 13: Like Meadow Pipit, Wheatear has experienced fluctuations in populations, but the overall trend since 1994 is one of decline.

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Wales: population trends

Trends for 60 species in Wales are reported and displayed in these pages. There is a mixed picture for birds of prey in Wales, whereas House Sparrow, beleaguered across much of the UK, is on the up.

STATISTICALLY SIGNIFICANT RESULTS

Period	No. species	Greatest change in Welsh trends*	
Long-term (95–23) increases	17	Canada Goose	675%
Long-term (95–23) decreases	15	Swift	-76%
Short-term (23–24) increases	3	Chiffchaff	19%
Short-term (23–24) decreases	4	Red Kite	-35%

* Species are colour coded by the BoCC4 Wales assessment.

RAPTORS

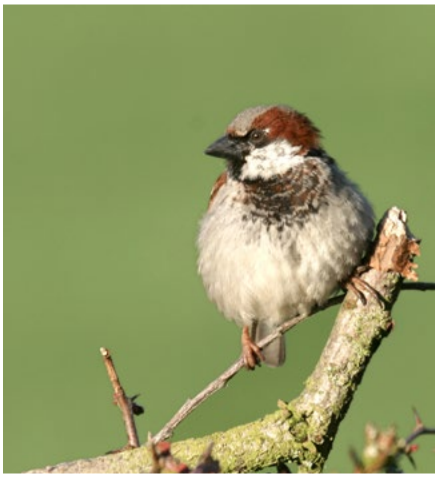
The picture for birds of prey in Wales is a mixed one. **Red Kite**, the national bird of Wales, has increased in the last 10 years on the back of a six-fold increase since the beginning of BBS. That these increases sound so impressive is due to the their starting from a low base following years of persecution, with Wales being a refuge. But, it also showed the largest one-year decrease in Wales between 2023 and 2024.

A UK wide study – led by RSPB – has shown that the overall predicted impact of the growth of on-shore renewable energy isn't likely to lead to significant changes in habitat available for birds (Copping *et al.* 2024). Nevertheless, at an individual site level, species like Red Kite are sensitive to the impacts of on-shore wind development. Using BBS data, along with Bird Atlas and APEP data, a joint study between BTO Cymru and BSG Ecology modelled the potential impacts of current and proposed wind developments on Welsh Red Kite populations (Hereward *et al.* 2024a). The results suggest that the current growth of the Red Kite population in Wales is unlikely to be affected, though more caution is likely to be needed when considering developments close to SPAs – see p12.

Meanwhile, **Buzzard**, the second bird of prey for which Welsh population trends are published, has declined by 17% in the last 10 years. Buzzard is in decline in other parts of the UK too; the species has been in decline in Scotland since 2002, whereas in England we report the first five-year decline – a modest 6% since 2018 – this following a more than three-fold increase between 1995 and 2018. Whether this change in England is the start of a natural plateauing, or instead a signal of the effects of High Pathogenicity Avian Influenza (HPAI) remains to be seen. Irrespective, it is clear that long-term schemes like BBS, WeBS and SMP will form an important tool to monitor the effects of HPAI for many species.

Kestrel and **Sparrowhawk** are not observed on a sufficient number of BBS squares to have Wales-specific trends. To bridge the gap in some of our knowledge of Wales' raptors, in particular aspects of their breeding success and productivity, 2024 saw the launch of Cudyll Cymru, the Welsh Raptor Monitoring Scheme, which uses a 'patch based' approach. The target species are Buzzard, Kestrel, **Raven**, Red Kite and Sparrowhawk. Volunteers will have a range of monitoring options to choose from, depending on their experience level and/or time commitments. These range from vantage point counts to nest-recording and ringing. To find out more, visit: www.bto.org/cudyll-cymru.

◀ Red Kite is one of five species of raptor being monitored under **Cudyll Cymru**, the new raptor monitoring scheme for Wales.



HOUSE SPARROW

House Sparrow has nearly doubled in Wales since 1995, faring much better than other parts of the UK, particularly in England where populations have declined by a quarter in the last 28 years (Figure 14) and by 71% between 1977 and 2022. Much of this decline occurred between 1980 and 1995 and is measured by CBC. It is unknown why the Welsh population of House Sparrow is doing so well, but it is certainly a cause for hope and reflects its Amber-listed status in Wales, compared with the overall UK Red-list status.

ROOK

The results of the All Wales **Rook** Survey were published in 2024 (Hereward *et al.*2024b), with the previous survey being in 1996. Since that time, Rooks have declined in abundance (the new estimate is of 44,127 pairs) and in occupancy, being lost from an estimated 5.6% of tetrads since 1996. The number of nests per rookery also declined by 20%, with much regional variation. However, 2024 sees the third successive annual increase in the unsmoothed BBS index from a low in 2021.

RED KITE: SARAH KELMAN/BTO; HOUSE SPARROW: JOHN HARDING/BTO

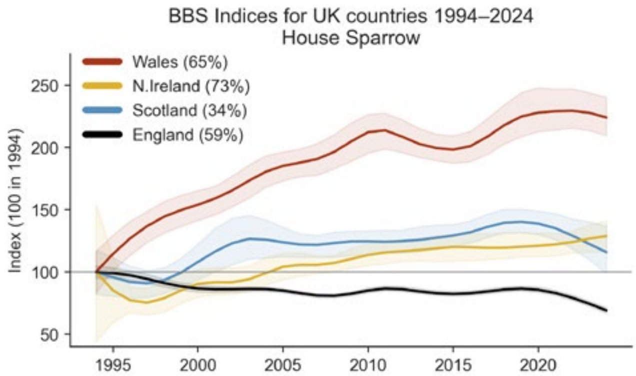


Figure 14: House Sparrow in Wales has doubled in number over the period 1995–2023, compared with England where the species has suffered declines going back to at least the 1970s.

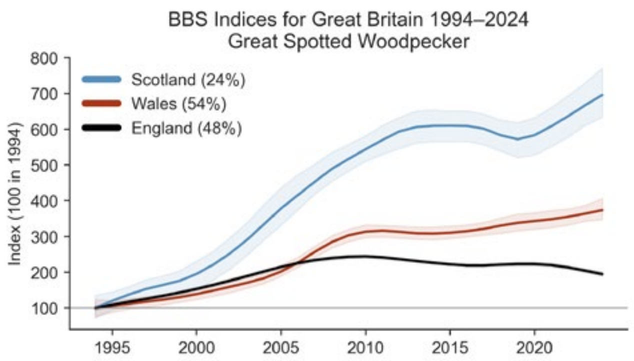


Figure 15: Great Spotted Woodpecker has more than trebled in Wales since 1995. There has also been a substantial increase in Scotland. Meanwhile, following a more than four-fold increase in England between 1965 and 2010, there has been a 10% decline since 2013.

FIND OUT MORE...

Copping, J.P. *et al.* 2024. Ambitious onshore renewable energy deployment does not exacerbate future UK land-use challenges. *Cell Reports Sustainability* **1:** 100122. doi.org/10.1016/j.crsus.2024.100122

Hereward, H.F.R. *et al.* 2024a. *Modelling population-level impacts of wind farm collision risk on Welsh Red Kites.* BTO Research Report **766**. BTO, Thetford, UK

Hereward, H.F.R. *et al.* 2024b. Status and distribution of Rook *Corvus frugilegus* in Wales 2022/23. *Milvus: the Journal of the Welsh Ornithological Society* **4:** 32–50.

Table 5: Trends in Wales during 2023–24, 2013–23 and 1995–2023.

Species†	Min. sample	1-year (23-24)	10-year (13-23)	28-year (95-23)	LCL	UCL
Canada Goose	39	**-19**	**93 ***	**675 ***	294	1,648
Mallard	77	**-7**	**17**	**1**	-50	76
Pheasant	112	**9**	**-11**	**14**	-27	57
Swift	63	**36**	**-56 ***	**-76 ***	-85	-60
Cuckoo	66	**-27**	**23**	**-6**	-34	28
Feral Pigeon	41	**30**	**3**	**29**	-8	113
Stock Dove	39	**10**	**0**	**92 ***	13	195
Woodpigeon	217	**2**	**12**	**43 ***	20	69
Collared Dove	84	**-16**	**1**	**22**	-10	74
Curlew	31	**38**	**-43 ***	**-76 ***	-85	-60
(Grey Heron)	46	**-28**	**11**	**-3**	-50	69
Red Kite	39	**-35 ***	**67 ***	**545 ***	267	1,288
Buzzard	160	**21**	**-17 ***	**-15**	-30	2
Gt Spotted Woodpecker	104	**2**	**18 ***	**243 ***	182	348
Green Woodpecker	47	**-14**	**-4**	**-33 ***	-54	-8
Jay	86	**-14**	**-3**	**35**	-14	95
Magpie	182	**-8**	**0**	**-19 ***	-34	-6
Jackdaw	159	**-2**	**-12**	**9**	-32	76
Rook	81	**38**	**-31**	**-51 ***	-70	-21
Carrion Crow	234	**0**	**-8**	**4**	-12	20
Raven	108	**-10**	**-17**	**7**	-33	65
Coal Tit	86	**-13**	**-13**	**-29 ***	-46	-5
Blue Tit	204	**-16 ***	**-20 ***	**-9**	-20	6
Great Tit	196	**1**	**-20 ***	**16**	-1	38
Skylark	116	**0**	**-9**	**-14**	-32	9
Swallow	193	**-16 ***	**-44 ***	**-23 ***	-36	-9
House Martin	91	**10**	**-47 ***	**-43 ***	-58	-18
Long-tailed Tit	71	**-26**	**-15**	**9**	-19	49
Willow Warbler	176	**13 ***	**-13 ***	**-19**	-35	1
Chiffchaff	173	**19 ***	**25 ***	**117 ***	84	159
Blackcap	156	**9**	**14 ***	**189 ***	132	277
Garden Warbler	62	**-27**	**-15**	**-27**	-50	3
Whitethroat	95	**-25 ***	**-27 ***	**-34 ***	-46	-15
Goldcrest	96	**27**	**10**	**-35 ***	-53	-7
Wren	229	**11 ***	**21 ***	**32 ***	18	48
Nuthatch	85	**-9**	**3**	**58 ***	22	112
Treecreeper	46	**-18**	**-1**	**8**	-22	54
Starling	85	**22**	**30 ***	**-61 ***	-74	-46
Song Thrush	193	**10**	**34 ***	**49 ***	29	73
Mistle Thrush	115	**20**	**22 ***	**12**	-15	45
Blackbird	228	**-4**	**15 ***	**57 ***	46	72
Robin	221	**4**	**29 ***	**19 ***	7	33
Redstart	72	**-8**	**-26 ***	**3**	-17	27
Stonechat	53	**2**	**173 ***	**391 ***	249	740
Wheatear	60	**24**	**-24 ***	**-34 ***	-49	-8
House Sparrow	148	**-9**	**12**	**99 ***	59	146
Dunnock	182	**-2**	**5**	**33 ***	7	62
Grey Wagtail	30	**-14**	**-5**	**-28**	-57	27
Pied Wagtail	134	**2**	**1**	**2**	-21	28
Meadow Pipit	102	**-10**	**-23 ***	**-21**	-41	3
Tree Pipit	38	**-11**	**-21**	**-25**	-53	15
Chaffinch	223	**-2**	**-44 ***	**-48 ***	-55	-40
Bullfinch	73	**12**	**0**	**1**	-20	32
Greenfinch	96	**10**	**-62 ***	**-76 ***	-83	-67
Linnet	105	**16**	**7**	**-13**	-32	15
Redpoll	36	**-9**	**-24**	**–**	–	–
Goldfinch	159	**5**	**21 ***	**114 ***	65	178
Siskin	38	**6**	**33**	**125 ***	40	278
Yellowhammer	29	**-34**	**–**	**-75 ***	-85	-64
Reed Bunting	32	**8**	**13**	**50**	-18	198

† Species are colour coded by BoCC4 Wales assessment.

GREAT SPOTTED WOODPECKER: JOHN HARDING/BTO

Northern Ireland: population trends

We report trends on 39 species for Northern Ireland. In addition to the 38 species from previous years, a five-year trend is reported for the first time for Raven. A 10-year trend is also added for Feral Pigeon.

STATISTICALLY SIGNIFICANT RESULTS

Period	No. species	Greatest change in Northern Irish trends*	
Long-term (95–23) increases	16	Blackcap	2,021%
Long-term (95–23) decreases	1	Greenfinch	-82%
Short-term (23–24) increases	7	Song Thrush	40%
Short-term (23–24) decreases	7	Redpoll	-65%

RAVEN REVIEWS

A five-year trend is now published for **Raven** in Northern Ireland, meaning that this species has a published trend in all parts of the UK. Raven is returning to many parts of its former range following centuries of persecution. In Northern Ireland, the new five year trend shows a 43% increase since 2018, most likely continuing on from gains throughout the 1990s. Raven has also shown a moderate increase in the Republic of Ireland, where it is monitored by the Countryside Bird Survey. Here too, there has been a recent increase since around 2015. Across the entire island of Ireland, Raven have increased their breeding range, with changes between the 1988–91 and 2007–11 Atlases being seen particularly in the lower lying centre of the island, following earlier recolonisation of more upland areas. Raven are also monitored by the Northern Ireland Raptor Study Group.

ACROSS THE WATER

Several species monitored in Northern Ireland have trends that differ from populations in Great Britain. **Blackbird**, having been relatively stable for the period 2000 to 2020, has undergone an increase of nearly a third in the last five years in Northern Ireland. Meanwhile, Blackbird has declined in England and the UK overall in the last decade, whilst continuing to do well in Wales.

Woodpigeon has seen a steady increase in the country since the start of BBS, compared with England, where an increase of 45% during 1995–2010 has been followed by a very slight decline of 3% in 2013–23. Finally, **Meadow Pipit** – in decline in England and Wales – shows no overall change in Northern Ireland, although all UK populations show large fluctuations, with the period 2003–10 seeing a drastic drop across all parts of the UK, followed by partial recovery.

Several other species are doing well, in Northern Ireland with **Blackcap** numbers continuing to soar and **Skylark** increasing by 63% in the last 10 years. Blackcaps are on the increase in all parts of the UK, and there is evidence that the long-term Skylark declines in the UK are also being reversed (p19).

Woodpigeon in Northern Ireland has shown the greatest relative increase of any UK country. ▼

WOODPIGEON: JOHN HARDING/BTO

Table 6: Trends in Northern Ireland during 2023–24, 2013–23 and 1995–2023.

Species	Min. sample	1-year (23-24)	10-year (13-23)	28-year (95-23)	LCL	UCL
Mallard	32	-12	7	212	-1	441
Pheasant	46	-13	-13	85 *	5	321
Feral Pigeon	30	-50 *	37	–	–	–
Woodpigeon	94	3	25 *	142 *	86	220
Collared Dove	42	2	-10	63	-6	264
Buzzard	38	-9	0	1,082 *	485	3,107
Magpie	91	-2	-21 *	-10	-34	14
Jackdaw	85	-19 *	-19 *	50 *	22	118
Rook	79	-4	-4	-17	-39	14
Hooded Crow	90	7	12	189 *	123	300
Coal Tit	68	0	-27 *	17	-21	68
Blue Tit	85	3	10	11	-18	48
Great Tit	82	-4	-12 *	126 *	73	188
Skylark	27	25	63 *	-20	-43	8
Swallow	90	-32 *	-18 *	-19	-40	12
House Martin	50	-5	-15	85	-4	225
Willow Warbler	87	3	-3	62 *	35	100
Chiffchaff	40	32 *	4	23	-9	64
Sedge Warbler	28	-17	-28	–	–	–

Species	Min. sample	1-year (23-24)	10-year (13-23)	28-year (95-23)	LCL	UCL
Blackcap	52	31 *	48 *	2,021 *	1,495	3,585
Goldcrest	52	40 *	77 *	99 *	39	182
Wren	100	16 *	31 *	74 *	32	124
Starling	86	-25 *	-20 *	8	-21	54
Song Thrush	86	40 *	68 *	112 *	68	185
Mistle Thrush	61	3	-12	-23	-61	44
Blackbird	95	30 *	40 *	83 *	47	119
Robin	97	25 *	25 *	33 *	5	58
House Sparrow	65	-13	8	49 *	2	151
Dunnock	78	3	4	67 *	3	155
Pied Wagtail	52	-19	-25 *	18	-17	76
Meadow Pipit	66	-7	12	10	-16	62
Chaffinch	99	7	-22 *	16	-8	36
Bullfinch	37	-18	-17	-5	-35	43
Greenfinch	29	-41	-71 *	-82 *	-90	-71
Linnet	39	43	-13	-8	-43	45
Redpoll	24	-65 *	-50 *	-27	-67	96
Goldfinch	61	-34 *	16	533 *	309	1,376
Reed Bunting	32	-43 *	-24 *	-40	-64	24

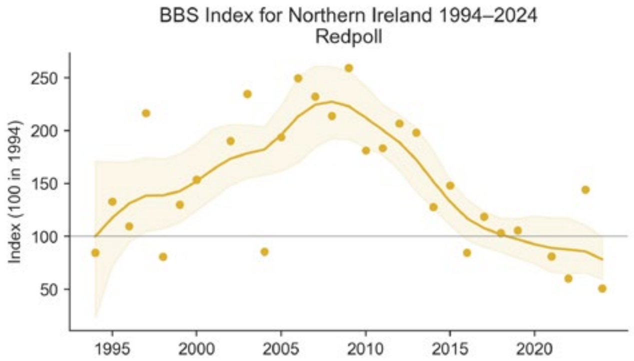


Figure 16: The 65% decline of **Redpoll** from 2023–24 follows a similarly large increase (161%) from 2022–23. Lesser Redpoll, now a subspecies under Redpoll, increased rapidly in both the Republic of Ireland and Northern Ireland from the mid 1990s to 2010, but have since declined in Northern Ireland by 50%.

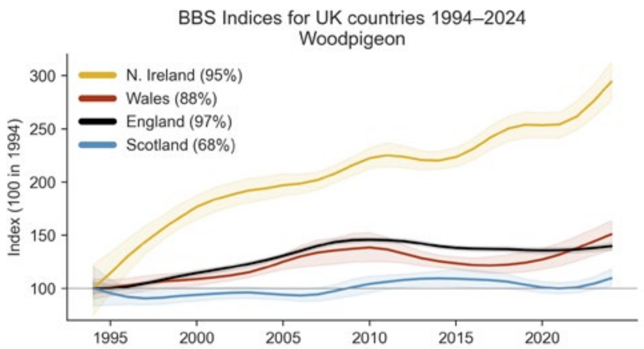


Figure 17: Northern Ireland has seen the greatest relative increase in Woodpigeon numbers of any UK country since 1994.

Isle of Man

Eight squares were surveyed in 2024 by seven different volunteers, maintaining the consistent coverage of the last six years.

There were a number of 'BBS firsts' for the Isle of Man in 2024, with **Redshank**, **Dunlin**, **Sandwich Tern** and **Common Gull** all seen for the first time on a BBS survey in the Isle of Man. It was also the year in which the highest number of **Cormorants** were seen during an Isle of Man BBS (82) as well as **Woodpigeon** (52), **Robin** (58), **Wheatear** (8) and **House Sparrow** (36). **Greenfinch** was not recorded on a BBS survey for the first time since 2020.

Much as **Great Spotted Woodpecker** has increased across Wales and Scotland (p25, Figure 15), so too has this species' westward spread been seen at a smaller scale on the Isle of Man. 2024 was the third consecutive year that this species was seen on a BBS square, having never previously been recorded during the survey. The same is true in Northern Ireland; only since 2016 has it been reported via BBS.

Channel Islands

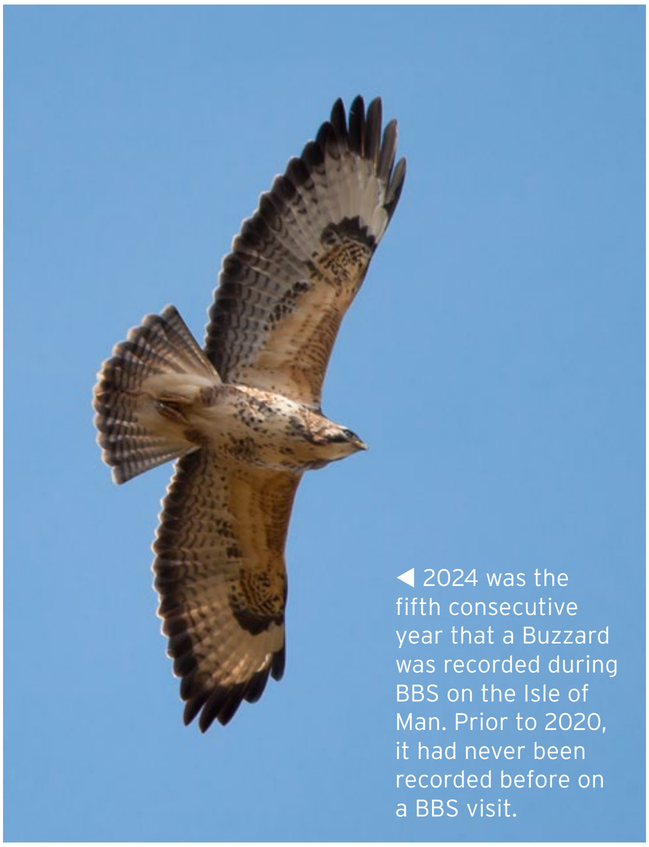
Twenty-two squares were surveyed on the Channel Islands in 2024, the best coverage since 2017, with a welcome boost in Alderney, courtesy of Alderney Wildlife Trust. These squares, along with those in the Isle of Man, contribute to the UK population trends.

Whilst **Firecrest** occupancy on Guernsey and Jersey on BBS squares has been increasing in the last five years, 2024 was the first year since 1996 that no **Goldcrests** were reported on the Channel Islands during a BBS survey visit.

A **Black Kite** was recorded for the second time in BBS, with a single bird seen during an early visit on Guernsey. It was also the fourth consecutive year of **Nightjar** being recorded on the island of Jersey. All records come from a single square in the south of the island.

Seventy-eight species were recorded across Jersey, Guernsey and Alderney in 2024 by 15 volunteers, bringing the total number of species recorded over 31 years of BBS to 147.

Based on simple occupancy rates since 2006, when BBS coverage has been consistently over 15 squares, a number of species appear to be increasing, including **Buzzard** and **Goldfinch**, whereas **Swallow** and **House Martin** – as in England – appear to be decreasing.



◀ 2024 was the fifth consecutive year that a Buzzard was recorded during BBS on the Isle of Man. Prior to 2020, it had never been recorded before on a BBS visit.

English regions: population trends

New trends over the three different time periods continue to be made available for English Regions. One such species is Corn Bunting with an increasing all-time trend of 184% in south-west England.

YORKSHIRE CURLEW

The **Curlew** declines seen in many parts of the UK (see p22) are not uniform. Between the three countries of Great Britain, there is variation in this change, with England seeing the smallest change and the only country where Curlew has been relatively stable in the last decade.

However, even within England, and in particular in the north – which supports the bulk of the English population – there is variation between BBS regions. In North West and North East there have been significant declines (48% and 32% long-term declines respectively), though with some signs of stabilisation in the last decade, whereas in the region covering Yorkshire & Humberside, (hereafter 'Yorkshire') Curlew numbers have not changed (Figure 18a). Yorkshire contains both the North York Moors and Yorkshire Dales national parks, where there is an abundance of moorland habitat managed as grouse moors. Using BBS data, Franks *et al.* 2017 showed Curlews were more abundant in areas likely managed for **Red Grouse** (a correlation with higher Red Grouse numbers) and they declined less where crows were less numerous.

A more recent study comparing Curlew breeding success on moorland managed for grouse with paired non-grouse moorland sites found that productivity was four times higher on grouse moors. Active predator control, particularly of corvids and **Red Fox**, which is practiced on grouse moors was identified as the main factor driving this difference. The study also showed a similar difference in **Lapwing** productivity. However, Lapwing do not show the same regional-level population differences as Curlew, with evidence of 20-year declines in all three regions (Figure 18b).

Whether the relative stability of Curlew seen in the Yorkshire region is as a result of this type of management would need further work, including establishing how BBS squares from which these trends are produced have varied in their habitat and management type. Whilst managing predation is important, other aspects, including intensification of agricultural breeding habitats and the location of woodland planting also play pivotal roles influencing Curlew productivity.

Curlew is currently the focus of much targeted conservation work across the UK. Many local partnerships in England are part of the larger Curlew Recovery Partnerships England (CRP), of which BTO and RSPB are members of the steering group.

CURLEW: PAUL HILLION/BTO

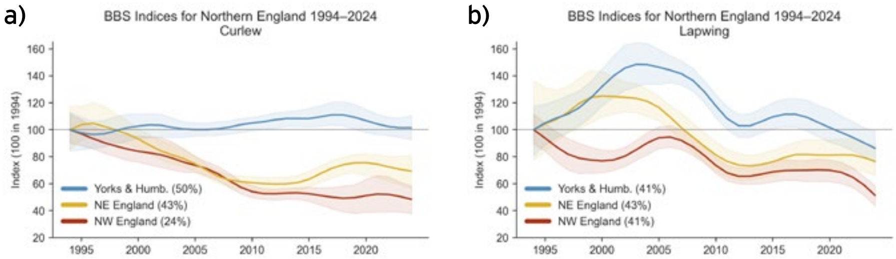


Figure 18: Curlew (a) remains stable in Yorkshire but has declined in other regions in the north of England. Following nearly 10 years of increase in Yorkshire, Lapwing (b) have since declined here as well.

FIND OUT MORE...

Baines, D. ***et al.*** 2023. Lethal predator control on UK moorland is associated with high breeding success of curlew, a globally near-threatened wader. *Eur. Journal of Wildlife Research* **69:** doi.org/10.1007/s10344-022-01631-5

Franks, S.E. ***et al.*** 2017. Environmental correlates of breeding abundance and population change of Eurasian Curlew *Numenius arquata* in Britain. *Bird Study* **64:** 393–409 doi.org/10.1080/00063657.2017.1359233

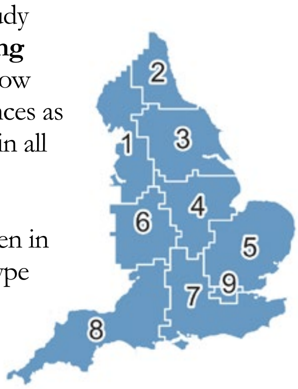


Table 7: Coverage and trends in each English Region

	Region	Squares	No. of trends	Significant increases	Significant declines
1	North West	233	58	17	22
2	North East	147	40	10	12
3	Yorkshire & Humber	252	58	20	16
4	East Midlands	280	58	18	18
5	East of England	363	70	21	26
6	West Midlands	197	55	20	16
7	South East	745	71	16	33
8	South West	546	64	15	21
9	London	100	27	11	10

Table 8: Trends in English regions during 1995–2023.

Species	North West		North East		Yorkshire & Humber		East Midlands		East of England		West Midlands		South East		South West		London	
	95-23	Sample	95-23	Sample	95-23	Sample	95-23	Sample	95-23	Sample	95-23	Sample	95-23	Sample	95-23	Sample	95-23	Sample
Canada Goose	122 *	75	–	–	216 *	37	42	48	57	61	42 *	73	39	140	191	61	–	–
Greylag Goose	–	–	–	–	1,037 *	51	552 *	39	181 *	57	–	–	128 *	50	–	–	–	–
Mute Swan	–	–	–	–	–	–	–	–	237 *	43	–	–	-43	59	19	40	–	–
Shelduck	–	–	–	–	–	–	–	–	3	37	–	–	–	–	–	–	–	–
Mallard	6	156	92 *	40	24	114	2	115	-4	197	33 *	120	1	259	23	171	-29	43
Tufted Duck	–	–	–	–	–	–	–	–	–	–	–	–	4	31	–	–	–	–
Red Grouse	–	–	–	–	-13	52	–	–	–	–	–	–	–	–	–	–	–	–
Grey Partridge	-73 *	22	–	–	-55 *	30	-43	32	-65 *	42	–	–	-81 *	27	–	–	–	–
Pheasant	126 *	144	28	80	53 *	165	13	170	-23 *	288	75 *	146	2	429	41 *	313	–	–
Red-legged Partridge	–	–	–	–	0	57	-40 *	77	-39 *	181	49	36	81 *	134	128 *	67	–	–
Swift	-76 *	97	-80 *	33	-61 *	84	-70 *	79	-58 *	145	-67 *	69	-72 *	169	-74 *	146	-70 *	57
Cuckoo	-51 *	30	–	–	-68 *	45	-73 *	46	-67 *	99	-79 *	46	-77 *	153	-83 *	69	–	–
Feral Pigeon	-27	75	–	–	-39	66	-12	53	0	79	-19	43	21	123	-12	74	-10	75
Stock Dove	32	59	–	–	115 *	64	6	87	40 *	159	111 *	92	78 *	248	40 *	152	–	–
Woodpigeon	86 *	217	41 *	96	112 *	191	39 *	211	22 *	338	29 *	187	12	544	51 *	396	38 *	85
Turtle Dove	–	–	–	–	–	–	–	–	-97 *	48	–	–	-99 *	34	–	–	–	–
Collared Dove	-19	130	-34	36	-47 *	88	-31 *	114	4	210	-46 *	114	-33 *	314	-27 *	211	-33 *	52
Moorhen	-31 *	68	–	–	1	41	-35 *	60	-42 *	122	-21	59	-38 *	148	-33	74	–	–
Coot	-45	30	–	–	–	–	-11	30	-32	38	38	30	-10	68	–	–	–	–
Oystercatcher	15	61	30	33	305 *	56	–	–	41 *	37	–	–	–	–	–	–	–	–
Lapwing	-37 *	111	-24	51	-14	113	-72 *	58	-53 *	70	-48 *	35	-75 *	93	-77 *	23	–	–
Golden Plover	–	–	–	–	-13	40	–	–	–	–	–	–	–	–	–	–	–	–
Curlew	-48 *	85	-32 *	54	4	119	–	–	–	–	-70 *	24	–	–	–	–	–	–
Snipe	–	–	–	–	36	40	–	–	–	–	–	–	–	–	–	–	–	–
(Cormorant)	–	–	–	–	–	–	–	–	3	50	–	–	42	58	2	36	–	–
(Grey Heron)	-34 *	75	–	–	66 *	39	-19	53	-40 *	82	-2	56	-24	134	-36 *	88	–	–
Sparrowhawk	-51 *	31	–	–	–	–	–	–	-27	45	–	–	-40 *	65	-21	50	–	–
Red Kite	–	–	–	–	–	–	–	–	28,628*	42	–	–	16,080*	115	–	–	–	–
Buzzard	74 *	81	6,114 *	37	3,282 *	58	7,963 *	78	25,721*	101	135 *	106	1,057 *	220	-3	256	–	–
Gt Spotted Woodpecker	86 *	87	55	32	65 *	58	172 *	71	77 *	158	86 *	112	66 *	350	126 *	199	89 *	41
Green Woodpecker	–	–	–	–	–	–	149 *	54	31 *	171	7	63	-22 *	324	-16	144	-12	30
Kestrel	-34 *	66	–	–	-7	65	12	68	-12	112	-37 *	39	-40 *	138	-46 *	79	–	–
Ring-necked Parakeet	–	–	–	–	–	–	–	–	–	–	–	–	602 *	42	–	–	38,091*	53
Jay	18	70	–	–	–	–	28	37	22 *	126	-23	63	-23 *	258	-1	124	-38 *	41
Magpie	-17 *	183	-6	43	-10	112	15	163	43 *	258	-5	165	6	461	-10	326	50 *	83
Jackdaw	89 *	149	12	73	73 *	136	113 *	144	168 *	245	124 *	146	75 *	428	31 *	318	–	–
Rook	-28	86	-40 *	53	-25	120	-6	106	8	186	12	88	-20	280	-22 *	244	–	–
Carrion Crow	26 *	224	-10	92	37 *	195	48 *	200	113 *	317	13	185	17 *	526	8	392	51 *	84
Raven	–	–	–	–	–	–	–	–	–	–	148 *	35	–	–	-17	95	–	–
Coal Tit	72 *	74	-2	47	55 *	52	7	43	-23 *	68	27	52	-10	173	10	119	–	–
Marsh Tit	–	–	–	–	–	–	–	–	–	–	–	–	-47 *	53	-18	31	–	–
Blue Tit	-22 *	203	-18 *	74	-7	167	26 *	197	25 *	318	-8	185	-8 *	529	-17 *	378	-7	84
Great Tit	8	191	34 *	67	15	148	37 *	184	6	301	4	180	5	515	28 *	368	114 *	80
Skylark	-13	115	-20 *	80	3	161	-1	171	-18 *	289	-2	119	-11 *	341	-23 *	244	–	–
Swallow	-49 *	188	-37 *	84	-47 *	167	-18 *	159	-35 *	227	-37 *	144	-30 *	338	-12	325	–	–
House Martin	-45 *	92	-51 *	32	-46 *	69	-48 *	59	-68 *	94	-58 *	77	-74 *	142	-62 *	155	–	–
Long-tailed Tit	23	87	–	–	26	59	46 *	89	0	162	-4	92	-33 *	271	32 *	173	-22	33
Willow Warbler	-5	143	-29	77	-40 *	125	-46 *	94	-87 *	102	-52 *	87	-88 *	145	-66 *	151	–	–
Chiffchaff	549 *	117	524 *	57	483 *	100	648 *	127	229 *	237	272 *	153	97 *	434	55 *	339	252 *	37
Sedge Warbler	–	–	–	–	–	–	–	–	-7	46	–	–	-19	36	-3	35	–	–
Reed Warbler	–	–	–	–	–	–	–	–	29	42	–	–	-4	37	–	–	–	–
Blackcap	272 *	125	98 *	53	130 *	108	190 *	144	130 *	264	171 *	147	140 *	450	130 *	325	200 *	52
Garden Warbler	-75 *	27	–	–	–	–	-25	35	-32 *	59	-21	45	-41 *	103	-54 *	64	–	–
Lesser Whitethroat	–	–	–	–	–	–	-3	39	26	84	4	30	-21	62	-35 *	43	–	–
Whitethroat	-20 *	87	36 *	48	-5	92	22 *	150	8	263	19 *	109	31 *	327	-14	229	–	–
Goldcrest	104 *	51	-7	30	32	30	67	36	40 *	83	140 *	51	16	225	-8	149	–	–
Wren	66 *	215	29 *	90	37 *	194	50 *	202	41 *	314	43 *	182	14 *	522	9	389	34 *	79
Nuthatch	243 *	50	–	–	–	–	–	–	212 *	39	148 *	57	65 *	221	94 *	106	–	–
Treecreeper	–	–	–	–	–	–	–	–	14	32	–	–	-6	105	-19	56	–	–
Starling	-64 *	168	-58 *	66	-66 *	129	-68 *	137	-50 *	230	-73 *	124	-69 *	351	-73 *	200	-72 *	80
Song Thrush	91 *	168	11	73	60 *	133	64 *	155	2	253	97 *	160	-8	472	12	334	-47 *	51
Mistle Thrush	-37 *	114	-29 *	43	-57 *	85	-51 *	83	-70 *	126	-28 *	87	-62 *	233	-48 *	134	-83 *	31
Blackbird	36 *	214	19	85	25 *	186	11	209	-9 *	330	18 *	188	-11 *	543	13 *	398	-66 *	85
Spotted Flycatcher	–	–	–	–	–	–	–	–	-88 *	17	–	–	-66 *	28	-61 *	28	–	–
Robin	50 *	206	24 *	81	62 *	166	50 *	198	46 *	313	57 *	185	20 *	527	16 *	385	91 *	83
Wheatear	-52 *	49	–	–	10	49	–	–	–	–	–	–	–	–	–	–	–	–
Tree Sparrow	9	29	–	–	20	45	-36	30	–	–	–	–	–	–	–	–	–	–
House Sparrow	-17	158	-41	50	-30 *	109	-29 *	130	-37 *	198	-16 *	145	-36 *	334	11	265	-62 *	71
Dunnock	-1	178	3	68	-17 *	144	-5	184	-1	285	32 *	171	-14 *	469	1	352	-15	64
Yellow Wagtail	–	–	–	–	–	–	-46 *	39	-48 *	48	–	–	–	–	–	–	–	–
Grey Wagtail	–	–	–	–	–	–	–	–	–	–	–	–	11	31	-25	33	–	–
Pied Wagtail	-30 *	127	-19	54	-31 *	112	-17	102	-10	153	-9	87	-26 *	214	-15	164	–	–
Meadow Pipit	-17	86	-19	59	-8	108	-52 *	41	-70 *	39	–	–	-54 *	50	-11	51	–	–
Chaffinch	-39 *	210	-20	94	-21 *	190	-29 *	204	-54 *	323	-61 *	181	-58 *	513	-48 *	384	-60 *	53
Bullfinch	8	43	–	–	55	35	1	54	-74 *	62	-31 *	54	-62 *	140	-36 *	119	–	–
Greenfinch	-53 *	144	-67 *	44	-57 *	102	-53 *	137	-57 *	243	-55 *	133	-79 *	372	-65 *	272	-68 *	54
Linnet	-15	87	-41 *	53	-28 *	102	-32 *	125	-8	184	-24	77	-43 *	239	-23 *	200	–	–
Goldfinch	163 *	171	178 *	64	124 *	142	163 *	159	119 *	242	233 *	138	112 *	397	121 *	316	364 *	57
Corn Bunting	–	–	–	–	–	–	–	–	-22	39	–	–	-32	32	184 *	30	–	–
Yellowhammer	-64 *	49	-52 *	47	-24 *	94	-27 *	143	-27 *	223	-74 *	97	-50 *	256	-51 *	173	–	–
Reed Bunting	8	64	–	–	101 *	52	66 *	70	13	84	–	–	-54 *	62	9	36	–	–

Mammal monitoring and population trends

BBS mammal data are used to produce population trends for nine mammal species for the UK as a whole, its constituent countries and English regions.

Recording mammals is an optional part of BBS. Here, we present the population trends of nine species of mammal as well as ponder what we might be able to document in the future.

DEER MANAGEMENT

In recognition of the damage caused by trampling and browsing by deer, especially in woodlands, NatureScot has launched two pilot schemes to support deer management. The schemes, first opened in August 2024, aim to support the additional culling of deer in Scotland, an activity that is largely undertaken by private landowners and individuals out of their own pocket.

Both **Red Deer** and **Roe Deer** have increased substantially across the UK, both having more than doubled in number since BBS surveyors started recording mammals in 1995. In Scotland, the long-term trends for Roe Deer and Red Deer are 77% and 52% increases respectively, though in the case of Red Deer, there has been relatively little change in the last 10 years (Figure 19). The incentive schemes are available in specific areas of Scotland's central belt and the Highlands. In both of these areas, the growing numbers of deer (Red Deer and Roe Deer as highlighted here, but also **Sika Deer**), are considered problematic. Whilst Sika Deer may be some way from having a UK BBS trend reported, being seen on 22 squares in 2024, **Chinese Water Deer** was recorded on 35 UK squares in 2024, a record for this species. A five-year trend is not far around the corner.

SEAL THE DEAL

Whilst all deer species in the UK – native or otherwise – are relatively common and widespread, not all mammal species that could be described as such are regularly seen on BBS squares. **Common (Harbour) Seals** and **Grey Seals** are typically only seen on coastal stretches, though this is not universally the case – a Grey Seal was observed as far inland as Earith, Cambridgeshire in 2022. Seals do make their way upstream into river systems and are seen periodically in the River Great Ouse some 56 km from The Wash. That it was seen during a BBS survey was all the more surprising!

FIND OUT MORE...

NatureScot 2024. Deer cull incentive schemes launch to help tackle nature and climate crisis. www.nature.scot/deer-cull-incentive-schemes [accessed 14/11/2024]

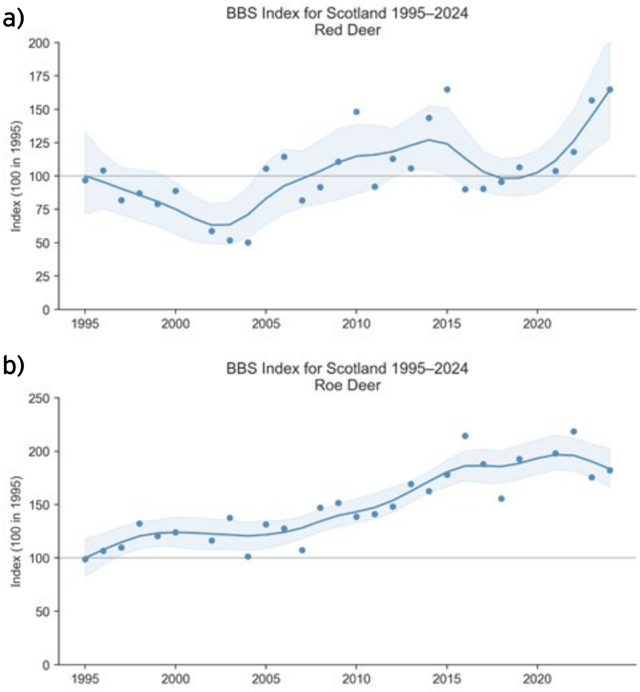
Table 9: All mammal species recorded in 2024.

Species	Squares recorded
Red-necked Wallaby	1
Rabbit	1,363
Brown Hare	1,057
Mountain/Irish Hare	76
European Beaver	3
Grey Squirrel	1,186
Red Squirrel	39
Bank Vole	18
Water Vole	8
Field Vole	26
Yellow-necked Mouse	1
Wood Mouse	29
House Mouse	3
Brown Rat	60
Hedgehog	37
Common Shrew	37
Pygmy Shrew	4
Lesser White-toothed Shrew	1
Mole	386
Bat – var.sp.	8
Domestic Cat	289
Red Fox	421
Grey Seal	12
Common Seal	6
Badger	230
Pine Marten	23
Otter	24
Stoat	36
Weasel	15
American Mink	4
Wild Boar	4
Reeves's Muntjac	362
Fallow Deer	167
Red Deer	158
Sika Deer	22
Chinese Water Deer	35
Roe Deer	1,008
Park Cattle	5
Feral Goat	9
Minke Whale	1
Harbour Porpoise	1

'Squares recorded' include counts of live mammals, field signs, dead mammals and local knowledge.

GREY SEAL: NEIL CALBRADE

a)



b)

Figure 19: Red Deer (a) and Roe Deer (b) population indices in Scotland 1995–2024.

Table 10: Mammal trends in UK.

Species	Min. sample	1-year (23-24)	10-year (13-23)	27-year (96-23)	LCL	UCL
Rabbit	1,459	**-20 ***	**-39 ***	**-72 ***	-79	-67
Brown Hare	788	**-8**	**40 ***	**35 ***	23	48
Mountain/Irish Hare	56	**16**	**-50 ***	**-64 ***	-76	-42
Grey Squirrel	859	**-28 ***	**33 ***	**20 ***	9	32
Red Fox	274	**-4**	**-38 ***	**-52 ***	-58	-44
Reeves's Muntjac	136	**8**	**127 ***	**321 ***	193	516
(Fallow Deer)	73	**64**	**204 ***	**260**	-27	871
(Red Deer)	78	**-15**	**38**	**105 ***	30	210
Roe Deer	527	**-1**	**40 ***	**117 ***	87	151

Table 11: Mammal trends in England.

Species	Min. sample	1-year (23-24)	10-year (13-23)	27-year (96-23)	LCL	UCL
Rabbit	1,197	**-19 ***	**-46 ***	**-66 ***	-71	-60
Brown Hare	667	**-8**	**50 ***	**47 ***	32	65
Grey Squirrel	767	**-24 ***	**35 ***	**22 ***	8	35
Red Fox	223	**-11**	**-35 ***	**-52 ***	-59	-44
Reeves's Muntjac	135	**8**	**126 ***	**315 ***	187	534
(Fallow Deer)	69	**40**	**248 ***	**409 ***	186	796
Roe Deer	406	**-4**	**62 ***	**160 ***	120	217

Table 12: Mammal trends in Scotland.

Species	Min. sample	1-year (23-24)	10-year (13-23)	27-year (96-23)	LCL	UCL
Rabbit	113	**-13**	**-29**	**-88 ***	-94	-77
Brown Hare	92	**-12**	**17**	**9**	-13	47
Grey Squirrel	32	**-22**	**25**	**–**	–	–
(Red Deer)	56	**5**	**18**	**52 ***	5	130
Roe Deer	120	**4**	**17 ***	**77 ***	41	130

Table 13: Mammal trends in Wales.

Species	Min. sample	1-year (23-24)	10-year (13-23)	27-year (96-23)	LCL	UCL
Rabbit	96	**-13**	**-29**	**-38 ***	-64	-10
Brown Hare	33	**42**	**6**	**–**	–	–
Grey Squirrel	63	**-50 ***	**27 ***	**7**	-14	38

Table 14: Mammal trends in Northern Ireland.

Species	Min. sample	1-year (23-24)	10-year (13-23)	27-year (96-23)	LCL	UCL
Rabbit	45	**-38 ***	**-8**	**-45 ***	-70	-14
Mountain/Irish Hare	27	**-40 ***	**-48 ***	**–**	–	–

NOTE: Trends are displayed in the same way as they are for the birds. Page 17 covers interpreting trends. Trends for **Red** and **Fallow Deer** are reported with caveats. These are herding species and trends should be interpreted with caution, the presence or absence of a herd on a given BBS visit could influence the overall trend.

Table 15: Mammal trends in English regions.

Species	North West		North East		Yorkshire & Humber		East Midlands		East of England		West Midlands		South East		South West		London	
	96-23	Sample	96-23	Sample	96-23	Sample	96-23	Sample	96-23	Sample	96-23	Sample	96-23	Sample	96-23	Sample	96-23	Sample
Rabbit	**-71 ***	100	**-70 ***	45	**-46 ***	124	**-76 ***	112	**-67 ***	207	**-70 ***	109	**-76 ***	300	**-47 ***	191	–	–
Brown Hare	**1**	62	**72 ***	36	**64 ***	84	**96 ***	99	**54 ***	155	**-20**	42	**5**	109	**62 ***	80	–	–
Grey Squirrel	**99 ***	62	–	–	**-5**	41	**81 ***	52	**11**	111	**-4**	79	**12**	235	**42 ***	124	**15**	53
Red Fox	–	–	–	–	–	–	–	–	**-32 ***	31	–	–	**-37 ***	65	**-60 ***	45	–	–
Reeves's Muntjac	–	–	–	–	–	–	–	–	**360 ***	63	–	–	**134 ***	42	–	–	–	–
Roe Deer	–	–	–	–	**370 ***	42	–	–	**297 ***	36	–	–	**127 ***	140	**60 ***	116	–	–

MAMMAL TREND GRAPHS ONLINE: www.bto.org/bbs-mammals

RED DEER: SARAH KELMAN/BTO

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Waterways Breeding Bird Survey: news and coverage

The Waterways Breeding Bird Survey forms part of the BTO/JNCC/RSPB Breeding Bird Survey partnership agreement and uses BBS-style transects along waterways – targeting the population monitoring of waterway specialists.

James Heywood, BBS National Organiser, BTO

We report on coverage and sightings for WBBS for 2024, and overleaf provide an update on the ongoing development of the survey.

Coverage across the UK received a small but welcome boost in 2024 (Table 16), thanks to a renewal of activity in Scotland. Over the course of the year, 1,753 different 500-m transect sections were covered on WBBS (Figure 20), amounting to 1,660 km walked along watercourses by WBBS volunteers. That amounts to over four and half times the length of the river Severn, the UK's longest river.

A total of 167 species were recorded on WBBS transects during the year. A single **Fulmar** was seen on a stretch in North Yorkshire and a **Turnstone** in Caithness, both on the handful of stretches that extends all the way to the coast. Further inland, there were single records of **Hen Harrier** in the north of Scotland and **Goshawk** in Shropshire.

Figure 20: WBBS stretches surveyed in 2024. ▶

Table 16: The number of WBBS stretches with data received to date and the total number of volunteers participating, by year.

	England	Scotland	Wales	Northern Ireland	UK total	No. of vols.
1998	133	27	8	0	168	**132**
1999	133	36	14	3	186	**170**
2000	129	32	14	1	176	**159**
2001*	38	12	1	0	51	**49**
2002	151	49	26	2	228	**203**
2003	178	53	30	1	262	**236**
2004	191	59	37	0	287	**258**
2005	210	52	39	0	301	**269**
2006	202	57	32	4	295	**257**
2007	190	48	32	0	270	**239**
2008	200	48	27	1	276	**241**
2009	212	47	25	1	285	**248**
2010	204	43	23	1	271	**238**
2011	207	44	19	3	273	**240**
2012	204	57	21	3	285	**244**
2013	206	52	23	2	283	**246**
2014	203	53	26	2	284	**248**
2015	214	61	28	2	305	**269**
2016	215	57	30	2	304	**266**
2017	222	55	26	3	306	**269**
2018	219	49	24	2	294	**261**
2019	210	50	23	2	285	**249**
2020†	125	21	3	3	152	**135**
2021	190	63	23	3	279	**243**
2022	196	62	20	3	281	**250**
2023	198	54	19	3	274	**244**
2024	196	60	18	3	277	**249**

**2001: foot-and-mouth disease , † 2020: COVID-19*

United Kingdom: WBBS population trends

The WBBS continues to produce population trends for 28 species associated with waterways where the reporting threshold of being recorded on an average of 30 stretches or more since the survey began in 1998 is met. Gadwall is the latest to have a 10-year trend.

STATISTICALLY SIGNIFICANT RESULTS

Period	No. species	Greatest change in UK WBBS trends	
Long-term (99–23) increases	2	Greylag Goose	111%
Long-term (99–23) decreases	11	Lapwing	-66%
Short-term (23–24) increases	1	Cetti's Warbler	30%
Short-term (23–24) decreases	3	Dipper	-31%

The all-time, 10-year and one-year trends are displayed here and online. Further five-year trends are published online at www.bto.org/wbbs-results. Of the 28 waterway specialists for which trends were possible, four species (reported in brackets) carry a caveat, explained on page 17.

DIPPING DOWN

Whilst WBBS reports on the population trends of species associated with waterways, only a few of these can be said to be truly waterway specialists. **Dipper** is one of these species and – like so many of the species listed in Table 17 – is in decline (Figure 21).

On the basis of UK WBBS transect data, Dipper have declined by 32% in the period 1998–2023. Of particular concern is a 31% decline in the last year alone. The trend for Dipper on BBS transects is down by 53% in the period 1995–2023. Across both BBS and WBBS, the pattern remains the same – following decline throughout the 1990s and 2000s, there was a sign of increase up until 2015, following which the decline has continued.

There has been a general trend towards earlier breeding in Dipper (Crick & Sparks 1999), possibly as a result of climate change. Breeding performance has increased over time. Meanwhile, findings from a long-term study in Norway – where Dipper is the national bird – have identified that population fluctuations have been associated with winter temperature; frozen conditions lead to reduced foraging opportunities (Nilsson *et al.* 2011). High winter river discharges have also been linked to changes in phenology, with higher discharges in the winter preceding the breeding season leading to earlier breeding (Nilsson *et al.* 2020). In the UK, Royan *et al.* (2015), which used WBBS data, predicted that the occurrence of Dipper in Wales and Scotland would decrease in response to climate change induced alteration in river flow, which in turn would impact habitat suitability. Are we seeing these changes already?

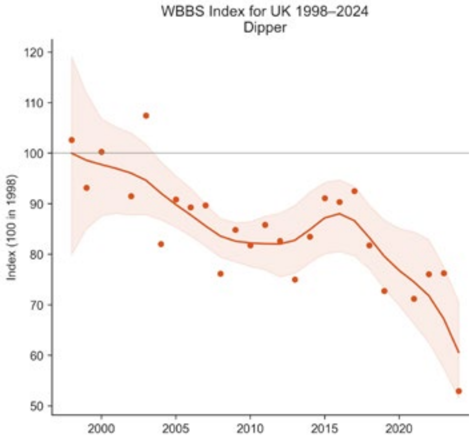

Figure 21: WBBS derived **UK** population trend of Dipper.

DIPPER: SARAH KELMAN/BTO

FIND OUT MORE...

Crick, H.Q.P. & Sparks, T.H. 1999. Climate change related to egg-laying trends. *Nature* **399**: 423–423. www.nature.com/articles/20839

Nilsson, A.L.K. *et al.* 2011. Climate effects on population fluctuations of the white-throated dipper *Cinclus cinclus*. *Journal of Animal Ecology* **80**: 235-243. doi.org/10.1111/j.1365-2656.2010.01755.x

Nilsson, A.L.K. *et al.* 2020. Hydrology influences breeding time in the white-throated dipper. *BMC Ecology* **20**: 70. doi.org/10.1186/s12898-020-00338-y

Royan, A. *et al.* 2015. Climate-induced changes in river flow regimes will alter future bird distributions. *Ecosphere* **6**: 70. doi.org/10.1890/ES14-00245.1

WBBS DEVELOPMENT

WBBS volunteers, ROs and data users – including many of the Statutory Nature Conservation Bodies, the Environment Agency and others interested in freshwater conservation – were sent a questionnaire during the spring and summer of 2024 on their views on any potential development of WBBS. Out of 390 volunteers, 171 replied, along with 82 WBBS Regional Organisers and 60 stakeholders from 27 different organisations. As well as comparing WBBS trends with BBS trends calculated from sectors that run alongside the same type of habitats, BTO has undertaken a review of the responses of the questionnaires. A number of options or recommendations are already taking shape, including:

- An urgent need to develop a new site-selection method. Whilst some areas continue to struggle to achieve coverage, others are 'full'.
- Potential changes to the protocol:
    - Having more flexibility in skill level/species identification needs. Instead of recording all species, a two-tier system could be introduced, whereby volunteers can opt to record everything or just a set list of riparian species;
    - Removing the need to record in distance bands;
    - Allowing surveyors to survey non-contiguous sections of a watercourse;
    - Adopting – at least for certain sites or regions – a 'rover' style approach that has proved so successful for BBS in the uplands; and
    - Greater capacity to record information on habitat management and disturbance, which was very strongly favoured by all volunteers and stakeholders.

The next steps will be a wider workshop involving organisations with interests in freshwater conservation, where the needs of data users will also be addressed.

Table 17: UK population trends during 2023–24, 2013–23 and 1999–2023.

Species	Min. sample	1-year (23-24)	10-year (13-23)	23-year (99-23)	LCL	UCL
Canada Goose	105	0	-7	83	-8	237
Greylag Goose	62	-27 *	25	111 *	24	271
Mute Swan	115	3	-6	-17	-39	4
Mandarin Duck	43	-18	73 *	–	–	–
Gadwall	30	-3	2	–	–	–
Mallard	240	-14 *	-18 *	-14 *	-25	0
Tufted Duck	43	7	-48 *	-64 *	-80	-17
Goosander	57	-11	31	48 *	2	107
Moorhen	149	-3	-6	-30 *	-43	-18
Coot	67	-2	-38 *	-48 *	-71	-19
Oystercatcher	81	-2	-23 *	-49 *	-62	-28
Lapwing	66	-16	-23 *	-66 *	-77	-48
Curlew	56	-8	-30 *	-65 *	-76	-48
Common Sandpiper	69	-4	-15	-38 *	-49	-24
(Common Tern)	31	-16	-58 *	-65 *	-78	-46
(Cormorant)	74	-22	8	0	-19	25
(Grey Heron)	179	-4	1	-30 *	-39	-20
(Little Egret)	35	44	232 *	–	–	–
Kingfisher	72	-29	-2	-16	-37	16
Sand Martin	78	-25	49 *	52	-10	137
Cetti's Warbler	34	30 *	290 *	–	–	–
Sedge Warbler	92	-15	-14	-51 *	-61	-37
Reed Warbler	60	16	2	-11	-34	18
Whitethroat	133	8	-29 *	-9	-27	13
Dipper	90	-31 *	-19	-32 *	-49	-7
Grey Wagtail	132	9	0	-27 *	-41	-9
Pied Wagtail	154	-8	-34 *	-52 *	-60	-40
Reed Bunting	114	-11	-18 *	-17 *	-33	-2

INTERPRETING THE RESULTS: see page 17
RESULTS ONLINE: www.bto.org/wbbs-results

KINGFISHER: EDMUND FELLOWES/BTO

SPECIAL THANKS

As is the case with the BBS (see back cover), the WBBS also relies on the dedication and enthusiasm of Regional Organisers who manage the survey locally. Without these volunteers, it would not be possible to manage such large surveys and we are in debt to them all.

The back cover shows a complete list of the ROs who manage the Breeding Bird Survey locally; many of these ROs also co-ordinate the WBBS. For the list of those WBBS Regional Organisers who focus solely on managing WBBS (and are therefore not listed on the back page), please see the table opposite. If you would like to find out more about becoming a Regional Organiser and what is involved, please email: wbbs@bto.org

WBBS Regional Organisers in 2024:

ENGLAND	
Huntingdon & Peterborough	VACANT
Staffordshire (North, South, West)	VACANT
NORTHERN IRELAND	
Antrim & Belfast, Armagh, Down, Londonderry and Tyrone	Michael Stinson
WALES	
Montgomery	VACANT

We currently have vacancies for WBBS Regional Organisers in Anglesey, Cambridgeshire, Carmarthen, Devon, Essex (North-West), Huntingdon & Peterborough, Lincolnshire (South), Merseyside, Montgomery, Radnorshire, Staffordshire (North, South & West), The Wirral and Yorkshire (Leeds & Wakefield, Richmond).

In addition to the ROs, we offer our sincere thanks to all the volunteers and landowners who enable these surveys to take place and have continued impact.

SPECIAL THANKS: BBS REGIONAL ORGANISERS

We would like to thank all surveyors and ROs for making the BBS the success it is today. Space does not permit all observers to be acknowledged individually, but we would especially like to thank the ROs for their efforts.

BBS Regional Organisers in 2024:

ENGLAND

Avon	Peter Bryant
Bedfordshire	VACANT (now Phil Cannings)
Berkshire	Sean Murphy
Birmingham & West Midlands	Steve Davies
Buckinghamshire	Phil Tizzard (now VACANT)
Cambridgeshire	VACANT
Cheshire (Mid)	Paul Miller
Cheshire (North-East and South)	Hugh Pulsford
Cleveland	Michael Leakey
Cornwall	Michael Williams
Cumbria	Colin Gay
Derbyshire (North, South)	Simon Roddis
Devon	VACANT
Dorset	Pete Cadogan
Durham	David Sowerbutts
Essex (North-East)	Rod Bleach
Essex (North-West)	VACANT
Essex (South)	VACANT (now Sean Murphy)
Gloucestershire	Gordon Kirk
Hampshire	George Batho
Herefordshire	Chris Robinson
Hertfordshire	Martin Ketcher
Huntingdon & Peterborough	Mick Twinn
Isle of Wight	Teresa Tearle
Isles of Scilly	Will Wagstaff
Kent	Bob Knight
Lancashire (East)	VACANT
Lancashire (North-West, South)	Mark & Heather Walsh
Leicestershire & Rutland	Dave Wright
Lincolnshire (East)	Phil Espin
Lincolnshire (North)	Chris Gunn
Lincolnshire (South)	VACANT
Lincolnshire (West)	VACANT (now Howard Gannaway)
London (North)	Ben Hillier
London (South)	Richard Arnold
Manchester	Nick Hilton
Merseyside	VACANT
Norfolk (North-East)	Chris Hudson
Norfolk (North-West)	Jonathan Martin
Norfolk (South-East)	Rachel Warren
Norfolk (South-West)	Vince Matthews
Northamptonshire	Barrie Galpin
Northumberland	Muriel Cadwallender
Nottinghamshire	VACANT (now Jo Whitley)
Oxfordshire (North)	Frances Buckel
Oxfordshire (South)	John Melling
Shropshire	Jonathan Groom
Somerset	Eve Tigwell
Staffordshire (North, South, West)	Gerald Gittens
Suffolk	Mick Wright
Surrey	Penny Williams
Sussex	Helen Crabtree
The Wirral	Paul Miller
Warwickshire	Annette Jarratt-Knock
Wiltshire (North, South)	Polly Marino
Worcestershire	Steve Davies
Yorkshire (Bradford)	Mike Denton
Yorkshire (Central)	Mike Brown
Yorkshire (East, Hull)	Brian Walker
Yorkshire (Leeds & Wakefield)	VACANT
Yorkshire (North-East)	Nicholas Gibbons
Yorkshire (North-West)	VACANT (now Richard Candeland)
Yorkshire (Richmond)	VACANT
Yorkshire (South-East, South-West)	Grant Bigg
Yorkshire (York)	Rob Chapman

SCOTLAND

Aberdeen	David Gregory
Angus	Ron Lawie
Argyll (Mull, Coll, Tiree & Morven)	Ewan Miles
Argyll (mainland & Gigha) & Bute	Nigel Scriven
Arran	James Cassels
Ayrshire	Dave McGarvie
Benbecula & The Uists	Yvonne Benting (now VACANT)
Borders	Neil Stratton
Caithness	Donald Omand
Central	Neil Bielby
Dumfries	Andy Riches
Fife & Kinross	Paul Blackburn
Inverness (East & Speyside, West)	Hugh Insley
Islay, Jura & Colonsay	David Wood
Kincardine & Deeside	Claire Marsden
Kirkcudbright	Andrew Bielinski
Lanark, Renfrew & Dunbarton	Gordon Brady
Lewis & Harris	Emma Niederberger
Lothian	Stephen Metcalfe
Moray & Nairn	Melvin Morrison
Orkney	Joseph Gilman
Perthshire	Mike Bell
Rhum, Eigg, Canna & Muck	Bob Swann
Ross-shire	Simon Cohen
Shetland	VACANT
Skye	Carol Hawley
Sutherland	Bob Swann
Wigtown	Andrew Bielinski

WALES

Anglesey	Ian Hawkins
Brecknock	Andrew King
Caernarfon	Rhion Pritchard
Cardigan	Naomi Davis
Carmarthen	VACANT
Clwyd (East)	Anne Brenchley
Clwyd (West)	Mel ab Owain
Glamorgan (Mid, South)	Daniel Jenkins-Jones
Glamorgan (West)	Lyndon Jeffery
Gwent	Richard Clarke
Merioneth	Dave Anning
Montgomery	Margaret Town
Pembrokeshire	Annie Haycock
Radnorshire	VACANT

NORTHERN IRELAND

Antrim & Belfast	Kevin Mawhinney
Armagh	Stephen Hewitt
Down	Alastair McIlwain
Fermanagh	Michael Stinson
Londonderry	Claire Hassan
Tyrone	Steven Fyffe

CHANNEL ISLANDS

Channel Islands (excl. Jersey)	Chris Mourant
Jersey	Tony Paintin

ISLE OF MAN

Isle of Man	David Kennett

We would be grateful for help organising the BBS in regions currently without a Regional Organiser (marked VACANT). If you live in one of these regions and would be interested in taking on the role, please let us know.

Many thanks are due to the following ROs who retired during the past year, having supported the BBS in their regions: Yvonne Benting and Phil Tizzard.

We would like to thank and welcome Richard Candeland, Phil Cannings, Howard Gannaway and Jo Whitley, who have taken over as ROs during the past year.

Finally, we would like to thank all the landowners who kindly allow volunteers to walk BBS and WBBS transects on their land.

Post to @BBS_birds

Post to @bbs-birds.bsky.social

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The Effects of Solar Farms on Local Biodiversity: A Comparative Study

BY

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Joint Funded By:

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April 2016

The Effects of Solar Farms on Local Biodiversity: A Comparative Study

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This project was initiated by Kate Covill of Orta Solar, who also sourced the funding for the work. Kate was instrumental in setting up the project and it would not have been possible without her enthusiasm and perseverance.

We would like to thank those solar organisations who allowed us access to their sites, as well as the site managers who met us on site (often early in the morning) and helped with setting up the equipment. Thank you also to the landowners who provided us with an adjacent control plot.

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The information, data and advice which has been prepared and provided is true, and has been prepared and provided in accordance with the Chartered Institute of Ecology and Environmental Management's (CIEEM) Code of Professional Conduct. We confirm that the opinions expressed are our true and professional bona fide opinions.

The Effects of Solar Farms on Local Biodiversity: A Comparative Study

CONTENTS

NON-TECHNICAL SUMMARY

Very little research has been carried out on the impacts of solar farms on biodiversity, despite the proliferation of this industry within the UK.

This study investigates whether solar farms can lead to greater ecological diversity when compared with equivalent undeveloped sites. The research focussed on four key indicators; botany (both grasses and broadleaved plants), invertebrates (specifically butterflies and bumblebees), birds (including notable species and ground nesting birds) and bats, assessing both species diversity and abundance in each case.

A total of 11 solar farms were identified across the southern UK for inclusion in this study. All sites had been completed for at least one growing season. Approaches to land management varied from primarily livestock grazing through to primarily wildlife-focused management. At each site the level of management for wildlife was assessed as low, medium or high based upon activities such as re-seeding, grazing or mowing regimes, use of herbicides and management of hedgerows and field margins.

To assess changes in biodiversity relating to the solar farm, we compared wildlife in the solar farm to wildlife at a “control” plot nearby. The control plot was outside the solar array, but within the same farm. Most importantly, the control plot was under the same management as the solar farm was prior to its construction. The purpose of the control plot was to give an indication of wildlife levels before the solar farm was constructed.

Botanical, invertebrate, bird and bat surveys were then carried out during 2015 on both the solar plot and the adjacent matched control plot. The results of these surveys were compared statistically to identify any changes in biodiversity the solar farm, and its land management, had brought about.

The results of the botanical surveys revealed that over all, solar farms had greater diversity than control plots, and this was especially the case for broadleaved plants. This greater diversity was partly the result of re-seeding of solar farms: where species-rich wild flower mixes had been sown this diversity was greater, but even where agricultural grass mixes had been used diversity was greater as compared to the largely arable control plots.

Management of grassland also influenced botanical diversity. At sites with conservation grazing (winter and spring sheep grazing with a pause through the summer for wild flowers to flower and set seed), plant diversity had increased through natural processes as compared to the original seed mix.

The invertebrate surveys revealed that butterflies and bumblebees were in greater abundance on solar farms than on control plots, and the greatest numbers occurred where botanical diversity was also high. The number of species did not differ significantly between most solar farms and control plots. However, at several sites with higher botanical diversity, and where management for wildlife was considered to be ‘high’, a greater diversity of bumblebee and butterfly species was observed.

The bird surveys revealed that over all, a greater diversity of birds was found within solar plots when compared with control plots. On two of the sites, a greater abundance of birds was observed on the solar farms when compared with control plots. The greater abundance and species of birds on these sites suggests foraging opportunities within the solar farms are greater than on the adjacent undeveloped sites.

This is likely to reflect the change from a homogenous arable environment to a diverse grassland habitat that also contains structures for cover or perching.

When weighting bird species according to their conservation status, solar farms scored significantly higher in terms of bird diversity and abundance, indicating their importance for declining bird species. The decline of many of these species has been attributed to intensification of agricultural practices. Solar farms with a focus on wildlife management tend towards limited use of pesticides, lower livestock stocking densities and the re-establishment of field margins, which would benefit many of these bird species.

There was no overall difference in the numbers of skylark territories when comparing solar plots to control plots, although one site showed a significantly higher number within the control plot. Nesting skylarks were confirmed within several of the control plots but at only one solar plot. The nest within the solar plot was located within the security fencing surrounding the array, but outside of the actual footprint of the array. The study shows that although skylarks may not nest beneath solar arrays, they do nest within solar farms and they do incorporate solar farms into their territorial boundaries for foraging.

The results of the bat surveys revealed that there were significantly higher levels of bat activity at the control plots when compared with the solar plots at three of the sites but no difference in bat diversity. The lower levels of bat activity within the solar plots may reflect the problems bats have discerning artificially smooth surfaces such as solar panels. The results of the survey are, however, inconclusive due to potential issues with the survey methodology and warrant further research into this area.

Observations of other species during the surveys included the presence of owl pellets on the solar panels, indicating that owls were utilising them for perching. Large numbers of brown hare were also noted within the solar farms at several of the sites.

When sites were ranked for overall biodiversity value, it was revealed that the three sites with the greatest management focus towards wildlife ranked highest for biodiversity overall.

In conclusion, the study revealed that solar farms can lead to an increase in the diversity and abundance of broad leaved plants, grasses, butterflies, bumblebees and birds. The level of benefit to biodiversity is highly dependent on the management of the site, with greater focus on wildlife management leading to greater biodiversity benefit. The sites with the highest wildlife value were seeded with a diverse seed mix upon completion of construction, limited the use of herbicides, provided good marginal habitat for wildlife and employed a conservation grazing or mowing regime.

1 INTRODUCTION

Background to the Project

1.1.1 Solar Photovoltaic (PV) technology is a relatively new industry within the UK, which has expanded greatly over the last five years from a total capacity of around 32MW in 2010 to over 8GW in 2015[1].

1.1.2 PV technology can be utilised in many ways, however, the main area of growth has been large-scale solar farms which are often constructed on agricultural land or brownfield sites. These can range in size from 1ha to 90ha and have varied greatly in terms of the management of the site post-construction, with some being managed specifically for wildlife and others continuing to be agriculturally worked, predominately through sheep grazing.

1.1.3 During the planning process, a greater emphasis has been placed on seeking ecological enhancements over the last few years as wildlife benefits are perceived to balance any negative effects relating to visual impact as well as contributing to national and local conservation targets. Several guidance documents have been produced to guide developers and local authorities, including Natural England's "*TIN 101: Solar Parks: Maximising Environmental Benefits*"[2] and BRE / National Solar Centre's "*Biodiversity Guidance for Solar Developers*"[3], which was produced with input from a number of solar development companies and environmental organisations.

1.1.4 Despite the growing emphasis on ecological enhancements within solar farms, very little research has been undertaken on the effects of solar farms on wildlife in the UK and the effectiveness of these enhancements. A literature review carried out by BSG in 2014[4] highlighted the limited availability of research in this area and the difficulty in drawing conclusions on the potential impacts of solar farms on wildlife. Much of the research has been carried out within other European countries, where solar farms are often constructed within very different habitats, or in the United States, where concentrated solar power technology[i] is utilised in addition to PV.

1.1.5 A preliminary study was conducted in the UK in 2013 which measured biodiversity within four solar farms, each with neighbouring control plots. The study focussed on grassland herbaceous plants, butterflies and bumblebees and concluded that under suitable management, solar farms can deliver measurable benefits to biodiversity[5]. The study has been used as a basis for further research, as outlined within this report, with a widened scope to look at a larger number of sites and wider indicator taxa. A similar study carried out in 2013 recorded greater biodiversity on a solar farm in West Sussex as compared to an adjoining arable field[6].

[i] This system uses mirrors or lenses to focus sunlight onto a small fixed point where heat energy can be utilised and impacts on wildlife are very different when compared with PV technology.

2 OBJECTIVE AND AIMS

2.1.1 The purpose of this study is to investigate whether solar farms are able to increase the ecological value of the land they occupy. The over-arching objective, posed as a question, is: '*Can solar farms and their associated management lead to a greater ecological diversity as compared to equivalent undeveloped land*?' This objective can be broken down to the following questions:

2.1.2 **Can solar farms create conditions for greater botanical diversity?** There are likely to be changes in botany resulting from the change of land management within the solar farm. The reduction in the intensity of agricultural activities including the application of herbicides and fertilizers may result in a greater floristic diversity. Less intensive grazing may also encourage the establishment of broadleaved plants. Solar farms may have management in place designed specifically to encourage wildlife, for example, diverse native seed mixes established and with no grazing or cutting through the flowering season. The study explored the difference in plant diversity between a solar farm and control plot (land which is under the same management as the solar farm was previously) in order to determine any changes in botany relating to land management. In addition to management, the solar farm structure may provide a variety of microclimates with shaded and unshaded areas or wetter and drier environments resulting from the physical effects of installing solar panels within the field. This study investigated whether there was a difference between the assemblage of plants directly beneath the solar panels with that between the rows, where more sunlight and rainfall would be expected to reach.

2.1.3 **Can solar farms encourage greater invertebrate diversity?** The reduction in intensive agricultural management and potential increase in botanical diversity would be likely to affect other taxonomic groups, such as invertebrates, which rely on plants for food and shelter. This study investigated whether a greater diversity and abundance of invertebrates was encountered within solar farms when compared to an adjacent control plot.

2.1.4 **Can solar farms encourage a greater diversity of birds?** The increase in plant diversity and reduction in agricultural pressure may provide suitable conditions for farmland birds, with a corresponding increase in bird diversity. This study investigated both number of species and their abundance, but also the conservation significance of the birds recorded. Bird diversity was compared between solar farm and control plot. In addition, the pattern of use within the solar farm (within the array, site margins) was investigated. There is a general consensus that ground-nesting birds which require unbroken sightlines, such as skylarks *Alauda arvensis,* will be discouraged from nesting within solar farms due to the cluttered environment, however, no studies have been conducted to examine this theory. The study examined the presence of ground nesting birds and how they utilise solar farms, including feeding and nesting sites, if present.

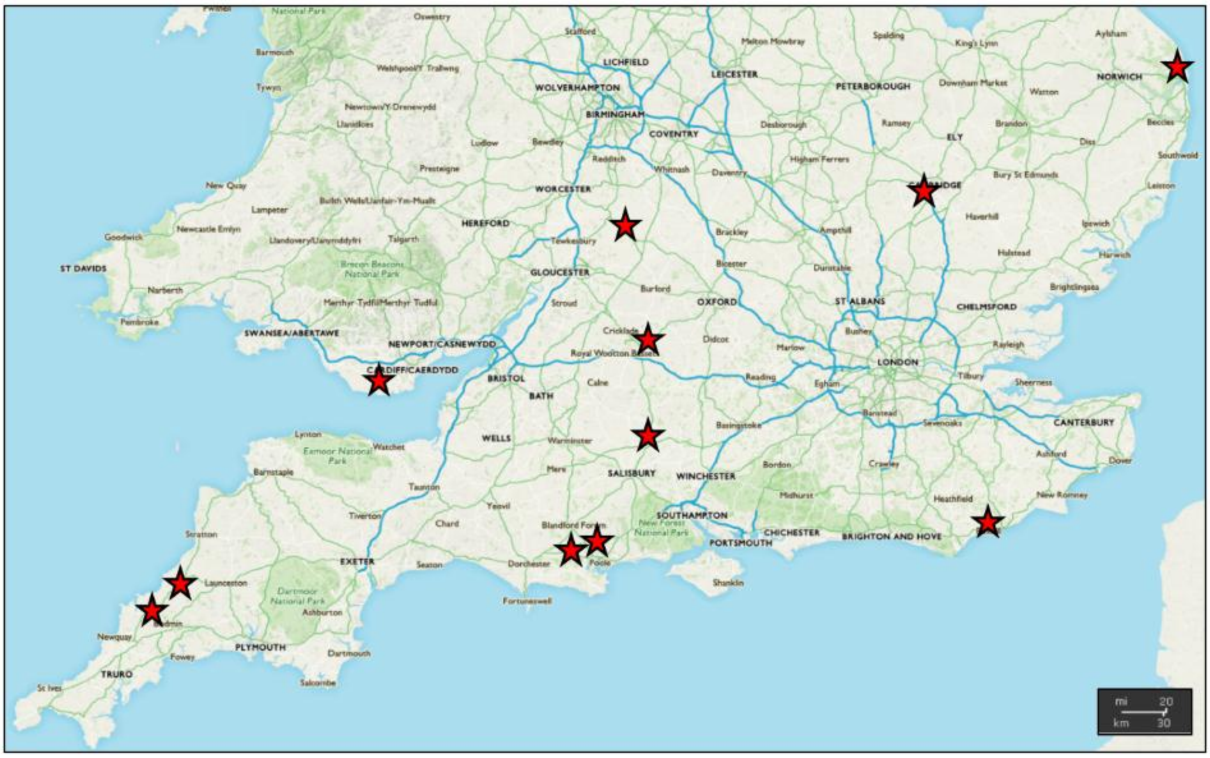
2.1.5 **Can solar farms encourage a greater diversity of bats?** The study also investigates the usage of solar farms by bats. Should solar farms offer a greater invertebrate abundance and diversity, this may result in a valuable foraging resource for bats and it has been theorised that the solar panels may even act as navigational features for bats in the same way that linear habitats such as hedgerows and watercourses do. Bat diversity was measured and compared between solar farms and their control plots.

3 APPROACH

3.1 Site Selection and survey design

3.1.1 A total of 11 solar farms were selected for this study. These ranged in geographical location across Cambridgeshire, Cornwall, Dorset, Gloucestershire, Hampshire, Norfolk, Oxfordshire, Sussex and the Vale of Glamorgan. The approximate locations of the sites surveyed are shown in Figure 3.1 below.

Figure 3.1: Map to Show Approximate Locations of Survey Sites (Red Stars) (*Ordnance Survey Open Map*)



3.1.2 The sites were selected using the following criteria:

- a good geographical spread (although the sites represent the higher prevalence of solar farms within the southern half of the country);
- a range of management practices including those with no focus on biodiversity (but primarily used for grazing) to those with a strong focus on management for biodiversity;
- sites which had been completed and seeded for at least one growing season; and
- a mixture of sites that were previously arable or pasture.

3.1.3 The selection of sites was somewhat limited by those operators that were willing to provide access as there were health and safety considerations related to working within a solar farm. In most cases, the surveyor had to be accompanied by the site manager outside of normal working hours in order to conduct the bird surveys. Therefore, the desired mixture of previously arable and pasture sites could not be obtained and there is a bias towards previously arable sites within the study.

3.1.4 A field within the solar farm was identified for survey. For some sites, this comprised the entire array and with others it was one field within a larger solar farm. The surveyed field within the array (hereafter referred to the 'solar plot') was then matched with a field within the same land ownership, but outside the solar farm (the 'control plot'). Considerations when choosing the control plot included size, shape, similarity in adjacent vegetation, and distance from roads. The control plots were under the same management regime (i.e. arable crop production or intensive pasture) as the solar plot was prior to the construction of the array.

3.1.5 The purpose of the control plot was to provide an indication of the level of biodiversity occurring if the solar farm had not been developed. Survey results from the solar plot and control plot were compared statistically to investigate any difference, so providing an indication of any biodiversity changes occurring as a result of the solar development, and specifically, the land management associated with the solar farm.

3.2 Site Management

3.2.1 The management of the solar and control plots at the time of the survey are outlined in Table 3.1, including any seeding, grazing or mowing, use of herbicides and a description of boundary features such as hedgerows and field margins.

3.2.2 The final column of the table below shows a qualitative evaluation of the approach that the solar site adopts with respect to wildlife. This has been calculated based upon a consideration of the approach adopted by the manager of the array to a range of issues:

- whether the site was seeded with a diverse seed mix;
- if and how herbicides were used;
- whether the site was subject to grazing or mowing and how this was managed; and
- whether the field margins were managed in an ecologically sensitive manner.

3.2.3 Each site was scored according to the approach under each of these categories with an overall ranking of 'high', 'medium' or 'low' awarded to each site based upon the scores within the various categories. This methodology and the outcomes are therefore subjective. The outcomes were however cross-checked with the professional opinion of the field surveyors regarding the approach to habitat management within the solar array and the outcomes were found to be similar and as such, this qualitative approach to assessment is considered to be robust.

Table 3.1: Description of the Management of the Solar and Control Plots

Site No.	Surveyed Areas (ha)	Location Context	Date Solar Farm Connected	Details of Solar Farm Seeding	Grazing/ Mowing Regime on Solar Plot	Use of Herbicide on Solar Site	Description of Field Boundaries on Solar Site	Description of Field Boundaries on Control Site	Mgmt of Control Plot	Mgmt Plan Adhered to?	Mgmt focus towards wildlife
Site 1	Surveyed solar plot: 9.69ha Entire solar site: 17.17ha Size of control plot: 11.3ha Distance between solar and control plots: 280m	In a predominantly arable setting, with occasional woodland coppices, and adjacent a reservoir to the east.	February 2013	Seeded with a rye-grass grazing mix	Cutting and removal of arisings x 3 per year.	Spraying beneath panels to control vegetation.	Hedgerow on all edges with newly planted infill (approx. 6 years ago). Diverse with good structure. Trees planted along N boundary.	East side, 30m wide band of tree/shrub planting. Northern boundary is a private railway line. South and west are hedgerows.	Rape-seed crop (non-organically farmed)	N/A. No management plan	Medium
Site 2	Surveyed solar plot: 11.68ha Entire solar site: 16ha Size of control plot 11.71ha Distance between solar and control plots: 17m	Surrounded by a mix of agricultural land, disused quarries, and plantation and broadleaved woodlands.	March 2014	Seeded with a rye-grass grazing mix	Sheep in a permanent rotation – approximately 100 sheep.	Limited – spot treatment.	Mix of mature and newly planted hedgerows with generous grass strip (at least 3m) between hedge and security fence of solar farm. This grass strip was managed by a mechanical cut in late summer.	Mature hedgerows with some large standards. Field seeded tight to the hedgerow.	Silage (non-organically farmed)	Biodiversity Management Plan – not fully adhered to: specified 3 different seed mixes such as EM5, EM10 and retained arable herbs which were not planted.	Low
Site 3	Surveyed solar plot: 5ha Entire solar site: 30ha Size of control plot: 3.5ha Distance between solar and control plots: 27m	Mixed landscape with pasture, coastal grazing, rivers, lowland fens and a range of broadleaved woodlands. Either side of an A-road and north of a river.	March 2014	Seeded with a rye-grass grazing mix	Conservation grazing from 2015, with sheep taken off during summer and a mechanical cut in summer 2015.	No	Mix of mature and newly planted hedgerows with generous grass strip (2-4m) between hedge and security fence of solar farm. This grass strip was managed by a mechanical cut in late summer. The hedge of the southern boundary of the solar farm runs alongside a ditch.	Mature hedgerows and woodland at boundary. Field planted tight to the boundary with less than a 1m margin between crops and the field boundary.	Barley (non-organically farmed)	Biodiversity Management Plan – not fully adhered to: specified planting species rich acid grassland in 10 areas beneath the arrays, these were not planted. Some bird boxes installed and new hedgerows planted.	Low
Site 4	Surveyed solar plot: 13.6ha Entire solar site: 29ha Size of control plot: 11.8ha Distance between solar and control plots: 10m	Surrounded by largely arable farmland, a mix of broadleaved woodlands and coastal grazing. 1.6km from the coast.	March 2014	Seeded with a rye-grass grazing mix	Sheep in a permanent rotation – approximately 100 sheep.	Spot spraying of thistle & docks. Blanket spraying of fence line areas and inverter areas.	Hedges of varying age: some mature with standards, some newly planted. On one boundary between the hedge and the security fence there is a grass margin of approx. 4m, which is managed with twice yearly cuts.	Hedges of varying age: some mature with standards, some newly planted. The control site was planted with crop tight to the hedgerow.	Barley (non-organically farmed)	Biodiversity Management Plan – not fully adhered to: specified sowing of areas with a meadow seed mix, which was not done.	Med
Site 5	Surveyed solar plot: 18ha (the entire solar site was surveyed) Size of control plot: 11.3ha Distance between solar and control plots: 20m	Mixed farmland with areas of ancient broadleaved woodlands and lowland fens.	February 2015	Seeded with King's Species Rich Grass Mix (contains 7 species of native grasses) as well as 13 species of native wildflower	Conservation grazing, with sheep taken off during summer for a flowering break.	Some mowing to control weeds.	Wide field margins in places (over 30m) managed for wildlife. Mature hedgerows with some tree planting. Small woodland copses present at boundaries.	Narrow field margins. Mature hedgerows with areas of woodland present.	Broad bean crop (non-organically farmed)	Site Environmental Management Plan fully adhered to.	High
Site 6	Surveyed solar plot: 14ha (the entire solar site was surveyed) Size of control plot: 13.4ha Distance between solar and control plots: 6m	A mix of ancient woodland and conifer plantation woodland. Less than 2km from the coast.	March 2014	Seeded with a rye-grass grazing mix	Conservation grazing from 2015, with sheep taken off during summer and a mechanical cut in summer 2015.	No	Mature hedgerows with large standards and woodland. Generous grass strip (at least 3m) between hedge and security fence of solar farm. This grass strip was managed by a mechanical cut in late summer.	Mature hedgerows with large standards and woodland. Field seeded tight to the hedgerow.	White clover ley (non-organically farmed)	Biodiversity Management Plan – not fully adhered to: specified planting species rich acid grassland in 10 areas beneath the arrays and tussocky grassland strips, these were not planted.	Med

Site No.	Surveyed Areas (ha)	Location Context	Date Solar Farm Connected	Details of Solar Farm Seeding	Grazing/ Mowing Regime on Solar Plot	Use of Herbicide on Solar Site	Description of Field Boundaries on Solar Site	Description of Field Boundaries on Control Site	Mgmt of Control Plot	Mgmt Plan Adhered to?	Mgmt focus towards wildlife
Site 7	Surveyed solar plot: 13.33ha (the entire solar site was surveyed) Size of control plot: 20.4ha Distance between solar and control plots: 10m	Predominantly mixed agricultural landscape with mature hedgerows and small patches of woodland, A-roads run near the south and east bounds of the site.	March 2013	Originally seeded with Emorsgate EM2 or EM6 but seed did not establish. Will be reseeded April/May 2016.	Mowed	Spot spraying of weeds	40-50m wildflower meadow buffer present along south and southwest bounds comprising fine grasses, red campion, daisies, no dense thatch formed yet. Control and solar site share a woodland belt along the western boundaries. The remainder of the hedges had been in-fill planted and had varied structures.	Western boundary is a woodland belt, the northern Is a mature hedgerow, the southern boundary is a gappy but developing hedgerow and the eastern a line of scrub.	Arable crop (non-organically farmed)	Biodiversity Management Plan produced – not fully adhered to: bat and bird boxes have not been installed, and conifer trees were planted along the hedgerows instead of he recommended native trees.	**Med**
Site 8	Surveyed solar plot: 5.12ha Entire solar site: 16.1ha Size of control plot: 5.72ha Distance between solar and control plots: 10m	Agricultural landscape dominated by improved grassland with occasional small pockets of woodland.	March 2014	Not seeded by solar operator, but likely to have been seeded with rye-grass grazing mix by farmer	Sheep grazed	N/A - No weed control has yet taken place.	Diverse field margins planted with clover mix, although not forming tussocky structure as yet. Hedgerows mature with standard trees with some evidence of poaching by sheep.	Hedgerow around entire field. Mature, with standard trees.	Maize crop (spring sown) (non-organically farmed)	N/A - No management plan produced.	**Med**
Site 9	Surveyed solar plot: 4ha Entire solar site: 14.19ha Size of control plot: 3.9ha Distance between solar and control plots: 130m	Predominantly arable landscape with patches of broadleaved and some ancient woodland, and a river running 350m east of the site.	March 2013	Seeded yearly with rye-grass grazing mix	Hay cut and sheep grazed at time of survey	Spot spraying of weeds	A max of 15m between the site security fence and the hedge which runs around ¾ of the site, kept mown by the farmer. The hedge to the west of the site had failed to establish. Shares a hedge with the control site.	Earth bund covered by wildflowers along lane to the south. Hedgerow along lane to the east. Hedgerows along west and northern sides.	Barley crop (non-organically farmed)	No management plan though the Planting Plan was not adhered to. The native hedgerow along the west of the site had failed to establish and EM1 seed mix was not used.	**Low**
Site 10	Surveyed solar plot: 12.14ha (the entire solar site was surveyed) Size of control plot: 16.18ha Distance between solar and control plots: 190m	Row of wind turbines along the northern boundary. A-road to south. Mixed agricultural landscape with patches of woodland.	July 2011	Diverse wildflower mix (8 species of broadleaved plant)	Annual cut with sheep grazing through the winter and spring (conservation grazing)	Selective spot spraying of problem sp. (thistle, dock, nettle)	Large grassland buffer around site. Extensive open areas within fenced area. Good connectivity between seeded grassland in array with other corridors of seeded grassland along tracks and beneath turbines. A hedgerow to the south and east but no other boundaries. Wind turbines to the north with grassy field margin.	South-west boundary has a course grassland/scrub strip with a large number of poppies. Scrub/field margin along lane to the west. Wind turbines to the north, below which is seeded with wildflower mix. No boundary to the east.	Barley (non-organically farmed)	N/A - No management plan was produced.	**High**
Site 11	Surveyed solar plot: 9.3ha (the entire solar site was surveyed) Size of control plot: 10.8ha Distance between solar and control plots: 22m	In a predominantly agricultural (mixed arable and pasture) landscape with small patches of woodland and some mature hedgerows.	March 2014	Seeded with a mixture of native and non-native pollinator attracting plants. Not seeded directly beneath panels.	Wildlife-sensitive mowing regime employed (2 to 3 cuts per year).	N/A - no weed control beyond mowing.	Site bounded by mixed hedgerows.	Long grass left on part of the site (possibly for skylarks). Hedgerows present on three sides of boundary (E, N and W). Grassland and scrub developing to the SW.	Newly planted grass crop cut for silage (non-organically farmed)	Habitat Management Portfolio - bird boxes have been installed, as well as reptile hibernacula and small pond.	**High**

3.3 Data Collection

3.3.1 Four biodiversity indicators were selected: botany, birds, invertebrates (bumblebees and butterflies) and bats. The survey protocol for each discipline is provided within Appendix A. A brief description of the approach to data collection is outlined below.

3.3.2 These indicators were selected for a variety of reasons including: the role and importance of the receptor within an ecological community; whether the species group is used as a typical indicator of biodiversity and ecosystem health[7]; the ease and practicality of collecting information within the available survey period and budget; species groups for which questions remain regarding the impact of solar arrays; and species groups which are thought to be adversely affected by solar arrays.

Botany

3.3.3 Quadrat surveys were used to compare the botany present within the solar array and the control plot. Ten quadrats were surveyed within the solar plot (from between the panel rows) and 10 quadrats from the control plot for this purpose. Within the solar plot, a further 10 quadrats were collected directly beneath the solar panel rows. These quadrats were compared to those collected between the rows to assess the effects of shading and water stress on plant communities. The locations of the quadrats were randomly picked prior to visiting site in order to avoid surveyor bias.

Invertebrates

3.3.4 Invertebrate surveys focussed on bumblebees and butterflies within both the solar plot and control plot. A total of ten, 100m transects were walked within the solar plot and within the control plot; these transects were spaced evenly through the site. The species and number of individuals were recorded on each transect.

Birds

3.3.5 Three bird surveys were conducted both within the solar plot and within the control plot. Surveyors walked a pre-defined transect route recording the species and abundance of all birds seen or heard. Additionally, the behaviour of each bird was categorised into calling/singing, foraging or flying over site and the location of the bird was marked as either within the field or the field boundary. This method is an adapted form of the Breeding Bird Survey (BBS) method developed by the RSPB, BTO and JNCC[8].

3.3.6 Ground nesting birds were mapped and behaviours recorded in order to assess the numbers of territories and presence of active nests.

Bats

3.3.7 Static bat detectors were installed within both the solar plot and the control plot. Microphones were set approximately 50m from the nearest field boundary at a height of approximately 3m. These were left recording for around 10 nights and the data subsequently analysed using Kaleidoscope Pro software. This methodology allowed an assessment of the number of bat species using each site and the number of passes per night, giving an indication of activity levels.

3.4 Statistical Analysis

3.4.1 The data was subject to various statistical analyses in order to demonstrate whether any of the relationships and patterns observed were statistically significant. Chi-Squared Test was used to consider

differences between the findings within the solar plot and the control plot and Mann Witney-U Test was used to assess the significance of overall differences between the control and solar plots in the aggregated findings for all sites. Further details of the statistical analyses used are presented in Appendix B.

4 LIMITATIONS

4.1 Site Selection

4.1.1 Where possible, the control plot was selected to reflect the management of the solar plot immediately prior to the construction of the array. However, one of the solar farms (Site 2) was constructed on land used previously for arable crop production but was within a farm where arable and pasture rotation was undertaken. At the time of survey it was only possible to select a control plot under intensive pasture management. Given the regular rotation of this land between pasture and arable, this was not seen as a major limitation.

4.1.2 It was not possible to obtain a good mixture of sites which were previously arable and pasture, due to difficulties in gaining access to sites. Therefore, the study shows a bias towards previously arable plots, with only two (Sites 6 and 11) on previously pasture land.

4.2 Botany

4.2.1 Several of the sites had recently been cut or were grazed to a very short sward by sheep. It most cases, plants could be identified to species level; however, it is possible that some species may have been missed due to not being apparent during the survey.

4.3 Birds

4.3.1 Surveys were conducted between April and July; bird surveys become less effective later in the season as males stop singing and defending territories when they are feeding young, therefore, surveys conducted in June and July may have under-recorded singing birds. However, this bias will have been equally introduced to all sites.

4.3.2 Ground nesting bird territory mapping was not carried out at one of the sites due to an error in the recording methodology.

4.4 Invertebrates

4.4.1 Due to generally poor weather conditions during 2015, several bird and invertebrate surveys were undertaken under suboptimal conditions. Although rain was avoided, several surveys were undertaken on cloudy days with a light wind, which is suboptimal for butterfly and bumblebee surveys. Where possible, survey dates were changed, however, in some cases this was not possible due to the long bouts of suboptimal weather in June/July 2015. As the surveys on the control and solar plots were conducted on the same morning, this limitation would not affect the comparative analysis, but may have resulted in lower numbers than expected for both solar and control plots.

4.5 Bats

4.5.1 Due to malfunctions in the recording equipment, only 8 of the 11 sites were successfully surveyed for bats. The technical difficulties included static detectors failing to record, or on one of the sites the detector within the solar plot recorded continuous noise, which appeared to have cancelled out any bat activity. It was not clear whether this noise was emitted from electrical equipment associated with the array or if it was a malfunction within the bat detector. This resulted in the bat data being excluded from the ranking of overall biodiversity value for each site.

4.6 General

4.6.1 Later in the season, it became difficult to navigate through the control sites which were planted with rapeseed due to the density and height of the crop. Therefore, the transects and quadrats had to be modified to follow existing tramlines. However, due to the monoculture nature of the crop it is not thought that this would affect the results of the survey.

5 RESULTS

5.1 Introduction

5.1.1 The results of the surveys are set out within this section with statistical information shown in table form. All highly significant differences (where the probability that the results show a non-random difference is more than 99%, or P=<0.01) are shown as “HSD” and highlighted in dark green. All significant differences (where the probability that the results show a non-random difference is more than 95%, or P=<0.05) are shown as “SD” and highlighted in light green. Where an inverse relationship is found (i.e. where the results show significantly higher numbers on the control plot when compared with the solar plot), significant results are highlighted in orange.

5.1.2 The term “Diversity” has been used to express species richness, i.e. the number of different species present within a sample. The term “Abundance” has been used to express the number of individuals present within a sample (of all species).

5.2 Botany

5.2.1 The botanical data was analysed to compare the diversity between control/solar plots and between sites. The diversity within solar plots was also explored to investigate whether there was a difference in the sward directly beneath the panels compared with between the rows of panels. The results are summarised below.

5.2.2 Overall, when looking at the number of plant species found on all solar plots combined (144) compared with control plots (70), there were significantly more species on solar plots (Chi-Squared P=<0.001), as shown in Figure 5.1.

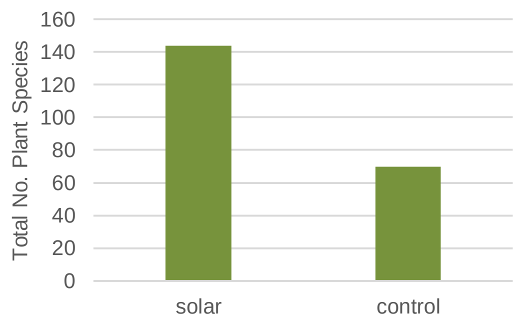


Figure 5.1: Overall Comparison of Solar and Control Plot Botanical Diversity

<u>Comparing Botanical Diversity Between Solar and Control Plots</u>

5.2.3 Solar plots contained between 15 and 41 species of plant. By contrast, control plots contained between 2 and 18 species of plant.

5.2.4 The analysis below encompasses “broadleaved plants”, which includes all species with wide leaves rather than narrow leaves. Narrow leaved plants which grow from the base (graminoids) have been given a separate group (“grasses”) and includes grasses, rushes and sedges.

5.2.5 Total plant diversity (i.e. the combined totals of broadleaved plants and grasses) was significantly higher within the solar plots when compared with the control plots and this difference was found to be highly significant (P=0.0001). For individual sites plant diversity was significantly greater in solar plots at nine sites (highly significant difference; P<0.01) and at two sites there was no significant difference (Table 5.1).

Table 5.1: Diversity of Plants Compared between Solar Plots (S) and Control Plots (C) for Each Site using Chi-Square Test. An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	Total Species		Significance
	S	C	
Site 1	25	2	HSD (P=0.000)
Site 2	23	7	HSD (P=0.003)
Site 3	28	5	HSD (P=0.000)
Site 4	15	7	NS (P=0.08)
Site 5	22	8	HSD (P=<0.01)
Site 6	22	18	NS (P=0.52)
Site 7	31	6	HSD (P=0.000)
Site 8	21	6	HSD (P=0.003)
Site 9	25	4	HSD (P=0.000)
Site 10	24	9	HSD (P=0.009)
Site 11	41	18	HSD (P=0.002)
Overall comparison of solar plots and control plots			HSD (P=0.0001)

5.2.6 When comparing grass diversity between solar plot and control plot for all sites, grass species diversity was greater in solar plots and this difference was highly significant (P=0.0005). When comparing individual sites, in two sites the solar plot displayed greater diversity which was highly significant (P<0.01), and in two plots which was significant (P<0.05). In seven plots, there was no significant difference in the diversity of grasses between solar plot and control plot. The statistical results are shown in Table 5.2.

Table 5.2: Grass Species Diversity Compared Between Solar Plots (S) and Control Plots (C) for Each Site using Chi-Square Test. An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	Total species		Significance
	S	C	
Site 1	11	1	HSD (P=<0.004)
Site 2	5	3	NS (P=0.48)
Site 3	7	1	SD (P=<0.03)
Site 4	4	3	NS (P=0.71)
Site 5	8	0	HSD (P=0.005)
Site 6	7	7	NS (P=1.0)
Site 7	7	1	SD (P=0.03)
Site 8	6	1	NS (P=0.06)
Site 9	7	3	NS (P=0.21)
Site 10	10	5	NS (P=0.19)
Site 11	10	4	NS (P=0.11)
Overall comparison of solar plots and control plots			HSD (P=0.0005)

5.2.7 For broadleaved plants, diversity was greatest in solar plots as compared to control plots and this difference was highly significant (P=0.0002). For individual sites, the diversity was greater in eight solar plots as compared to their control plots. This difference was highly significant (P<0.01) in five sites, and significant (P<0.05) in three sites. In three sites, there was no difference in broadleaved plant diversity between the solar plot and control plot (Table 5.3).

Table 5.3: Diversity of Broadleaved Plants Compared between Solar Plots (S) and Control Plots (C) for Each Site using Chi-Square Test. An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	Total species		Significance
	S	C	
Site 1	14	1	HSD (P=0.001)
Site 2	18	4	HSD (P=0.002)
Site 3	21	4	HSD (P=0.001)
Site 4	11	4	NS (P=0.07)
Site 5	14	8	NS (P=0.2)
Site 6	15	11	NS (P=0.43)
Site 7	24	5	HSD (P=<0.001)
Site 8	15	5	SD (P=0.03)
Site 9	18	1	HSD (P=<0.001)
Site 10	14	4	SD (P=0.018)
Site 11	31	14	SD (P=0.011)
Overall comparison of solar plots and control plots			HSD (P=0.0002)

<u>Comparing Botanical Diversity Within Solar Farms</u>

5.2.8 An analysis of the data collected from within the solar plots was conducted, looking at those samples collected in the middle of the rows (i.e. in the open) and those collected from beneath the panels (i.e. shaded). There was no significant difference in plant diversity beneath the panels as compared to between the rows when comparing all plots together (P=0.08; Table 5.4)

5.2.9 Comparing plant diversity in the middle and under the rows, at nine solar plots there was no significant difference, at one plot there was significantly higher diversity in the middle of the rows and in another plot there was significantly higher diversity of plants beneath the panels (Table 5.4).

Table 5.4: Diversity of Plants in Solar Farms Compared Between Panel Rows (M) and Beneath Panels (U) for Each Site using Chi-Square Test. An Overall Comparison between the Two Locations using Mann-Whitney U Test is Shown in the Bottom Row

Site	Total species		Significance
	M	U	
Site 1	22	11	NS (P=0.055)
Site 2	18	17	NS (P=0.87)
Site 3	24	17	NS (P=0.27)
Site 4	12	13	NS (P=0.87)
Site 5	20	17	NS (P=0.62)
Site 6	22	16	NS (P=0.33)
Site 7	22	17	NS (P=0.42)
Site 8	18	7	SD (P=<0.02)
Site 9	9	20	SD (P=0.04)
Site 10	19	24	NS (P=0.44)
Site 11	28	20	NS (P=0.25)
Overall comparison of between panel rows and beneath panels			NS P=0.08

5.2.10 Comparing the diversity of grasses within solar plots, no significant difference was found beneath the panels as compared to between the rows in all eleven plots (P=0.07) and there was no significant difference found at the site level (Table 5.5).

Table 5.5: Diversity of Grasses in Solar Farms Compared Between Panel Rows (M) and Beneath Panels (U) for Each Plot using Chi-Square Test. An Overall Comparison between the Two Locations using Mann-Whitney U Test is Shown in the Bottom Row

Site	Total species		Significance
	M	U	
Site 1	10	5	NS (P=0.19)
Site 2	5	3	NS (P=0.48)
Site 3	7	5	NS (P=0.53)
Site 4	2	4	NS (P=0.41)
Site 5	8	6	NS (P=0.59)
Site 6	7	6	NS (P=0.78)
Site 7	5	2	SD (P=0.25)
Site 8	6	3	NS (P=<0.32)
Site 9	5	5	NS (P=1.00)
Site 10	9	10	NS (P=0.81)
Site 11	7	5	NS (P=0.56)
Overall comparison of between panel rows and beneath panels			NS (P=0.07)

5.2.11 Comparing the diversity of broad-leaved plants between the rows vs underneath the panels, there was no significant difference for all sites together (P=0.44). Looking at individual sites, two sites displayed greater botanical diversity between the rows than under the panels, with the difference being highly significant (P=0.01) in one site and significant (P=0.045) at the other. At one further site, broadleaved plant diversity was greater beneath the panels than between the rows, this difference being significant (P=0.018). At the remaining eight sites there was no significant difference in diversity between rows and beneath (Table 5.6).

Table 5.6: Diversity of Broadleaved Plants in Solar Farms Compared Between Panel Rows (M) and Beneath Panels (U) for each site using Chi-Square Test. An Overall Comparison between the Two Locations using Mann-Whitney U Test is Shown in the Bottom Row

Site	Total species		Significance
	M	U	
Site 1	12	6	NS (P=0.16)
Site 2	13	14	NS (P=0.84)
Site 3	17	12	HSD (P<0.01)
Site 4	10	9	NS (P=0.81)
Site 5	12	11	NS (P=0.83)
Site 6	15	10	NS (P=0.32)
Site 7	17	15	NS (P=0.72)
Site 8	12	4	SD (P=0.045)
Site 9	4	15	SD (P=0.018)
Site 10	10	14	NS (P=0.41)
Site 11	21	15	NS (P=0.32)
Overall comparison of between panel rows and beneath panels			NS (P=0.44)

5.3 Invertebrates

5.3.1 The invertebrate transect data was analysed to compare species diversity and abundance between solar and control plots for each site and as an overall measure. This section has been split into an analysis of butterflies and bumblebees.

5.3.2 Overall, when looking at the number of both butterfly and bumblebee species found on all solar plots combined (29) compared with control plots (21), there was no significant difference (Chi-Squared P=0.26). There was, however, a significantly higher abundance of invertebrates on solar plots (Chi-Squared P=<0.001), as shown in Figure 5.2.

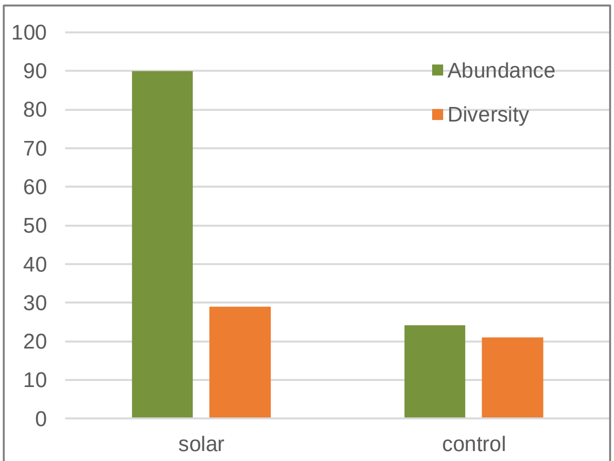


Figure 5.2: Overall Comparison of Solar and Control Plot Invertebrate Diversity and Abundance

Butterflies

5.3.3 The number of species of butterfly observed in solar plots ranged from 2 to 5, with a mean of 3.4. For control plots, the range was 0 to 3 with a mean value of 1.8. There was a highly significant difference

between the numbers of butterfly species recorded within solar plot and control plot when all sites were considered together (P=0.008).

5.3.4 In terms of individual sites, the number of butterfly species observed was significantly higher in the solar plot than the control plot at a single site (P=0.045), as shown in Table 5.7.

Table 5.7: Diversity of Butterflies Compared between Solar Plot (S) and Control Plots (C) for Each Site using Chi-Square Test. An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	Total Species		Significance
	S	C	
Site 1	3	2	NS (P=0.65)
Site 2	2	0	NS (P=>0.05)
Site 3	4	2	NS (P=0.41)
Site 4	2	2	NS (P=1.00)
Site 5	4	3	NS (P=0.70)
Site 6	2	3	NS (P=0.65)
Site 7	4	2	NS (P=0.41)
Site 8	3	3	NS (P=1.00)
Site 9	4	2	NS (P=0.41)
Site 10	4	0	SD (P=0.045)
Site 11	5	1	NS (P=0.10)
Overall comparison of solar plots and control plots			HSD (P=0.008)

5.3.5 In terms of numbers of individual butterflies observed, for solar plots the number ranged from 3 to 99 with a mean of 19.9, and for control plots, 0 to 68 with a mean of 8.3. The number of butterflies observed per survey in all solar plots was statistically higher than in all control plots (P=0.005), with the difference being highly significant (Table 5.8).

5.3.6 Looking at individual site surveys, the number of butterflies observed was greater in the solar plot than the control plot for surveys at six sites. This difference was statistically highly significant at four sites, and significant at a further two sites. However, in one site the reverse was true, with significantly greater numbers of butterflies being observed in the control plot, which was highly significantly different (P=<0.001), as shown in Table 5.8.

Table 5.8: Butterfly Abundance Compared between Solar Plot (S) and Control Plots (C) for Each Site using Chi-Square Test. An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	Mean Abundance Across All Surveys		Significance
	S	C	
Site 1	11	3	SD (P= 0.03)
Site 2	3	0	NS (P=>0.05)
Site 3	15	3	HSD (P=0.004)
Site 4	4	2	NS (P= 0.41)
Site 5	99	7	HSD (P=<0.001)
Site 6	13	68	HSD (P=<0.001)
Site 7	10	2	SD (P=0.02)
Site 8	3	3	NS (P= 1.00)
Site 9	6	2	NS (P=0.15)
Site 10	16	0	HSD (P=<0.001)
Site 11	39	1	HSD (P=<0.01)
Overall comparison of solar plots and control plots			HSD (P=0.005)

Bumblebees

5.3.7 The number of species of bumblebee per survey observed in solar plots ranged from 0 to 10, with a mean per survey of 3.6. For control plots, the range was 0 to 5 with a mean value per survey of 1.7. However, overall, the number of bumblebee species observed per survey in solar plots was not statistically different from control plots (P=0.06).

5.3.8 Comparing bumblebees at individual sites, the number of species observed was significantly higher in the solar plot than the control plot at one site (P=0.01), as shown in Table 5.9.

Table 5.9: Diversity of Bumblebees Compared between Solar Plot (S) and Control Plots (C) for Each Site using Chi-Square Test. An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	Total Species		Significance
	S	C	
Site 1	3	0	NS (P=0.08)
Site 2	2	2	NS (P=>0.05)
Site 3	4	2	NS (P=0.41)
Site 4	2	2	NS (P=1.00)
Site 5	6	0	SD (P=0.01)
Site 6	3	3	NS (P=0.65)
Site 7	10	5	NS (P=0.19)
Site 8	1	1	NS (P=1.00)
Site 9	1	1	NS (P=1.00)
Site 10	2	2	NS (P=1.00)
Site 11	5	1	NS (P=0.10)
Overall comparison of solar plots and control plots			NS (P=0.06)

5.3.9 Considering the number of individual bumblebees observed per survey, for solar plots the number ranged from 1 to 196 with a mean of 43.8, and for control plots, 0 to 36 with a mean of 6.8. The number of bumblebees observed per survey in all solar plots was statistically higher than in all control plots (P=0.02).

5.3.10 Looking at individual sites, the number of bumblebees observed was significantly higher in the solar plot than the control plot for seven sites and the results were highly significantly different (see Table 5.10).

Table 5.10: Bumblebee Abundance Compared between Solar Plots (S) and Control Plots (C) for Each Site using Chi-Square Test. An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	Mean Abundance Across All Surveys		Significance
	S	C	
Site 1	8	0	HSD (P=<0.001)
Site 2	35	6	HSD (P=<0.01)
Site 3	4	2	NS (P=0.41)
Site 4	196	36	HSD (P=<0.001)
Site 5	54	0	HSD (P=<0.001)
Site 6	13	6	NS (P=>0.05)
Site 7	82	16	HSD (P=<0.001)
Site 8	1	1	NS (P=1.00)
Site 9	1	1	NS (P=1.00)
Site 10	49	6	HSD (P=<0.001)
Site 11	39	1	HSD (P=<0.001)
Overall comparison of solar plots and control plots			SD (P=0.02)

5.4 Birds

5.4.1 The data collected from the bird surveys was analysed in various ways in order to investigate differences between the solar and control plots and between sites. This included looking at diversity and abundance as well as behaviour, conservation status and territory mapping for any ground nesting birds recorded. The results of the analysis are outlined below.

5.4.2 Overall, when comparing the number of bird species found on all solar plots combined (60) compared with control plots (51), there was no significant difference (Chi-Squared P=0.39). There was, however, a significantly higher abundance of birds on solar plots (Chi-Squared P=0.02), as shown in Figure 5.3.

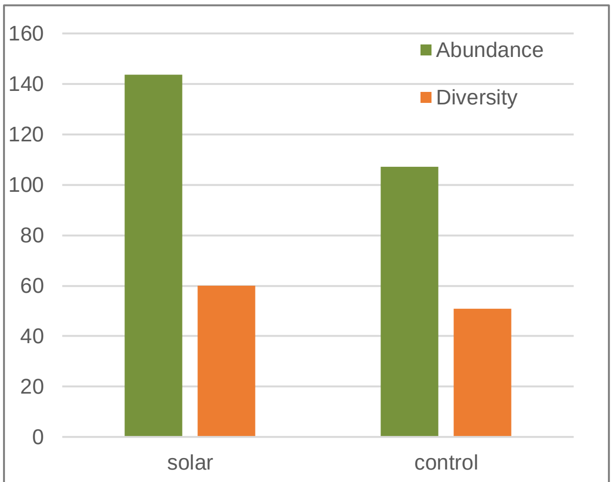


Figure 5.3: Overall Comparison of Solar and Control Plot Bird Diversity and Abundance

<u>Comparing Species Diversity Between Solar and Control Plots</u>

5.4.3 The number of species of birds observed per survey within the solar plots ranged from 6 to 23 with a mean of 15.2. The number of species within the control plots ranged from 4 to 21 with a mean of 12.8.

5.4.4 When all surveys carried out on solar plots were compared with control plots, there was a significantly higher diversity of birds found within the solar plots (P=0.04).

5.4.5 When looking at the total number of bird species recorded over all three surveys for each site, there was no significant difference between solar plots and control plots, as can be seen within Table 5.11. However, in 10 of the 11 sites the species diversity was higher on the solar plot although this was not statistically significant.

Table 5.11: Diversity of Birds Compared between Solar Plots (S) and Control Plots (C) for Each Site using Chi-Square Test. An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	Total Species		Significance
	S	C	
Site 1	30	23	NS (P=0.34)
Site 2	29	21	NS (P=0.26)
Site 3	20	21	NS (P=0.88)
Site 4	28	20	NS (P=0.25)
Site 5	24	20	NS (P=0.55)
Site 6	28	27	NS (P=0.89)
Site 7	18	18	NS (P=1.00)
Site 8	19	18	NS (P=0.87)
Site 9	21	18	NS (P=0.63)
Site 10	24	15	NS (P=0.15)
Site 11	23	22	NS (P=0.88)
Overall comparison of solar plots and control plots			SD (P=0.04)

Comparing Bird Abundance Between Solar and Control Plots

5.4.6 The total numbers of birds observed during each survey was examined. The abundance on solar plots ranged from 13 to 135 individual birds observed during a single survey, with a mean of 47.8 individuals. The number of birds observed on the control plots ranged from 12 to 77 with a mean of 38.8 individuals.

5.4.7 When looking at the difference between bird abundance on all solar plots compared with all control plots, there was no statistically significant difference (P=0.06).However, it is worth noting that bird abundance was higher on the solar plot at 8 of the 11 sites, indicating a trend, albeit not statistically significant.

5.4.8 When comparing bird abundance between solar plots and control plots for individual sites, in two sites there were significant higher numbers of birds recorded within the solar plot when compared with the control plot (this was statistically highly significantly different). In the remaining nine sites, no significant difference was found, as shown in Table 5.12.

Table 5.12: Bird Abundance Compared between Solar Plots (S) and Control Plots (C) for Each Site using Chi-Square Test. An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	Mean		Significance
	S	C	
Site 1	50	34	NS (P=0.09)
Site 2	66	50	NS (P=0.15)
Site 3	26	26	NS (P=0.96)
Site 4	110	67	HSD (P=0.0013)
Site 5	46	30	NS (P=0.07)
Site 6	66	57	NS (P=0.42)
Site 7	29	29	NS (P=0.93)
Site 8	21	19	NS (P=0.75)
Site 9	20	20	NS (P=0.92)
Site 10	50	24	HSD (P=0.002)
Site 11	41	38	NS (P=0.71)
Overall comparison of solar plots and control plots			NS (P=0.06)

Bird Behaviour

5.4.9 Information on bird behaviour was collected during the surveys. An analysis has been carried out on this data, however, very few significant differences were observed when comparing behaviour at solar and control plots.

5.4.10 At Site 2, a significantly lower diversity of birds was observed foraging within the field boundaries on the solar plot when compared with the control (Chi-squared test P=0.02), however, a significantly higher abundance of birds was recorded foraging within the field on the solar plot when compared with the control.

5.4.11 At Site 4, a significantly higher diversity and abundance of birds was observed foraging within the field at the solar plots when compared with the control plots (Chi-squared test P=0.02 and P=0.0001 respectively).

Similarly, at Site 10 a significantly higher diversity and abundance of birds was observed foraging within the field at the solar plot (Chi-squared test P=0.01 and P=0.00004 respectively).

5.4.12 At Site 5, a significantly higher diversity of birds was observed singing within the field at the solar plot when compared with the control plot (Chi-squared test P=0.03).

5.4.13 Overall, when comparing bird behaviours between all solar and control plots, no statistically significant difference was observed.

<u>Comparing Notable Bird Species Between Solar and Control Plots</u>

5.4.14 The bird species recorded within each site was weighted depending on its conservation status (Red or Amber listed Bird of Conservation Concern). When comparing solar and control plots overall, the solar plots scored significantly higher than control plots (P=0.04) indicating that they are more important for birds of conservation concern.

5.4.15 When looking at the results on a site by site basis, the results show no statistical difference between solar and control plots when looking at bird diversity, as shown in Table 5.13.

Table 5.13: Weighted Scoring of Bird Species Compared Between Solar Plots (S) and Control Plots (C) for Each Site using Chi-Square Test (Scoring: Red Listed=3; Amber Listed=2; Non-Notable=1). An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	Total Score Across All Surveys		Significance
	S	C	
Site 1	44	34	NS (P=0.26)
Site 2	45	30	NS (P=0.08)
Site 3	31	30	NS (P=0.90)
Site 4	41	30	NS (P=0.19)
Site 5	33	30	NS (P=0.71)
Site 6	41	41	NS (P=1.00)
Site 7	28	24	NS (P=0.58)
Site 8	30	28	NS (P=0.79)
Site 9	30	23	NS (P=0.34)
Site 10	38	23	NS (P=0.055)
Site 11	33	34	NS (P=0.90)
Overall comparison of solar plots and control plots			SD (P=0.04)

5.4.16 When looking at abundance of birds of conservation concern, with species recorded weighted depending on their conservation interest, overall, solar plots scored significantly higher when compared with control plots (P=0.04).

5.4.17 When looking at the results on a site-by-site basis, a statistically highly significant difference can be seen within four sites, where the score for the solar plot was significantly greater than that for the control plot, as shown in Table 5.14.

Table 5.14: Weighted Scoring of Abundance of Birds Compared Between Solar Plots (S) and Control Plots (C) for Each Site using Chi-Square Test (Scoring: Red Listed=3; Amber Listed=2; Non-Notable=1). An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	Mean Score Across All Surveys		Significance
	S	C	
Site 1	64	48	NS (P=0.12)
Site 2	115	69	HSD (P=<0.001)
Site 3	37	35	NS (P=0.84)
Site 4	140	97	HSD (P=0.005)
Site 5	61	35	HSD (P=0.006)
Site 6	92	79	NS (P=0.31)
Site 7	47	44	NS (P=0.78)
Site 8	37	35	NS (P=0.78)
Site 9	27	26	NS (P=0.86)
Site 10	88	51	HSD (P=0.0014)
Site 11	55	64	NS (P=0.39)
Overall comparison of solar plots and control plots			SD (P=0.04)

Ground Nesting Birds

5.4.18 Where ground nesting birds were identified, behaviour and movements were mapped in order to ascertain the likely number of territories and active nests within each plot.

5.4.19 The only species of ground-nesting bird consistently recorded across all but one site was skylark. The only other ground-nesting bird species recorded was one juvenile meadow pipit *Anthus pratensis*; calling within the boundary of the control plot at Site 9.

Skylark Territories

5.4.20 The results of the territory mapping are shown in Appendix C. Mapping of ground nesting birds was not carried out at Site 5.

5.4.21 The total number of territories recorded for control and solar plots were 29 and 26 respectively. Table 5.15 below provides the number of territories recorded for each site in solar and control plots; with the results of a Chi-Square test on this data also being presented. The sites varied greatly, with several solar plots accommodating more territories and some control sites accommodating more territories, however, only Site 11 had significantly more skylark territories on the control plot when compared with the solar plot (P=0.014). The overall comparison of solar and control plots was also not significant.

Table 5.15: Number of Ground Nesting Bird Territories Compared between Solar Plots (S) and Control Plots (C) for Each Site using Chi-Square Test. An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	No. Territories		Significance
	S	C	
Site 1	4	7	NS (P=0.37)
Site 2	3	2	NS (P=0.65)
Site 3	2	0	NS (P=0.16)
Site 4	3	3	NS (P=1.00)
Site 5 (no data)			
Site 6	2	0	NS (P=0.16)
Site 7	1	1	NS (P=1.00)
Site 8	2	4	NS (P=0.41)
Site 9	2	1	NS (P=0.56)
Site 10	7	5	NS (P=0.56)
Site 11	0	6	SD (P=0.014)
Overall comparison of solar plots and control plots			NS (P=0.97)

<u>Skylark Nesting</u>

Skylark nesting was confirmed through observing adults carrying food to a site repeatedly. The actual nests were not searched for in order to avoid disturbance and prevent accidental damage to the nest through trampling.

5.4.22 Skylark nesting was confirmed by surveyors at Site 10 within the solar plot, but outside of the footprint of the array itself (Appendix C refers). This was the only instance of a confirmed nest within any of the solar plots surveyed.

5.4.23 Skylark nesting behaviour was recorded within several of the control plots. Surveyors noted that possible nesting within tramlines of the control plot at Site 10 was occurring, but could not be confirmed due to the dense arable crop. Site 11 had an unconfirmed skylark nest recorded adjacent the western boundary of (but outside of) the control plot. Unconfirmed numbers of skylark nesting were recorded at Site 7, with skylark noted as nesting within the centre of the control plot.

<u>Skylark Foraging</u>

5.4.24 Skylark foraging was observed across all but two of the sites included in the study. Table 5.16 below details the numbers of skylark recorded foraging across solar and control plots.

5.4.25 There were significantly more skylarks recorded foraging within the solar plots when compared with the control plots at two of the sites, however, the overall comparison between solar and control was not significant.

Table 5.16: Number of Instances of Skylark Foraging Compared between Solar Plots (S) and Control Plots (C) for Each Site using Chi-Square Test. An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	No. Foraging Instances		Significance
	S	C	
Site 1	0	1	NS (P=0.32)
Site 2	11	1	HSD (P=<0.01)
Site 3	2	2	NS (P=1.00)
Site 4	8	0	HSD (P=<0.01)
Site 5	0	0	N/A
Site 6	1	1	NS (P=1.00)
Site 7	0	1	NS (P=0.32)
Site 8	3	0	NS (P=0.08)
Site 9	0	0	N/A
Site 10	3	9	NS (P=0.08)
Site 11	0	3	NS (P=0.08)
Overall comparison of solar plots and control plots			NS (P=0.81)

5.5 Bats

5.5.1 Both the numbers of bats recorded and the species diversity were examined for solar plots and control plots. Due to equipment failure, only eight of the eleven sites were surveyed.

5.5.2 Overall, when looking at the number of bat species found on all solar plots combined (8) compared with control plots (8), there was no difference. There was, however, a significantly higher total number of bat passes on the control plots when compared with solar (Chi-Squared P=<0.001), as shown in Figure 5.4.

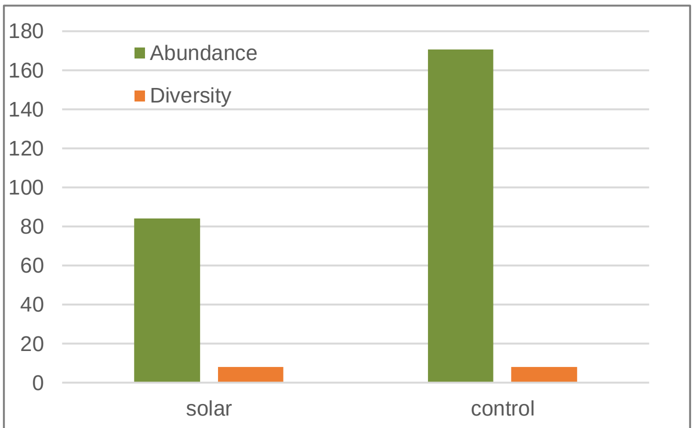


Figure 5.4: Overall Comparison of Solar and Control Plot Bat Diversity and Activity

Comparing Bat Activity Between Solar and Control Plots

5.5.3 The number of bat passes per night ranged from 1.78 to 24.44 on solar plots and 7.22 to 71.5 on control plots. When considering all sites combined, there was no significant difference between the numbers of bat passes between solar and control plots (P=0.08), as shown in Table 5.17.

5.5.4 When comparing the number of bat passes per night between solar plots and control plots, three of the sites showed significantly higher numbers of bat passes within the control plots when compared with the solar plots (and this was a highly significant difference). The five remaining sites showed no significant

difference when comparing solar to control plots, although it should be noted bat activity was higher in control than solar plots in four out of the five sites.

Table 5.17: Bat Activity Compared between Solar Plots (S) and Control Plots (C) for Each Site using Chi-Square Test. An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	Mean Passes per Night		Significance
	S	C	
Site 1	10	9	NS (P=0.81)
Site 3	2	14	HSD (P=0.003)
Site 4	7	13	NS (P=0.20)
Site 5	3	9	NS (P=0.053)
Site 6	6	11	NS (P=0.23)
Site 9	24	50	HSD (P=0.003)
Site 10	2	7	NS (P=0.07)
Site 11	27	72	HSD (P=<0.001)
Overall comparison of solar plots and control plots			NS (P=0.09)

Comparing Bat Diversity Between Solar and Control Plots

5.5.5 The number of species recorded by the static detectors on the solar plots ranged from 4 to 7, while on the control plots the number of species ranged from 3 to 8. When assessing all of the survey sites combined, there was no statistically significant difference between the number of species recorded within the solar plots when compared with the control plots (P=0.55).

5.5.6 When comparing the species diversity of bats recorded within the solar and control plots on a site-by-site basis, it can be seen that no statistically significant difference was found when comparing solar to control plots across any sites, as shown in Table 5.18.

Table 5.18: Bat Diversity Compared between Solar Plots (S) and Control Plots (C) for Each Site using Chi-Square Test. An Overall Comparison between Solar and Control using Mann-Whitney U Test is Shown in the Bottom Row

Site	No. Species Recorded		Significance
	S	C	
Site 1	7	5	NS (P=0.56)
Site 3	5	8	NS (P=0.41)
Site 4	8	7	NS (P=0.80)
Site 5	5	7	NS (P=0.56)
Site 6	7	8	NS (P=0.80)
Site 9	5	6	NS (P=0.76)
Site 10	4	5	NS (P=0.74)
Site 11	5	3	NS (P=0.48)
Overall comparison of solar plots and control plots			NS (P=0.55)

5.6 Observations of Other Species

5.6.1 Beehives were present within the solar plot on Site 11 and large numbers of honeybees *Apis mellifera* were noted during the invertebrate surveys. This site is being managed for pollinating invertebrates with a specific seed mix being sown to benefit these species.

5.6.2 Owl pellets were observed on the solar panels at Site 8 on the southern row (although they could not be reached in order to identify to species), which was adjacent to a field margin comprising rough grassland. Anecdotal evidence of owls using the solar array was also obtained from the site manager at Site 9. A tawny owl *Strix aluco*was was observed during one of the bird surveys on Site 4. It is likely that the presence of a more diverse habitat along with rough grassland within field boundaries provides good habitat for small mammals, which owls prey on. The panels are also likely to provide suitable perching opportunities for hunting. Similarly, large numbers of raptors were observed within solar plots, particularly on Site 10 where kestrels *Falco tinnunculus* and a red kite *Milvus milvus* were observed hunting within the array.

5.6.3 Brown hare *Lepus europaeus* was found to be particularly abundant within solar plots, with counts ranging from 3 to 12 on a single survey. Hares were less abundant on control plots, with counts ranging from 1 to 3 on a single survey. The hares were seen to form scrapes beneath the panels and appeared to be utilising them for shelter. Natural gaps beneath the security fencing and gates were used to access the site. The highest number of hares were observed within Site 1.

5.6.4 Fox *Vulpes vulpes* scat was observed within the solar plot on Site 1. No evidence of badgers *Meles meles* was observed within the solar plots, although a sett was found within the control plot on Site 7 and badger latrines within the control plot on Site 9.

6 RANKING OF SOLAR SITES

6.1.1 An overall score has been calculated for each site reflecting its rank for each biodiversity indicator.

6.1.2 The rank has been calculated by comparing the difference in the score of the solar plot to its corresponding control plot. This way any variation in diversity and abundance of species which might be explained by the geographic location of the site or its surrounding landscape can be largely eliminated. The rank therefore illustrates how successful or otherwise the solar plot has been at creating a positive change in diversity when compared with the adjacent control plot.

6.1.3 Bats have not been included within the ranking as unfortunately, an incomplete data set was held for this group and as such, it was not possible to ascribe a ranking to a number of the sites. It should be noted that a general trend observed within the bat data was for an inverse relationship between the abundance of bats in the solar plots when compared to the control plots. As such it may have been difficult to score bats in the same manner as other sites have been scored. This is not to say that the findings with respect of bats are not considered important; however, there may be explanations behind the findings of the bat monitoring. This is discussed further in Chapter 7.

6.1.4 It is acknowledged that, as both abundance and diversity have been included for invertebrates and birds, there is some degree of bias. However, the final scoring combines both of these measures and so can be seen as a reflection of biological diversity (a combination of species diversity and abundance).

Table 6.1: Sites Ranked According to Overall Biodiversity Value (based on each indicator), with Higher Ranking Sites Coloured Darker Green and Lower Ranking Sites Coloured Lighter Green. The Final Column Shows the Grade of each Site in Terms of its Management Focus Towards Wildlife.

Site	Grass Diversity Rank	Broad-Leaved Plant Diversity Rank	Butterfly Diversity Rank	Butterfly Abundance Rank	Bumblebee Diversity Rank	Bumblebee Abundance Rank	Bird Abundance Rank	Bird Diversity Rank	Sum of Ranks	FINAL RANK	Management Focus Towards Wildlife
Site 10	6	7	1	3	6	4	2	1	30	1	High
Site 11	3	2	1	2	3	5	7	7	30	1	High
Site 5	2	10	7	1	1	3	3	5	32	3	High
Site 7	3	1	3	5	2	2	9	10	35	4	Med
Site 1	1	6	7	5	4	7	3	4	37	5	Med
Site 2	9	5	3	8	6	6	3	2	42	6	Low
Site 3	3	2	3	4	5	9	9	11	46	7	Low
Site 4	10	9	9	9	6	1	1	2	47	8	Med
Site 9	8	2	3	7	6	10	9	6	51	9	Low
Site 8	6	7	9	10	6	10	8	7	63	10	Med
Site 6	11	11	11	11	6	8	6	7	71	11	Med

6.1.6 The three highest ranking sites were Sites 10 and 11 (joint first) and 5 (second), which were also graded as having a 'high' management focus towards wildlife. All three of these sites were seeded with a diverse mix, although, interestingly, Site 5 scored lowly in terms of broadleaved plant diversity, but highly for grasses, and Site 10 displayed moderate plant diversity.

6.1.7 Site 11 was previously grassland and the control plot comprised a grassland field, although the solar farm had been reseeded post construction, therefore, the higher plant diversity is not surprising.

6.1.8 The three top sites all have relatively high butterfly and bumblebee rankings as well as birds for sites 10 and 5.

6.1.9 Site 7 is ranked fourth overall due to high broadleaved species diversity and a high diversity of invertebrates, particularly bumblebees. This is possibly due to the failure of the sown seed mix to establish, which has resulted in an abundance of early colonising plants such as arable weeds. The marginal habitat (a wide wildflower meadow buffer) may also attract invertebrate species.

6.1.10 Sites 1 and 2 are ranked fifth and sixth overall due to strong bird assemblages and high grass diversity at Site 1. Site 2 was previously arable, however, was compared with a grassland control plot due to the current rotation of the farm at the time. Although this site was low ranking in terms of grass diversity, it had a moderate broadleaved plant rank.

6.1.11 Site 3, which ranked seventh overall, had relatively high botanical diversity but moderate invertebrate scoring and poor bird diversity. Site 4 is ranked eighth overall, which exhibits some of the lowest botanical diversity, but scores highly in terms of bird diversity and bumblebee abundance. Site 9 ranked ninth, but had a high diversity of broadleaved plants and butterflies.

6.1.12 The lowest ranking sites were Site 8 and 6 which generally had low scores for all indicators, but were classed as having a 'medium' management focus towards wildlife due to diverse field margins at site 8 and a conservation grazing regime at Site 6 (although this was initiated in the same year that the survey was conducted so the full effects may not yet be realised). The control plot at Site 6 had also been managed as a ley and so exhibited a high plant diversity compared with a grazed pasture site. Site 6 was one of the two sites that were previously grassland.

7 DISCUSSION

7.1.1 This study was designed to address the following over-arching question: Can solar farms and their associated management lead to a greater ecological diversity as compared to equivalent undeveloped land? In tackling this question, several areas of investigation were followed.

Does active management of solar farms lead to greater botanical diversity?

7.1.2 This study demonstrates that solar farms were significantly more botanically diverse overall for grasses and broadleaved plants. This result is expected given that control plots were either arable fields or intensive pasture and therefore botanical diversity was restricted to a monoculture crop and a low diversity of arable weeds, or pasture composed of one or two agricultural grasses. All solar farms had been seeded with grass mixes including a minimum of several species of grass and on three sites including wild flowers. This initial seeding provided equal or greater botanical diversity than the site's arable or pasture origins.

7.1.3 As well as the initial seed mix, it is likely that botanical diversity within solar farms is responding to favourable management practices. All solar farms in this study were constructed on arable or intensive pasture, and therefore had been subjected to intensive agricultural management including regular herbicide treatments and application of chemical fertilizers, as the control plots still were.

Conservation Grassland Management

7.1.4 For the solar farms included in this study, the intensity of management has been significantly reduced in terms of agricultural inputs. On one site, herbicide has been widely applied (beneath the panels), but on most sites herbicide application is limited to spot treatment of weeds. It is logical that a reduction in the use of broad-spectrum herbicides would lead to greater diversity of broadleaved plants. No sites were known to be spreading fertilizer. The high soil fertility of arable farmland favours a few dominant species of plant, but as soil fertility reduces in the absence of fertilizer, so the diversity of both grasses and broadleaved plants is able to, and indeed is anticipated to, increase.

7.1.5 Sheep grazing is known to be a good mechanism for grassland diversification where sheep are at lower stocking densities, and especially where grazing is stopped during the flowering season (April to July), as occurs on several sites. However, where sheep grazing is undertaken at higher stocking density, and without a pause for flowering there is little opportunity for the grassland to diversify.

7.1.6 Evidence for the effects of management can be found in sites 10 and 5. Both sites had been sown with diverse grasses and wild flowers, which provided an initial step change in the number of plants. However, both sites too have been grazed with sheep at low stocking density and with a pause for flowering in the spring and summer,

and with minimal application of herbicides. This management approach encourages wild flowers, as evidenced by an increase in plant diversity: at Site 10, the number of species of broadleaved plants recorded was greater than the original seed mix (8 sown as compared to 14 observed). Likewise, at Site 5, the number of species has increased by one grass species (from 7 to 8) and one broadleaved plant (from 13 to 14) from those originally sown. At Site 10, the rapid colonisation of broadleaved plant species is likely to have been facilitated by wild flower headlands occurring close to the solar farm.

7.1.7 By contrast, at Site 6, Site 2 and Site 4[ii], intensive sheep grazing at higher stocking density and with no pause for flowering, has led to a relatively low botanical diversity: these sites ranked lowest of all in terms of botany. For Sites 6 and 4, there was no significant difference in plant diversity between solar and control plots.

Ryegrass Seed Mix with Year Round Grazing

7.1.8 The sites within this study ranged from being 1-4 years old, therefore, a detailed analysis of how plant diversity if affected by the age of the site could not be conducted. Further study may focus on a larger number of sites with a greater age range in order to determine whether more established sites have a greater diversity of plant species. It should be noted that solar farms often have planning permission which lasts around 25 years, although in the UK solar farms are in the early stages of their operational lifetime. The botanical benefits may become more pronounced once the farms have been established for a decade or more.

7.1.9 It is worth specifically discussing the three sites which were compared with grassland control plots; Sites 6 and 11 were previously grassland and had grassland control plots. Site 2 was previously arable, but the control plot comprised grassland due to a lack of a suitable arable control site. These sites varied in terms of their ecological assessments. Sites 2 and 11 had a significantly higher diversity of plant species on the solar plots, which was related to broadleaved plants rather than grasses. On Site 11, this is likely due to the fact that the solar array had been re-seeded with a diverse mix post construction, however, Site 2 was seeded with a rye-grass mix similar to that of the control plot, therefore, the increase in broadleaved diversity is more likely to be a result of the cessation of intensive agricultural farming. The solar plot at Site 6 had slightly more broadleaved plants, however, this was not statistically higher than the control plot.

7.1.10 The difference between botanical diversity on sites which were previously arable or previously pasture would make an interesting basis for future research, but would require a greater number of sites of each type to be statistically robust. Previously arable sites which are converted to solar farms are predominately low grade agricultural sites; poorer soils are likely to provide a better habitat for a wider diversity of plants.

[ii] It should be noted that conservation grazing has been instated at Sites 3 and 6 in 2015 but that this is too recent to have influenced the botanical results herein.

7.1.11 Therefore, where suitable management exists, botanical diversity is expected to increase over time, with some plants emerging from the seed bank in response to favourable conditions, and others colonising from airborne or animal-carried seed.

Do the physical structures of solar farms encourage a greater botanical diversity when compared with equivalent undeveloped agricultural land?

7.1.12 Botanical diversity on solar farms may be influenced by the diversity of ecological conditions provided by the solar panels themselves. In several sites, greater broadleaved plant diversity was observed between the rows as compared to beneath the panels. This difference is likely to be due to the effects of shading and drying beneath the panels, where more extreme ecological conditions are likely to occur. It is likely that more 'natural' field conditions exist between rows, where shading is less and rainfall is not impeded by the panels. Therefore, in the more extreme conditions beneath the panels, one might expect only more specialist plants tolerant to these conditions to grow. This may be a focus of further analysis work of the current data, however, it was not under the remit of this study.

7.1.13 However, the reverse was also found at one site, where diversity of broadleaved plants was greater beneath the panels than between the rows. On this site (Site 9), the effects of regular cutting may have reduced the botanical diversity of the area between the rows (the area beneath the

Management of pernicious weeds

The Weeds Act 1959 specifies five injurious weeds: Common Ragwort, Spear Thistle, Creeping or Field Thistle, Broad Leaved Dock and Curled Dock. Under this Act the Secretary of State may serve an enforcement notice on the occupier of land on which injurious weeds are growing, requiring the occupier to take action to prevent their spread.

Recognising that certain pernicious weeds must be controlled by law, and tall weeds also present a risk of over-shadowing solar panels, some form of weed management is usually required on solar farms. From observations during this survey, and indeed, from wider survey work on solar farms, it has been noted that pernicious weeds tend to proliferate beneath solar panels.

In one site weeds were being controlled by regular spraying of broad-spectrum herbicide which kills off the majority of grasses and broadleaved plants. In the authors' experience this strategy may be effective in the short term, but also invites repeat problems with pernicious weeds. Spraying creates bare ground which is ideal for weeds to colonise. Weeds such as ragwort and thistle produce large quantities of wind-borne seed designed for colonising bare ground.

To reduce the risk of weed colonisation, it is recommended all bare areas be sown with a seed mix of some description to cover the ground in vegetation. Before re-sowing it is recommended that all existing weeds are spot treated. A wild flower and fine grass mix is recommended as it a) provides a stable mat of vegetation which once established will outcompete weed species, and b) provides forage and habitat for wildlife. A suitable mix of shade tolerant and low growing species can be selected for beneath the solar panels.

In recognition of the need for some weed control spot treatment with a non-residual translocated herbicide is considered the most ecologically sensitive option. As the grassland becomes established beneath the panels the requirements for regular treatment should decline, as weeds tend to be early colonisers.

Re-sowing bare areas beneath the panels rather than spraying should provide a long-term solution to the weed problem. This approach is expected to substantially decrease management costs over the life of the solar farm by minimising spraying of herbicide, which also has benefits for biodiversity.

panels is not usually accessible to mechanical mowers). This management approach may have led to greater plant diversity beneath the panels.

7.1.14 It is worth noting that in some instances the vegetation directly under the panels was more vigorous in growth than between the panels and it may be that there is an effect, often observed in shaded habitats such as woodland, where shade can lead to increased humidity and reduced drying out of soils, particularly when the site is relatively wet to begin with. Over time, it may be that shade tolerant species such as woodland specialist plants, may colonise the areas beneath the panels, as has been seen in sites outside of this study (Hannah Montag pers. obs. of ferns growing under panels).

7.1.15 It was noted that at Site 1 spraying of herbicide on vegetation beneath the panels was likely to rapidly reduce the diversity of broadleaved plants. At this site the diversity of both grasses and broadleaved plants was lower beneath the panels than between the rows, but this difference was on the cusp of being significant (P=0.055). It is anticipated that in time, such a management approach will lead to a marked reduction in botanical diversity.

7.1.16 It should be noted that a number of indirect effects of the presence of solar panels might influence botany under and between the panel rows. Where sheep graze sites, their grazing and resting patterns will vary across the site, with the area beneath panels being used for shelter during adverse weather. Where sites are mowed, the area beneath the panels cannot be accessed by tractor-towed mowers and so a different method (usually hand held strimmers) is used. These variations in management convey differing selective pressures upon the grassland sward and may lead to differences in plant assemblages.

Can solar farms encourage greater invertebrate diversity?

7.1.17 Over all, the abundance of butterflies and bumblebees was greater on solar plots than at control plots. The sites which had the highest butterfly abundance were those that had management in place considered to be ‘high’ in terms of its focus upon wildlife (Sites 5, 10 and 11). Those with the highest bumblebee abundance (Sites 4, 5 and 7) had ‘medium’ to ‘high’ management focus on wildlife. Sites 5, 10 and 11 were sown with a species-rich seed mix including wild flowers which are likely to include suitable foraging plants for both butterflies and bumblebees (although they appear to be benefitting butterflies more significantly). This high botanical diversity is likely the principal reason for the greater abundance of invertebrates on these sites.

7.1.18 The exception to the above was Site 4, where botanical diversity was low. Here, a bloom of white clover occurred during the survey period which attracted a large abundance of bumblebees (196), but of just 2 common species.

7.1.19 Invertebrate species diversity at solar farms, as in the wider environment, will be heavily influenced by botanical diversity, as plants provide essential forage, habitat and structure for nesting and egg laying. The suitability of a plant as a food source depends upon its floral structure, with bees and butterflies being adapted for different structures. In addition, several butterflies rely on a single or very few plant species for laying eggs and larval stages and can only breed on a site if this species is present. Therefore, to attract a wide range of bumblebees and butterflies, it is necessary to have a high diversity of plants.

7.1.20 At two sites invertebrate species richness was significantly greater within the solar plots as compared to the control plots. At Site 10, significantly higher numbers of butterfly species were observed, and at Site 5

[iii] The Weeds Act 1959 specifies five injurious weeds: Common Ragwort, Spear Thistle, Creeping or Field Thistle, Broad Leaved Dock and Curled Dock. Under this Act the Secretary of State may serve an enforcement notice on the occupier of land on which injurious weeds are growing, requiring the occupier to take action to prevent their spread.

significantly higher bumblebee species were observed within the solar plots. This result reflects the sowing of these solar plots with wild flower mixes providing suitable forage for a wide range of invertebrates. Further, at Site 10, the relative longevity of the site (4 years) is likely to influence this result. At Site 7, the highest bumblebee diversity of all solar plots was observed (10 species), even though this was not significantly higher than its control plot. For this site, too, botanical diversity is the reason for high invertebrate diversity: Site 7 displays the second highest plant diversity of all the solar plots.

7.1.21 On the majority of solar farms included in this survey, invertebrate species richness was generally not significantly different between solar plot and control plot on a site-by-site basis (although overall, butterfly diversity was higher on solar plots). This is because the botanical diversity on many of the solar plots is still quite low and based upon an agricultural seed mix. However, as botany improves over time in response to favourable management, so invertebrate diversity would be expected to improve. In addition, the solar farms are relatively new features of the landscape, and so even where there is higher botanical diversity it will take some time for species to discover and utilise the sites.


Small Copper Butterfly on Thistle

7.1.22 Agricultural flowers such as white clover or crops such as oil seed rape may attract an abundance of bees, but this is likely to be short lived (3-4 weeks of the year) and benefit only a few species. To benefit a high diversity of invertebrate species in larger numbers, it is necessary to sow a meadow with a range of grass and wild flower species. Higher plant diversity will have the added benefit of providing early and late season flowering which in turn will provide nectar sources at times of year when food sources for bumblebees are in short supply.

7.1.23 The results of the surveys indicate that solar farms can have a part to play in ecosystem services, through increasing the abundance and diversity of pollinator species. They may act as an important reservoir of pollinating invertebrates, particularly within intensively farmed landscapes where other suitable habitats are scarce. The fact that generally solar farms are constructed on land of poor agricultural value may mean that the economic benefits of providing a pollinating invertebrate resource (and thus benefitting adjacent agricultural land) may outweigh that of planting crops within the site. Additional indirect ecosystem services may be through the reduction in agricultural inputs leading to cleaner groundwater or adjacent waterbodies. Further study may look at calculating the economic value of solar farms in terms of their ecosystem services.

Can solar farms encourage a greater diversity of birds?

7.1.24 The conclusions reached so far indicate that solar farms can support a greater diversity of plants as well as greater numbers of butterflies and bumblebees, particularly under management which focuses on optimising

biodiversity. This increase in plant and invertebrate availability may lead to more opportunities for foraging birds in terms of invertebrate prey and seed availability.

7.1.25 Overall, a higher diversity of birds was found within solar plots when compared with control plots (although none of the results were significant on a site-by-site basis). This may reflect the change from a homogenous arable environment to one with more foraging opportunities as well as structures for cover or perching.

7.1.26 The abundance of birds was not significantly different between solar and control plots, however, the results indicate a trend towards higher numbers of birds using solar farms when compared with control plots (the P value was close to the threshold of significant at 0.06). There were significantly more birds on the solar plot compared with the control plot at two sites. Again, this higher number of birds observed is likely to reflect the increase in foraging opportunities available. Interestingly, the two sites where significantly more birds were observed within the solar plot (Sites 4 and 10) comprised sites of medium to high management focus on wildlife, although Site 4 ranked low in terms of both plants and butterflies. As mentioned previously, Site 4 had an abundance of flowering clover at the time of the survey and this had led to an increase in bee abundance which could in turn attract foraging birds.

7.1.27 The reduction in intensive agricultural activities and provision of permanent foraging habitat for birds may encourage declining farmland birds into the solar array. Many of these species are declining due to the recent changes in farming practices including the use of pesticides, reduction in field margins, higher stocking densities etc.

Low Intensity Sheep Grazing Outside Flowering Season

7.1.28 The study shows that overall, both a higher diversity *and* abundance of birds of conservation concern utilise solar arrays when compared with control plots. This has implications for bird conservation and indicates that solar farms may be able to provide an important resource for declining species. The results of the analysis of bird behaviours shows that four sites are important for birds foraging within the fields and, interestingly, these are the same four sites that are important for notable bird abundance.

7.1.29 Those notable species which were only found on solar plots and not on control plots were: kestrel, tawny owl, stock dove *Columba oenas*, willow warbler *Phylloscopus trochilus* and mallard *Anas platyrhynchos*. Only reed bunting *Emberiza schoeniclus* was observed on control plots and not on solar sites. It is interesting that two of the five species found on solar sites only were raptors and at Site 10, kestrels were observed frequently hunting within the array, as well as a foraging red kite. Additionally, owl pellets were found on the solar panels at one of the sites. It may be that the less intensively managed grassland and tussocky field margins at those sites managed specifically for wildlife has led to an increase in small mammals, which are prey for these raptor

species. Future research may focus on the use of solar sites by raptors (which would also include nocturnal surveys) or an investigation into the abundance and diversity of small mammals through Longworth trapping and footprint tunnel surveys.

7.1.30 Another aim of the study was to investigate the usage of solar sites by ground nesting birds, as it is generally assumed that these species will be dissuaded from utilising these sites due to the cluttered nature of the environment. Skylark was the only ground nesting bird which was regularly recorded and the analysis shows that at only one site was the number of skylark territories within the control plot significantly higher than at the solar plot. Overall, there was no significant difference between solar and control plots. This shows that skylarks are utilising solar farms within their territorial boundaries. However, only one confirmed nest was identified within a solar plot (at Site 10, the highest overall ranking site when looking at all indicators). The nest was situated outside of the footprint of the array but within the security fencing surrounding the site in an area of grassland measuring approximately 40x90m. This has implications for assessing impacts on skylarks and mitigation for this species within other solar farm sites, as quite often within the layout of solar farms large areas remain outside of the footprint of the array due to various factors (underground services, public rights of way, visual impacts etc.). If these areas can be managed specifically for ground nesting birds, they may contribute towards mitigation for these species. It should be noted, however, that Site 10 was situated in an area with very few hedgerows and trees and so where these features are present, a larger open area may be required to encourage ground nesting.

7.1.31 Although the study shows that skylarks do not nest within the footprint of the array, it does show that this species will forage within solar farms. Indeed, within two of the Sites (2 and 4), significantly higher numbers of foraging skylarks were observed within the solar plots when compared to the control plots.

7.1.32 In conclusion, although skylarks were not found to utilise solar sites for nesting, they do incorporate them into their territorial boundaries and some of the sites may represent a valuable foraging resource for this species. An interesting focus for future research would be to assess the productivity of skylarks utilising solar and control plots. A proposed hypothesis may be that skylarks nesting adjacent to solar farms would be more productive than those on control plots due to the increase in foraging resources.

Can solar farms encourage a greater diversity of bats?

7.1.33 The findings of the study generally suggest that fewer bats are recorded within the solar array than within the control plot, although the differences in abundance of bats was only significant on a small number of sites and the overall comparison of solar and control plots was not significantly different. It also appears clear that bats do not entirely avoid solar arrays with regular activity by bats recorded at all sites.

7.1.34 The bat activity at both solar and control plots was generally very low when compared with other static surveys of this type, although this is likely to reflect the placement of the microphones in the middle of the fields, as most species of bat utilise hedgerow habitats or other linear features for navigation.

7.1.35 Interestingly, although the bat activity was low, the number of species was relatively high, although there was no significant difference between solar and control plots. A peak number of eight species were recorded at several sites and this includes the pooling of the *Myotis* genus, which cannot be separated to species by call alone. It should be noted, however, that the distribution of bat species is limited within the UK and several of the sites were located in areas where more species of bats are present, therefore, a direct comparison between sites cannot be made.

7.1.36 It is unclear if the general reduced levels of activity recorded within the solar plots when compared with the control plots is a real relationship or whether this is an artefact of the survey methodology.

7.1.37 The detectors employed during the surveys were fitted with high-gain microphones which are able to pick up calls, in particular loud calls, at substantial distance. Microphones were therefore placed at least 50m from field boundaries, where possible.


Placement of Static Bat Detector and Microphone

7.1.38 As such, whilst the microphones were placed at least 50m from the field boundaries within both the arrays and the control plots it is unclear if the bats recorded by the detectors were recorded within the fields or at the field boundaries. Furthermore, due to the presence of the solar panels within the array it is likely that calls would attenuate more quickly within this cluttered environment than within the control sites which had a more uniform and low-lying structure. Vegetation heights were on every control site lower than the height of the panels.

7.1.39 In retrospect, therefore, the methodology employed to assess the diversity and abundance of bats foraging within the array and control sites had certain limitations.

7.1.40 Nevertheless, it remains possible that there is a reduced level of bat activity within solar array sites. This may be explained by the interaction of the bats with the solar panels. Research suggests bats may be confused by artificially smooth surfaces. Bats have been observed trying to drink from flat panels within laboratory settings[9] and it has been suggested that they may have difficulty in perceiving glassy surfaces as they do not reflect the echolocation calls in the same way as a natural (and rough) surface. Instead, bats perceive smooth surfaces as holes and may even collide with these surfaces (pers. com. Stefan Greif). Whilst it seems likely in a natural setting confusion would not be a significant risk, as bats will learn to navigate these objects, the presence of smooth surfaces may be disconcerting to bats who consequently avoid these areas in favour of typical natural environments which they are familiar with.

7.1.41 It should also be noted that if the evidence of the invertebrate studies translates through to night-time invertebrates (midges, moths etc.) it would suggest that the solar arrays will provide a better foraging resource for bats than the control areas. As such the solar arrays and panels whilst having disadvantages and representing unfamiliar, difficult to perceive structures, may ultimately become adopted by bats as they provide excellent foraging opportunities. As bats are particularly long-lived animals it may be several years before the effects of habituation become apparent. It may be that providing wide, diversely seeded field margins would benefit bat species more than enhancing the grassland within the array itself.

7.1.42 The findings of the study suggest that a variety of species of bats do use solar arrays but possibly at a lower level than within the control plots. If this pattern is true then the proliferation of solar arrays across the UK could be having a small but nevertheless, adverse effect upon foraging and commuting bats. Clearly further study of

the relationship between bats and solar arrays are required. We would recommend that such further surveys include the use of both manned and static detectors and that a survey methodology is devised which avoids the possibility of high gain microphones recording bats at some distance from the location of the microphone. Infrared cameras may be employed in order to investigate the behaviour of bats around the solar panels.

Other Observations

7.1.43 Whilst conducting the surveys for the selected biological indicators, anecdotal observations on other species observed were also recorded.

7.1.44 One notable observation was that large numbers of brown hare were recorded within the solar farms compared with surrounding land. This is a species of conservation concern due to declines in numbers in many parts of the country. During the surveys, these animals were often flushed from beneath the strings of panels where they had formed scrapes. It appears that solar arrays provide preferential habitat for hares, which would usually form scrapes in the middle of large arable fields or long grassland during the summer months. It may be that the panels offer shelter from sun/rain as well as protection from aerial predators. The animals are also likely to have a good horizontal field of view under the panels to be able to detect ground predators. Therefore, this artificial habitat may lead to increased hare survival or productivity, although further research would be required in order to investigate this further.

8 CONCLUSIONS

8.1 Summary of Conclusions

- The over-arching finding of this study is that where solar farms implement management that is focused upon wildlife, an increase in biodiversity can be detected across a number of different species groups.
- In this study, wildlife focused management included the seeding of a site with a diverse seed mix, limited use of herbicides, conservation grazing or mowing and management of marginal habitats for wildlife. In sites where these elements were implemented, greater increases in biodiversity were recorded.
- Botanical diversity was found to be greater in solar farms than equivalent agricultural land. This partly reflects sowing of new grassland, including species-rich meadow mixes, but also reflects less intensive management typical of a solar farm.
- Where botanical diversity is greater, this leads to a greater abundance of butterflies and bumblebees, and in several cases, an increase in species diversity too.
- The increase in botanical diversity and consequently the availability of invertebrates also results in a higher diversity of bird species and in some cases, abundance. The study revealed that solar sites are particularly important for birds of conservation concern.
- While greater botanical diversity is somewhat expected, especially where diverse seed mixes have been sown, the importance of this finding should not be under-estimated. Botanical diversity provides the basic building blocks from which greater biological diversity can be achieved (as demonstrated by the increases recorded for other species groups).
- Wild flower meadows have declined by 97% in the UK since the 1950's. The establishment of wildflower meadows within the UK's intensively farmed landscape would significantly contribute to the UKs biodiversity targets. This study shows that a diverse meadow also has a knock-on positive effect on wider species, including birds of conservation concern.
- Furthermore, by providing diverse meadow habitat, solar farms will contribute a mosaic of habitat types which is important foraging habitat for a wide range of species, especially in a farmed landscape. This is likely to benefit species which occur in a wide range of habitats such as bumblebees as well as species requiring diverse landscapes such as hares. A mosaic habitat will also benefit specific bird species, with a low sward height benefitting some species and a longer sward benefitting others.
- By encouraging high abundances of bees and butterflies, solar farms can become net producers of pollinating insects. These insects perform a vital task of pollinating crops (including cereal crops, vegetables, soft fruits and orchard fruits) and are in decline across the UK. Solar farms are likely to benefit surrounding farmland by increasing the local abundance of pollinators.
- Solar farms are likely to provide further benefits to humanity (such benefits are termed ecosystem services) including carbon storage, water cycling, erosion control and provision of pest controlling species such as solitary wasps and farmland birds. The provision of ecosystem services by solar farms should be the subject of future research.
- Solar farms are unique in the farmed landscape in that they provide a high value crop (solar power) while leaving the majority of the land area free for wildlife management. There are very few other ways that farmers can earn a sustainable amount of money by creating large areas of conservation habitat.

AREAS OF POTENTIAL FUTURE RESEARCH

- Further study including sites of a greater range of ages in order to examine how the age of a solar farm affects plant diversity.
- Comparison of solar sites that were previously pasture compared with those which were previously arable to examine plant diversity.
- Analysis of species found beneath solar panels and whether there is a bias towards more specialist, shade tolerant plants.
- Economic analysis of solar farms and their contribution to ecosystem services.
- Examination of the use of solar farms by raptor species (including nocturnal surveys for owls).
- Study of the diversity/abundance of small mammals within solar farms (as linked to the presence of raptor species) which may include Longworth trapping (potentially with mark and recapture) and footprint tunnel surveys.
- Investigation into the productivity of skylarks in the local landscape of a solar farm in order to investigate the hypothesis that skylark productivity is higher adjacent to solar farms due to the increase in foraging opportunities.
- Further research into the impacts of solar arrays on bats. This should include manned surveys as well as further static surveys potentially utilising a different methodology (such as reducing microphone gain). Infrared cameras may also be utilised to investigate bat behaviour around solar panels.
- Investigation into the usage of solar farms by brown hare.
- Further research into other taxa including amphibians and reptiles as well as other invertebrate species.

9 MANAGEMENT RECOMMENDATIONS

9.1.1 Given the results of the surveys, the following management practices would be recommended in order to optimise the benefits of a solar farm for biodiversity:

- To enhance biodiversity, it is recommended that all or part of a solar farm is re-sown with a diverse wild flower and fine grass mix.
- The best approach would be to re-seed most or all of the site, and to incorporate as many native species of grass and wild flower as possible. However, it should be noted that even including a few species of grass and herb should have positive benefits.
- An experienced ecologist should advise on the seed mix to ensure it includes suitable forage plants for both butterflies and bumblebees, and to avoid tall species which may overshadow the panels.
- Fine grasses should be used in place of typical agricultural grasses, e.g. rye-grass, which is aggressive and does not encourage diversity.
- In all sites where re-seeding has been done it is recommended that monitoring is undertaken to ensure the vegetation develops as planned.
- All plantings (seed mixes and woody plants) must be native species and should be of local provenance.
- Solar farms should be managed through conservation grazing, with sheep grazing from September – March and a pause from April – August to allow wild flowers to flower and set seed. If mowing is the management option, then a similar approach should be adopted, with a pause in cutting from April – September.
- Where solar sites comprise multiple fields, implementing different management regimes would benefit a wider range of species. For example, one field may be grazed year-round in order to encourage species that require a short sward height, while the main site area should be managed as above. If mowing is the management option, the date of cutting may be varied across the site or between years in order to encourage plant species that may flower and seed at different times.
- All bare areas of a solar farm should be re-seeded as soon as possible with an appropriate meadow mix to a) cover bare ground and reduce the risk of weeds, and b) increase the botanical diversity of the site.
- Use of herbicide should be restricted to spot treating of pernicious weeds (docks, thistles and ragwort) wherever possible. Herbicides reduce wild flower diversity and create conditions suitable for weeds.
- Open areas within the solar farm (wayleaves or voids) should be managed specifically for ground nesting birds by grazing at low stocking density through the winter and allowing the grasses to grow up through the bird breeding season (March – July inclusive).

10 REFERENCES

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APPENDIX A: SURVEY METHODOLOGIES

Botany

All botanical visits were conducted from mid-June to late July (16/06/15 to 21/07/15) in order to standardise surveys.

The surveys comprised the assessment of the grassland sward utilising $50cm^2$ quadrats. Percentage cover of each plant species within the quadrat was recorded using the Domin Scale:

% Cover	Domin Score
91–100%	10
76–90%	9
51–75%	8
34–50%	7
26–33%	6
11–25%	5
4–10%	4
<4% (>10 individual plants)	3
<4% (5-10 individual plants)	2
<4% (<5 individual plants)	1

A total of 30 quadrats were recorded at each site, comprising:

- 10 quadrats within the treatment plot - unshaded, between strings of panels
- 10 quadrats within the treatment plot – directly beneath panels, adjacent to the above
- 10 quadrats within control plot

The quadrat locations were selected using random points generated within qGIS[iv] mapping software and were located on the ground using a GPS device.

Birds

A total of three bird surveys were conducted at each site during late April to early July. The treatment and control plot surveys were carried out on the same day between 06:00am and 10:00am.

The bird surveys followed a fixed transect designed in a ‘zig zag’ pattern, with the transect being started on the northern field boundary, then crossing the plot every 100m until the southern field boundary is reached. The length of the transect therefore varied from site to site, but was roughly the same distance between the paired treatment and control plots.

[iv] Quantum GIS Development Team (2014). Quantum GIS Geographic Information System. Open Source Geospatial Foundation Project.http://qgis.osgeo.org

All bird species within 50m of the transect route were recorded, including the behaviour (calling/singing, foraging, flying over site) and location (within field or within field boundary). As far as possible, birds were not double-counted, however, this methodology allows for some double counting.

Where ground nesting birds were observed, the location and behaviour was mapped on a separate survey sheet using the BTO common bird census territory mapping methodology[v]. These were then utilised to assess the numbers of ground nesting bird territories and potential location of nests.

<u>Invertebrates</u>

Invertebrate surveys concentrated on two taxa; bumblebees and butterflies. A total of ten 100m transects were carried out within the treatment plot and ten within the control plot.

Invertebrate surveys were conducted during June, with five sites being revisited for a second survey in mid-June to early July.

Transects were spaced evenly throughout the field, positioned in an east/west arrangement, with one transect at the northern field boundary and one at the southern.

The transects were were walked at a slow pace, with all bumblebee and butterfly species within 2.5m of each side of the transect line recorded. The ground ahead was also scanned, with binoculars used where required.

<u>Bats</u>

Automated bat surveys were conducted at both the treatment and control plot using Song Meter 2 Acoustic Monitoring systems. The detectors were placed in the centre of the fields, at a height determined by the size of the solar panels within the treatment plot; both microphones were positioned 150mm above the height of the solar panels. Detectors were deployed from early June to early July and collected two weeks later.

Microphones were attached to extendable poles within the control plots or batons attached to the solar panel frames and left to record for a period of at least 10 days. The batteries lasted for varying amounts of time on each site, depending on the amount of bat passes or noise recorded.

Upon collection, the data was subsequently analysed using Kaleidoscope software. This computer program automatically analyses bat calls using a stored library of comparison calls. Any less widespread bats which were automatically identified by the software were also manually checked to verify the species recorded.

[v] Marchant, J.H. 1983. *Common Birds Census instructions*. BTO, Tring. 12pp

APPENDIX B: STATISTICAL ANALYSIS

The majority of data collected on site consisted of frequencies, that is the number of species or individuals observed. In most cases the comparison of solar plot and control plot surveys involved comparing the number of species found in each, e.g. 7 species of butterfly observed in the solar plot vs. 3 observed in the control plot. In such cases, the Chi Square statistical test[vi] was used to determine if the difference between the solar plot and control plot was significant. It is possible to directly compare these results because the same survey methods and effort were used in the solar plot and control plot.

While Chi Square works for individual sites, it was necessary to compare all butterfly survey results on solar plots with control plots. In these cases, the 17 surveys[vii] for solar plots were compared with the 17 for control plots using the Mann Whitney U test[viii].

To explore botanical diversity, the results of individual quadrats within the solar plot were compared to those within the control plot, so 10 solar quadrats were compared to 10 control quadrats (only the ‘between panels’ quadrats were used in this analysis) for each site. The Mann-Whitney U test was used to compare botanical results.

Within the solar plot, we investigated whether there was any difference in botany between the panels vs. beneath the panels. As above, the Mann-Whitney U test was used to compare the results.

Where notable birds were identified during bird surveys, this was explored further. Birds were categorised depending on their conservation status, based on those listed within the British Trust for Ornithology Birds of Conservation Concern[ix]. This list contains red and amber designated birds which are showing declines in population and so are of particular conservation concern. A weighted scoring system was utilised within the analysis of the data where non-notable birds (those not on the Birds of Conservation Concern list) were given a score of 1, amber listed birds were given a score of 2 and red listed a score of 3. An overall score could then be obtained in order to carry out the statistical analysis.

An over-arching analysis of all 11 solar plots was conducted where the results for all solar plots were pooled and compared to the 11 control plots. This approach was designed to investigate what patterns existed overall between solar and control plots. It was possible to pool data for all sites because the same survey methods and effort had been applied at each site.

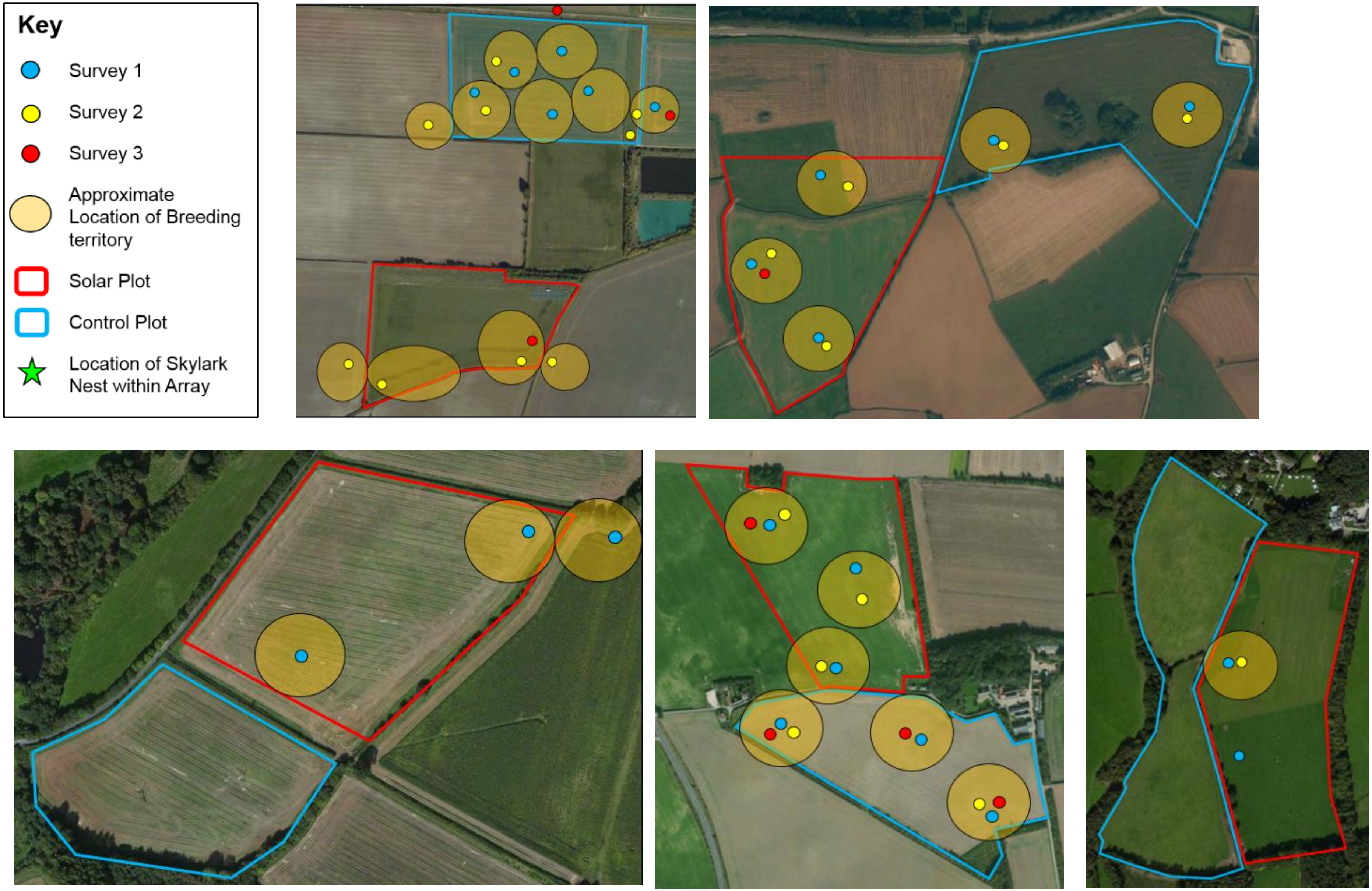
[vi] This non-parametric statistical test is designed to compare individual numbers and is able to deal with count data.

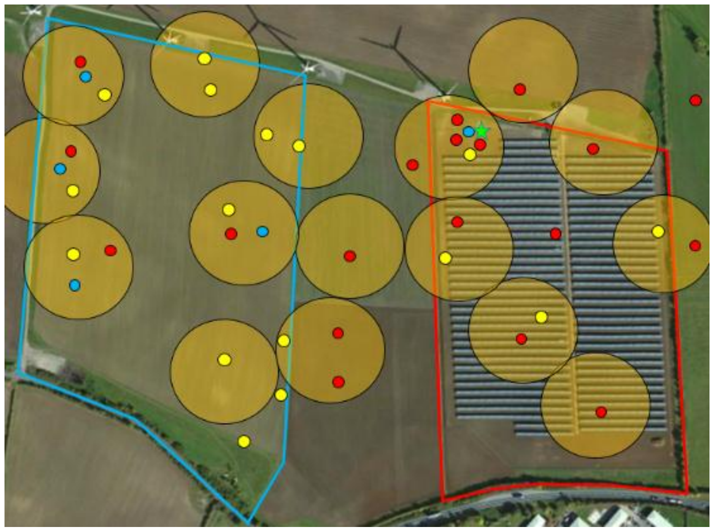
[vii] There were 17 invertebrate surveys in total spread across 11 solar farms. On 6 solar farms 2 surveys were conducted while on 5 solar farms a single survey was conducted.

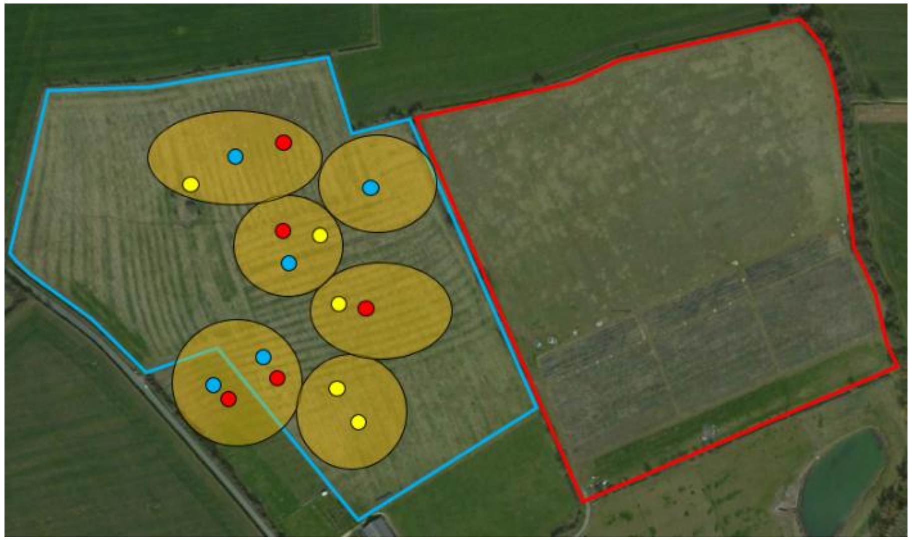
[viii] The Mann-Whitney U test is a non-parametric statistical test that compares two data sets and is able to deal with count data.

[ix] Eaton MA, Aebischer NJ, Brown AF, Hearn RD, Lock L, Musgrove AJ, Noble DG, Stroud DA and Gregory RD (2015) Birds of Conservation Concern 4: the population status of birds in the United Kingdom, Channel Islands and Isle of Man. British Birds 108, 708–746.

Appendix C: Ground Nesting Bird Territory Maps







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inpractice

Bulletin of the Chartered Institute of Ecology and Environmental Management

What's that Fungus? A Guide to Finding and Identifying Fungi

Waxcap Grasslands: The Forgotten Treasure

Using Bryophytes as Indicator Species in Habitat Surveys

Know Thy *Sphagnum*: Lessons for Understanding Bogs

Bryophytes, Lichens and Fungi

Editorial

Welcome

This is an unusual edition of *In Practice* in that it is focused on a specific group of organisms. Not only that, but it is concerned with a group that are unusual and often overlooked: the bryophytes (mosses, liverworts and hornworts), fungi and lichens. These are sometimes referred to as 'lower plants'. That's not because they are small and often found growing on the ground, but because they were some of the first organisms to colonise land. Often grouped together, they are not actually closely related and their ecological requirements can be quite different. What they have in common is that they are frequently overlooked in ecological surveys and assessments, such as the waxcap grasslands described by Anderson and Barden (page 32). This is unfortunate as Ireland and Britain support some unique communities of these species, including globally important populations of oceanic bryophytes in Atlantic 'temperate rainforest' on the west coasts of Ireland, Scotland and Wales. Both recognition and conservation action are required to preserve and enhance these valuable components of our native ecosystems.

Many of these communities are under threat from factors such as climate change and land-use changes. Climate change can impact species in all of these groups as many are dependent upon specific local microclimatic conditions. Some species will increase their range in response to a changing climate (see Pakeman *et al*., page 27) but this is not possible for species that are already at the edge of their range, such as specialist montane bryophyte communities found in late-lying Scottish snowbeds.

However, it is habitat loss from land-use change that is currently the main driver of species change in these three groups. Grazing was found to be the most dominant pressure on bryophyte and lichen communities in Scotland's 'rainforest zone' (Simpson 2022). Overgrazing can lead to a loss of woodland and heathland and an increase in grassland, particularly in the uplands. For species sensitive to local humidity, this can increase the potential impacts of climate change. There are 'hyperoceanic' bryophytes in Ireland which are found only on north-east-facing slopes of mountains in the very west, where there are more than 220 wet days per year (Hodd and Sheehy Skeffington 2011). Historic overgrazing has reduced the cover and height of the heathland in which these species grow, changing the local microclimate and reducing humidity. This makes these globally important bryophyte populations more susceptible to changing climatic conditions (Hodd and Sheehy Skeffington 2011).

Overgrazing can also facilitate invasion of woodlands by non-native species, which further impacts native species regeneration and can reduce light availability. This affects bryophytes and lichens differently as many woodland bryophytes are tolerant of low light conditions and some rare species can actually thrive in dark, humid, impenetrable thickets of rhododendron scrub (see Hodd, page 42). This could create a dilemma for ecologists as rhododendron prevents native tree species from regenerating and is a hostile environment for light-loving lichen species. Lichens are impacted by undergrazing to a greater extent than bryophytes, as they tend to be more light-demanding and are easily lost from grassland, heathland and woodland when the vegetation becomes tall and shady.

Bryophytes, fungi and lichens are also very sensitive to the effects of elevated nutrients on habitats. As they are small they are easily outcompeted, for instance by tall grass species in fertilised grassland. But there is also the direct impact of high levels of nutrients such as ammonia and nitrates, which can lead to bleaching and browning of bryophytes and lichens in woodlands and on bogs. The sensitivity of these species to changes in climate, land use, grazing, drainage and nutrient levels makes them useful indicator species, which is explored in articles by Denyer (page 21), Massey (page 18), Pakeman *et al*. and Smith (page 14).

Many of the impacts described here are either reversible or can be ameliorated by correct policy and habitat management and restoration. But first we need to increase our knowledge and appreciation of these diverse and important species groups. As a bryologist myself I will be re-reading the articles by Anderson and Barden, Cooch *et al*. (page 38) and Orr (page 8) to improve my fungi knowledge. Hopefully the articles in this dedicated issue of *In Practice* will contribute to your learning in this area too.

Joanne Denyer MCIEEM

Acknowledgements

Thanks to Dave Genney and Kat O'Brien (NatureScot) and Rory Hodd for their thoughts on the key issues facing these species in Scotland and Ireland.

References

Hodd, R.L., Sheehy Skeffington, M.J. (2011). Mixed northern hepatic mat: a threatened and unique bryophyte community. *Field Bryology*, **104**: 2–11.

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In this issue

Cover photo: Sporophytes of the genus *Bryum*, a genus of mosses in the family Bryaceae. Photo credit: Dave Genney.

In Practice

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CIEEM News

Recent webinars

We continue to run a full and varied series of webinars for members and the sector. Readers may be interested in the below recent webinars that are available on the CIEEM Resource Hub.

- ENDS 100 Power List Discussion Panel
- Early Careers Webinar: Top tips on applying for a job in the sector
- Defra's Nature Green Paper and Environmental Targets
- Becoming a Chartered Ecologist
- An Overview of CIEEM's CPD Tool, MyCareerPath

Past webinars are available in the CIEEM Resource Hub (https://cieem.net/i-am/resources-hub/). Also look out for future webinars in events and training listing on the website (https://events.cieem.net/Events/Event-Listing.aspx).

Recent blog posts

Recent blog posts on the CIEEM website (https://cieem.net/news/) include:

- Conservation detection dogs: searching for best practice – by Louise Wilson and Angela Winstanley
- Floodplain meadows: the sustainable and productive choice for landscape scale lowland floodplain restoration – by Emma Rothero, Catriona Bass and Sarah Wells
- *Sphagnum*: An Ecosystem Engineer – by Penny Anderson CEcol FCIEEM(rtd)
- Let's Celebrate Volunteers: A Word from the CIEEM President
- Let's Celebrate Volunteers: Members Groups
- Let's Celebrate Volunteers: Professional Development Team
- Let's Celebrate Volunteers: Professional Standards Team
- Let's Celebrate Volunteers: Policy Team
- Let's Celebrate Volunteers: Membership Team
- Economics for Ecologists – Knowing your ESG from your GCN – by Morgan Taylor CEnv MCIEEM
- We Are At The Crossroads of the Climate Emergency; It Is Now or Never to Keep 1.5°C Alive – Blog
- Key Actions to Tackle the Climate Emergency and Biodiversity Crisis: Everyone Can Make a Difference – by John Box
- The Disappointing Environmental Credentials of the Next UK Prime Minister – by Jason Reeves

If you would like to contribute your own blog, please contact SophieLowe@cieem.net.

Staff changes

In July, **Will Filmore** joined the team as Finance Officer. And in August we welcomed **Dannii Mathews** as Professional Standards Administrator and **Lea Nightingale** as Equality, Diversity and Inclusion Engagement Officer. **Alison Wells** starts on 1 September as Membership and Marketing Administrator.

In Practice digital editions

If you would like to reduce your and CIEEM's carbon footprint and receive only digital editions in the future, please let us know by contacting enquiries@cieem.net.

CIEEM Conferences 2022

Date	Title	Location
23–24 November	2022 Autumn Conference: Delivering a Nature Positive, Carbon Negative Future	Edinburgh

Find out more: https://cieem.net/events

In Practice Themes and Deadlines

Edition	Theme	Article submission deadline
December 22	Non-themed (submissions welcome on any topic)	n/a
March 23	Rewilding, Habitat Restoration & Species Reintroductions	18 November 22
June 23	Invertebrates	17 February 23
September 23	Diversity, Accessibility & Capacity in the Sector	19 May 23
December 23	Non-themed (submissions welcome on any topic)	18 August 23

If you would like to contribute to one of these issues, please contact the Editor at nikprowse@cieem.net. Contributions are welcomed from both members and non-members. Further information and guidance for authors can also be found at: https://cieem.net/in-practice/

Did You See?

Survey of local authorities highlights lack of capacity to deliver Biodiversity Net Gain

A study commissioned by Defra shows the levels of resource, capacity and expertise in English local authorities cannot deal with existing planning workload, let alone any increase required for additional work on Biodiversity Net Gain (BNG). Only 5% of respondents said their current ecological resource is adequate to scrutinise all applications affecting biodiversity, while fewer than 10% reported that their current expertise and resources will be adequate to deliver BNG.

https://cieem.net/survey-of-local-authorities-highlights-lack-of-capacity-to-deliver-biodiversity-net-gain/

'Business for Biodiversity' platform launched in Ireland

Irish Government is encouraging businesses to sign up to Business for Biodiversity, a new platform to guide action on the biodiversity crisis. The platform will help businesses to measure, design and demonstrate their biodiversity impact, drawing on a network of expertise led by Natural Capital Ireland, the National Biodiversity Data Centre and Business in the Community Ireland.

https://www.gov.ie/en/press-release/4510f-new-business-for-biodiversity-platform-will-help-businesses-to-take-strategic-action-for-biodiversity/

Five highly protected marine areas planned for English waters

Five highly protected marine areas (HPMAs) could be created by the government to ban all fishing and rewild the sea. The designations are proposed for the coast of Lindisfarne in Northumberland and at Allonby Bay, Cumbria, and at three offshore sites, two in the North Sea and one at Dolphin Head in the English Channel. The sites are expected to lead to full HPMA status for some or all of the English sites in 2023 following a consultation.

https://www.theguardian.com/environment/2022/jun/20/five-highly-protected-marine-areas-set-up-in-english-waters-fishing-ban

Interim Environmental Protection Assessor for Wales issues first annual report | Asesydd Interim Diogelu'r Amgylchedd Cymru: Adroddiad Blynyddol

Dr Nerys Llewelyn Jones was appointed as the Interim Environmental Protection Assessor for Wales in March 2021 to consider concerns raised by the public about the functioning of environmental law in Wales. This is the first annual report on the submissions received and any action that has been taken in relation to them.

https://gov.wales/interim-environmental-protection-assessor-wales-annual-report-2021-22

https://llyw.cymru/asesydd-interim-diogelur-amgylchedd-cymru-adroddiad-blynyddol-2021-22?_ga=2.10786674.791575674.1656679190304361932.1645736813

Venue and date confirmed for biodiversity COP15

The Convention on Biological Diversity (CBD) has confirmed that the COP15 meeting – at which a new Global Biodiversity Framework (GBF) will be agreed – will take place in in Montreal, Canada from 7–19 December 2022.

https://cieem.net/venue-and-date-confirmed-for-biodiversity-cop15/

Scottish Government launches draft Biodiversity Strategy

Scottish Government has published a draft Biodiversity Strategy, setting a new goal to end biodiversity loss by 2030 and restore biodiversity by 2045. The high-level document sets out series of outcomes for both 2030 and 2045 in six areas, including: Farmland, Woodlands and Forestry, Soils and Uplands; Marine Environment; Freshwater Environment; Coastal Environments; Urban Environments, and Overall Health, Resilience and Connectivity.

https://cieem.net/scottish-government-launches-draft-new-scottish-biodiversity-strategy/

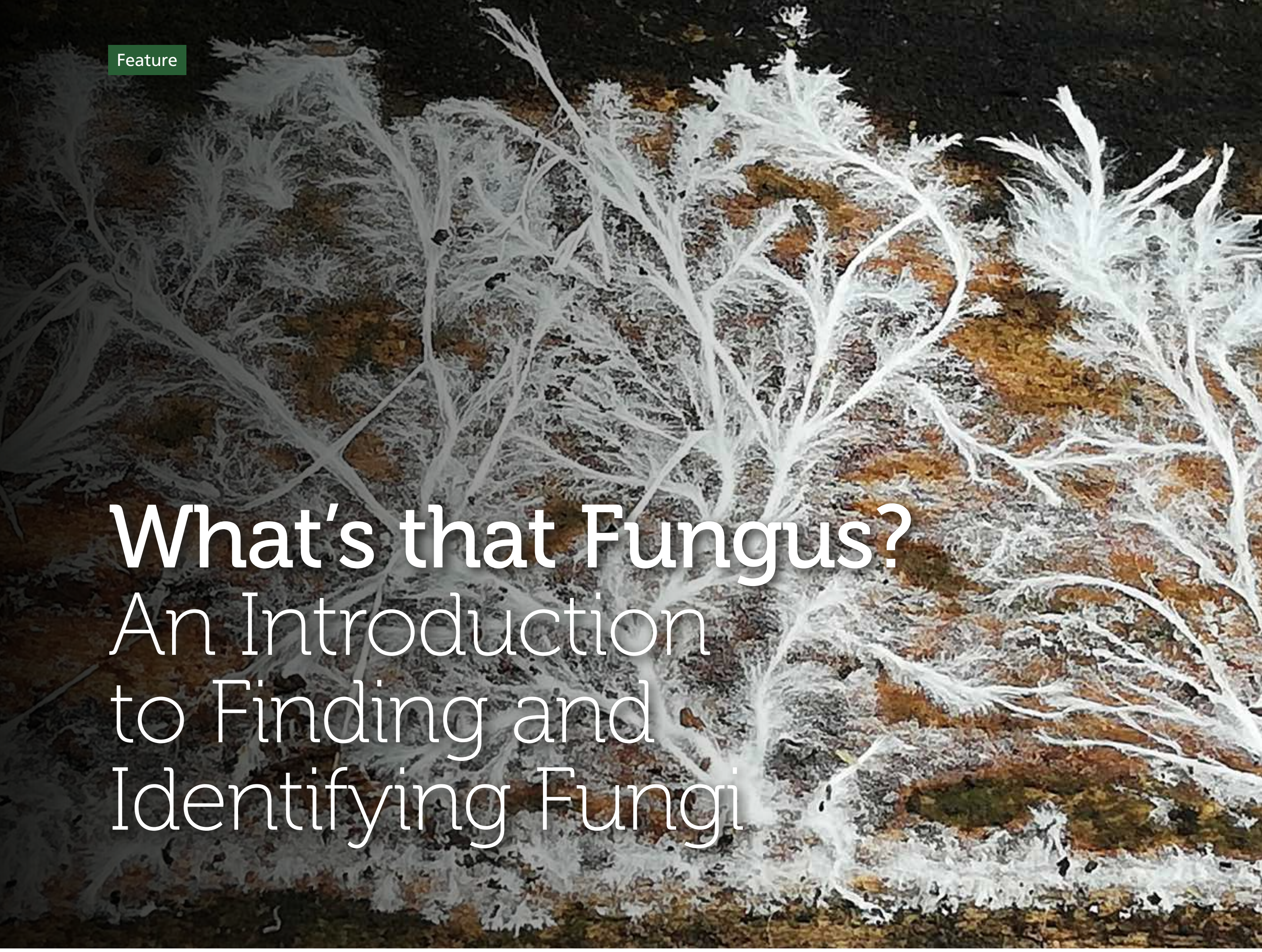
EU Nature Restoration Law: A boost for biodiversity and climate

The European Commission has proposed a new nature restoration law with binding targets on pollinators, wetlands, rivers, forests, marine ecosystems, urban areas and peatlands. The new law aims to bring nature back across the continent for the benefit of biodiversity, climate and people.

https://www.iucn.org/news/europe/202206/eu-nature-restoration-law-a-boost-biodiversity-and-climate

Find more news from CIEEM at: www.cieem.net/news

Feature



What's that Fungus? An Introduction to Finding and Identifying Fungi

Figure 1. A mycelial network on damp wood.

Nathan Orr
Tetra Tech

Keywords: cap, mycelium, mycorrhizal, parasite, pore surface, saprotroph, spore, stipe

When setting out to identify a fungus and to incorporate its presence into the biological assessment of a site, it is important to understand the multiple roles that fungi play. This branch of life has been under-represented because it is often unseen. Only given their own branch on the tree of life in the 1960s, and with no specific degree-level courses in mycology offered by any UK university, fungi are truly the 'forgotten kingdom'. In this article I will introduce you to the roles that fungi play in our environment and the methodology used in their identification. I hope to inspire you to take a closer look and take note of fungal diversity.

Introduction

Studies have shown that fungi were one of the earliest life forms to move onto land and that they were towering over the early plants, growing several metres tall, over 420 million years ago (Brahic 2007). It is now more generally accepted that they formed, and continue to form, a critical role in ecosystem formation, maintenance and function. Their ability to crack rock and break down dead material to increase nutrient supply, especially in poor soils where plants would not survive, was crucial for the colonisation of land. The fungal network associated with plant roots gives plants the ability to gather resources that would otherwise be inaccessible, and from a wide area. This relationship and their abilities to process dead and often toxic materials may offer hope for the remediation of contaminated landscapes in future. The adaptations of fungi helped shape the planet, with its vast diversity of habitats, and fungi play essential roles in most of them. However, despite this, they are often overlooked even in ecology.

But what is a fungus? Even though only 120,000 species of fungi have been identified, it is estimated there are somewhere between 2 to 4 million species in total (Hawksworth and Lücking 2017). There are three major groups:

1. single-celled microscopic yeasts, the co-creators of bread and alcohol
2. multicellular filamentous moulds, the providers of penicillin
3. macroscopic filamentous fungi, which create the reproductive organs that we call mushrooms or toadstools (I believe that, traditionally, edible fungi are called mushrooms and inedible or poisonous ones are called toadstools).

Macroscopic filamentous fungi are made up of tiny strands called hyphae. They weave and burrow through their chosen substrate, forming interconnecting, immensely complex webs called mycelia (Figure 1). In an ancient woodland, a teaspoon full of soil can contain 100 million hyphae or more, which form a significant portion of the soil mass (Stamets 2005). This group is the focus here, as they are the type of fungus we are most likely to encounter as ecologists and they can be more easily used as indicators of biodiversity in a habitat.

Fungus identification: where do you start?

When beginning to assess the fungi in a habitat the first step is finding them. The most prolific time of year for fungi is the autumn, from September to November, but you will find them at all times of the year if you know where to look. Some fungi are brightly coloured, big and showy, but the majority are small, unassuming and grow in out-of-the-way corners. Fungi are capable of constructing and inflating their fruiting bodies very quickly, but need water to do so, so looking a day or two after rain is also a good way to increase your chances of finding fruiting bodies. A notebook, camera or mobile phone (I use a phone as the macro-photographic capability on many phones is amazing) and sample pots are essential for fungal identification. There are also chemical reagents that can help identification: potassium hydroxide solution and Melzer's reagent cause colour changes in certain fungi. As with all chemical reagents they should be used with caution and following the correct guidance and training.

The last thing on the list for field identification is a reference guide. A good fungi book is a great starting point, but online sources have more flexibility to keep up with the changes in taxonomic information. My first fungi book was *Mushrooms* by Roger Phillips (2006), which has common names and detailed photos, although the classification is now out of date. I use Geoffrey Kibby's *Mushrooms and Toadstools* volumes 1–3 (Kibby 2017, 2020, 2021) but this does not use common names which makes it less accessible when you are starting out. Online resources are able to keep up with the rapid changes in fungal classification and are covered at the end of this article.

Location, location, location

Once out in the field it is good to know where to start to look and the roles of fungi in different environments. Fungi can occur in a range of habitats from grasslands to woodlands and gardens, and checking tree stumps, log piles, dead wood (on the ground or still attached), animal scat and dead plant material can lead you to the saprotrophs ('the rotters'), which make the nutrients in dead or decaying material available to other organisms (Figure 2).

The mycorrhizal species are those that form a relationship with the roots of plants and exchange nutrients and water for the complex hydrocarbons that plants produce through photosynthesis. There are four UK tree genera or species that you should look for first as they have a range of fungal partners, so increasing your chance of finding mycorrhizal fungi: these are English oak (*Quercus robor*), beech (*Fagus sylvatica*), birch (*Betula* spp.) and pine (*Pinus* spp). Beneath any of these is a good place to start your search. But don't stop looking beneath other trees

Figure 2. The saprotrophic velvet shank, *Flammulina velutipes.*

Figure 3. Fly agaric (*Amanita muscaria*), a mychorhizal fungus that grows with a number of tree species. I find it most often with birch and pine and the species has one of the most iconic mushrooms.

Figure 4. Scarlet caterpillar club (*Cordyceps militaris*), a parasitic fungus whose host is an insect larva, in this case probably the larvae of a crane fly (*Tipula* spp.). This was found in my own garden; toothpick shown for scale.

"The first step is finding the fungi. The most prolific time of year is the autumn, from September to November, but you will find them at all times of the year if you know where to look."

or shrubs, as you never know what you will find. Over 90% of all plants rely on a relationship with fungi in their roots (Feijen *et al.* 2018) (Figure 3).

The final role that a fungus can play is as a parasite. It is harder to predict where a parasite will crop up, but you may well have encountered some, like honey fungus, *Amarilla* spp., before. There are parasitic fungi for plants, other fungi and even animals, particularly the arthropods. Some parasitic fungi of insects can control or hijack a host, forcing it to move to a place where the fungal spores will better infect the next generation of insects. *Entomophthora muscae* may be in your home already as it is a fungus that infects housefly species. Another example of a fungus that parasitises insects is shown in Figure 4.

Identification features

Field identification of fungi is not a simple task and, in fact, definitive species identification in the field is not possible for many. Fungi and their fruiting bodies are diverse to say the least and can be very variable, even within a species. For example, one species, *Laccaria laccata,* has the common name of the deceiver as its appearance between individual specimens varies so significantly. There are certain species that are very identifiable by their shape or colour, but most will need microscopic analysis of their spores and the mechanisms that deliver the spores. Many of fungal identification guides, including the Kibby and Phillips guides mentioned above, show spore size, shape and colour. Websites, like first-nature.com, supply images of the spores and identifying structures that you can reference. However, there are some fungi that can only be distinguished to species level through DNA analysis. I have tried to give you a few starting points to help identification, but practice and experience are key (it has taken me 8 years to gather the knowledge I have now).

Cap

Once you have found a fungus the first thing to look at is the cap. The shape, colouration, texture and markings can be distinctive. Caps can be viscid (slimy), rough and hairy, smooth, waxy, ribbed or felt-like. They may be flattened, bell-shaped, funnel-shaped or rolled over at the rims. These descriptions aren't exhaustive: there are lots of variations. Cap features will help to narrow your search and can be indicative of a particular fungal family or genus (Figure 5).

Figure 5. Examples of cap variation. (a) Pleated inkcap (*Parasola plicatis*) has a ribbed cap. (b) Weeping widow (*Lacrymaria lacrymabunda*) is almost furry and weeps a blue liquid when damaged. (c) Rosey bonnet (*Mycena rosea*) has a distinctive bonnet shape.

> **"The first thing to look at is the cap. Shape, colouration, texture and markings can be distinctive. Cap features will help narrow your search and can be indicative of family or genus."**

Spore-producing surface

One of the most important things to look at in fungi is the spore-producing surface. Basidiomycetes, the spore droppers, use gills, spines or tube-like features on the pore surface to drop their spores. Ascomycetes, the spore shooters, in contrast, form their spores in a sack-like ascus which ejects the spores (Phillips 2006). With gilled fungi, the spacing of the gills, their thickness and the colouration are all important indicators. How the spore surface attaches to the stipe (or stem; see below) can provide one way to ascertain the family. For example, the funnel caps tend to have gills that run down onto the stipe and the gills of *Amanita* spp. are 'free', which means they do not attach to the stipe. Spore surfaces may have other characteristics: one of the identifying features of the *Russula* or brittlegills, is that if you rub the gills they break and look like almond flakes. Another group, the *Lactarius* or milkcaps, can bleed a latex-like liquid when damaged. The *Cortinarius* or webcaps can be distinguished from other genera by the fact that as their cap expands a filamentous web can often be found from the edge of the cap to the stipe. Other mushrooms use pore tubes to deliver their spores: when you turn the cap it looks like a velvet cushion with tiny holes all over. Pore surfaces can be brightly coloured, and some species show a colour change when damaged. Some even turn blue! The Ascomycetes are often cup-shaped or, due to their method of sporulation, have crazily contoured surfaces and can send out a cloud of spores if blown on (Figure 6).

Stipe

The stipe, or stem, of a fungus can help you in the process of identification. What is its texture? Colouration? Thickness? Is it brittle? Is it hollow?

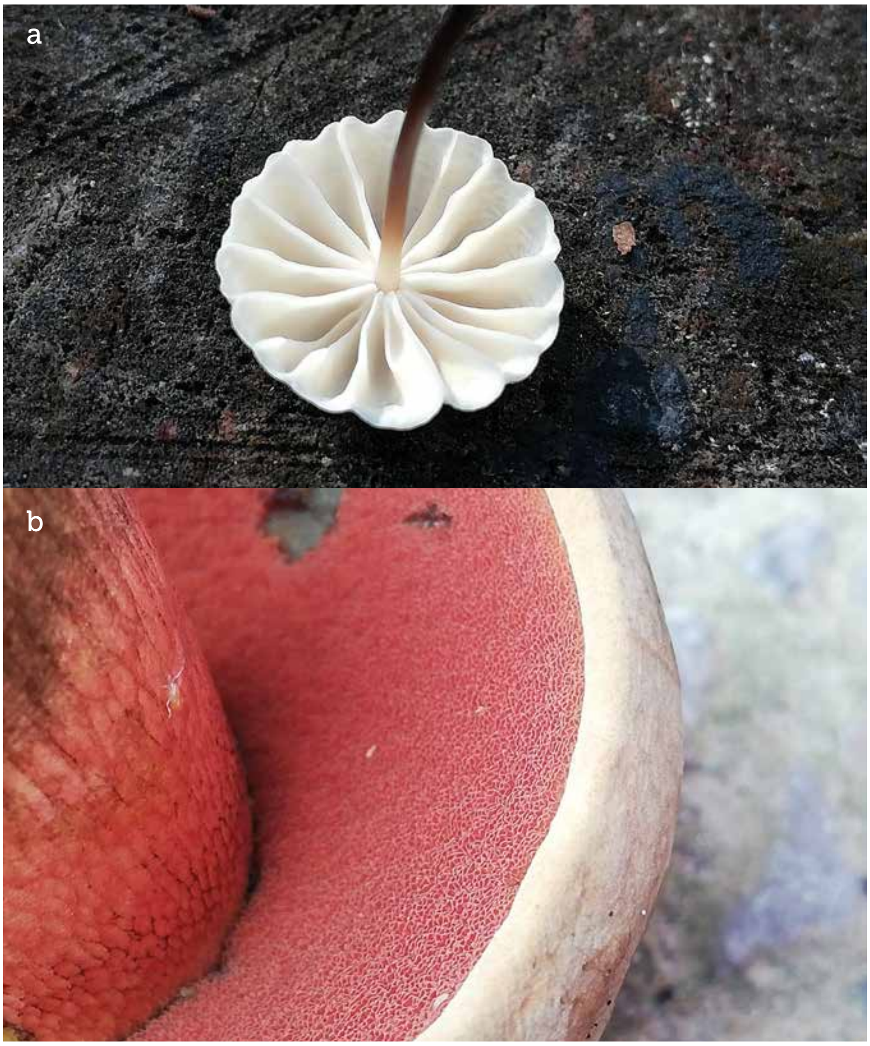


Figure 6. Examples of spore surfaces. (a) *Marasmius* spp., with its wide, simple gills. (b) *Bolete* spp., with a bright pore surface.

Figure 7. When the cap of the fly agaric (*A. muscaria*) bursts through the universal veil it forms the 'spots' and the 'skirt'.

Does it have any marks or ribbing? Is it bulbous at the bottom or even missing entirely? Is there evidence of the universal veil? The universal veil is the egg-like structure that *Amanita*, stinkhorns (*Phallus impudicus*), and other species grow from (Figure 7).

Dissection

Cutting a fungus in half, both the cap and stipe, can often provide more data for your identification. It may be hollow, brittle or thickly fleshed. Cutting may also stimulate a colour change, or the production of latex.

Sniff test

After you have conducted your visual checks it's time to use your other senses. Give the fungus a good old sniff! Many fungi have a distinctive smell that can be indicative of species. Some smell of ammonia, bleach or almonds, some can smell mealy or just plain mushroomy. If you find a stinkhorn or its relatives, I advise you to not breathe too deeply as their common name is well deserved; they smell of rotting flesh to attract flies to spread their spores! It is not dangerous to smell fungi but always wash your hands after handling them; the reasons for this discussed below.

Setting and collection

Finally, look at the environment where you found your fungus. What is it growing from? Is it from dead material or from the ground? What plants, not just trees, but shrubs, herbs and even mosses, are present? One of the key indicators of potential waxcap grassland is its moss content, so what may appear to be a flower-poor, grazed or cut grassland in August is actually much more than that in October when the mushrooms appear.

After all the field observations are recorded there is another simple check that can be undertaken. Collect a sample mushroom and, when you get home, place the pore surface of of the mushroom's cap down on a piece of paper, or onto a microscope slide if you have one. Place a cup or pot over it to stop draughts and leave it overnight. Any dropping spores will be deposited on the paper. They could be white, black, brown, pink or any shade in between and this colouration can help identify the genus of the fungus if not

The online community is one of the greatest tools for identifying fungi. There are many great mycology groups out there, full of enthusiasts and experts who can point you in the right direction.

its species. Most identification guides and websites provide information on spore and print colouration as it is a key identifying feature.

Collection of fungi is necessary for identification purposes, but I always err on the side of caution when picking samples to minimise the impact. I pick samples when there is more than one fruiting body and I try to take only one sample of each species. Although you are not harming the fungus, and the mushroom is only a reproductive fruiting body, I feel we should all manage our impact on the environment and remove as little as possible from the habitats we study. There are also species that are listed on the Red Data list, compiled by the British Mycology Society and found on their website (for the address see the next section), such as *Cortinarius saginus*, a fungus that is coloured blood red, and these should not be picked. This list of over 800 threatened fungi has yet to be included as an official IUCN Red List as it is still under development. For these reasons, I feel that photography and field records are critical and that sample taking should be managed sensibly, although this is a personal preference.

There are also issues with toxicity in fungi, but there are no fungi that are dangerous to touch in the UK. I don't wear gloves to handle samples; it is the ingestion of the mushroom or the toxins they carry that causes illness, pain and even death. Always wash your hands after handling samples, especially before you eat. There are many mushrooms that are dangerous if consumed and I do not recommend that any fungi are eaten if you are even a little unsure of their identification. If you mis-identify a fungus and eat a toxic one, it may result in death or at best make you severely unwell. I do not collect wild mushrooms for food for this very reason. There is also a species that is illegal to possess as it is a class A drug, the liberty cap, or 'magic mushroom' (*Psilocybe semilanceata*), so avoid picking this one! Please remember to store any fungal specimen safely and keep away from children and pets.

Online resources

Once you have collated the information on your fungal assemblage it's time to hit the books or use one of the greatest tools for identification of fungi: the online community. There are many great mycology groups out there, full of enthusiasts and experts who can help point you in the right direction.

I use www.first-nature.com to check my species identification and often visit the website (www.britmycolsoc.org.uk/) and the Facebook group of the British Mycology Society, who also organise local events. The Coal Spoil Fungi Community Page and Mushroom Identification Forum (UK) on Facebook are amazing resources through which you can gain expert input.

Look at @ukfungusday for content and great articles from people like Professor Lynne Boddy of Cardiff University. There are some great mycologists online, including Paul Stamets (@paulstamets), whose TED talks are worth checking out. @fascinatedbyfungi provides insight and an infectious enthusiasm for the subject.

Conclusion

I hope I have stimulated an interest in looking a little closer and into taking more notice of the fungi that form such an important and interconnecting role in our environment. From the micro to the macro, fungi are everywhere! There is still so much more to discover and to talk about with fungi, like waxcap meadows, fungal relationships with gastropods or insects, fungal invasive species and much more, but that will have to wait for a future opportunity.

Photo credits

All photographs show species from the UK and were taken by the author on a mobile phone camera.

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Feature

Know Thy *Sphagnum*: Species-specific Lessons for Understanding Bogs

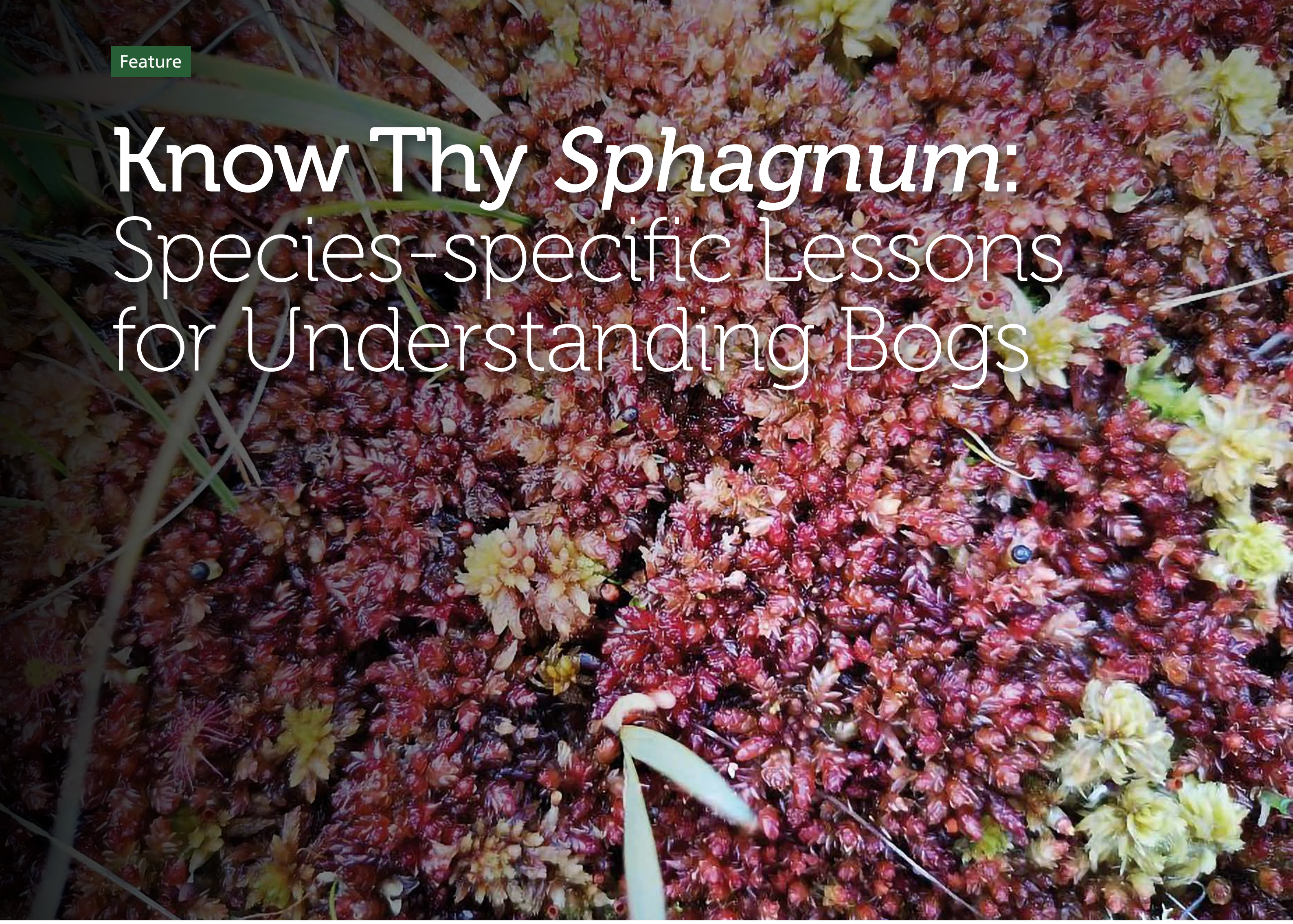

Figure 1. *Sphagnum medium*. Photo credit: George Smith.

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Keywords: bryophytes, indicators, peatlands, restoration, flush, cutover

Sphagnum species are the most important group of plants in Irish and British bogs. Because they have a reputation for being difficult to identify to species level, they are often lumped together in assessments. With some practice, however, most can be confidently identified in the field. Here, I provide some pointers on distinguishing the main bog Sphagna and how different species can be used to assess conservation condition, hydrology and restoration potential of near-intact bogs and bogs that have been damaged by peat extraction or other disturbances.

Introduction

Let's be honest. When we're surveying and assessing bogs, how many of us look at the carpets of greeny-browny-red moss and just jot down a few notes on the cover of "*Sphagnum* spp."? Would we do the same and lump together other groups of plants, like sedges or grasses, in our survey work and expect that was enough to evaluate the conservation value or condition of a habitat? Of course not. Like other groups of plants, *Sphagnum* species have their own individual habitat preferences and functions within the ecosystem. Since *Sphagnum* mosses are the creators and powerhouses of the bog, understanding the characteristics of individual species can provide considerable information. The species present can tell us about the conservation value of the bogs where they live and the ecosystem services they provide. This overview of some of the key bog *Sphagnum* species focuses on raised bogs in Ireland and Britain, but much of it will also apply to blanket bogs.

Sphagnum species have a reputation for being difficult to identify. There is some justification for this, but in reality they are no more difficult than many groups of higher plants, such as sedges. Most bog species can be confidently identified in the field with practice, and there are a number of excellent guides that can help. Perhaps the best is the British Bryological Society's *Mosses and Liverworts of Britain and Ireland: a Field Guide* (Atherton *et al.* 2010). There are also some guides that are *Sphagnum*-specific, such as the Field Studies Council key (Godfrey and Rogers 2021) and the older *Sphagnum: a Field Guide* (Hill 1992), the latter of which is available for download on the British Bryological Society website.

Indicators of good condition

The most important question about the conservation condition of a raised bog is whether it is peat-forming or not. Bogs that are actively forming peat correspond to the priority Habitats Directive Annex I habitat active raised bogs [*7110]. Two large, chunky bog Sphagna that are good peat-formers are *Sphagnum papillosum* and *Sphagnum medium* (Figure 1) (these species were formerly part of *Sphagnum magellanicum*; see Blockeel *et al*. (2021) for the most recent changes to the names of *Sphagnum* and other bryophytes). These species are distinguished from all others on the open bog by their size, stubby branches and hooded stem leaves. They are easily separated from each other by the yellow-brown colour of *S. papillosum* and the wine red of *S. medium*. These two species are found in damp hollows, and often form extensive lawns in active raised bog. A healthy cover of *S. papillosum* on cutover bog (an area of bog where peat extraction has removed the upper layers of peat and vegetation) is a good sign it is rewetting either naturally or as a result of restoration work.

Sphagnum rubellum (formerly *S. capillifolium* ssp. *rubellum*; Figure 2) is perhaps the most common *Sphagnum* in Ireland and Britain and is also reported to be a good peat-forming species (Laine *et al.* 2009). It is often the only *Sphagnum* found in the drier parts of bogs, however, and so it isn't always a reliable indicator of good conditions. *S. rubellum* is a small species, usually candy pink, that forms low hummocks. It is often green or mostly green, especially when shaded. This is often a source of frustration, but with experience, even most green forms can be confidently identified from other field characters.

Perhaps the two best indicators of high-quality raised bog habitat are the hummock-forming species *Sphagnum austinii* and *Sphagnum beothuk* (formerly aggregated with *Sphagnum fuscum*). *S. austinii* is usually described as brown, but in reality each shoot is usually a blend of colours from green in the centre to yellow-orange to rosy red. Leaves are tightly pressed to their tapering branches, and the whole hummock is dense and tight as a drum. *S. beothuk* is a delicate, handsome chocolate brown species. These species are quite rare in England and Wales; they remain widespread but uncommon in Ireland and Scotland (Blockeel *et al.* 2014). Healthy and frequent hummocks of these two species is a good sign of a bog in excellent condition. Since their hummock form is ideal for retaining water, however, scattered hummocks can linger for a long time on parts of bogs that are otherwise in poor shape. They can even resist fire when the surrounding bog, including looser-growing *Sphagnum*, has been burnt. *S. austinii* and *S. beothuk* seem to be slow to colonise new habitat. They are quite rare on cutover bog, even when they are present on the adjacent high bog and the cutover is wet, long-abandoned and supports other *Sphagnum* species.

In contrast, the aquatic *Sphagnum cuspidatum* is a rapid coloniser of blocked drains and rewetted bog, including cutover. It is usually easy to identify from its yellow-green colour and very fine branch leaves, which notoriously resemble wet fur when the plant is submerged. Abundant *S. cuspidatum* in bog pools or areas of shallow standing water on restored cutover bog indicates a fairly stable, high water table. It appears to be sensitive to being disturbed and dislodged by the wind, and so may be absent from larger areas of open water with a long fetch.

Indicators of poor condition

Bogs are naturally wet, nutrient-poor ecosystems and can be damaged by a number of activities that change these conditions. Drains in a bog or proximity to steep banks where peat extraction has taken place can lead to drier, degraded conditions. Fire on a bog directly damages vegetation and can change the structure and composition of the upper peat layers. Fire and drainage increase the availability of nutrients through the breakdown and mineralisation of peat. Airborne nitrogen deposition from agricultural and other sources can directly increase the fertility of bogs.

Figure 2. *Sphagnum rubellum*. Photo credit: George Smith.

Figure 3. *Sphagnum subnitens*. Photo credit: George Smith

Drier and more nutrient-rich conditions can lead to changes in the abundances of *Sphagnum* and other moss species. Two species, *Sphagnum tenellum* and *Sphagnum subnitens* (Figure 3), are normally found in small quantities on bogs in good condition. They respond well to disturbance, however, and become more abundant on damaged or stressed bogs. *S. tenellum* is a very small *Sphagnum* that is easily recognised by its size, its bright yellow-orange colour, and spreading leaves at branch tips that resemble a bird's open beak. On good-quality bogs it is usually intermingled with other *Sphagnum* species. On bogs in poor condition, it forms larger patches on degraded peat.

S. subnitens resembles a slightly larger, scruffier version of *S. rubellum* (Figure 2), but its colour is well-lit conditions is salmon pink and the centre of the capitulum (the fuzzy 'head' of young branches at the top of a shoot) is usually green. Although it is naturally found in small amounts on bogs, it prefers more mineral-rich habitats than most bog Sphagna, such as transition mires, wet heaths and peaty hollows in woodlands. *S. subnitens* being more abundant on a bog than usual suggests that nitrogen deposition or other damaging activities have led to an increase in nutrient availability.

Indicators of flushing

Another group of *Sphagnum* species is a valuable indicator of flushed conditions, where flowing water increases availability of nutrients and oxygen in the peat, or other places with slightly elevated nutrients or alkalinity. On near-intact bogs, flushes or soaks can form where surface water runoff is concentrated along a particular flow path. Using *Sphagnum* species to identify flushes can improve our understanding of bog hydrology, which is important for bog restoration efforts. Likewise, the appearance of flush species in a new location can indicate changes in surface water flow caused by subsidence in the parts of a damaged bog that are drying out. On cutover bogs, flushed conditions can also arise along surface water flow paths. They are also found where peat has been cut down to a level where there is some mineral input from groundwater, but where conditions remain acidic and mainly nutrient-poor. In the latter case, the long-term outcome of restoration work may not be active raised bog, but poor fen instead.

Sphagnum fallax, a slender yellow-green to golden species with a typically neat appearance, is characteristic of flushed situations. There are also two similar, closely related but rarer species to be aware of, *Sphagnum angustifolium* and *Sphagnum flexuosum*, that are indicative of more base-rich environments than *S. fallax* prefers.

Sphagnum palustre (Figure 4) is probably the most eye-catching flush species. It is a large species, pale green to yellow-brown with hooded branch leaves. It can resemble *S. papillosum* sometimes, but is usually distinguishable by its longer, more pointed branches and by the darker peach or brownish-red colouration in the centre of the capitulum.

S. palustre is also the most important indicator species for the Habitats Directive Annex I priority habitat bog woodland [*91D0]. Bog woodland in good condition is characterised by deep cushions of *S. palustre* as well as other flush Sphagna, including *S. fallax* and *Sphagnum fimbriatum* (Figure 5). The

Figure 4. *Sphagnum palustre* in bog woodland. Photo credit: George Smith.

Figure 5. *Sphagnum fimbriatum* in bog woodland. Photo credit: George Smith.

latter is particularly characteristic of bog woodland. *S. fimbriatum* at first glance is green and non-descript, but it is easily identified in the field with a closer look at the stem leaves. Pull off the capitulum, and you can see around the stem the broad, erect leaves with a ragged margin that are often described as looking like an Elizabethan ruff.

Sphagnum divinum has recently been separated from *S. medium*. It resembles that species in its large size, hooded stem leaves and wine red colour. It tends to be slightly paler, but its most diagnostic characters are longer branches that taper to a finer point with leaves more closely appressed. Its habitat preferences in Ireland and Britain are still being learned, but it seems to be frequent enough on somewhat flushed cutover bog, at least in the Irish midlands.

The lagg zone of an intact raised bog is the transition zone between the bog and the surrounding mineral soil. Historically, lagg zones comprised a range of fen and other wetland habitats. As a result of peat extraction and reclamation for agriculture, only fragments of lagg zone habitats remain in Ireland or Britain. Carrownagappul Bog and Carrowbehy Bog in County Roscommon in Ireland both support some near-intact lagg zones. In addition to *S. subnitens* discussed above, base-tolerant Sphagna are characteristic of these areas, with *Sphagnum contortum* and *Sphagnum teres* the most frequent. *S. contortum* is usually a biscuit brown to orange-brown colour with curved branches. *S. teres* is unmistakeable when well grown: it is ginger brown with a green-centred capitulum that sports a prominent conical terminal bud. *S. contortum* also occurs on cutover bog where peat extraction has reached down to the groundwater-influenced fen peat layers. Such areas are of conservation interest, and also present an opportunity for lagg zone restoration, which has received little attention thus far in Ireland or Britain. Lagg zones are a rare and valuable ecosystem in and of themselves, but in addition their restoration would benefit the hydrology of the adjoining bog by supporting the maintenance of a high water table (Crowley *et al.* 2022).

And more…

Understanding the ecological preferences of *Sphagnum* species and learning how to identify them can provide valuable insights into the ecology, hydrology and conservation status of bogs. Similarly, knowledge of other bryophyte species can add to our understanding of bogs and other bryophyte-rich habitats. For example, the pale whitish-green *Leucobryum glaucum* forms dense hummocks similar to *Sphagnum austinii*, and it is most abundant in wet, actively peat-forming bogs. Learning to identify *Sphagnum* and other bryophyte species can be daunting at first, but there are several resources available to help, including the *Field Guide* (Atherton *et al.* 2010) mentioned above. The British Bryological Society – both the website (www.britishbryologicalsociety.org.uk) and the members – is a wealth of information, and several local groups hold regular field meetings where beginners are always welcome. Learning from others in the field is the best way of getting to grips with a new group of plants or animals, and bryologists are always eager to make converts.

Acknowledgements

I am grateful to all the British Bryological Society members who generously gave their time to help me better understand *Sphagnum*. Dr Joanne Denyer provided helpful insights into species responses to nitrogen deposition and disturbance.

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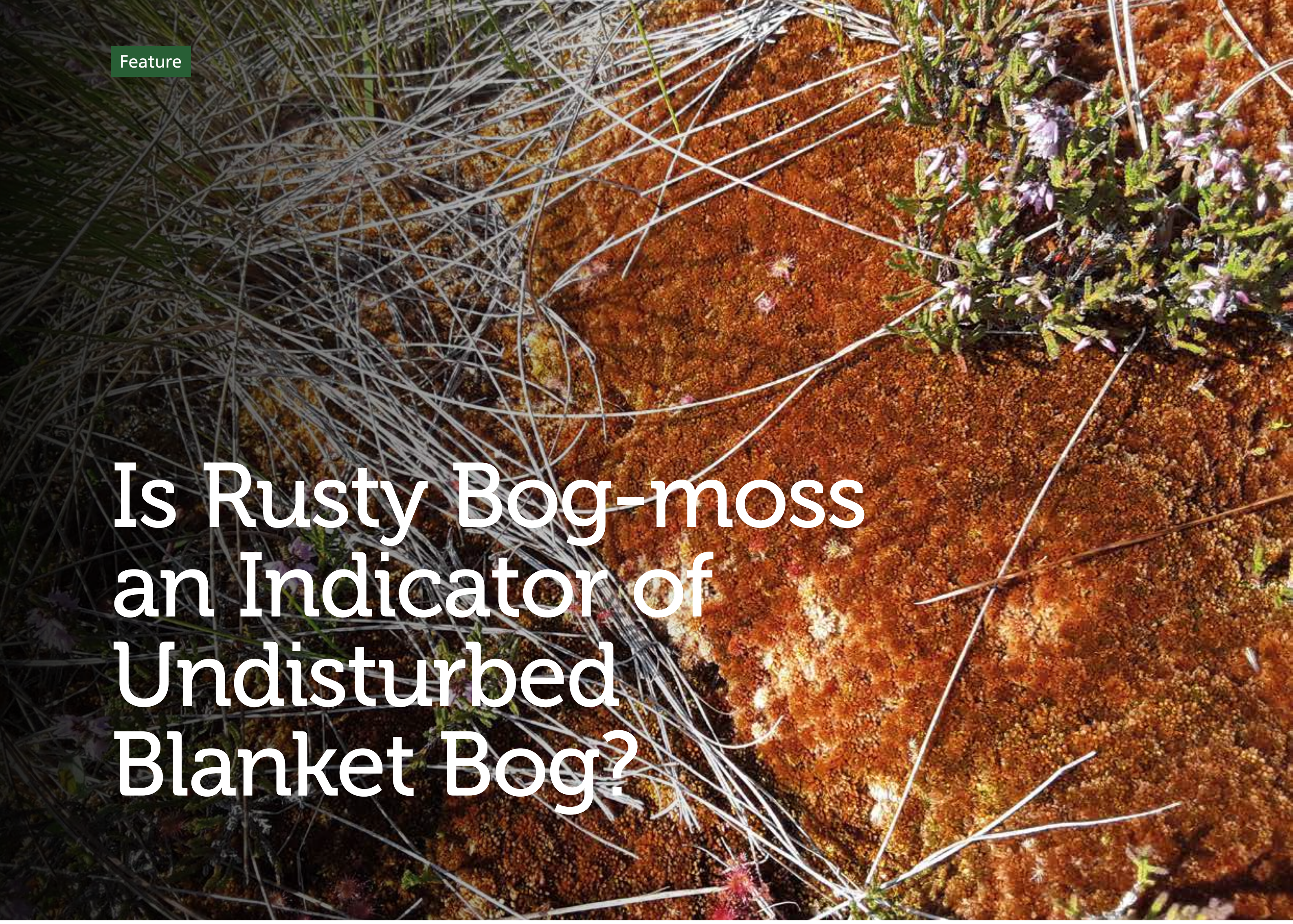
Feature



Is Rusty Bog-moss an Indicator of Undisturbed Blanket Bog?

Figure 1. A wet, near-natural bog with a hummock of rusty bog-moss, Scotland 2021. Photo credit: Kate Massey.

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Keywords: blanket bog, indicator species, rusty bog-moss

Rusty bog-moss (*Sphagnum fuscum*) is sometimes used in peatland guidance as a species whose presence indicates near-natural or undisturbed blanket bog. But does its presence alone indicate that the blanket bog is undisturbed or in near-natural condition? This short article describes field situations from upland Scotland which demonstrate that rusty bog-moss is not necessarily an indicator of undisturbed or near-natural blanket bog and is actually found across a spectrum of bog conditions. Rather, its presence in degraded conditions may indicate a relic of former high-quality bog habitat and better indicates a strong potential for blanket bog restoration.

Introduction

Rusty bog-moss (*Sphagnum fuscum*) (and its recently recognised, closely associated dark morph *Sphagnum beothuk*; Hill 2017[1]) is a bog-moss that forms compact, ginger-brown hummocks in upland blanket bogs. The hummocks are conspicuously coloured and prominent within the landscape as they are typically up to 50 cm tall and 75 cm across at the base, although can be much larger (Atherton *et al*. 2010). There are numerous records of rusty bog-moss across the whole of the UK and Ireland on the NBN Atlas, with the highest concentrations in Scotland appearing to be around the Cairngorms and the Flow Country (NBN Atlas, nd). These areas are where most of the rusty bog-moss field observations reported in this short paper have taken place.

The relatively common *S. fuscum* is not on UK species lists (e.g. Scottish Biodiversity List, Biodiversity List – England, Biodiversity List – Wales, UK Biodiversity Action Plan) and has no legal protection. Nevertheless, this readily identifiable bog-moss has become an important consideration for ecologists and Ecological Impact Assessment (EcIA) practitioners in relation to wind farm applications in Scotland. This is because it has been reported to occur on undisturbed blanket bog and has been used as an indicator of such (e.g. JNCC 1994, Atherton *et al*. 2010, NatureScot 2020, NBN Atlas nd). The blanket bog Site of Special Scientific Interest selection criteria states that rusty bog-moss is a "plant species indicating peat formation capability and/or lack of disturbance" (JNCC 1994). It goes on to report that blanket bogs with hummocks of rusty bog-moss are therefore "near-natural and of high quality" (JNCC 1994). Based on this, the presence of rusty bog-moss has been listed in NatureScot's recent guidance (2020) on development – for example, for wind farms and other renewable energy proposals on peatland habitats – as a potential reason for statutory objection to developments and has been listed as a reason for objections including at public local inquiries.

Thus, currently, and rather unexpectedly, rusty bog-moss now has some bearing in the policy implementation of Scottish renewables development.

Figure 2. Rusty bog-moss within areas of degraded blanket bog, Scotland 2021. Photo credit: Kate Massey.

Rusty bog-moss in field situations

This situation posits the question: does the presence of rusty bog-moss alone indicate that the blanket bog is in near-natural condition (and so an indicator of undisturbed or high-quality bog) or is reality more nuanced? Without doubt, rusty bog-moss can be found in blanket bogs that are in near-natural condition, often among bog pools and with a variety of bog-moss species also present. Where rusty bog-moss occurs in near-natural conditions it provides a striking visual characteristic across the blanket bog landscape of burnt umber hummocks beside wet hollows (Figure 1). In these instances, the rusty bog-moss hummocks are likely to be in a 'building' phase of hummock formation and an important component of carbon sequestration.

During field surveys across upland Scotland rusty bog-moss has been recorded in blanket bog habitats which have clearly been degraded through current and historic management practices such as high grazing pressure, drainage and burning. This often results in erosion features being widespread (e.g. Figure 2). It has been recorded in small pockets of blanket bog vegetation surrounded by extensive habitat degradation. How long rusty bog-moss can survive in these situations is unclear, but it is likely that the degrading management practices of drainage and over-grazing have been occurring for decades, if not centuries. Relic hummocks of rusty bog-moss therefore appear to remain long after the blanket bog has ceased to be in a near-natural condition.

Indeed, sometimes rusty bog-moss has been recorded on the edge of large erosion features in blanket bog modified through a combination of deer grazing pressure and wind/rain erosion (e.g. Figure 3). In these situations, the hummocks are likely to be in a degraded phase rather than the building phase and less important to carbon sequestration. Clearly in these instances rusty bog-moss is not growing within blanket bog with a 'lack of disturbance' or in a 'near-natural' condition. However, it may be more likely to persist in degraded areas with wetter climes, for example those areas with particularly high rainfall or at altitude with high levels of cloud cover.

When considering if a blanket bog is in near-natural condition or has experienced a lack of disturbance the ecological context needs to be considered carefully. For example, are there signs of current and historic management practices that have impacted the bog? Is there a natural surface pattern of hummocks and hollows and waterlogged conditions?

Therefore, the presence of rusty bog-moss only really indicates that a blanket bog has had a lack of disturbance, or is in near-natural conditions, when other indicators are also present, including bog pools, the bog vegetation being wet underfoot, an intact bog surface with a natural surface pattern of hummocks and hollows and a complex of microforms. Where rusty bog-moss is found within a degraded context it is clearly not indicating a lack of disturbance or high-quality near-natural bog. So, what does the presence of rusty bog-moss indicate under these circumstances? It is likely that, in these circumstances, rusty bog-moss is a relic of former high-quality bog and perhaps indicates a strong potential for habitat restoration. This is something to consider exploring under enhancement measures or Biodiversity Net Gain in EcIA.

Conclusion

The conclusion from working on multiple upland sites across Scotland is that a binary present/absent approach, when considering rusty bog-moss, is not appropriate as an indicator of undisturbed blanket bog. Rusty bog-moss is found across a spectrum of conditions, not only in those of

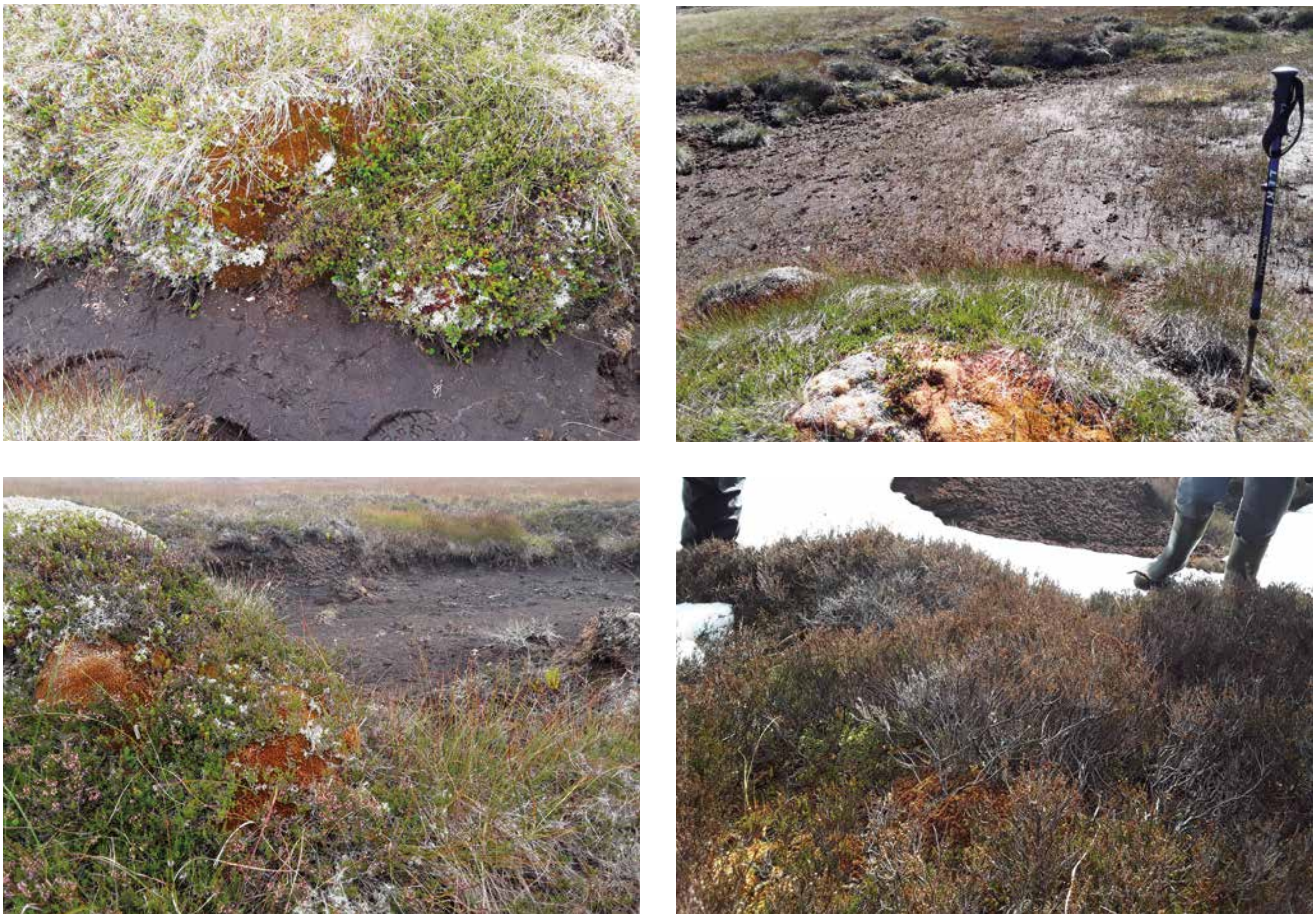

Figure 3. Rusty bog-moss beside erosion features, Scotland 2021 and 2022. Photo credits: Kate Massey.

undisturbed or near-natural conditions. This is likely to be obvious to botanists and plant ecologists: there are very few species that are 100% associated with one habitat, type of soil, etc. The combined indicator values of all species are what should be used together with the characteristics of the physical environment and management practices. Clearly, when assessing the importance of ecological receptors such as blanket bog, for example as part of an EcIA, practitioners should consider a whole range of characteristics as per EcIA guidelines (CIEEM 2018).

The answer to the question posed in the title is that rusty bog-moss is not necessarily an indicator of undisturbed or near-natural blanket bog and is found across a spectrum of bog conditions. Rather, its presence in degraded conditions may be as a relic species and indicate former high-quality bog habitat and better indicates a strong potential for blanket bog restoration. Therefore, development guidance on peatland habitat should be amended to reflect the reality of its occurrence.

Acknowledgements

Many thanks to Dr Peter Cosgrove FCIEEM for his encouragement and support in writing this paper.

Note

1 *Sphagnum fuscum* has recently been separated by some authorities into two species: *Sphagnum fuscum* and *Sphagnum beothuk*. The species are very similar in the field and can only be reliably separated by experienced bryologists under microscopic examination (Hill 2017). In the current paper only *S. fuscum* is referred to, to correspond with historic references and for ease of reference in the field, but it is acknowledged that *S. beothuk* may be incorporated into the paper under the guise of *S. fuscum*.

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Using Bryophytes as Indicator Species in Habitat Surveys

Figure 1. *Cinclidotus fontinaloides* (brown moss on rocks) marking the high (winter) water level of a turlough in the west of Ireland. Photo taken in the summer when the turlough was almost completely dry. Photo credit: Joanne Denyer.

Joanne Denyer MCIEEM
Denyer Ecology

Keywords: fen, grassland, habitat classification, liverwort, moss

Bryophytes (mosses, liverworts and hornworts) are a fascinating and diverse group. However, many botanists do not record or use bryophytes in their survey work as they are known as a 'difficult group' to identify. This misses an opportunity, as bryophytes can provide information on environmental conditions useful to habitat surveyors, such as seasonal changes in water levels, soil and water nutrients and pH, air pollution and habitat condition. These habitat features are not always obvious when assessing a habitat using vascular plants alone, or when a survey is undertaken outside of the main flowering plant season (e.g. winter). Knowledge of some common bryophytes can therefore provide useful information for botanists undertaking habitat survey, even if bryophytes are not the target of the survey.

Introduction

This article outlines why bryophytes are useful indicator species and how field ecologists and botanists would gain information by learning some common species. Examples from grassland and fen habitats are presented to demonstrate how bryophytes can be used as indicator species. The final section gives some useful resources to help ecologists and botanists to develop their own bryophyte indicator lists for use in their projects. There are notes on getting started with bryophyte identification, but that is not covered in detail in this article.

What is an indicator species?

In ecology, indicator species are species which can be used to provide information about an environment that might not otherwise be obvious. Information from an indicator species could be soil or water pH, which would otherwise require water sampling to assess; or the winter flood levels of a seasonal water body, which would not be obvious to a surveyor visiting in summer.

The key characters of an indicator species are that they are (1) characteristic of specific habitat types and/or environmental conditions, (2) fairly widespread geographically and (3) possible to identify in the field with a hand lens and a little experience. It is rare that one species can act as an indicator on its own and so by using information from more than one species more accurate habitat information will be obtained.

An indicator species could be an animal, lichen or fungus, but this article is focused on using plants as indicator species for habitat surveyors. Indicator species can provide information useful for habitat surveyors to assist with habitat classification and mapping and assessing the condition of a habitat.

What makes bryophytes useful indicator species in habitat surveys?

Experienced botanists frequently use vascular plant species to classify, evaluate and map habitats. Bryophytes can provide useful additional information due to a number of key characteristics, as follows.

- Many species are widespread geographically (bryophytes often have wider global distributions than vascular plants).
- Bryophytes are present in most habitats and habitat niches (including urban habitats, montane grassland, dry exposed rock, humid woodland, brackish coastal habitats and freshwater environments).
- Bryophyte species are the most abundant (biomass and/or surface area cover) in some habitats (for example raised and blanket bog, alkaline fen, upland woodland, montane grassland, petrifying springs and metalliferous mine spoil).
- Bryophytes are (mostly) not seasonal in their growth and are present and identifiable at all times of the year.

Bryophytes are highly sensitive to environmental conditions which makes them useful indicator species (Vanderpoorten and Goffinet 2009). Unlike vascular plants, bryophytes do not have roots (although they may have rhizoids which anchor them to a surface) and most species lack internal water and nutrient transport systems (Goffinet and Shaw 2009). The leaves of most mosses, leafy liverworts and simple thalloid liverworts are largely one cell thick to assist easy uptake of water and nutrients directly over the leaf surface. As they have limited control over nutrient uptake into their cells they can be very sensitive to levels of nutrients in air, water and in the substrate they are growing on (including rock and tree bark; Goffinet and Shaw 2009). Likewise, as they cannot control water loss from leaves, or replace lost water through roots, they cannot prevent their leaves from drying out. Species that can tolerate drought (those on dry, exposed walls for instance) do so by being desiccation-tolerant, or poikilohydric (Goffinet and Shaw 2009). This means that they photosynthesise when wet and 'shut down' when dry. They have mechanisms to protect cells from drying damage and can resume photosynthesis (and growth) rapidly when re-wetted. Some of these species can tolerate years of being dry and physiologically inactive. On a dry wall or natural rock, mosses can appear dry, brown and shrivelled. If sprayed with water from a bottle they can rapidly open their leaves and appear green in colour and look like completely different species: this can be important for identification.

Conversely, there are some species which are highly sensitive to changes in humidity and cannot tolerate drying out. These species tend to have westerly oceanic/Atlantic distributions in Ireland and Britain (Ratcliffe 1968), where humidity is higher. The most sensitive of these species (the hyperoceanic species) are not only restricted to the extreme west (Preston and Hill 1999, Hodd *et al.* 2014), where there is high rainfall, they also occur only in habitats and habitat niches that protect them from drying, such as north-east-facing heathy slopes on mountains or ravine woodlands (Hodd and Sheehy Skeffington 2011).

As bryophytes can be highly sensitive to local conditions, they can be used to indicate a range of factors such as climate, local humidity, air pollution, soil nutrients, soil, water and tree bark acidity (pH), whether or not a peat system

> **"Habitat features are not always obvious when using vascular plants alone. Knowledge of some common bryophytes can provide useful information for botanists undertaking habitat survey."**

is actively peat-forming, and water levels in wetland systems. For instance, *Cinclidotus fontinaloides* (Figure 1; often known as turlough moss in Ireland) can indicate the winter high water levels of turlough systems (the seasonal water bodies on limestone frequent in parts of Ireland). In winter it will be completely inundated, but in summer it may be high and dry for months, well away from any remaining standing water (Figure 1). This can be very useful to help assess if a wetland is a turlough that floods in winter and when mapping the extent of a turlough in the summer months when water levels are low.

Examples of using bryophytes to classify habitats

Usually no single species will act as an indicator, but there are some species (in particular those typical of calcareous habitats) which have very strong habitat preferences and may sometimes be useful as indicators on their own (e.g. *Ctenidium molluscum*; Figure 2). Overall bryophyte abundance and diversity is also helpful in assessing habitat age, condition and quality. Some examples of the use of bryophytes in classifying and assessing grassland and wetland habitats are given in Boxes 1 and 2. These are based on Irish habitat classifications, but the species are also found in the UK. The aim is not to provide a definitive reference for grassland habitats but more to demonstrate how bryophytes may be provide useful information.

How to start?

This may seem daunting, but just a limited number of bryophytes (fewer than 50) can assist in separating many different habitats. Most of these should be identifiable in the field with a ×10 or ×20 hand lens (see Box 3). The

Figure 2. The moss *Ctenidium molluscum* is restricted to base-rich (high pH) habitats and is a good indicator of calcareous grasslands. It is a very distinctive species with a golden colour, feathery branching and curled leaves. The circle shows a small patch of the pale yellow-green *Tortella tortuosa* (also restricted to calcareous habitats). Photo credit: Joanne Denyer.

Box 1. Grassland habitats

Grassland habitats are not usually bryophyte-dominated (excluding some upland or montane grasslands). However, bryophytes can still provide usually habitat information, particularly when visiting a site outside of the main field season for vascular plants. Bryophytes can help one decide whether the grassland at a site is potentially of conservation interest and whether a repeat survey (in the main field season) is required. In grasslands, bryophytes can indicate soil fertility, soil pH and wetness. In the examples shown in Table 1 bryophytes are used (in conjunction with vascular plants) to identify different grassland types for habitat classification and mapping purposes.

Bryophytes can also be used to assess grassland habitat condition, for instance as part of a condition assessment for an EU Habitats Directive Annex I habitat. Lists of positive and negative indicator species are used as part of an overall habitat condition assessment. For Irish grasslands there are a number of indicator species lists (e.g. Martin *et al.* 2018 and O'Neill *et al.* 2013) and these are updated as more habitat information is obtained from national surveys. In Ireland, the moss *Ctenidium molluscum* is an indicator of the Annex I habitat 'Semi-natural dry grasslands and scrubland facies on calcareous substrates' [6210] and the calcareous sub-community of the Annex I priority habitat 'Species-rich *Nardus* grasslands, on siliceous substrates in mountain areas (and sub-mountain areas, in Continental Europe)' [*6230].

Box 2. Wetland habitats

In wetland habitats, bryophytes can be used to identify gradients in wetland fertility (nutrient levels), pH, water levels and water source (groundwater versus surface water). The presence/absence and abundance of particular species can be used to classify and assess the condition of various fen habitats. For instance, both poor fen and bog habitats are acidic, but poor fens have some nutrient input from surface water and therefore have a different bryophyte community from rain-fed (nutrient-poor) bogs. The *Sphagnum* species *Sphagnum palustre*, *S. fallax* and *S. fimbriatum* are all typical and abundant in poor fen, but are absent from good-quality raised and blanket bog habitats. This highlights the value of learning a few common *Sphagnum* species as they can be excellent indicators (see also George Smith's article on Know Thy *Sphagnum* elsewhere in this issue, pp. 14–17). Higher nutrient levels in wetlands can also be indicated by the presence of *Calliergonella cuspidata* (Figure 3). Where this species is abundant a habitat is likely to be wet meadow or marsh, rather than lower-nutrient alkaline fen. 'Brown mosses' such as *Palustriella falcata* (Figure 4) indicate high pH levels, such as found in alkaline fen and springs. In Table 2 an example is provided of the use of bryophytes to assist in the identification of four Annex I wetland habitats that share similar vascular plant species and can sometimes be hard to separate.

examples above were developed using a range of resources. So, if you're new to all this, where should you start? First, decide what you want to use bryophytes to indicate. Is it to help with habitat mapping, to assess habitat condition, or to assess air pollution impacts? Is it for a particular habitat or habitat group? What geographic area are you working in? Then look at what resources are available to create lists of potential bryophyte indicator species for your particular survey needs. Useful resources include the following.

- The British Bryological Society (BBS) field guide *Mosses and Liverworts of Britain and Ireland* (Atherton *et al.* 2010): in the back of the book there are lists of common species for the main habitat types found in Ireland and Britain. These are very useful to help beginners get to know the key species for each habitat.

> **"Starting to identify bryophytes may seem daunting, but knowing just a limited number can assist in separating many different habitats."**

Figure 3. The moss *Calliergonella cuspidata* dominating an area of wet grassland/marsh, clearly visible during a winter survey. Photo credit: Joanne Denyer.

Figure 4. *Palustriella falcata* is one of the 'brown mosses' that indicates alkaline fen. Here it is abundant at the edge of a pool at the springhead of an Annex I priority petrifying spring, clearly visible in a winter survey. Photo credit: Joanne Denyer.

- *BRYOATT: Attributes of British and Irish Mosses, Liverworts and Hornworts* (Hill *et al*. 2007). This resource lists key attributes for all bryophytes in Ireland and Britain and is available as both a PDF and an Excel spreadsheet. It gives scores for each species that indicate that species' tolerance of factors such as light, moisture, nutrients and pH. It can be freely downloaded from the Biological Records Centre (BRC) website: www.brc.ac.uk/biblio/bryoatt-attributes-british-and-irish-mosses-liverworts-and-hornworts-spreadsheet (note that some species have changed names since this was published).
- *The Atlas of British and Irish Bryophytes* (vols 1 and 2; Blockeel *et al.* 2014) gives relatively recent distribution maps for bryophytes and includes some habitat and ecology information in the species accounts.

Table 1 Grassland examples

	Improved grassland
Soil pH	Usually neutral to slightly acid/basic
Soil wetness	Dry–damp
Soil fertility	High
Bryophyte indicator species	*Brachythecium rutabulum, Kindbergia praelonga, Oxyrrhynchium hians* and *Rhytidiadelphus squarrosus*
Species notes	Typical bryophyte species are generalist bryophytes and can be found in most urban lawns.
Bryophyte diversity	Low
Bryophyte cover	Low

Table 2 Using bryophytes to separate four Annex I wetland habitats

	***Molinia* meadows on calcareous, peaty or clayey-silt laden soils [6410]**
Bryophyte indicator species	*Calliergonella cuspidata* is the main bryophyte present.
Bryophyte diversity	Low
Bryophyte cover	Low–moderate

Unimproved neutral grassland	Unimproved acid grassland	Unimproved calcareous grassland	Wet grassland
Usually neutral to slightly acid/basic	Acidic	Basic	Usually neutral to slightly acid/basic
Dry–damp	Dry–damp	Dry	Damp–seasonally flooded
Low	Low	Low	Low to moderate
As for improved grassland, but with *Pseudoscleropodium purum*	**Tall vegetation** *Brachythecium albicans, Pleurozium schreberi, Rhytidiadelphus loreus, Hypnum jutlandicum* and *Hylocomium splendens* **Short vegetation/bare ground** *Campylopus* species, *Ceratodon purpureus* and *Polytrichum* species Humid vegetation *Sphagnum* species	**Mosses** *Ctenidium molluscum, Flexitrichum gracile, Didymodon fallax, Encalypta streptocarpa, Eurhynchium striatum, Fissidens dubius, Homalothecium lutescens, Hypnum cupressiforme* var. *lacunosum, Neckera crispa, Tortella tortuosa, Trichostomum brachydontium* and *Trichostomum crispulum* **Liverworts** *Leiocolea turbinata* and *Scapania* aspera	*Calliergonella cuspidata*
Pseudoscleropodium purum can be found in grasslands of most pH, but is usually only abundant in low to moderately fertile habitats.	Species of wet heath and bog, such as *Sphagnum* species, may occasionally be present, for instance where *Molinia caerulea* is abundant on previously cut-over peat.	Calcareous grassland has species which are more restricted to calcareous (high pH) habitats and the only a few species may be needed to identify potentially interesting calcareous grassland.	Wet grassland types usually have moderate to high cover of *Calliergonella cuspidata*. This can be useful when surveying grassland in a dry summer as it gives an indication of winter wetness levels.
Low	Moderate	High	Moderate
Low–moderate	Moderate–high	Moderate–high	Usually high

Alkaline fens [7230]	Transition mires and quaking bogs [7140]	Petrifying springs with tufa formation [*7220]
Calliergonella cuspidata less prominent and 'brown mosses' are dominant.	Elements of both acidic poor fen and alkaline fen: 'Brown mosses'† present: most commonly species with a tolerance for slightly lower pH such as *Bryum pseudotriquetrum, Calliergon giganteum, Campylium stellatum* and *Scorpidium scorpioides*. Sphagnum species are usually present, particularly species which can tolerate higher pH habitats such as *S. contortum*.	'Brown mosses'† are present but species with the highest pH tolerance are usually dominant (e.g. *Palustriella commutata* and *P. falcata*) with additional bryophytes not usually found in alkaline fen such as *Eucladium verticillatum* and *Didymodon tophaceus*. The liverworts *Aneura pinguis* and *Pellia endiviifolia* are more prominent in petrifying springs than alkaline fen.
High	High	High
High	High	High

†Brown mosses is a term used to refer to a group of bryophytes typical of alkaline fen condition (many of which, but not all are golden or brownish in colour). A broad definition of 'brown mosses' would include *Bryum pseudotriquetrum, Calliergon giganteum, Campylium stellatum, Ctenidium molluscum, Fissidens adianthoides, Palustriella commutata, Palustriella falcata, Sarmentypnum sarmentosum, Scorpidium cossonii, Scorpidium revolvens, Scorpidium scorpioides* and *Warnstorfia sarmentosa*.

- Habitat condition assessment guidance for the area you are interested in. In Ireland this is usually included in the latest *Irish Wildlife Manual* for that habitat (e.g. grassland, fen, upland habitats, petrifying springs) and will list bryophytes that can be used as positive and negative indicators. These are available on the National Parks and Wildlife Service (NPWS) website (www.npws.ie). There are comparable guides in other areas (such as the JNCC Common Standards Monitoring guidance).
- The article 'A new checklist of the bryophytes of Britain and Ireland, 2020' (Blockeel *et al.* 2021). This is the latest checklist with the most up-to-date nomenclature for bryophytes. A checklist which cross-references older names (from 2008) with the 2020 names is available to download from the BBS website in the Resources section (www.britishbryologicalsociety.org.uk/).
- *Bryophyte Ecology* (Glime 2021) is an online book which is free to download and contains chapters on physiological ecology and habitats.

Box 3. A note on bryophyte identification

An expert bryologist must have a high level of both field and microscope skills and it may take years to gain sufficient experience to be able to undertake dedicated bryophyte site surveys. However, not everyone will want to become an expert bryologist with the expertise required to undertake site specific surveys of bryophyte-dominated habitats such as oceanic woodland, dune slacks, snowbeds, petrifying spring and metalliferous soils. It is possible to learn a good range of bryophyte indicator species relatively quickly to assist with habitat surveys. With a little practice many of these species can be identified in the field with a ×10 or ×20 hand lens and do not require microscopic identification.

The BBS field guide *Mosses and Liverworts of Britain and Ireland* (Atherton *et al.* 2010) is a useful book for beginners. This field guide has an introduction to bryophyte key identification features and a field key which includes most indicator species likely to be needed for habitat survey.

The BBS website contains much useful information on getting started with bryophyte identification, useful downloads (census catalogue, species lists, recording cards, spell-checker for Word, etc.), details of referees, recent news, lists of regional groups, forthcoming meetings and courses.

Conclusion

A knowledge of bryophytes can assist botanists undertaking habitat surveys by providing useful information on environmental factors such as local climate, air pollution, soil and water nutrients, soil and water pH and water levels of seasonal water bodies. This can be used, in conjunction with information from the vascular plant flora present, to identify and map habitat types and assess the condition of a habitat. It is particularly useful for bryophyte-dominated habitats and when an initial site visit is made outside of the main vascular plant flowering season (e.g. for winter survey work). Most botanists should be able (if they wish) to learn a small number of bryophytes to assist in habitat survey work. This article lists some of the main resources available (many free to download) to help surveyors get started in this area.

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Can We Use Bryophyte and Lichen Species Occupancy Data as Indicators of Global Change?

Figure 1. *Polytrichastrum alpinum*. Photo credit: Dave Genney.

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Large quantities of unstructured biodiversity data are collected every year, some of which contribute to publications like the *State of Nature* (Hayhow *et al.* 2019). These data can be linked to information about species habitat and climate preferences to identify the impact of different global change drivers on different taxa. This article describes two approaches using bryophyte and lichen occupancy data and their use as indicators of ecosystem health.

Keywords: bryophytes, climate, habitat preferences, indicators, lichens, nitrogen pollution, Scotland

Introduction

The readers of *In Practice* do not need reminding about the ongoing biodiversity crisis and the evidence marshalled to demonstrate it, not least in the recent Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) report (IPBES 2019) and the *State of Nature* reporting. In order to respond appropriately to these losses, trends in biodiversity have to be attributed to different drivers.

Attribution may be straightforward for some species, especially where research has identified the links between population or range loss and specific drivers. For instance, the loss of arable weeds is associated with changing cultivation practices, better seed cleaning and herbicides (Robinson and Sutherland 2002). However, synthesising such information can be beset by problems of bias towards well-studied species or easily studied drivers. An alternative approach to identify drivers without such bias is to link information on species trends to information on ecological preferences that in turn serve as a proxy for a driver. This requires species groups with existing, comprehensive information on their ecological preferences: these include bryophytes and lichens.

We have tried different approaches to test this using two types of indicator. Firstly, we used a set of ecological preferences first developed by Ellenberg (1988), and familiar to many plant ecologists, where species have been assigned a score – usually on a scale of 1 to 9 – based on the conditions they are normally found in. These describe a species' preferences, among others, for moisture (F), light (L), nitrogen (N) and soil pH (R) (Hill *et al.* 2007 for bryophytes, Wirth 2010 for lichens). These can be linked to drivers such as land use change and pollution. Secondly, we used climate attributes calculated as the mean precipitation (Prec), mean January (TJan) and mean July (TJul) temperatures of species ranges in the British Isles for bryophytes (Hill *et al.* 2007) and Great Britain for lichens (Pakeman *et al.* 2022), which are clearly linked to climate change.

What is driving changes in bryophyte and lichen occupancy?

The Combined Marine and Terrestrial Biodiversity Indicator for Scotland (Eaton *et al.* 2021) built on work undertaken for the *State of Nature* report for Scotland (Walton *et al.* 2019) to produce species trend data for 380 species based on abundance trends and 1578 species based on occupancy trends. Occupancy is defined in this context as the presence of a species with a 10 km × 10 km grid square (hectad). We took this occupancy trend data for 326 bryophyte (218 mosses and 108 liverworts) and the 437 lichen species and analysed these trends according to ecological and climate preferences (Pakeman *et al.* 2022).

Trend data were available for the short- (2005–2015) and long-term (1971/1972–2015) for both bryophytes and lichens and the analysis covered habitats, four ecological preference indicators and three climate preference indicators. Only a portion of the analysis can be summarised here, and we specifically focus on short-term trends, but the paper (Pakeman *et al.* 2022) is available as open access with all the analyses.

Analysis of short-term trends in bryophyte occupancy by European Nature Information System (EUNIS) level 1 habitats shows positive trends for the majority of species from coastal (B), heathland (F) and woodland, scrub and hedgerow (G; including F9 and FA; Figure 2a). Short-term trends for lichen species of woodland and heathland are negative (Figure 2b) but there are positive trends for species of grasslands (E). The positive trend for woodland bryophytes may be related to woodland expansion, but as this in turn may be related to conversion of heathland to woodland the overall positive response of heathland bryophytes must be a response to improved conditions, potentially due to reduced grazing levels. The opposite trends for lichens in heathlands and woodlands is striking, suggesting that they may be in competition for space and that there is replacement of lichens by bryophytes. This also highlights how combining analyses for bryophytes and lichens may miss important patterns.

There is very strong evidence that species of drier locations are more likely to show positive trends for both bryophytes (Figure 3a) and lichens (Figure 3b). For bryophytes, a similar, but only moderately strong, pattern is seen for Ellenberg moisture preferences; species of drier habitats are more likely to have positive trends than those of wetter ones (not shown). This suggests that both bryophyte and lichen communities are shifting towards

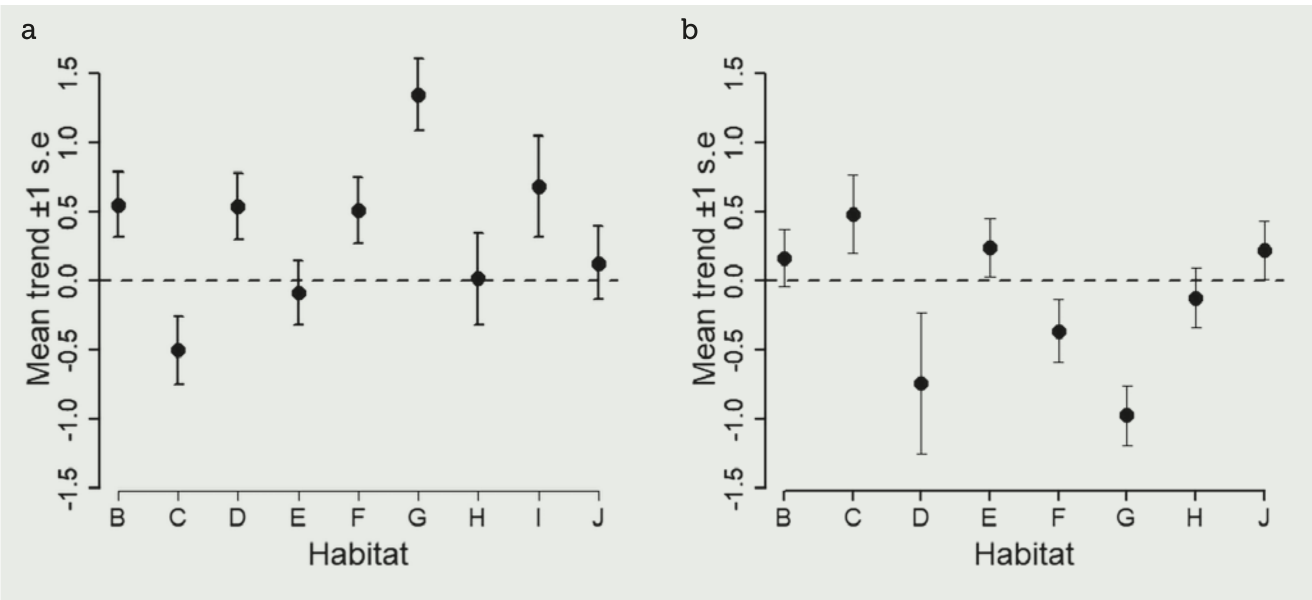

Figure 2. Mean (±1 standard error) short-term (2005–2015) trends of (a) bryophyte and (b) lichen species by EUNIS level 1 habitat class with overlapping membership of each habitat class. B, coastal habitats; C, inland surface waters; D, mires, bogs and fens; E, grasslands; F2 to F4, heath, G and F9/FA, woodland and forest; H, inland unvegetated or sparsely vegetated habitats; I, regularly or recently cultivated habitats; J, constructed, industrial and other artificial habitats.

those more tolerant of limited moisture. While Scotland is getting wetter, the response may show that bryophytes and lichens are responding to periods of drought that are longer or more intense (Kirkpatrick Baird *et al.* 2021).

Other notable trends are that bryophytes of shadier, nutrient-rich and warmer areas are more likely to show positive trends than those of more open, nutrient-poor or cooler areas. This suggests that levels of disturbance are dropping in both woodland and open habitats and that potentially woodland expansion has had an effect, and also that there are continuing impacts of nitrogen pollution and climate change on bryophyte communities. Lichens of more base-rich substrates are also more likely to expand in occupancy than those of more acid ones, potentially indicating recovery from acidic deposition.

Can we develop new indicators based on occupancy data?

A second approach that skips the stage of calculating species trends was tested for Scottish bryophytes (Pakeman *et al.* 2019). All occurrence records from the National Biodiversity Network Atlas were downloaded for bryophytes from 1960 to 2016, and these were converted to simpler presence/absence data, specifically one record per 10 km × 10 km grid cell per year in those cases where a species was present. Each record was then replaced by its respective ecological or climate preference value. For instance, in the analysis of trends in bryophyte nitrogen preferences, records of *Rhytidiadelphus squarrosus* were assigned their Ellenberg N score of 4. Means for each hectad per year were calculated and these were used to model trends through time accounting for repeated measures and spatial autocorrelation.

The analysis revealed some clear and, mostly, interpretable trends. The national trend for Ellenberg's light (L) indicator is a linear decrease with time (Figure 4a) and can be interpreted as a response to increased tree planting, reduced woodland management and a general reduction of grazing in many habitats leading to denser shade from the canopy. There is a clear, and significant, quadratic trend for Ellenberg's nitrogen (N) indicator values with a peak around 1998 (Figure 4b). Nitrogen deposition peaked in 1990, so this analysis suggests the recovery was delayed but that there has been a shift since 1998 towards recording of bryophytes of less nutrient-rich habitats. There was also a strong linear increase in the two temperature indicators, TJul (Figure 4c) and TJan (not shown), suggesting that increased temperatures have had an impact on bryophyte communities.

The advantage of this approach over one based on species trends is that it is easier to identify non-linear responses and that all species are used in the calculations, not just those common enough to generate a trend. The clear interpretability of the nitrogen and July temperature trends has led to these two metrics being adopted as national Ecosystem Health Indicators 14a and 14b in Scotland (see Resources).

Methodological considerations

There are some clear potential issues with both sets of analyses. Firstly, all the data have been collected in an *ad hoc* fashion rather than with set sampling designs and protocols. However, the sheer size of the datasets means that it is difficult to see how biases in data collection could affect the detected results. For instance, the contrasting trends in bryophyte and lichen occupancy are not the result of a reduction in recorder effort for lichens. Also, occupancy may not be a good measure of population size, but for many species of bryophytes and lichens their small size and microhabitat distributions make accurate monitoring extremely challenging. Secondly, using Ellenberg indicators restricts species to

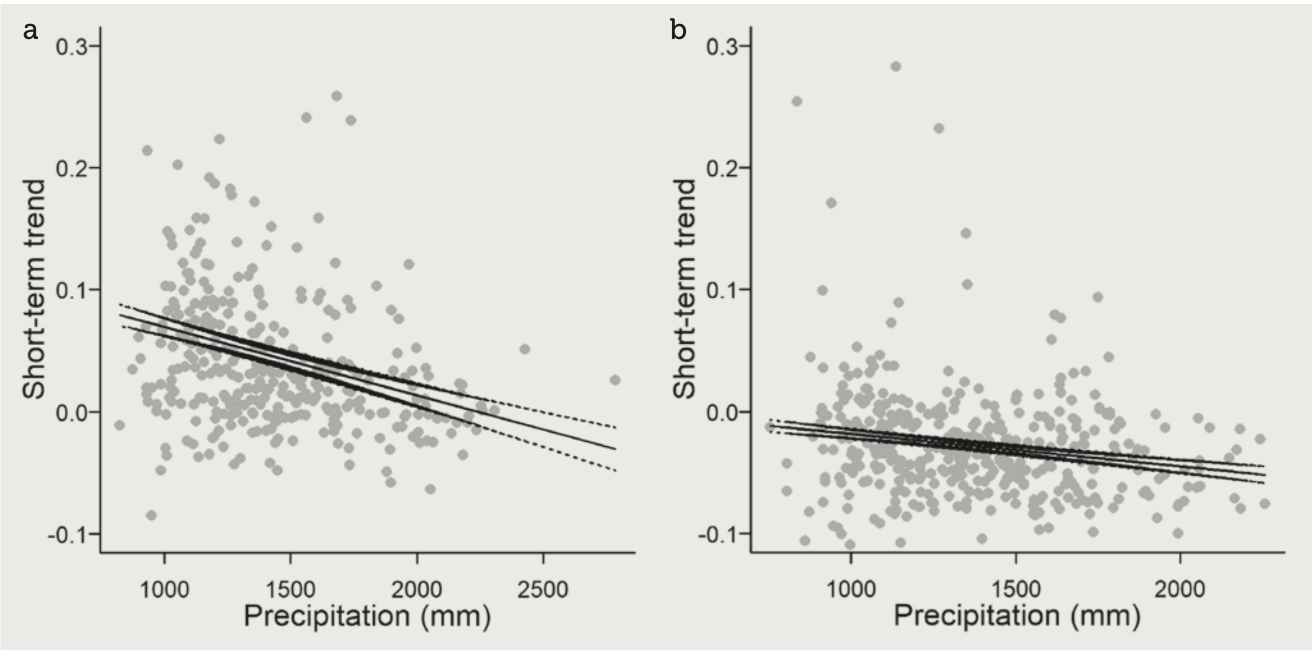

Figure 3. Short-term (2005–2015) trends of (a) bryophyte and (b) lichen species occupancy according to the mean annual precipitation of their range (mm). Fitted relationship (solid line) and 95% confidence intervals (dashed lines) from the generalised linear model.

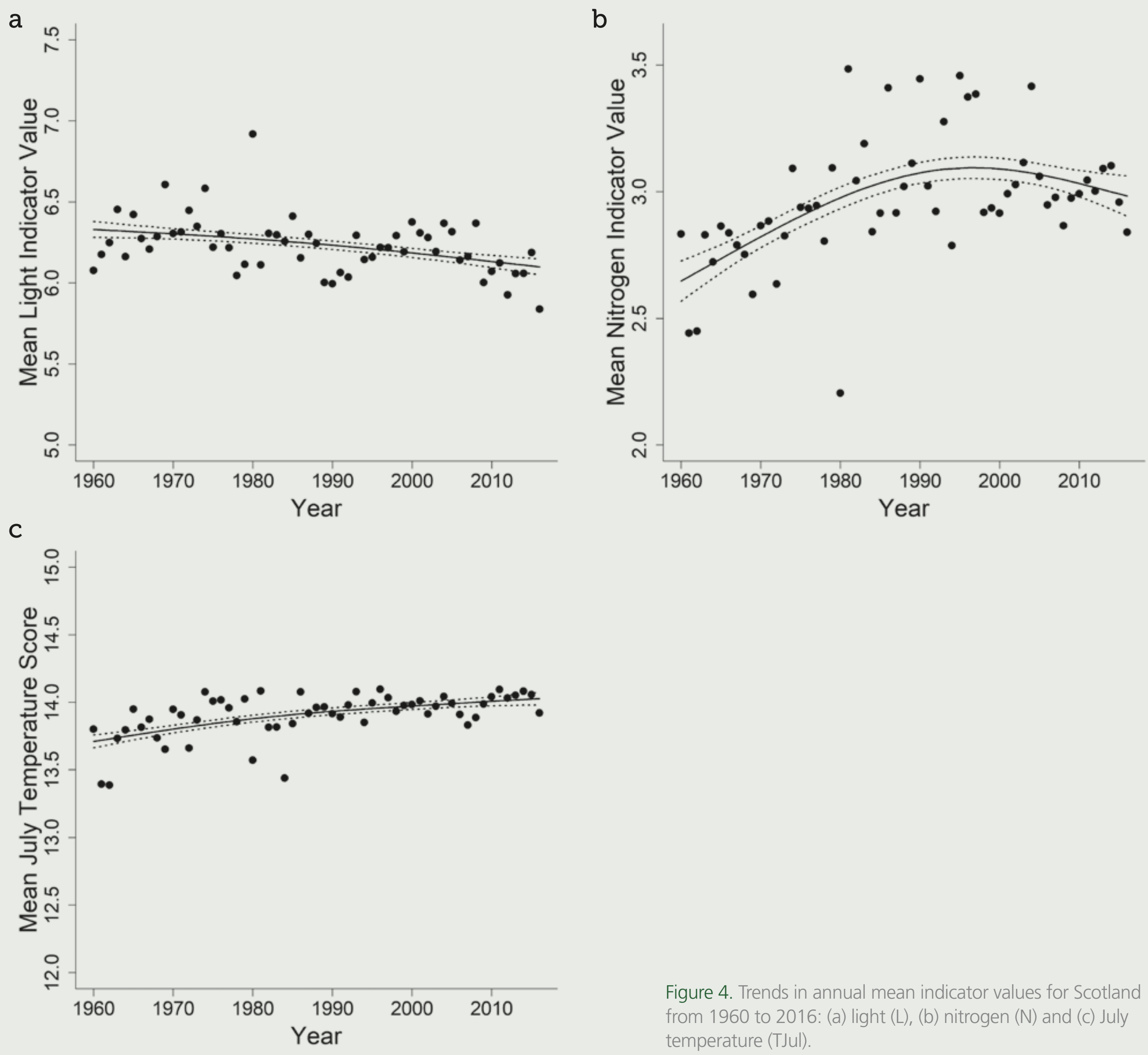

Figure 4. Trends in annual mean indicator values for Scotland from 1960 to 2016: (a) light (L), (b) nitrogen (N) and (c) July temperature (TJul).

Figure 5. *Dicranum bergeri* (*undulatum*). Photo credit: Dave Genney.

a place on a whole-number scale with little precision, but many studies (e.g. Schaffers and Sýkora 2000) have shown that conclusions are robust. Finally, there are issues around allocating species to habitats and how to weight generalists against specialists. The analysis we have done so far gives specialists and generalists within a habitat the same weight. More information about changes within habitats is held in the trends of specialist species as the trends in generalist species are affected by changes in multiple habitats, but we need to identify data to allocate the trends of generalists across habitats. Working on the statistical issues with this allocation is something we are still getting to grips with.

Conclusions

Bryophytes and lichens are usually fairly low down the pecking order in terms of biodiversity interest, but they are a major part of Scotland's contribution to European and global biodiversity. The alignment of the availability of large quantities of occurrence records and good ecological knowledge of their preferences has allowed us to demonstrate which drivers might be affecting occupancy trends and, in turn, tell us about the state of Scotland's natural capital.

Both approaches are largely in agreement. There is a tendency for species with positive trends to be those from warmer and drier parts of the country, indicating that climate change has already left a signature in both bryophyte and lichen communities. There is also a clear tendency for species of shadier habitats to increase, potentially reflecting reduced disturbance and woodland expansion. There was one exception to the agreement in behaviour: the analysis of species trends indicated that bryophyte species preferring nitrogen-rich habitats were increasing, but the analysis of the hectad data suggested a reduction in mean N score since 1998. A potential reason for this disagreement is that the analysis of trends does not take into account the overall frequency of a species, so a moderately rare species has the same weight in that analysis as a ubiquitous one, and it ignores species that are too rare to have trends fitted.

Huge numbers of species records are available, in the UK via the National Biodiversity Network and internationally via the Global Biodiversity Information Facility (GBIF), and the approaches we have taken here demonstrate how ecological understanding can be garnered from such *ad hoc* data. We are currently developing the methods to cover other species groups and to deal with the issue of habitat specificity.

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Feature

Waxcap Grasslands: The Forgotten Treasure

Figure 1. Parrot waxcap, *Gliophorus psittacinus*, usually has some green colouring and very sticky cap; in acid grassland, south west Peak District. Photo credit: Penny Anderson.

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Neil Barden

Keywords: fungi, grasslands, waxcaps

Grassland fungi are often overlooked in ecological surveys, yet recent investigations show the very high value of some sites, especially in the uplands, frequently on a European scale and in grasslands often lacking plant diversity. We seek to raise awareness of these neglected grassland fungi, demonstrate their diversity and beauty, and indicate where to find and evaluate them. Recent advances in eDNA analysis are offering a new approach to fungi identification and site evaluation, but field mycology remains essential at the appropriate time of year.

Introduction

Not all grasslands of high nature conservation value boast a diverse flora of colourful wildflowers and grasses buzzing with insects. Grassland fungi can be equally colourful and diverse. Grassland fungi sites have been overlooked frequently in the past for conservation and protection owing to their often low floristic diversity; they are dismissed too frequently as florally dull. Yet the UK is home to some of the most important waxcap grasslands in the world, particularly in Wales, Scotland and the Pennines.

The specialist grassland fungi included in the generic 'waxcap' label are dominated by waxcaps (Hygrophoraceae). They are part of a grassland fungal assemblage that includes spindles, club and coral fungi (Clavarioids), pinkgills (*Entoloma*), earthtongues (*Geoglossum* and relatives) and crazed caps (*Dermoloma* and relatives). These groups are collectively labelled as CHEGD (the initials represent the different genera; Box 1), although recent DNA investigations have now split Hygrocybe into six new genera and some of the other groups remain poorly understood, taxonomically. Genetic research is still separating out new CHEGD species which may appear morphologically similar but are genetically distinct, especially pinkgills and earthtongues.

Box 1. CHEGD species

The five broad CHEGD groups consist currently of the following genera:

1. **Calvarioid** fungi: *Clavaria*, *Clavulinopsis*, *Ramariopsis*
2. **Hygrocybe s.l**.: *Cuphophyllus*, *Gliophyllus*, *Gloioxanthomyces*, *Hygrocybe s. str.*, *Neohygrocybe*, *Porpolompsis*
3. **Entoloma s.l.**
4. **Geoglossoid** fungi: *Geoglossum*, *Glutinglossum*, *Microglossum*, *Sabuloglossum*, *Trichoglossum*
5. **Dermoloma**: *Dermoloma*, *Porpoloma*, *Camarophyllopsis*, *Hodophilus*

Where to find good CHEGD grasslands

Potentially good CHEGD sites have one or more of the following characteristics: a short turf (grazed, mown or hay cut and then grazed), often plenty of mosses like *Rhytidiadelphus squarrosus* (which often indicates high sheep grazing pressures), well-drained soils, no evidence of disturbance (such as ploughing or drainage) for many years, little or no liming and low nutrient levels. The best grasslands are those close to or matching the U4 *Agrostis capillaris/Festuca ovina* community, with or without the accompanying herbs, MG5 mesotrophic grasslands (*Cynosurus cristatus/Centaurea nigra*) and calcareous grasslands CG1 and CG2 (*Festuca/Carlina* and *F. ovina/Avenula pratensis*) in the National Vegetation Classification (Rodwell 1992). There are some specialists of other habitats like heathland, and a few favour boggy wet sites or more acidic grasslands. Coastal clifftops, slopes and sand dunes, urban sites like lawns and parks, reservoir banks, old mineral workings, church and chapel grounds and roadside verges can all support grassland specialist fungi (Bosanquet *et al*. 2018). In the UK, the waxcap assemblage grows largely in grasslands, and are considered to be outcompeted by ectomycorrhizal fungi associated with trees in woodlands (Gareth Griffith, Chair in Mycology, Aberystwyth University, personal communication).

CHEGD grasslands: a relatively new phenomenon

Waxcap grasslands have been widely lost owing to agricultural improvements and nearly 90% of all waxcap species are on one or more European national Red Lists for threatened fungi. This emphasises their British importance and the very significant contribution our sites make to their international conservation. The threatened state of CHEGD fungal assemblages was not realised until the 1980s after research in The Netherlands and later in Scandinavia (Griffith *et al*. 2013) and their conservation status has been supported in the UK by several grassland Site of Special Scientific Interest notifications and the inclusion of some species in Biodiversity Action Plans. Subsequent surveys have shown that Britain is a stronghold in a European context for CHEGD fungi (Evans 2004) and more sites are being found annually.

The range of CHEGD species

A warm summer and wet autumn will herald a good waxcap year, as in 2020. Waxcaps, of which there are about 50 species, produce often brightly coloured, generally quite small toadstools and are usually the easier group to identify. Their textures vary from felt-like, to buttery or slippery and they have thick waxy gills. They are thought to be largely saprophytic. Box 2 provides identification guidance.

One of the commonest waxcaps is the pale orange-brown meadow waxcap (*Cuphophyllus pratensis*), growing in small groups (termed troops by mycologists). Parrot waxcap (*Gliophorus psittacinus*) is smaller, sticky and glistening and shows some greenish colouring (Figure 1). The scarlet waxcap (*Hygrocybe coccinea*) has a moist, domed cap and red or yellow gills, while the golden waxcap (*Hygrocybe chlorophana*) reflects its name. Snowy waxcap (*Cuphophyllus virgineus*) is another widespread species with a white (usually), moist cap and stem with decurrent gill attachment. Some

Box 2. Help with waxcap identification

Waxcap identification depends on observing:

- colour of the cap and stipe (which can vary along its length)
- shape of the cap – flat, convex, concave, conical, with a central point, etc. – and of the stipe
- colour of gills
- gill texture, type of attachment to the stipe and spacing
- cap and stipe texture: dry, sticky, oily, waxy, etc.
- fungal size
- smell.

Some of these features change with age.

Good identification guides:

- Wood and Dunkelman (2017) provides good photographs and summary features for a wide range of CHEGD and other grassland fungi.
- Information from Aberystwyth University where much waxcap research is being undertaken (www.aber.ac.uk/waxcap). This includes a waxcap key.
- Plantlife leaflet *Waxcaps and Grassland Fungi. A Guide to Identification and Management*, which includes photographs (www.plantlife.org.uk/application/files/6915/0460/9899/Waxcap_ID_guide_low_res_website.pdf).
- The Outer Hebrides Biological Recording group has a good waxcap key on their website: www.ohbr.org.uk/documents/leaflets/waxcaps-key.pdf
- There is a new online waxcap key too: https://sxbrc.org.uk/recording/keys/waxcaps/

species, such as the heath (*Gliophorus laetus*) and splendid waxcaps (*Hygrocybe splendidissima*), thrive better in acid sandy soils whereas others, like the pink or ballerina (*Porpolomopsis calyptriformis*; Figure 2) and the oily waxcaps (*Hygrocybe quieta*), prefer more neutral areas with deeper soils, often towards the bottom of slopes. The citrine waxcap (*Hygrocybe citrinovirens*) favours wetter conditions, while the egg-yolk waxcap (*Gloioxanthomyces vitallinus*) prefers peaty soil at moorland edges.

Some species are regarded as indicators of high-value sites, suggesting a good assemblage is likely to be present. These include the crimson waxcap (*Hygrocybe punicea*), which is generally much larger than those already described (Figure 3), the brown-capped dingy waxcap (*Hygrocybe ingrata*) and the nitrous waxcap (*Hygrocybe nitrata*), notable by its smell of spent gunpowder or fireworks.

Figure 2. Pink or ballerina waxcap, *Porpolomopsis calyptriformis*: medium-sized waxcap with distinctive pinkish cap and white stipe; south west Peak District. Photo credit: Penny Anderson.

Other members of the CHEGD fungal assemblage are equally important. Common club and coral fungi represent some 12% of the CHEGD taxa and include the white and golden spindles (*Clavaria fragilis* and *Clavulinopsis fusiformis*), the yellow and apricot clubs (*Clavulinopsis helvola* and *C. luteoalba*) and meadow coral (*Clavulinopsis corniculata*). There are at least 25

Figure 3. Crimson waxcap, *Hygrocybe punicea*, a large dark-red coloured waxcap found in acid grassland; Lyme Park, Cheshire. Photo credit: Penny Anderson.

Figure 4. Smoky spindles, *Clavaria fumosa*, in acid grassland, near Axe Edge, Peak District. Photo credit: Penny Anderson.

grassland clubs and corals of *Clavaria*, *Clavulinopsis* or *Ramariopsis* genera (Figure 4), varying in colour from rose to violet, smoky or apricot. Among the rarer species are violet coral (*Clavaria zollingeri*), rose spindles (*Clavaria rosea*) and beige coral (*Clavulinopsis umbrinella*). The violet coral is on the UK and European Red Lists, while the straw club (*Clavaria straminea*) is nationally restricted.

Pinkgills (a large group containing currently more than 100 species) usually have some bluish, lilac, violet or bluish-grey colouring or are more dull-coloured. They have pale, crowded gills in their mushroom-like cap and are difficult to identify, needing microscopic examination and considerable experience. As a result, their true distribution is less well understood than that of waxcaps.

The earthtongues (Geoglossoid fungi) are simple, small tongue or club-shaped structures which are blackish, green,

Figure 5. The rare olive earthtongue, *Microglossum olivaceum*, a Biodiversity Action Plan species, in acidic grassland on limestone, Dovedale tributary valley, Peak District. Photo credit: Penny Anderson.

purplish or even dark red. *Geoglossum* and *Microglossum* have smooth fruiting bodies while *Trichoglossum* species are covered with tiny bristles (visible with a lens). All the *Microglossum* species are rare (Figure 5). Crazed caps (*Dermoloma* and similar) are dry-capped mushrooms with cuticles that crack in a crazy pattern when flexed. *Dermoloma cuneifolium* is quite common, although others also occur, like *Dermoloma magicum*, which blackens when bruised.

Date waxcap (*Hygrocybe spadicea*), big blue pinkgill (*Entoloma bloxamii* s.l.) and olive earth tongue (*Microglossum olivaceum*) are sufficiently rare and threatened to have their own Biodiversity Action Plans. Date waxcap, with striking brown cap and yellow gills, prefers dry, warm, south-facing slopes. Big blue pinkgill and olive earthtongue status has been muddied by recent DNA sequencing, splitting them into more species. Other rarer grassland fungi include more pinkgills and orange, citrine, yellow foot, dingy and fibrous waxcaps (*Hygrocybe citrinopallida*, *H. flavipes*, *H. ingrata* and *H. intermedia*).

Surveying for CHEGD assemblages

CHEGD field surveys depend on the fruiting bodies being in evidence and their production varies with climate and season. The drought in 2018 resulted in a particularly poor fruiting season, suggesting the need for surveys over more than 1 year. Moreover, the first species might appear in August or earlier in some years but continue through to November or December, depending on frosts that kill off the fruiting bodies, meaning that surveys need to be undertaken ideally at least three times during this period to be sure of finding the majority of species. Pinkgills are often the first to appear, although some waxcaps like the fibrous waxcap (*H. intermedia*) emerge in August. In contrast, some of the earthtongues are more abundant in November or later.

It is not easy to find additional data on sites. There is no central database for CHEGD fungi, although the British Mycological Society holds some data on individual sites. Natural England (Evans 2004) collated existing information through contacts with individuals and organisations, but this is out of date now owing to the additional sites that have been surveyed. Some County Wildlife Trusts, affiliated groups or other organisations like Plantlife have some data.

“The first species might appear in August or earlier and continue to November or December. Undertake surveys at least three times during this period to be sure of finding the majority of species.”

Advances in genetic analyses recently has enabled soil samples to be analysed for their CHEGD species as well as other grassland fungi and some associated plants. Aberystwyth University is leading this research into metabarcoding of soil eDNA as a method for assessing the biodiversity of fungi (Griffith *et al*. 2019). The results often reveal more species than found in field surveys. For example, as part of recent research in the South West Peak Landscape Partnership Scheme (2022) programme, eDNA of grassland fungi was sampled on 25 farms. Of the top six farms, an average of only 66% of the eDNA fungi identified were also found in the field surveys. In addition, the fluid taxonomic status of some of the groups makes it difficult to provide exact species counts and identification. For example, in the same South West Peak eDNA survey, of the 137 named CHEGD fungi detected, 19 had previously been found in Europe but not the UK and six only from outside Europe.

The advantages of eDNA analyses for CHEGD species is that they can be undertaken at any time of year with little variation in the results and are less dependent on antecedent weather conditions compared with field surveys for fruiting bodies. There is no substitute, though, for the additional in-field evaluation of site, situation and findings that an experienced field mycologist/ecologist can bring.

Evaluating CHEGD grasslands

Waxcap sites are ranked by the total CHEGD taxa, preferably totalled from more than one visit. Until recently, a minimum number of waxcap taxa and waxcap-like fungi (H+D) was used to rank sites as being of international (22+), national (17–21), regional (9–16) or local (4–8) importance (Evans 2004). New guidelines for evaluating waxcap sites have now been produced (Bosanquet *et al*. 2018), needing 19 or more waxcaps to be of national importance. Sites with 12–18 taxa should be resurveyed to see if more species occur or could be regarded as of regional value. Seven or more clubs, spindles and corals, 15 pinkgills, five earthtongues and three crazed caps and their relations now also each qualify as nationally important sites based on the lists provided. Multiple qualifying groups renders a site of particularly high value (see Box 3).

Box 3. Sources of information for CHEGD evaluation

Bosanquet *et al*. (2018)

Section 4 on grassland fungi describes the criteria for site selection, and provides lists of all species known at the time and their diversity indicator status. This standard helps differentiate between sites of national or more regional value.

Evans (2004)

This assessment is based on waxcaps as applied prior to Bosanquet's new criteria and includes evaluation criteria for sites of less than national importance. It mentions the other grassland fungi groups too. The report also gives lists and some descriptions of the highest-value sites in England known at the time.

Bosanquet *et al*. (2018) also note all the CHEGD species that are regarded as indicators of sites that would support a high overall grassland fungal diversity. These high-diversity indicators are adapted from an earlier version through expert opinion to cover the whole of Britain. They have been chosen because of their rarity or scarcity, their strong association with ancient grassland sites, UK-wide distribution and international status.

There are some issues in relation to selecting and identifying sites of different levels of importance. In many instances, the CHEGD fungal interest lies in hotspots among more depauperate areas. In other cases, whole fields, or localised unimproved banks in a field, may host the fungal interest. Defining a site can therefore be difficult. Evans (2004) gives some examples. In her report, she identifies the Longshaw Estate (a National Trust property in the Peak District) as the most important site in England for nearly all its CHEGD groups. It is a 259 ha estate consisting of unimproved grassland, wetlands and mixed woodland plus ancient oak woodland in a gorge. The CHEGD interest is in three main hotspots rather than occurring throughout the estate, although new species and hotspots are continuing to be found (author's personal experience, 2021).

The range of sites listed as of international importance just for their waxcaps (Evans 2004) shows a bias towards the uplands, with Longshaw, Kerridge Hill (gritstone edge on the Cheshire side of the Peak District), Blencathra in the Lake District and Crimsworth Dean (south west Yorkshire). There is a good variety of lowland sites too, including Windsor Great Park, The Patches in west Gloucestershire and Brookwood Cemetery in Surrey.

It is believed that high-quality CHEGD grasslands require a considerable period of time to develop their full suite of species and thus their value (Evans 2004). Some species are regarded as early colonisers after perhaps 10 or 20 years, such as the blackening waxcap (*Hygrocybe conica*) and snowy waxcap (*Cuphophyllus virgineus*), and they can tolerate some nutrient elevation. But species like splendid waxcap (*Hygrocybe splendissima*) may take much longer (more than 30 years; Evans 2004). Some of the best sites are thought to have been undisturbed for hundreds of years (Evans 2004), although this is rather speculative.

The significance of good CHEGD sites

The conservation of the nationally and regionally important CHEGD sites is on a par with flower-rich meadows and other habitats in urgent need of protection and conservation management to maintain this country's biodiversity. Based on current knowledge, such sites cannot be re-created, or even fully restored, once agricultural improvements or other disturbances have taken place. They are unique. Moreover, recent research as part of the South West Peak Landscape Partnership Scheme (2022) programme has revealed that a sample of CHEGD grasslands in the area also support high soil organic matter carbon, averaging 9.6% in the top 10 cm, equating to about 100 tC/ha. This is a very high figure bearing in mind that more than 60% of a soil's carbon lies below 15 cm and the average total carbon content in the upper 30 cm of an acid soil is 87 tC/ha (Anderson 2021).

Of paramount importance therefore is the need to avoid tree planting and other disturbances in the richer CHEGD sites, both to protect the fungal communities and to avoid releasing the existing carbon. This is against the backdrop of national objectives for tree planting and for the preference for the less productive marginal land to be targeted. We must guard against the loss of our best CHEGD grassland assemblages to avoid losing both biodiversity and carbon.

Conclusions

This paper emphasises the significance of our high-value grassland fungal assemblages. Waxcaps are beautiful and cheerful additions to our conservation palette. It follows that their possible presence and value need to be included in any ecological assessment when change is being considered, either through the planning process or through land management strategies. It is increasingly urgent that the value of good waxcap sites is recognised and that they are surveyed, evaluated and adequately protected to safeguard their carbon and their soils and to avoid pressure, for example, to plant trees on them.

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Feature

The England Grassland Fungi Database: A Tool to Help Safeguard Grassland Fungi Sites

Keywords: biological records, fungi, grassland, tree planting, waxcap

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In England, it is nearly 20 years since the last assessment of grassland fungi sites was undertaken. Our understanding of the conservation status of these sites has improved significantly since then. One thing that hasn't changed is the continual and existential threat from land-use change and, despite our increasing knowledge, compared to some groups such as plants the information that we have about the distribution of sites and species is far from complete. To help ensure important fungi sites are accounted for in land-use decisions, Natural England is developing the England Grassland Fungi Database with the aim for it to become a publicly accessible tool to aid decisions around land use and to safeguard these important sites.

Figure 1. Examples of CHEGD fungi characteristic of undisturbed grassland: (a) *Clavulinopsis umbrinella* (Clavarioid), (b) *Hygrocybe intermedia* (*Hygrocybe* and allies), (c) *Entoloma bloxamii* agg. (Entoloma), (d) *Microglossum olivaceum* agg. (Geoglossoids) and (e) *Dermoloma magicum* (Dermoloma and allies). Photo credits: a–d, Sean Cooch; e, Clare Blencowe.

Grassland fungi are as charismatic as fungi get with their bright colours, slimy textures and scents of honey, cedar and burnt leather. Rich assemblages of these fungi, and, more precisely, what is known as the CHEGD group (an acronym for the Clavarioids (fairy-clubs, corals and spindles), *Hygrocybe* s.l. (waxcaps), *Entoloma* spp. (pink-gills), Geoglossoids (earthtongues) and *Dermoloma* and others (crazed-caps)) are characteristic of undisturbed grasslands (Figure 1).

The autecology of many of these species is still poorly understood and certainly their relationship with plants, mosses and other fungi requires much further research. Much like the well-documented loss of flower-rich grasslands, their low tolerance for high nitrogen levels from fertilisers, along with gross disturbance from cultivation, has led to similar losses of grassland fungi sites over much of the English lowlands. It is not unusual in some lowland counties for some of the most important sites to remain in unfertilised lawns and ancient churchyards. Many of the most extensive sites for grassland fungi are now thought to occur in the uplands, the upland fringes and other marginal lands that are still managed by extensive grazing and traditional hay-cutting.

In these remaining strongholds, both in upland and lowland areas the threat to grassland fungi sites from changing land use and management is increasing due to a shifting economic environment, particularly for farm income.

Alongside the more obvious dangers of development, 'green' policies perhaps pose the greatest threat to grassland fungi. The UK Government's tree-planting target of 30,000 ha per year is expected to disproportionately affect key grassland fungi sites. It is already the case that some recent tree-planting schemes have resulted in the loss of a few important waxcap sites. The risk also remains high for Biodiversity Net Gain and rewilding projects which will focus on similarly marginal land.

The international importance of England's fungi-rich grasslands has only relatively recently been recognised, with the first major assessment by English Nature almost 20 years ago (Evans 2004). Since then, the 2009 and 2018 revisions to the Site of Special Scientific Interest (SSSI) selection guidelines for grassland fungi have been a major step forward to defining the importance of these grasslands in a national context by setting threshold 'scores' for each of the CHEGD group (Table 1; Genney *et al.* 2009, Bosanquet *et al.* 2018). Despite this, grassland fungi continue to be overlooked in conservation planning. The number of protected sites notified for grassland fungi is still a tiny fraction of those that are known to meet the SSSI selection thresholds.

Table 1. Grassland fungi, SSSI selection thresholds and the number of sites identified in the England Grassland Fungi Database (EGFD) meeting the SSSI threshold. Note: recently received datasets are expected to increase these numbers significantly.

CHEGD group, genus or genera	Common name	SSSI threshold score	England sites meeting threshold
Clavarioid fungi	Clubs, corals and spindles	7	79
Hygrocybe s.l.	Waxcaps	19	99
Entoloma s.l.	Pink-gills	15	15
Geoglossoid fungi	Earthtongues	5	15
Dermoloma, Camarophyllopsis, Hodophilus, Porpoloma (*Pseudotricholoma metapodium*)	Crazed-caps, fanvaults and meadow-caps	3	17

Other factors putting grassland fungi sites at risk include poor statuary protection, a lack of taxonomic expertise, short and sporadic fruiting periods making grassland fungi difficult to identify out of season, no obvious associated plant communities and many important fungi sites not being priority habitat grasslands. There is clearly a huge need for accessible and easily understood data for grassland fungi to reduce impact some of these barriers and ensure fungi are accounted for in land-use decisions.

The England Grassland Fungi Database

The catalyst for developing a grassland fungi database was actually plants. Similar issues exist for plants and pressures on open habitats had triggered a need to look at records of vascular plants and habitat correlations. Natural England with the Botanical Society for Britain and Ireland (BSBI) have recently developed a botanical heat map to assess sites of botanical interest, many of which were unknown or for which data was not adequate for proper site evaluation (Walker *et al.* 2022).

For grassland fungi in the CHEGD set a data analysis exercise was carried out to similarly identify grassland fungi sites. Natural England are now developing the England Grassland Fungi Database (EGFD), which is a site-level, GIS-compatible database that can be used to assess the status and location of grassland fungi sites (Figure 2). This will ultimately form a map-based layer available on platforms such as MAGIC (https://magic.defra.gov.uk/magicmap.aspx). This will allow ecologists, foresters, farmers, local authorities and others to both safeguard grassland fungi through better-informed land-use decisions as well as securing management through new agri-environment schemes such as Defra's Environmental Land Management scheme.

The EGFD follows similar grassland fungi databases in Wales and Ireland. Like these, it is underpinned by over 60,000 fungus records from the past 50 years, sourced primarily from the Fungi Records Database of Britain and Ireland (FRDBI; BMS 2022a). The collation, cleaning and standardising of records

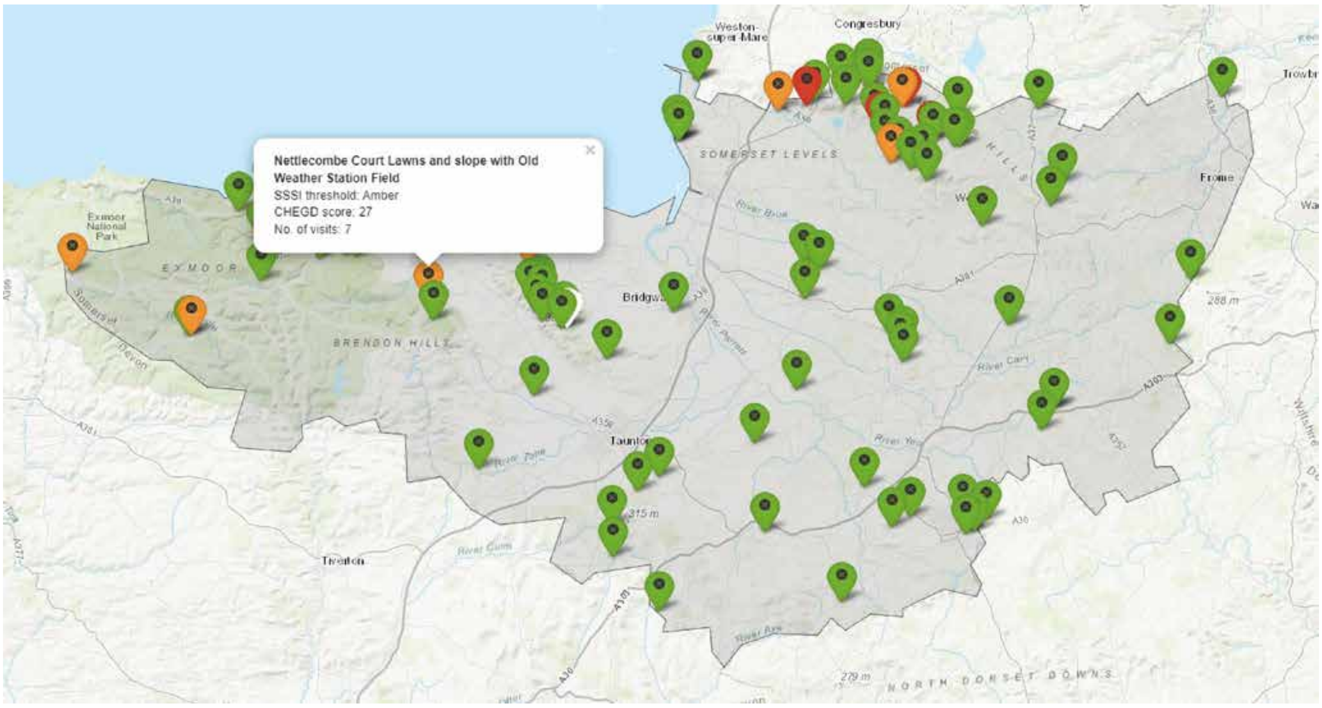

Figure 2. Provisional view of the England Grassland Fungi Database for Somerset. The EGFD is a spatial tool that can be used to identify important sites for CHEGD fungi.

has been mammoth task: duplicates (1159 records), confidential records (34 records) and poorly refenced records (2032 records) have been removed. Missing fields have been in-filled, grid references and site names have been standardised and all records have been given a 'preferred' site name and centroid grid reference.

To aid user interpretation, for each site, with 1 and 10 km grid squares, the EFGD returns CHEGD scores, indicator species (i.e. those indicative of rich fungi sites), number of site visits and whether the SSSI thresholds for each of the CHEGD fungi have been passed. New datasets have already been received from other sources and these will eventually be incorporated into the EGFD. A number of Local Environment Record Centres (e.g. Dorset and Sussex) have contributed data and a number of local fungus groups have provided county records along with the Peak District and Northumberland national parks, and of course social media has proved a useful tool for new records. There is still a lot of work to do, but the EGFD will become increasingly robust.

Box 1. What we've learned from the EGFD about England's grassland fungi

The EGFD confirms the importance of England's grasslands for fungi in a European context:

- 5867 CHEGD sites were identified (many functionally linked, forming larger aggregated sites)
- 44 sites in the EGFD meet the threshold for international importance for their waxcaps; up from 12 sites in 2004 (Evans 2004; Figure 3)
- 152 sites meet the threshold for SSSI designation in at least one of the CHEGD groups (Table 1)
- 52 sites passed the SSSI threshold for more than one group
- 70% of the sites that meet the SSSI threshold have no protection.

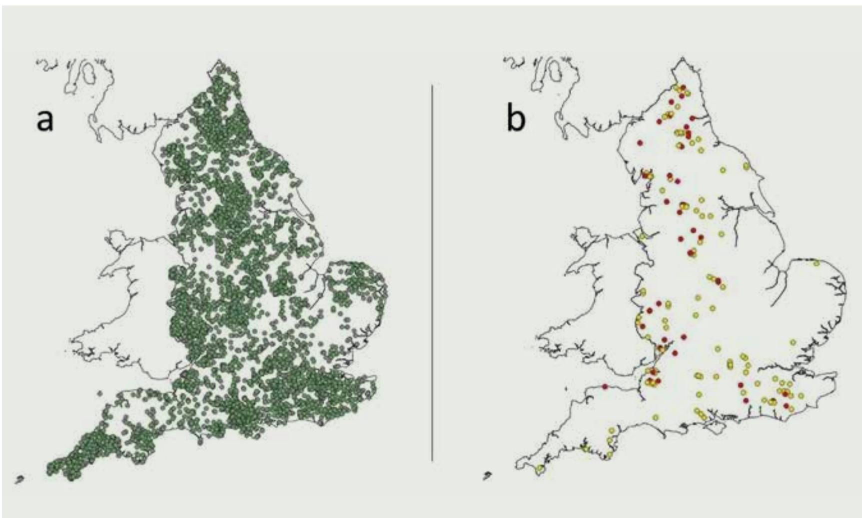

Figure 3. (a) All of England's grassland fungi sites identified through the England Grassland Fungi Database; (b) grassland fungi sites that meet the criteria for national and international (red) and national (yellow) importance.

Caution and interpretation

The EGFD has underscored the importance of England's grassland fungi resource (Box 1). Although the EFGD is the most comprehensive dataset for grassland fungi available it must not be seen as a definitive inventory. Effort has been made to make the data accessible; however, ecological interpretation will always be critical. Biological records are strongly biased by access and location of local experts and reported on an *ad hoc* basis, so there are likely to be a significant number of important sites that remain unrecorded, even in lowland counties.

Many of the best grassland fungi sites have had been visited on multiple occasions, but a surprising finding from the EFGD is that it is not uncommon for nationally important sites to have been visited just once or twice. It is therefore important to survey sites with just a small number of species, especially where there are species indicative of rich grasslands (High Diversity Indicators) such as the pink waxcap, date waxcap, violet coral and big blue pinkgill (Bosanquet *et al.* 2018).

The density of sites across the country is extremely variable. Varying from isolated churchyards to dense upland clusters, however, all exist within a wider ecological network. Interpretation of any site, whether it is on the EGFD or not, needs to be viewed in this context. Moreover, adjacent sites may be indicative of other local sites, particularly in the expansive grasslands of the uplands and its fringe.

Importantly, the EGFD does not replace the need for survey but, like any other biological records, it can help better land-use decisions to be made.

Accessing the EGFD

The aim is for the EGFD to be publicly available in late 2022 via MAGIC. The ambition is that it will be a dynamic tool that is regularly updated with both the existing data sources and new records. We deeply encourage users to record and submit their fungi sightings (Box 2) and actively contribute to safeguarding important fungi sites.

Box 2. Recording grassland fungi

With a finite and unpredictable fruiting period, its important to record grassland fungi whenever they are encountered. This helps to track their conservation status and identify new CHEGD sites. CHEGD fungi will be visible from late summer until Christmas, but the bulk of records in the EGFD of all CHEGD species occurred in October and November so targeting survey effort during this period will maximise records.

Fungi can be difficult to get started with but there are good resources for grassland fungi. The waxcaps are a good place to practice identification with these useful resources:

- Waxcap Identification Support Tool, hosted by Sussex Biodiversity Records Centre (Blencowe 2019)
- Waxcap Key on Aberystwyth University's waxcap website (Griffiths and Easton 2022)
- Plantlife's *Waxcaps and Grassland Fungi. A Guide to Identification and Management* (Plantlife 2013) and their smartphone app, Waxcapp (Plantlife 2022)
- Your local fungus group is a fount of knowledge: the British Mycological Society hosts a list of contacts (BMS 2022b)
- See also other articles in this issue, including What's that fungus? by Nathan Orr (pp. 8–13).

Acknowledgements

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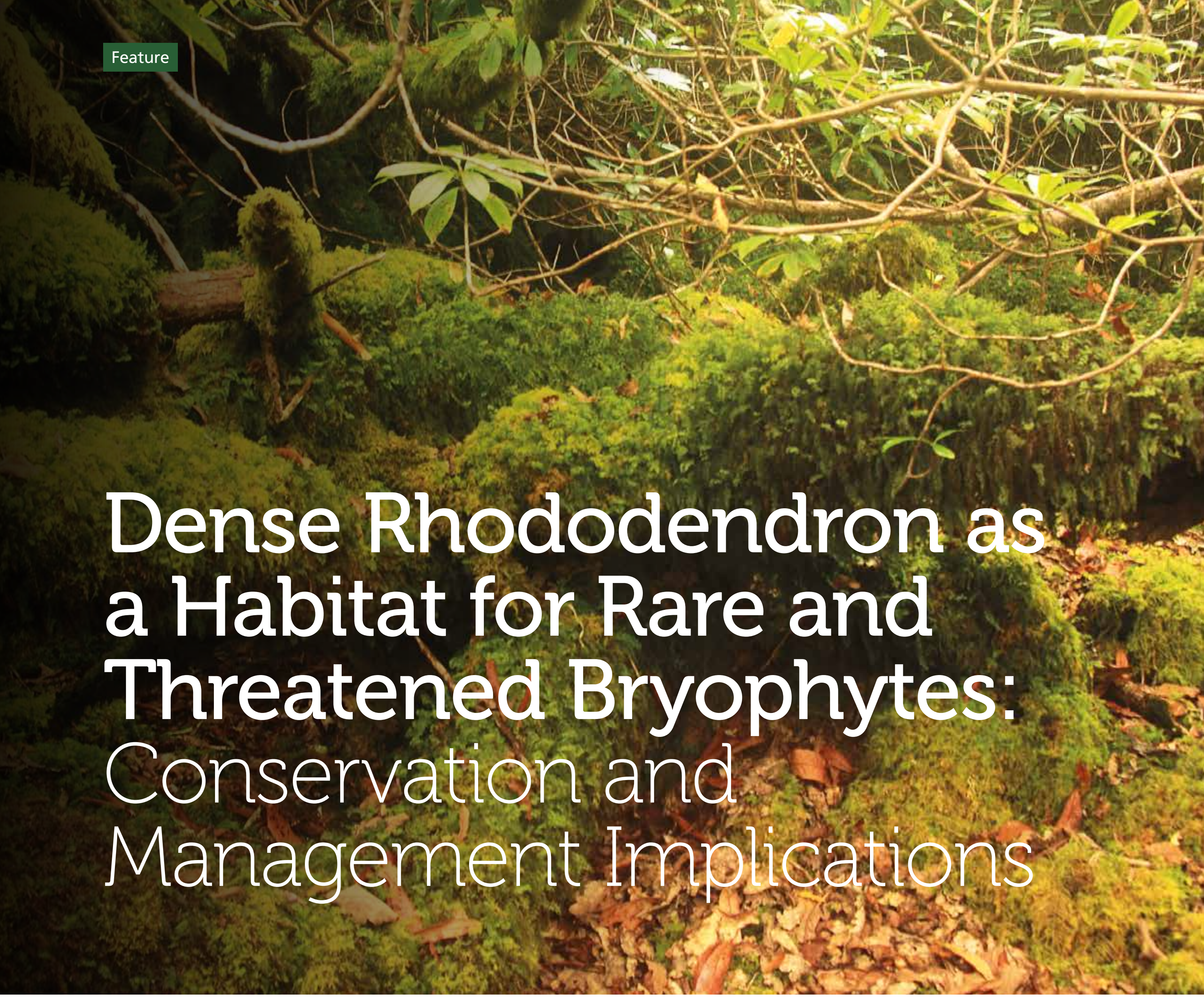

Dense Rhododendron as a Habitat for Rare and Threatened Bryophytes: Conservation and Management Implications

Figure 1. Dense growth of bryophytes and filmy ferns beneath dense rhododendron canopy in County Kerry. Photo credit: Rory Hodd.

Rory Hodd
Nimbosa Ecology

Keywords: bryophytes, invasive species, habitat management, oceanic woodland

Infestation by rhododendron is generally considered to be highly detrimental to vegetation of Atlantic oak woodlands. However, in some instances, perfect conditions exist beneath dense stands of rhododendron for the growth of a range of rare bryophyte (moss and liverwort) species and lush, diverse bryophyte communities thrive in less dense, older stands. This presents a conundrum regarding how to conserve these bryophytes while still effectively controlling the spread of rhododendron.

The rhododendron issue

The non-native shrub rhododendron (*Rhododendron ponticum*) is highly invasive, particularly in Atlantic oak (*Quercus petraea*) woodland in the far west of Ireland and Britain, where it forms dense stands, shading out the ground flora and inhibiting regeneration of natural vegetation. Rhododendron has been present in these islands since the 18th century and, possibly at least partially due to selective breeding and hybridisation, it has become extremely well adapted to the climate. It was widely planted in gardens and as game cover, being sold very cheaply due to its ease of propagation and readiness to set seed (Dehnen-Schmutz and Williamson 2006). It is this ease of germination and the abundance of seed produced that makes it such a successful coloniser, alongside its ability to thrive in deep shade and, once established, to provide unsuitable conditions for the growth of virtually all other plant species. It can rapidly become very difficult to control at both a site and landscape level and removing an infestation of rhododendron requires drastic and widescale clearance of mature plants, coupled with diligent longer-term management of regeneration.

Rhododendron can spread readily in a range of habitats, including heaths and bogs, but the habitat which provides the most suitable conditions for it to rapidly become established and take over is open, overgrazed woodland with numerous moss patches and dead wood in areas with a mild, humid climate. This has resulted in many highly important stands of Atlantic oak woodland becoming swamped with rhododendron on a massive scale, eliminating most of the ground flora and changing the structure of the woodland, as well as inhibiting regeneration of the key characteristic tree species of this habitat and altering the ecosystem processes of the habitat (Casati *et al.* 2022). These Atlantic oak woodlands are highly fragmented and suffered a huge decline in area to now occupy only very small pockets, and most remaining stands are highly threatened by a combination of overgrazing and infestation by invasive species, primary among these being rhododendron. Therefore, it can be considered that these woodlands are in terminal decline and will be lost as a functioning habitat without urgent and concerted conservation action.

The oceanic bryophyte flora

One of the most important and characteristic elements of Atlantic oak woodland in Ireland and Britain is its bryophyte flora, which is one of the richest bryophyte floras, not only in Europe, but also in the world, with over 200 species of moss and liverwort to be found in many good Atlantic oak woodlands (Rothero 2005). In addition to being highly diverse, in these woodlands bryophytes grow extremely well, forming lush cushions and mats, covering every rock and tree. A high proportion of the bryophytes present in this habitat are what are termed Atlantic bryophytes. These are species that occur mainly along the Atlantic fringe of Europe, where the mild, humid climate with frequent rainfall favours their growth, and are rare or absent in more continental areas. Some of these species show remarkably disjunct distributions, occurring elsewhere thousands of kilometres away and nowhere in the intervening areas.

A suite of species occur elsewhere in the tropics and subtropics, where they can be widespread, but in Europe they are rare and highly restricted. Not only do they require the overarching highly oceanic climatic conditions to survive, they also need ideal microclimatic conditions. Primary among these conditions is high and constant humidity, for which moderate to heavy shade from sunlight and shelter from strong winds is required. Without protection from these factors, drying out would occur and these rare and highly demanding species could not persist. The required conditions are best provided in Atlantic oak woodland and in deep, wooded ravines, where the presence of a river further raises the levels of humidity. Even within the best habitats, the most demanding of these species will only grow in deep shade beneath boulders in close proximity to flowing water, meaning that the niche suitable for their growth is extremely limited. Consequently, the majority of these species are highly restricted in Europe and in some instances are legally protected where they occur, for example on the Irish Flora Protection Order (Hodgetts *et al.* 2015).

Bryophytes and rhododendron

In general, studies have shown that the invasion of Atlantic oak woodlands by rhododendron has a smaller impact on the bryophyte flora than it has on the vascular plant flora. It has been found that, while a decline in cover of bryophytes is observed due to rhododendron invasion, species diversity does not decrease and species richness is maintained. Furthermore, once clearance has occurred, a novel bryophyte-dominated community becomes established in cleared areas of woodland, while the vascular flora struggles to return due to a depleted seedbank (Maclean *et al.* 2018). It was also found that epiphytic bryophyte communities, which contain a number of rare species, recovered quickly after clearance (Maclean *et al.* 2017).

These results would suggest that rhododendron invasion and clearance has a negligible impact on the bryophyte communities of these woodlands, and that invasion followed by clearance is advantageous and increases their abundance and diversity in the medium term, leading to a relatively stable bryophyte-dominated community becoming established. However, although this post-clearance community may have an overall high cover and diversity of bryophytes present, the majority of cover is likely to consist of relatively widespread bryophytes, at least in a local context, and conditions are likely to be too open and lacking in humidity to support populations of the rarest and most shade-demanding species. Therefore, the species composition and structure of the community present post-clearance is likely to be significantly different from that which would occur beneath dense rhododendron prior to clearance.

Detailed observations over the past decade of the bryophytes present within areas dominated by mature rhododendron in south-western and western Ireland have revealed that it provides an important habitat for a range of rare bryophytes, which elsewhere within their native range in Europe grow as small populations in a very limited niche. Primary among these species is the liverwort *Cephalozia crassifolia* (Figure 2). This liverwort is found outside of Ireland only in Spain (very rarely), the Azores, Madeira, the Caribbean and Central and South America (Blockeel *et al.* 2014). In these places, it would typically grow in the dense, humid shade of evergreen tropical and subtropical forest, such as the Laurosilva of the Azores and Madeira. This species does not occur in Britain, and in Ireland it is very restricted, occurring only in 10 sites, of which nearly all are on humic soil under the shade of dense rhododendron, or were until recently. The other populations are very small and restricted to deep crevices in oak woodland (Hodd 2015a, 2015b).

The core of *C. crassifolia*'s range is in County Kerry and all of the outlying populations occur beneath dense, mature rhododendron, including one in County Tipperary, which is far to the east of where this species would be expected to occur, as climatic conditions would not be suitably oceanic for its growth, without the extra shade and humidity provided by the dense rhododendron. In its core area of occurrence in Kerry, some populations beneath rhododendron are extensive, although it is impossible to determine the precise extent of the population present, due to the impenetrability of the dense rhododendron. It can be concluded that the spread of this species has been facilitated by the spread of rhododendron, and that it is likely that without rhododendron it would be far rarer and restricted to a small handful of sites in small quantity.

Another liverwort species that has benefited from the spread of rhododendron is *Teleranea europaea*. Endemic to Europea and Macaronesia, in these islands it occurs along the west coast of Ireland and in isolated sites in Cornwall and North Wales. Similar to *C. crassifolia*, it occurs at most sites beneath dense rhododendron on humic soil, where it can form large mats. It was only recently discovered in North Wales, in an area that had been cleared of rhododendron in the past two decades. The small patch which was discovered is likely to be the relict of a larger population and it is not clear whether it will persist at its current location without the shade formerly provided by rhododendron (Watling 2013). It seems likely that further populations of this species occurred in North Wales but were lost when rhododendron was cleared, without ever being recorded by bryologists. It is impossible to know whether this species ever occurred in more natural habitat in Wales, or whether it is a more recent colonist from Ireland, which took advantage of the ideal conditions provided by dense rhododendron.

Aside from these species that have greatly benefited from the spread of rhododendron, a range of other rare oceanic liverworts and mosses grow well under rhododendron and have spread into niches that they could not survive in without the dense shade provided by rhododendron, such as on the woodland floor. A relatively brief exploration along the fringes of possibly the largest and one of the most long-established areas of rhododendron in Ireland, in County Kerry, revealed a rich diversity of bryophytes, including many rare species (Hodd 2020). Records collected during this and other explorations of this extensive rhododendron-dominated area include at least 23 species of bryophyte that are either listed as Threatened by the Red List of Irish bryophytes (Lockhart *et al.* 2012) or as Nationally Rare or Scarce in Ireland (Hodgetts and Lockhart 2013). Additionally, five species legally protected on the Flora Protection Order have been recorded from this area of dense rhododendron.

Figure 2. The rare liverwort *Cephalozia crassifolia*, which grows primarily beneath rhododendron in its Irish sites. Photo credit: Claire Halpin.

In parts of this area, where the rhododendron may be up to 150 years old, there is less of a dense tangle of branches and the structure of the canopy is slightly more open, which allows a rich carpet of bryophytes to grow, alongside dense weft of filmy ferns (*Hymenophyllum* spp.), on both the rocks and the rhododendron branches. Species grow here on the relatively open woodland floor that typically would only grow in caves by water otherwise, such as the moss *Cyclodictyon laetevirens* (Figure 3).

Both the gametophyte and young sporophyte of the Killarney fern (*Trichomanes speciosum*), recently derived from gametophyte, were found in this area, and are likely to form an established mature sporophyte colony in time. Mature sporophyte may also be present elsewhere in the large portion of this mostly impenetrable area that remains unexplored. At a number of sites, both rhododendron and its fellow invasive species cherry laurel (*Prunus laurocerasus*) provide essential shade for sporophyte and gametophyte colonies of Killarney fern. Considering the size of the area covered by dense rhododendron, and the extreme difficulty involved in navigating through it, many other populations of rare bryophytes almost certainly remain, as yet, undetected beneath dense rhododendron both at this site and at other similar sites across Ireland and Britain. It is also highly likely that many populations of rare bryophytes have been unknowingly lost as a result of rhododendron clearance in the past.

Conservation and management considerations

The presence of these bryophyte species and communities presents a potential conundrum when it comes to management and eradication of rhododendron from infested

Figure 3. The moss *Cyclodictyon laetevirens*, which is usually restricted to damp caves and crevices, but is able to grow on the open woodland floor beneath rhododendron. Photo credit: Rory Hodd.

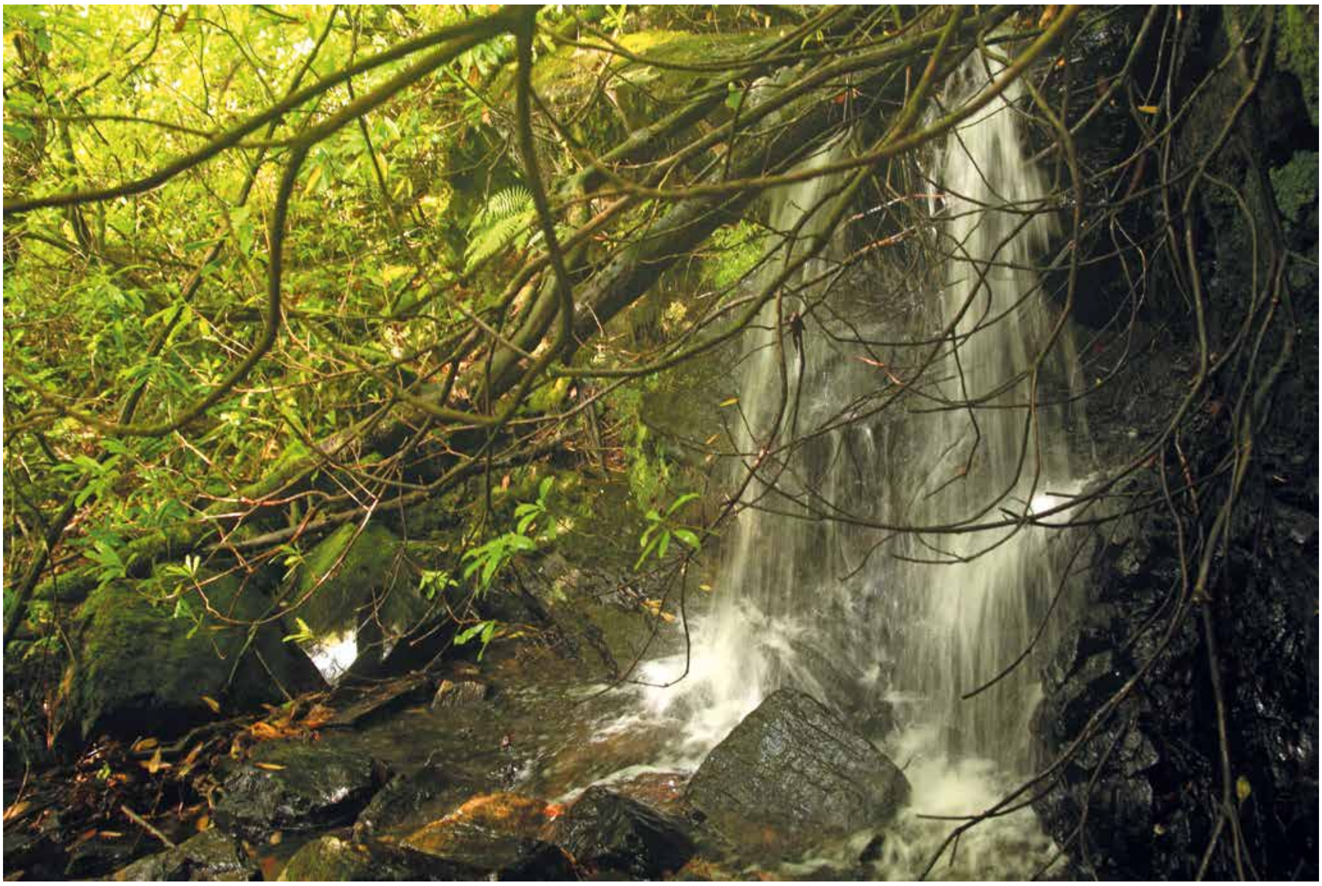

Figure 4. Habitat of the rare and protected liverwort *Lejeunea hibernica*, by a waterfall in dense rhododendron, County Kerry. Photo credit: Rory Hodd.

Atlantic oak woodland. Indiscriminate eradication of rhododendron is likely to result in the loss of populations of rare and threatened bryophytes and cause extensive damage to the bryophyte communities that have developed in the deep shade. Although these areas still remain important for many bryophyte species post-clearance, the composition is likely to change and many of the populations of rarer species will be damaged and lost. Evidence of damage to populations of rare species due to clearance has been seen at a site in County Kerry, where scattered depauperate shoots of *Cephalozia crassifolia* were discovered among other moribund bryophytes and algae in an area relatively recently cleared of dense rhododendron (Hodd 2015a). It is highly unlikely that the remaining shoots will survive at this location in the future as it is now unsuitable for the growth of this species. The question is whether this is a necessary sacrifice for the greater good of the habitat, or if it is possible to conserve these species and communities while simultaneously halting the spread of rhododendron.

While it is difficult to make an argument for retaining stands of dense rhododendron, even those which are important for rare bryophytes, indiscriminately clearing these areas without taking the bryophytes present into account would be a great mistake. Although any individual species or group of species may be of lesser importance than the functioning of the ecosystem as a whole, individually these bryophytes are among the rarest and most remarkable species which occur in these areas. As they occur at a scale below what most people pay attention to, the needs of bryophytes are often overlooked when taking conservation action. As a minimum, specialist surveys should be undertaken of well-established dense rhododendron, prior to clearance, in areas that are important for bryophytes, especially where humid ravines and rockfaces occur, to establish what stands to be lost. If important bryophytes are present in an area due to be cleared, measures should be devised to minimise disturbance to these populations and retain conditions of shade and humidity to allow them to survive into the future. Research has not been carried out into how this may best be done, but perhaps artificial shade could be put in place until shade levels from regeneration of native vegetation are sufficient to create suitable conditions for these species to survive free from human intervention. Translocation of populations of rare species to suitable areas of habitat free from rhododendron infestation may also be an option, although this is untested and may have a low success rate due to the highly specific requirements and sensitivity of the species involved.

Conclusion

Further thought and discussion is needed on this topic. Conservation measures should undoubtedly focus on restoring the remaining fragments of Atlantic oak woodland to a fully functioning and thriving ecosystem and facilitating its expansion across areas from which it has been lost. However, while endeavouring to achieve this, the rarest species of this habitat should not be unwittingly lost, even if their presence in many sites is due to the novel conditions provided by dense rhododendron growth. In the current situation of rapid biodiversity decline and habitat loss, where virtually all habitats are heavily impacted by human actions, it is of utmost importance to do everything than can be done to retain as much biodiversity as possible, a task that is often not straightforward or simple and requires careful thought about a range of elements.

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Blithe Spirit: Are Skylarks Being Overlooked in Impact Assessment?

Figure 1. Skylark, *Alauda arvensis*, in flight. Photo credit: Keith Williams.

Harry Fox
MCIEEM
Clarkson and Woods

Keywords: arable farmland, bird mitigation, ground nesting birds, set-aside

In the absence of guidance, potential effects of development on ground-nesting birds (GNBs) of open habitats are being overlooked, with mitigation often being arbitrarily formulated. This article focuses on skylarks *Alauda arvensis* to encourage a re-examination and discussion of assessment and mitigation best practice for GNBs of conservation concern.

Introduction

The spiralling song of the skylark is so embedded in the national psyche that for many, it embodies much of the British landscape. The likely UK population is around 1.5 million pairs, less than half of what it was in the early 1980s (https://app.bto.org/birdtrends/species.jsp?s=skyla&year=2018). The steady decline of the skylark population since the 1970s due to agricultural intensification and habitat loss is well documented and has led to their inclusion on the IUCN Red List, as well as being Priority Species throughout the UK. Indeed, the species is emblematic of the general decline in populations of many farmland birds, especially ground-nesting birds (GNBs) of open habitats, including lapwing *Vanellus vanellus*, yellow wagtail *Motacilla flava* and grey partridge *Perdix perdix*. Yet despite the publicity, and their capability of being material considerations in the planning process, it appears that skylarks and other GNBs are often undervalued – or simply missed altogether – in ecological assessments. Furthermore, where mitigation *is* recommended, are we sure that it is based on an ecologically sound rationale?

The highest densities of skylarks occur in upland and coastal regions and the arable heartlands of the east of England. Here, and in Northern Ireland, are the scenes of the greatest losses of skylarks in recent decades (Figure 2). The Centre for Ecology and Hydrology reported in 2020 that some 768,000 ha of grassland (including arable) were lost mostly to urban development and woodland planting between 1990 and 2015. Around 1–2% of greenbelt land is developed annually according to the Office for National Statistics, with the Government pledging to build a further 300,000 new homes per year. In a bid to tackle climate change and energy security, the Government has suggested the UK's solar energy generation capacity could grow five-fold to 70 GW and pledged a surge in support for onshore wind energy. While the fortunes of GNBs may be dramatically influenced by changes in agricultural policy, piecemeal developments have the potential to exacerbate local declines and place greater pressure on remaining habitats to absorb displaced birds.

Having examined publicly available Ecological Impact Assessments of developments on land supporting skylark territories, it would appear there is an inconsistency in understanding of not only skylark ecology, but opinion on what might constitute an impact, and what mitigation could be employed. This is likely to be the case for other GNBs but is understandable given the scant guidance on impact assessment for birds. Advice on the issue given to clients by different consultants varies wildly. This situation risks undermining the industry and creating a 'race to the bottom' where potentially ecologically harmful advice becomes prevalent.

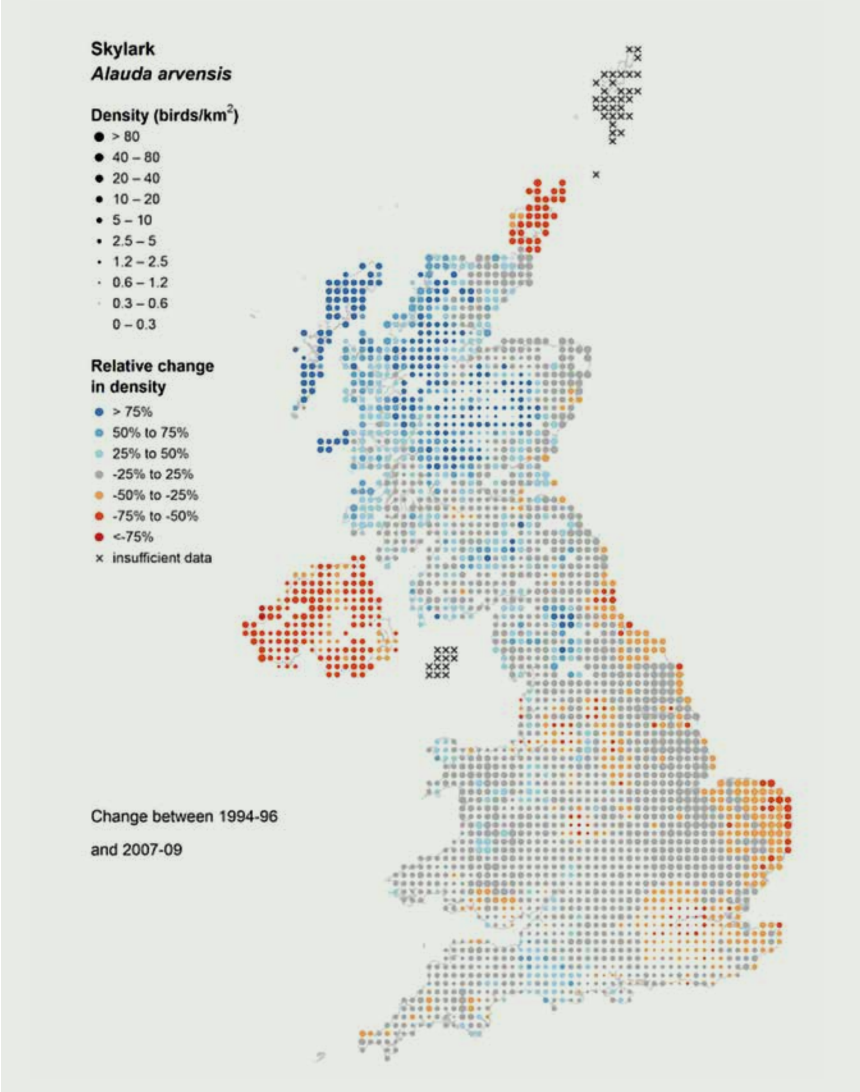

Figure 2. Skylark population change between 1994–96 and 2007–9. Data from the British Trust for Ornithology.

Skylark ecology

Skylarks have evolved to rely on secrecy and vigilance to avoid predation. Edge habitats are used by predators for hunting and cover (Donald 2004), so when selecting nest sites, skylarks require long, unbroken sightlines (Wilson *et al.* 1997). Tall structures such as trees, buildings or tall hedgerows all cause even optimal habitat to be avoided (Donald *et al.* 2001), unless the field area is particularly large (Whittingham *et al.* 2003). One study estimated the effect of dissuasion by tall structures to span approximately 200 m (Oelke 1968).

The height and density of vegetation for nesting is important because access to the ground, for moving through the vegetation back to nests, needs to be sufficiently free. Consequently, skylarks have a clear preference for vegetation height of between 20 and 60 cm, although taller crops such as linseed and rapeseed can be tolerated where the vegetation is less dense at ground level (Toepfer and Stubbe 2001).

Figure 3. Skylark nest.
Photo credit: Hannah Montag.

In optimal habitat, skylarks can have up to four broods per year. The number of nesting attempts a pair is able to make each year is a strong indicator of the stability of a skylark population (Donald 2004). As arable farmland is typified by 'winter cereals' (where the next crop is sown shortly after the summer harvest), the head start that crops receive over traditional spring sowing often precludes a third – or even a second – brood as they overtop 60 cm sooner (Donald and Vickery 2000). Additionally, taller vegetation forces birds to nest closer to tramlines, thereby increasing predation rates (Morris and Gilroy

2008), while more spraying and an earlier harvest together cause significant nest mortality. The loss of spring cereals alone has been said to account for the majority of change in skylark population in the last 30 years (Donald 2004).

While chicks are almost exclusively fed on invertebrates, adult birds also feed on seeds, grains and leaf shoots. As grassland habitats are usually less productive for invertebrates than for example, woodland, skylarks nest at comparatively lower densities than many other songbirds. Table 1 shows the relative densities of skylarks foraging in different agricultural habitats. The greatest densities are in unimproved grasslands and heaths, but in an agricultural setting, set-aside and fallow (where weeds encroach) is best (Poulsen *et al.* 1998). Pasture and other improved grassland usually supports the very lowest densities of skylarks on farmland (Donald 2004).

Development impacts

On a typical housing or solar scheme, it is difficult to see how potential displacement impacts on skylarks can be overlooked. Even with the inclusion of amenity grassland, easements or buffers of retained habitats are likely to be incompatible with the requirements of nesting skylarks, unless very large, undisturbed and managed to promote invertebrates. For example, in preparing this article, no conclusive records of skylark nests within an active solar array were found. This includes data derived from the post-construction monitoring of over 100 solar installations in England and Wales by our company and from observations from associates in the industry.

Male skylarks are frequently observed advertising territories over solar arrays. However, singing is not a conclusive indicator of a viable nest. Skylarks, like many other birds, exhibit strong nest-site fidelity (Donald 2004) and results from one well-established 60 ha solar site that we monitor showed that numbers of singing birds waned following construction from a peak of seven in 2015 to zero in 2020 and 2021.

Skylarks have, however, been recorded many times foraging within solar arrays and even feeding recently fledged young. Fledglings can disperse considerable distances from their nests in just a few days and continue to be fed by parent birds for between 8 and 12 days after fledging (Donald 2004), so this behaviour alone may not be considered evidence of nesting on site. It is possible, therefore, that development sites with suitable grassland might even provide 'nursery' habitat where nesting takes place on adjacent farmland.

The fate of displaced skylarks is unclear. As ecologists we will need to decide the likely significance of effects and whether mitigation should be considered. This decision will be informed by the number of territories displaced versus retained, any wider habitat fragmentation, the habitat type and territory density on surrounding land and the management of any retained or created habitat.

Considering the above, if the carrying capacity of neighbouring habitat allows, some degree of 'absorption' into the surroundings is theoretically possible. Where sites are in proximity to heaths, moorland or coastal grassland this may be more likely. However, in intensive arable landscapes, this is less so and an acceleration of a decline of local breeding success is possible, especially in combination with other development.

Options for mitigation

Their specific nesting requirements mean that effective compensation for skylark displacement requires either the provision of newly available habitat or the enhancement of existing habitat. Habitat enhancement could be designed to increase either the carrying capacity within mitigation land (thereby hosting displaced pairs) or the breeding success of pairs already present.

Arable sward-diversification measures which have been trialled with success for GNB enhancement include 'beetle banks', wider uncultivated margins and increased numbers of tramlines. While margins may be less likely to host actual nest sites, they are often incorporated into territories to exploit the foraging habitat they support and reduce the distance flown per foraging bout (Wilson *et al.* 1997, Donald 2004).

Perhaps the most familiar enhancement is the inclusion of 'skylark plots' within neighbouring arable land. Developed

Table 1. Example skylark territory densities according to habitat type and management. Adapted from Donald (2004) with additional data from research in References.

Habitat	Average density per hectare
Coastal marshes	0.76
Organic set-aside	0.56
Heath and steppe	0.56
Spring cereals	0.46
Set-aside/fallow	0.39
Organic cereals	0.38
Organic winter cereals	0.36
Intensive set-aside	0.36
Arable farmland	0.28
Rootcrops	0.27
Natural grassland	0.27
Moorland	0.26
Winter cereals	0.23
Mixed farmland	0.23
Organic silage	0.22
Pastoral farmland	0.18
Intensive cereals	0.17
Intensive winter cereals	0.15
Legumes	0.12
Oilseed	0.12
Organic grazed pasture	0.1
Brassicas	0.1
Intensive silage	0.08
Orchards	0.07
Rough grazing	0.06
Improved grassland	0.05
Intensive grazed pasture	0.02

by the RSPB in the 1990s, skylark plots are small (approx. 5 × 5 m) patches of undrilled land within arable fields created by turning off the seed drill momentarily at a rate of two per hectare. Plots are not designed to provide nest locations; rather, once colonised by weeds, they act as oases for invertebrates upon which birds can feed, increasing prey accessibility by opening up the sward. Several studies indicate success of plots in increasing territory densities, especially later in the season as the sward rises (Ogilvy *et al.* 2006).

It is common to see ecologists propose a basic metric such as two plots for each skylark territory displaced. It is not clear how this is decided upon and appears to confuse the 2 plots/ha rate of RSPB farmland management advice with a suggested rate per displaced territory. Territory densities in cereal crops vary between approximately 0.1 and 0.4 territories/ha (Donald 2004), increasing up to 0.8/ha with plots, so it is highly unlikely that 1 ha with plots would be able to support an additional displaced territory. We therefore argue against using this rate.

More recent research suggests confounding effects of plots on breeding success. An increase in predation has been shown in fields with plots (especially alongside aforementioned sward-diversification measures which create 'edges'; Morris and Gilroy 2008). Other studies fail to show significant benefits from incorporating plots, possibly due to poor colonisation by weeds, or increased pesticide overspray (Smith *et al.* 2009, Field *et al.* 2010). It is clear that the use of plots must be carefully judged and be just one of several options used, although not in the same fields.

The reversion to traditional spring-sown regimes with retention of winter stubbles provides a longer nesting season and better winter forage (Donald 2004). This is perhaps the best conventional arable management for skylarks, while set-aside and fallow are also excellent habitats (Poulsen *et al.* 1998), with organic farming showing further benefits, owing to reduced pesticide use and slower growing varieties.

An alternative mitigation metric

In the absence of other guidance, an alternative metric is presented that promotes optimal off-site compensation based on research into territory densities across different habitat types. The following method determines the amount of land which, when managed or enhanced accordingly, should accommodate a desired number of displaced skylark territories.

1. Use survey data to quantify the number of breeding territories in the development footprint. Example: 20 territories.
2. Calculate the density of territories across all skylark-suitable habitat to be impacted (the 'donor' site). Example: 20 territories/100 ha site = 0.2 territories/ha.
3. Decide on the number of territories to be compensated.
   a. It may be appropriate to discuss 100% compensation with your client as a worst-case scenario. Depending on the balance of other likely ecological impacts and benefits, there may be an 'acceptable' number of un-compensated displaced territories. Ultimately, this will be a professional judgement call based on site and development specifics.
   b. Other ecological effects inherent in the proposals may allow for a reduction in the need for compensation. For example, where the development site will retain or create sufficient grassland *foraging* habitat for skylarks, territories close to the edges of the development may benefit through increased breeding productivity. For example, we might assume that 50% of on-site territories occurring within 75 m of the development edge may not need to be compensated when suitable foraging land will be present on site, provided *sufficient nesting habitat is present on adjacent land to absorb them*. Example: eight on-site territories within 75 m of development boundary; 50% × 8 = 4 so 20 territories to be compensated becomes 16.
   c. If sufficiently open habitat is retained within proposals, or where there is an abundance of suitable habitat nearby which is likely to be below carrying capacity for GNBs, some absorption may theoretically reduce this further. However, caution should be exercised, and this effect may require baseline survey evidence.
   d. Cumulative impacts due to other development in proximity to donor and receptor sites should be examined, potentially raising compensation requirements.

Figure 4. Skylark on the ground. Photo credit: Keith Williams.

4. Determine the baseline territory density at the receptor site either from site survey or referencing research-based figures by crop type/ land use (e.g. Table 1). If the habitat is sufficiently similar to the 'donor site', it may be more appropriate to apply the figure calculated in step 2.
5. Calculate the net change in territory density possible at a receptor site before and after enhancement.
   a. Determine the theoretical territory density achievable through a positive change in management at the receptor site (see Table 1). Example: 0.56 territories/ha in set-aside.
   b. From this, subtract the actual (surveyed) or assumed (Table 1/step 2) receptor baseline. Example: 0.56 – 0.2 = 0.36.
6. Divide the number of territories to be compensated by the net density change figure (step 5b) to give the number of hectares to be positively managed to accommodate displaced territories. For example, 12/0.36 = 44.4 ha.

Candidate receptor fields should feature low (<2 m high) boundary features, no buildings and a short axis of >200 m. The more ambitious the proposed habitat enhancement (e.g. grazed pasture to set-aside), the less receptor land required. In the absence of grassland creation or arable de-intensification, this calculation could at least indicate the area over which measures such as skylark plots, margins, headlands, etc., should be adopted. The management prescriptions on farmed receptor sites resemble familiar agri-environment scheme options and would cause a slight reduction in agricultural productivity. The concept of reimbursement for income foregone is well-established and serves as a useful starting point for discussion with landowners. Agreements may need to build in a degree of crop rotation within the landholding. Compensatory management should be secured in the long term and be accompanied by a degree of monitoring to further understanding of development impacts and mitigation effectiveness.

Conclusions

The prototype methodology given here is not perfect, makes several assumptions and is as yet without monitoring data. However, it is anticipated to provide a starting point for discussion on GNB mitigation. Hopefully, potential impacts on GNBs can be better anticipated and considered within impact assessment. We look forward to hearing the opinions of other ecologists and researchers on the severity or otherwise of development upon GNBs and the potential for successful mitigation, including refinements to data in Table 1. We would like to see the development of a forum on bird mitigation for use by practitioners, with examples and resources. In time, this should improve the general understanding of bird ecology among ecologists and result in more consistency.

Since GNBs require a lot of space, it is unsurprising that these calculations often indicate large compensation areas might be required. Clearly, this is likely to result in difficult conversations with clients where previously none may have taken place. In our opinion, this only serves to reinforce the need for more scrutiny of the issue by the industry, and more widely by policy-makers.

On development projects, the onus is typically placed on developers or agents to source receptor sites, negotiate management contracts and ensure monitoring is undertaken. Often, this can lead to poor outcomes for wildlife with the breakdown of agreements or lack of follow-up, continuity of personnel or enforcement. Perhaps there is an opportunity to integrate compensation with targets under schemes such as the proposed Environmental Land Management programme? Or alternatively, a system for brokering ecological mitigation between developers and land managers along the lines of that carried out through district-level licensing or natural capital marketplaces. The reversion of relatively small areas of intensive farmland to traditional, low-intensity management with the inclusion of set-aside and wide headlands and winter stubbles could contribute meaningfully to net gain and Nature Recovery targets.

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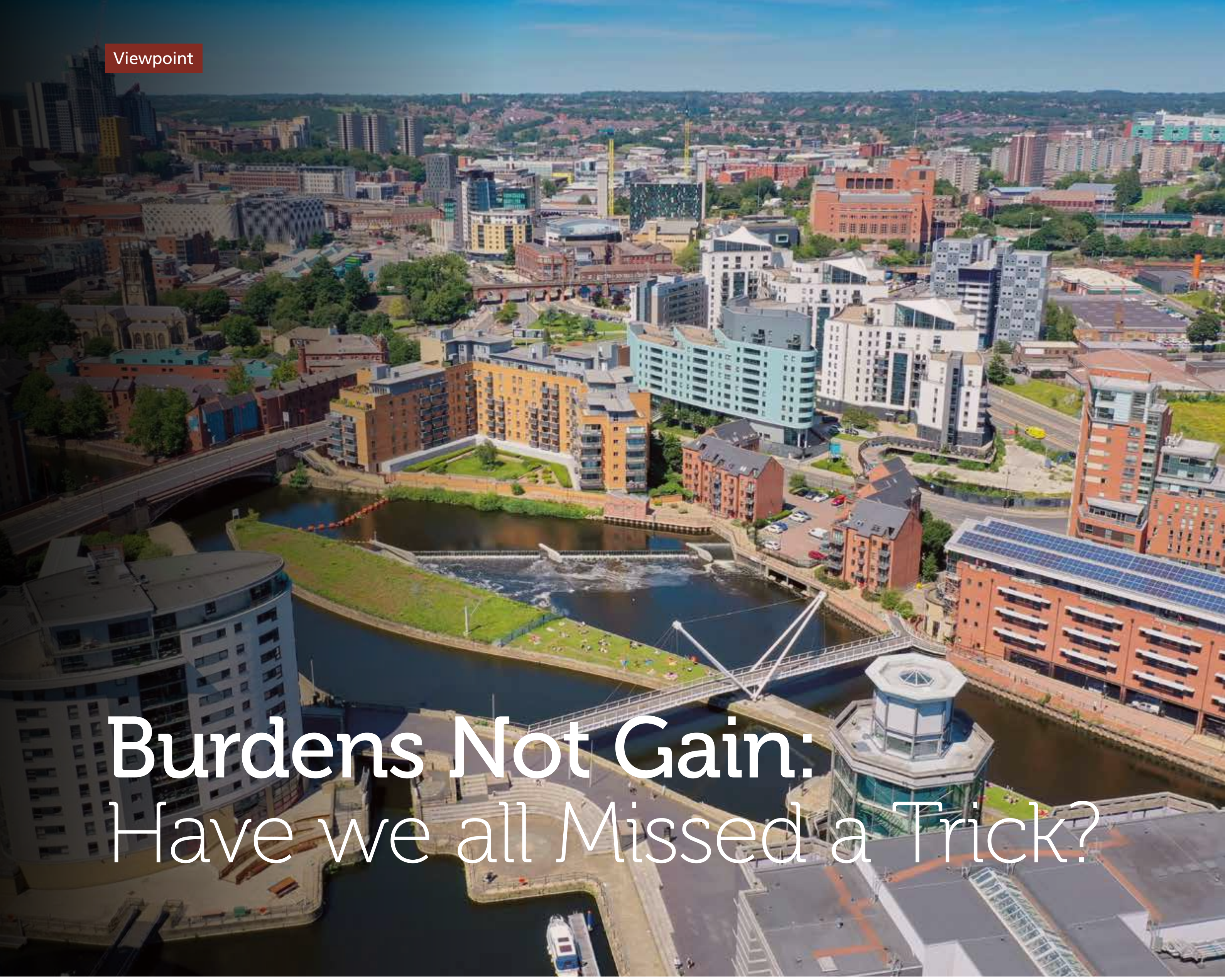

Burdens Not Gain: Have we all Missed a Trick?

Richard Marsh
Leeds City Council

Keywords: BNG burdens, LPA resources, private market, public sector

This viewpoint is about Biodiversity Net Gain, whether we have confidence the private market will deliver a long-lasting public good and whether we are introducing new legislation without the appropriate resources to implement it properly within the planning function of local councils. Trying to introduce new burdens without sufficient resources is also likely to manifest itself through lower job satisfaction for existing and future planning ecologists. Indeed, I have recently found my own mental and physical health being challenged.

Background

For the past 10 years I have been the Planning Ecologist for Leeds City Council. In my local planning authority (LPA) I'm the 'Nature Team'. When commenting on a planning application that is what the public see, and they may think there are several officers like me. I'm not full-time and sit alongside three Tree Officers, three Building Conservation Officers, three Landscape Architects and a bigger team of Urban Design officers and Contaminated Land officers. In this context, alongside those other disciplines, it's clear our 'Nature Team' needs to grow a bit.

Recently I've been pre-occupied with Biodiversity Net Gain (BNG), bringing planning and legal officers up to speed with this new way of measuring biodiversity and the changing expectations of developers. I've written guidance for our website and made sure ecological consultants active in my area are aware of it. I've given presentations and training, and written board papers and reports for heads of service, directors and the Chief Executive, many of whom I had never really spoken to previously. I have suddenly become popular at planning panel meetings where I explain to decision-making local councillors what BNG is and encourage support for off-site delivery of biodiversity. I've been a very good advocate for BNG so far, and it has not become mandatory yet.

The reality of implementing BNG for an LPA

I wonder why I have been putting this pressure on myself to get BNG moving forward so quickly. For many years, people in my role have been trying hard to push developers to go the extra mile, while knowing that we don't have legislation or the measuring tools to back us up. The Environment Act 2021 has perhaps given me the courage to push BNG higher up the agenda. It is a once-in-a-lifetime opportunity to join biodiversity and planning in a meaningful way, so planning ecologists across England should be happy and optimistic, shouldn't they?

I've spent time learning about BNG, reading the primary and secondary legislation and guidance. It's all about the words and nuances of those words. As a planning agent once said to me, *"it's all very well asking us to do something, but if it's not in legislation or policy we don't have to"*. Words are the planning ecologist's main tool. So far I have kept on top of those words and the intentions behind them.

Some things have changed for the better: we now have the measuring tool for biodiversity habitats in the planning system. Previously, it was all about subjective values and negotiation. You won some, but lost often. Or, you won but then, years later (after the developer had moved on), wander around a new housing development or off-site piece of land and realise that the appropriate management is not happening, gardens have extended on to greenspace, the local residents' committee has changed how the land should be managed or land to be used for biodiversity has been sold off to a local private developer or farmer. Let's not even mention the monitoring reports that should have been submitted annually. Implementation, monitoring and enforcement are all words that are meaningful to me, and none seem to happen enough for biodiversity.

My role has always involved the first two 'R's (reading surveys and writing consultation responses) but now planning ecologists need to become biodiversity accountants and know the third 'R' of the Defra Biodiversity Metric's maths really well. Through the Environment Act, local authorities are expected to become the 'BNG police'. This new regulatory role for biodiversity means LPAs need to be fully conversant in *four* 'R's, namely reading, writing, arithmetic and, now, regulation. I'm hoping my role does not evolve into purely looking at numbers and top-down regulation and reporting (a fifth 'R'?), as this would be a bit sad.

I've done the maths for the LPA where I work (which has approximately 1200 major and minor planning applications annually) and we would need an additional £320,000 annually to employ an eight-person BNG team spread across planning, enforcement, legal, GIS and validation to implement BNG successfully. We currently have no way of covering these new regulation and reporting costs through contributions from developers. The developers will already be purchasing off-site biodiversity units from private habitat banks/brokers so that any additional financial demands from the council will not affect their economic viability.

An alternative future for BNG

I hope BNG does change the way biodiversity is delivered, but it does feel like we may all have missed a trick. Imagine for a moment if BNG worked like this: Natural England are the sole point of contact for developers to purchase biodiversity units from. The cost of those biodiversity units across England varies and is based on average land prices for each of the 333 LPAs.

Using the Defra Metric to measure on-site impacts, the residual number of biodiversity units is calculated to achieve

> **"People in my role pushed developers to go the extra mile for BNG, while knowing we don't have the legislation or measuring tools to back us up."**

the 10% gain target (as per now). The developer must buy the corresponding shortfall in biodiversity units from Natural England as a biodiversity tax (not from a private habitat bank). Natural England uses some of the money to cover its own running costs and then works with a nationally recognised habitat delivery partner (with a proven ecological track record, such as the RSPB or Wildlife Trusts) to purchase land in the same LPA area where the development impacts arose.

This off-site land would then be managed as a nature reserve in perpetuity, with carefully designed areas where the public can and can't go. Success could simply be measured in physical area of new nature reserves: this could remove a lot of the costs and concerns about condition assessments and monitoring through the Metric for those off-site areas.

We could declare a national Local Nature Reserve revolution, going beyond those targets first set by John Box and Carolyn Harrison in their excellent accessible natural greenspace standards work (Box and Harrison 1993). What about 10 ha of Local Nature Reserve per 1000 population, or even 100 ha per 1000 population? We are in danger of people only knowing the LNR acronym to mean Local Nature Recovery Strategies rather than the very thing that could instead be the focus of most nature conservation work in England.

I would support BNG more readily if it had a vision of a new network of nature reserves across every LPA, and also new national nature reserves (or extensions to existing ones). This vision of getting developers to pay for new nature reserves near to where people live would hit so many Government targets in the 25 Year Environment Plan and the Lawton review (Lawton 2010). Instead, will the current BNG proposals of relying on the private market really deliver a vision of long-lasting 'nature nearby' (Natural England 2010)?

In Leeds (before BNG kicked in) we worked with the RSPB to create a new 400 ha wetland nature reserve on a former minerals site, St Aidan's. There are areas where the public can go, and where they can't go. After just a few years there are enough pairs of breeding black-necked grebes (*Podiceps nigricollis*) to justify Site of Special Scientific Interest status and Eurasian bitterns (*Botaurus stellaris*) can also be heard booming.

My vision for off-site BNG would also focus on investment for local wildlife sites (LWSs), improving their management and size. In Leeds we get asked every year by Defra to report on the area of LWSs under positive management (which is a national indicator called SDL160). But here in Leeds we do not have resources to measure this, even though we agree it is potentially a good indicator of biodiversity. BNG could be a source of funding for investment in LWSs and employment of officers to give positive land management advice to private landowners.

The current 'vision': using the private sector

I'm not sure what the national 'vision' really is for BNG, one that we can all get behind. It has a definition that we know off by heart, but it seems like the current vision is to take money from the private development sector and invest it in another part of the private sector to deliver biodiversity. The public sector regulates the whole thing under legislation with no properly considered level of income to cover the additional costs.

It seems we are creating a complex, new landscape of private habitat banks and brokers, as well as companies selling digital recording and reporting software to LPAs for monitoring who sells what, when, where and how often. Do we really have the confidence that we can keep tabs on and control all this data, and do it in a way that allows biodiversity to win? I'm not sure I'd want to be in charge of that particular job, or even be a small part of it.

I hope the private market can deliver public goods that include biodiversity but I fear the vast majority of landowners involved in BNG are doing it for the promise of financial returns.

It will also be interesting to see how LPAs interact with BNG if they are simply expected to regulate something that benefits and is delivered by the private sector. There may be differing ideological beliefs in this working relationship unless there is an openly shared vision.

Those old enough to remember the privatisation of British Rail and various utility companies in the 1980s will understand that we moved from knowing who ran our trains or provided our gas or phone line to today's many different private companies clamouring for our custom. Have market forces really led to better service and kept the prices down? Maybe in the future legislation will be required to re-nationalise our BNG.

I can see my own role moving to one of regulation, regulation and more regulation (with some frustration thrown in when enforcement resources are stretched beyond breaking point). Personally, I have started to feel the burden of BNG weighing on my own health as I acknowledge that my expectations about BNG and the reality are mismatched. I must be prone to a new form of health anxiety that I've named 'BNG-related stress'. I've never previously had counselling, but with the help of my therapist I have now recognised this condition. I may consider changing jobs at some point to set up a counselling service offering help to other LPA ecologists also suffering from BNG-related stress.

Final word

Before I sent this article to *In Practice*, I wasn't sure which readers it would speak to. I wrote it during unexpected time off work during which time I was experiencing chest pains. At one point it was nearly a resignation note to my employer – *"Can I still find aspects of my job to enjoy in a world of number crunching and regulation?"* Maybe it's a helpful nod to my Association of Local Government Ecologists colleagues in other LPAs across England: you are not alone and BNG-related stress is a real condition. Or perhaps the audience is the private habitat banks/brokers to encourage them to deliver off-site BNG through a new network of Local Nature Reserves and improving LWSs. Or maybe the civil servants in Defra and Natural England should take back control of BNG and build biodiversity back better and bigger in places that will also be there forever (or longer than 30 years, anyway).

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Restoring Species-rich Meadows in Telford, Shropshire: Using Simple Soil Chemistry and Standard Monitoring to Allocate Financial Resources

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Keywords: grassland monitoring, meadow restoration, soil chemistry, species-rich neutral grassland

Species-rich grasslands have a high nature conservation value and are uncommon because of agricultural improvements such as fertiliser application, drainage and reseeding. Low levels of key nutrients (phosphorus and potassium) in the soil are associated with the high plant diversity found in such grasslands. Simple soil testing can be used to predict the outcome of the restoration or creation of species-rich meadows. Monitoring justifies the allocation of resources by landowners and land managers to the appropriate grassland management over time.

Introduction

Species-rich grasslands are of considerable nature conservation importance in the UK and Europe, but their extent greatly declined in the 20th century due to agricultural intensification. Effective projects are required to deliver the vision of Lawton *et al*. (2010) for the future of the wildlife sites and ecological networks in England: more, bigger, better and joined.

Existing soils, hydrology, slope, aspect, proximity to similar habitats, sources of seeds and plant materials, land ownership and habitat management will determine the likely outcome of managing a species-rich meadow as well as meadow restoration and creation

(Gilbert and Anderson 1998, Blakeley and Buckley 2016). Given a suitable site, the fundamental issues are soils, hydrology and habitat management. Soils and hydrology cannot usually be altered and changes in habitat management usually require financial inputs. Owners, regulators and those allocating financial resources to deliver the restoration, creation and continuing management of species-rich grasslands over the long-term require good evidence that making changes to land management practices and committing resources will generate the desired outcomes.

The sites

This study covered 19 urban and urban-fringe species-rich neutral grasslands in Telford (Shropshire) owned by Telford and Wrekin Council (TWC). Lodge Field and Muxton Meadow are managed by the TWC landscape and open spaces contractors in conjunction with local community groups. The other sites are held by the Severn Gorge Countryside Trust (SGCT) on long-term lease and managed in conjunction with local contractors. The sites have slightly acid loamy and clayey soils that impede drainage and are fairly flat or gently sloping. The grassland communities could generally be described as MG5 crested dog's-tail (*Cynosurus cristatus*)–common knapweed (*Centaurea nigra*) grassland or MG6 perennial rye-grass (*Lolium perenne*)–crested dog's-tail grassland (Rodwell 1992) or a mixture of the two.

Grassland management is generally grass-cutting and removal in July/August followed at some sites by aftermath grazing with sheep until winter. Removing the vegetation keeps the soil nutrients low, maintains an open sward, encourages diversity in the grassland and prevents the natural progression to tall coarse grasses and colonisation by scrub species.

Lodge Field and Muxton Meadow are not aftermath grazed because of established public access: a spring-tine harrow has been used on occasion in recent years to mimic the effects of sheep grazing, creating some bare ground for plants to colonise. Church Road Fields (north and south) are seasonally grazed by sheep. Paradise Meadow, Maws Meadow and Haywood Pastures west are no longer managed as grasslands and are in transition to scrub and woodland.

Soil chemistry literature review and methodology

A literature review (Critchley *et al*. 2002a, 2002b, Walker *et al*. 2004, Gilbert *et al*. 2009) suggested a set of interlinked values derived from soil chemical analyses that form a model, or a set of decision rules, for allocating resources to manage species-rich neutral grasslands: extractable phosphorus <10 mg/L, extractable potassium <175 mg/L and pH 5.0–6.5.

Critchley *et al*. (2002a, 2002b) and Gilbert *et al*. (2009) provide empirical evidence of the relationships between grassland plant communities and soil properties in England and have demonstrated that low concentrations of soil extractable phosphorus are associated with the most highly valued grasslands. Low levels of soil phosphorus and potassium together were a feature of the most botanically valuable unimproved neutral grasslands. The coincidence of low levels of soil phosphorus and potassium in many communities suggests that a combination of both may have a greater influence on the vegetation than low levels of one or other nutrient (Critchley *et al*. 2002a).

Soil samples taken in August 2009 (Ropewalk Meadow and Jiggers Bank Meadow), March 2011 (the other SGCT fields), June 2015 (Lodge Field and Muxton Meadow) and July 2020 (from majority of the sites) were analysed commercially for pH, Olsen bicarbonate extractable phosphorus and extractable potassium (ammonium nitrate extractant). Note: extractable is taken to mean exchangeable and soil solution nutrients available to plants.

Grassland monitoring methodology

Monitoring the SGCT sites was undertaken at intervals from 2001 to 2020 following the Common Standards Monitoring (CSM) rapid assessment method for grasslands (Robertson and Jefferson 2000). Species presence in 2 m × 2 m quadrats was recorded in June or July usually at 20 stops on a structured walk with species frequencies across the quadrats assigned as frequent >40%, occasional 21–40% or rare ≤20%. The TWC sites (Lodge Field and Muxton Meadow) were subject to the CSM methodology in 2016.

> **Those delivering restoration, creation and management of species-rich grasslands require good evidence that making changes to land management practices and committing resources will generate the desired outcomes.**

The CSM methodology is designed to assess whether the nature conservation interest features of a grassland are in favourable condition by monitoring multiple attributes such as species composition, sward height, scrub cover and bare ground. These important monitoring results are difficult to represent in a simple way when using data gathered over a number of years, particularly where a number of grasslands are being compared. The representation of monitoring data over time and between sites is important for justifying the allocation of resources to the appropriate grassland management.

To address this point, a numerical output from the CSM monitoring data of a grassland, known as the Ecovalue, was derived from the species data recorded in the quadrats (Churton Ecology 2017). The Ecovalue methodology has been revised in minor ways (Box 1) and was applied to the monitoring data for the sites in this study. Different grassland sites can be easily compared, both one with another and over time (Table 1).

Soil chemistry and Ecovalue results

Soil pH values from the 19 neutral grasslands were 5.2–6.5, in the range of 5–6.5 expected for neutral grasslands from the literature review. Figure 1 shows the relationship between the soil chemistry of the 19 neutral grasslands and the Ecovalue of each grassland derived from the vegetation monitoring data that was nearest to the year with soil sampling. Grasslands with the higher Ecovalues (categories 2–5; Figure 2a) were all within the limit of 10 mg/L for

Box 1. Determining the Ecovalue of grasslands

The Ecovalue of the grasslands in the study was derived following Churton Ecology (2017) with minor revisions using the data on species present in the quadrats from the CSM monitoring. The types of vascular plant species and their frequencies across the quadrats were assigned numerical values and used to generate a score (Ecovalue) for a grassland.

The species are taken from the positive and negative indicator species for MG5 grasslands as set out in the CSM methodology (Robertson and Jefferson 2000). These indicator species were supplemented by Shropshire axiophytes (Lockton and Whild 2015, pp 7–9) that are notable plant species and are indicators of habitats of importance for nature conservation in Shropshire. The Churton Ecology (2017) methodology was modified by the omission of anthills (not a botanical feature) and hogweed (not a CSM negative indicator species) which were originally included as a positive feature and a negative indicator species respectively.

The CSM indicator species and Shropshire axiophytes present in the quadrats for each grassland were assigned numerical scores derived from arbitrary values assigned both to the type of species (Shropshire axiophytes 5, CSM positive indicator species that are not axiophytes 3, CSM negative indicator species –2) and to the species frequency across the set of quadrats (frequent 3, occasional 2, rare 1; rare was assigned 0 for negative indicator species).

As an example, a Shropshire axiophyte (value 5) that was frequent in the quadrats (value 3) would generate a score of 15, a CSM positive indicator species that was not a Shropshire axiophyte (value 3) that was rare (value 1) would generate a score of 3, a CSM negative indicator species (value –2) that was occasional (value 2) would generate a score of –4, and a CSM negative indicator species (value –2) that was rare (value 0) would generate a score of 0.

These scores were summed to generate the Ecovalue of a grassland:

- Ecovalue score ≥90 is category 5 (Site of Special Scientific Interest standard, MG5 grassland)
- Ecovalue score 50–89 is category 4 (Local Wildlife Site standard, MG5 or MG5/MG6 grassland)
- Ecovalue score 30–49 is category 3 (local or parish importance, MG5/MG6 or MG6 grassland)
- Ecovalue score 20–29 is category 2 (grassland of some nature conservation value, species-poor MG6 grassland)
- Ecovalue score <20 is category 1 (grassland of low nature conservation value, for example MG1 grassland).

Table 1. Ecovalue scores and categories from 2001 to 2020 ordered by most recent Ecovalue score. Ecovalue scores: ≥90, Ecovalue category 5 (green); 50–89, category 4 (yellow); 30–49, category 3 (blue); 20–29, category 2 (orange); <20, category 1 (pink). No data collected in 2002, 2004, 2006, 2009 and 2012.

	2001	2003	2005	2007	2008	2010	2011	2013	2014	2015	2016	2017	2018	2019	2020
Ropewalk Meadow	58			77		72				107					154
Church Road Fields south						62	50			52					84
Wilderness Meadow south	12			44			49						84		
Muxton Meadow east											76				
Wilderness Meadow north	26			39			51						60		
Wilderness Meadow middle	17			24			43						54		
Lodge Field											54				
Oilhouse Pasture west		23				39		36			38				49
Oilhouse Pasture middle		23				39		41			50				48
Jiggers Bank Meadow	10			12		23		22			28				43
Shakespeare Meadow	43				47		45					44			36
Lloyds Meadow east			18						28					30	
Maws Meadow	29				35			41					29		
Lloyds Meadow west			18			29			37					26	
Muxton Meadow west											20				
Big Crackshall														20	
Church Road Fields north						17	5								9
Haywood Pasture west	8				11			23					–9		
Paradise Meadow						5									

soil phosphorus suggested by the literature review and were generally less than 175 mg/L for soil potassium (the vertical dashed line in Figure 1). The exceptions were Church Road Fields south in 2011 and 2020 (Ecovalue 4 in both years) and Shakespeare Meadow in 2020 (Ecovalue 3) which had low concentrations of soil phosphorus but soil potassium concentrations >175 mg/L. The two grasslands that had the lowest Ecovalue (category 1) at the time of the soil sampling (Paradise, Church Road Fields north; Figure 2b) had very high soil potassium concentrations.

The Ecovalues of grasslands generally increased over time (Table 1) where the management was a haymeadow regime (cut in August, cuttings removed and usually aftermath grazing). Grasslands with more variable haymeadow regimes (Maws Meadow, Shakespeare Meadow) or that were grazed on a seasonal basis by sheep or cattle (Church Road Fields north and south, Haywood Pasture west) tended to have fluctuating Ecovalues. These five sites had soil phosphorus concentrations <10 mg/L but their soil potsassium concentrations were among the highest: all were >150 mg/L and four sites were >175 mg/L.

Counting orchids to monitor restoration

Annual monitoring of Lodge Field did not use the CSM methodology. A simpler monitoring method involved counting the flowering stems of the orchids (common spotted orchid *Dactylorhiza fuchsii*, southern marsh orchid *D. praetermissa* and their hybrid *D.* x *grandis*) in late June from 2005 to 2021. Around 20 local people walked in a line with each person holding a knot set 1.5 m apart on a string to maintain set distances between people. Each person counted the orchid stems on their right up to the next person (Figure 3).

Orchids in Lodge Field increased from 19 flowering stems in 2005 to 3338 stems in 2021 (Figure 4). The very low numbers of orchid stems in June 2020 appear to be related to it being the sunniest English spring and the driest May for England since records began in 1929 (Schulz and Tandon 2020). A logistic function fitted to the number of orchid stems (excluding 2020) implies that the number of orchid stems doubled

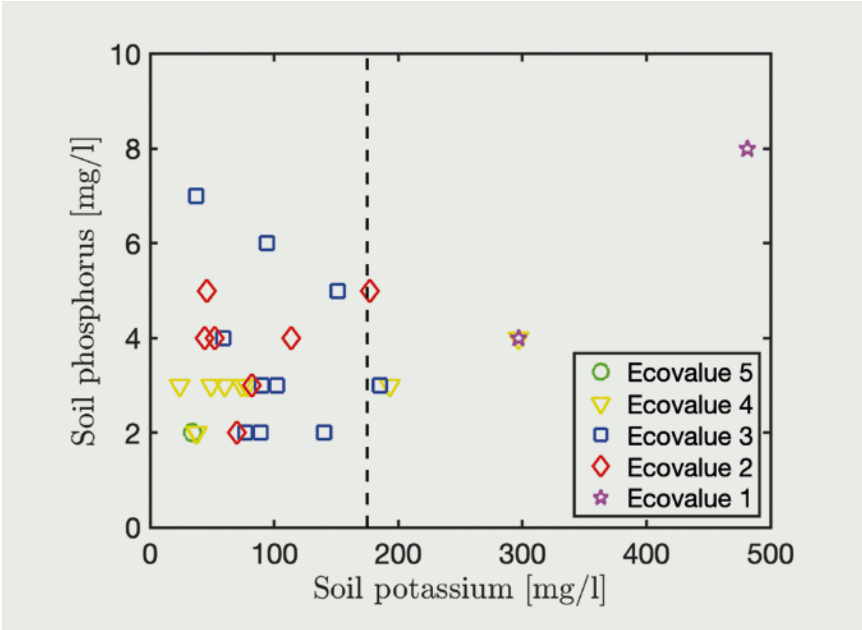

Figure 1. Soil phosphorus and potassium concentrations and Ecovalue category of the grasslands using the botanical monitoring year closest to the soil sampling date. The limit of quantification for soil phosphorus was 2 mg/L.

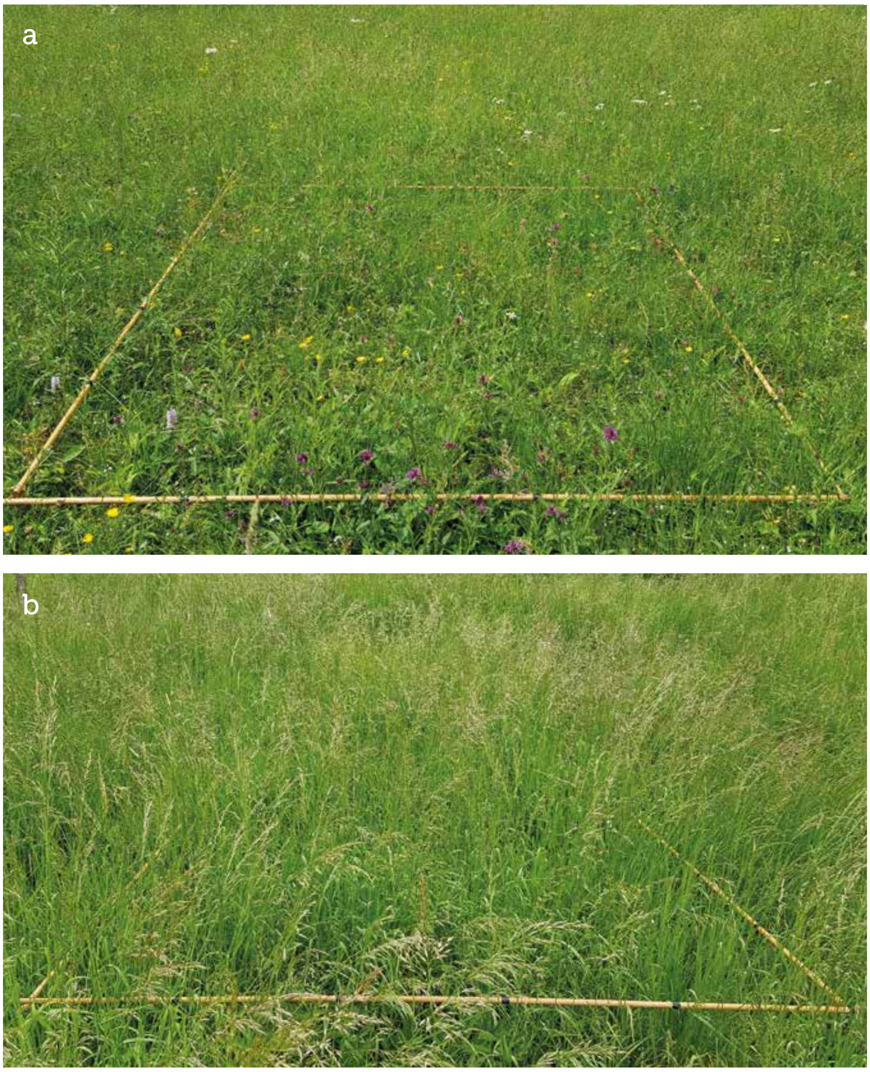

Figure 2. (a) Ropewalk Meadow, a species-rich grassland with short grasses and many herbaceous plants with the highest Ecovalue (category 5). (b) Church Road Fields north, a species-poor grassland dominated by tall grasses with the lowest Ecovalue (category 1). Photo credits: John Box.

Figure 3. Counting orchids in Lodge Field. Photo credit: Graham Peet.

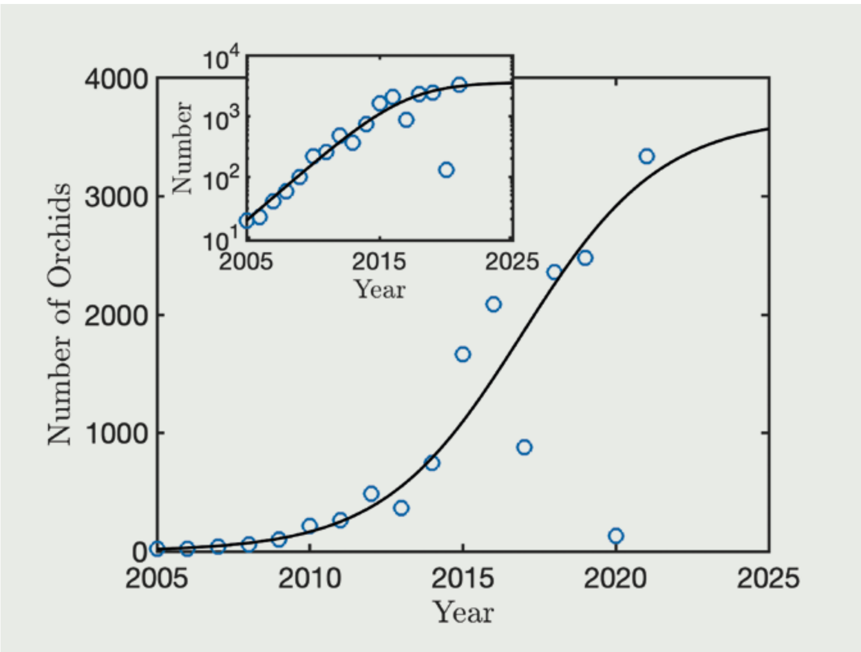

Figure 4. Counts of flowering stems of *Dactylorhiza* orchids in Lodge Field from 2005 to 2021. The curve is a logistic function fitted to the data (excluding the anomalous count in 2020) where: N_0 = 19 (the initial number of orchid stems in 2005), growth rate r = 0.44 and maximum value K = 3671. Inset: semi-log plot demonstrating exponential growth from 2005 to 2016.

> **Doubling soil extractable phosphorus lowered median species richness, turning a botanically interesting community into one of limited conservation value.**

approximately every 2 years between 2005 and 2016 and that the maximum number is likely to be around 4000.

Conclusions

The results from the 19 neutral grassland sites in Telford demonstrated that species-rich neutral grasslands that are MG5 and MG6 and are of Ecovalue category 2 or higher were associated with soil phosphorus concentrations of <10 mg/L and generally with soil potassium concentrations of <175 mg/L as suggested by the literature review.

Grasslands with the highest Ecovalues (categories 4 and 5) had soil phosphorus levels of <5 mg/L. This corresponds with the findings of Gilbert *et al*. (2009) for neutral grasslands that doubling the soil extractable phosphorus from 5 to 10 mg/kg was sufficient to lower the median species richness from 22 to 14 species/m^2, effectively turning a botanically interesting community into one of limited conservation value.

Neutral grasslands with such soil chemistry merit input of resources with the aim of increasing their nature conservation value. Grasslands that are being considered for habitat restoration (for example, species-poor MG6 grassland) require investigation of the soil chemistry before resources are allocated for their restoration. Grasslands with high soil phosphorus and/or potassium concentrations may not merit allocation of resources: they could continue to be grazed as pastures or allowed to become scrub and woodland. Agri-environment schemes and land management priorities can change and any decision on whether or not to restore a grassland should be based on a rational, evidence-based assessment.

Decision rules involving soil chemistry provide a useful tool for landowners, land managers and ecologists in determining which lowland grasslands should continue to be allocated financial resources for their ongoing management or restoration or creation as species-rich meadows. Local models of the decision rules could be developed in different geographical areas using local grasslands of high nature conservation value.

The Ecovalue categories and the trends in the scores for the 19 neutral grasslands (Table 1) can be related to soil chemistry and grassland management. Ecovalue scores could be combined with the soil chemistry data and the results from CSM monitoring to examine past decisions on grassland management and would assist future decisions. The boundaries between Ecovalue categories were set subjectively rather than empirically and flexibility is required in determining Ecovalue category boundaries for datasets in other geographical areas.

Monitoring the changes in the grassland at Lodge Field using annual counts of flowering orchid stems was appealing to local residents and to a wider audience. A combination of CSM monitoring, determining Ecovalue and counting orchids provides a simple and effective monitoring methodology for species-rich neutral grasslands.

Acknowledgements

The Severn Gorge Countryside Trust has allowed use of their data on grassland management and soil analyses, and their data on the vegetation monitoring that was undertaken by their consultant ecologists Kate Thorne (Churton Ecology) and John Handley (CH Ecology). Our thanks to Graham Peet for Figure 3. Finn Box generated Figure 4 and the logistic function for the orchid data. Our very grateful thanks to Penny Anderson, James Hicks and Phil Putwain for their useful comments and wise words on drafts of this paper.

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Continuing our EDI Journey

Sally Hayns CEcol FCIEEM
Chief Executive Officer, CIEEM

It is 2 years since we published a statement saying that 'we need to talk about diversity'. That was at a time when many of us had become increasingly conscious of the Black Lives Matter movement, following harrowing accounts of shameful treatment of people of colour. CIEEM strongly condemned then, and condemns now, the systemic issue of racism that has no place in our society or our profession.

A 2017 report by Policy Exchange[1] highlighted that the environmental professions in the UK were the second least racially diverse occupation of the 202 occupations measured (agriculture was the least diverse) and in the intervening years very little appeared to have changed. But, as our statement said, diversity and inclusivity are not just about race or ethnicity. They are also about gender identity, sexual orientation, age demographics, religion, disability and socio-economic status. We also need to look at the equity of the experiences in our profession.

We resolved to improve our own organisational performance in relation to becoming a more equitable, diverse and inclusive organisation but also to lead the profession in making change. So how are we doing?

Our **Equality, Diversity and Inclusion (EDI) Working Group** comprises both staff and member volunteers and meets regularly to identify steps that CIEEM can take in this space and review progress. For example, we have adopted the Royal Academy of Engineering and Science Council's *Diversity and Inclusion Progression Framework for Professional Bodies* which has enabled us to establish a baseline of performance in areas such as our governance, training, events and membership. Progress is slower than we would like, and much is dependent on creating a more diverse membership base from which to draw volunteers for governance roles, training delivery and conference presentations, but we are moving forwards. We also joined the **Diverse Sustainability Initiative**, a broad collaboration of companies and organisations across the environmental management space that looks to hold each other to account on corporate progress in EDI initiatives.

In 2021 we undertook a **members' survey on EDI issues** and published a report in May that year that highlighted those areas where we perform poorly as a profession. In addition to the expected low marks for racial diversity and inclusivity for people with physical disability, the survey highlighted the importance of embracing neurodiversity and recognising the impact of socio-economic background on access to ecology and environmental management careers. The report also highlighted areas of inequity where superficially members may appear 'included' but their experience and challenges were very different to those who appeared to represent the so-called 'norm'.

We followed this up with our research and report into barriers to ecology and environmental management careers for people of colour. The work, undertaken by specialist stakeholder engagement consultancy Dialogue Matters, was published in our *Breaking Down the Barriers to Inclusion* report, which identified a number of actions that CIEEM could lead or support that could, in time, start to make a real difference to the profession. We were also recognising the overlap between our EDI ambitions and our championing of the green skills agenda which aims to bring more people into the profession **to meet the environmental ambitions of emerging policy and legislation.**

As always, progress was hampered by resources, in terms of both money to do things and time to make things happen. Earlier this year CIEEM's Governing Board committed to a 5-year programme of expenditure to support our EDI work and we are delighted to welcome our newest member of staff, Lea Nightingale, as our EDI Engagement Officer. Lea has a wealth of EDI engagement experience and she will be sharing her ideas and plans in a coming edition of *In Practice*.

We want to do more, more quickly and we have been delighted that some companies and organisations who see EDI promotion as an issue of both social justice and investing in the future success of their business have agreed to help resource this important area of work as **EDI Partners** by committing £5000 per annum for 3 years towards relevant activities, including opportunities for staff engagement. Step forward (and thank you) RSK Biocensus, Arup and WSP.

RSK biocensus EXPERTS IN ECOLOGY

ARUP

wsp

As a first step we will soon be launching a new **Green Jobs for Nature** website – not a jobs board but an online resource that will raise the visibility of green jobs in our sector, showcase the range of opportunities available, how to get them and the best and worst bits about them, and provide career advice. This will be supported by a range of activities designed to reach out to young people and potential career changers, with a particular focus on communities that are under-represented in our profession.

We recognise these are still early steps. We have far to go, and we need to encourage and work with like-minded organisations to create change. But it does feel that our journey is underway. We would be delighted to hear from you if you want to be part of that journey, whether you have felt disadvantaged by your participation in CIEEM or in your work or you just want to be part of a movement of change. You can contact us at diversity@cieem.net.

Note

1. Policy Exchange (2017) *The Two Sides of Diversity* – see https://policyexchange.org.uk/

About the Author

Sally has been an ecologist for more than 30 years, working primarily in the eNGO and public sectors across a range of challenging and enjoyable roles. She joined CIEEM as CEO in 2010 and has been instrumental in driving forward change within the Institute and the profession. Sally is also a member of the UK Government's Green Jobs Delivery Group. Sally is passionate about the need for change within the profession to become more diverse and inclusive and 'fit for purpose', to embrace new technologies and innovations, and for practitioners to be proud of the work they do.

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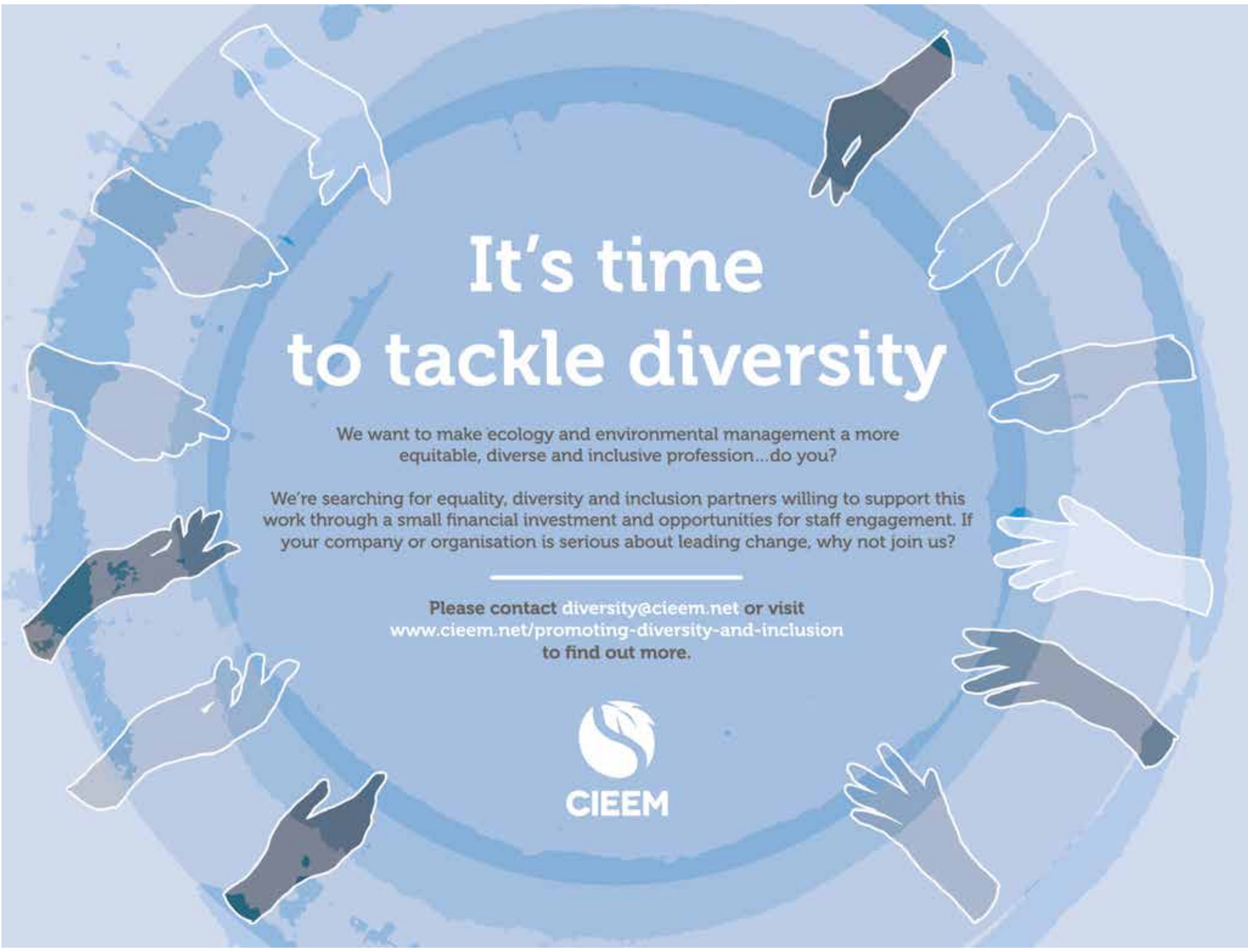


CIEEM Awards 2022: Time to Celebrate

Sally Hayns CEcol FCIEEM
Chief Executive Officer, CIEEM

Summer is a very busy time for many in our profession but it is important to take some time out to reflect and celebrate our achievements and how we are delivering or biodiversity. We were therefore delighted to be able to gather together in person at the Hilton Bankside hotel in London on 22 June to celebrate the winners of the 2022 CIEEM Awards. The conversation bubbled as much as the fizz before and during lunch. Nobody was on mute, there were no dodgy internet connections, no doorbells rang at key moments and everyone was smiling.

Following the drinks reception, sponsored by Ecus, guests were welcomed by our President, Richard Handley, who introduced our host for the day, Dr Caroline McParland. Caroline soon got things underway with the first presentation, that of CIEEM's most prestigious individual award, the CIEEM Medal. Former Vice President (England) Lisa Kerslake read out the citation for David Tyldesley FCIEEM FRTPI FRSA, talking not only about his professional achievements as an authority on the interpretation of environmental legislation, especially Habitat Regulations Assessment, but also his personal qualities as a teacher, mentor and friend. David was warmly applauded as he received the Medal and gave a thought-provoking but typically modest acceptance speech.

A delicious lunch followed and again, wine and conversation flowed freely before we settled down to the serious business of revealing the winners of the rest of the awards. A huge congratulations to all the shortlisted entries and winners, but also to the audience who kept up a high level of applause from the first to the last presentation.

So, to the results…

CIEEM President Richard Handley with Medal winner David Tyldesley.

Award	Shortlisted Project/Individual	Results
In Practice Sponsored by: greenhouse Design | Print | Signage | Display	*Urban wilding: are there lessons we should learn?* – by Richard Gowing (December 2021)	Winner
	Badger dung pits as a seasonal food resource for mammals and birds: implications for urban surveys – by Morgan Hughes and Scott Brown (December 2021)	Highly Commended
	Invasive signal crayfish in the UK: survey methods to inform evidence-based management – by Dan Chadwick, Lawrence Eagle, Eleri Pritchard, Carl Sayer, Michael Chadwick, Jan Axmacher and Paul Bradley (June 2021)	Highly Commended
Postgraduate Student Project Sponsored by: Stantec	Louise Henry ACIEEM – University of Leeds – *A big house in the country: Assessing the biodiversity and ecosystem service values of trees and their management trade-offs in the Harewood Estate parkland*	Winner
	Darren Wilson – Edinburgh Napier University – *Diet composition of Eurasian sparrowhawks Accipiter nisus in Edinburgh, Scotland*	Highly Commended
	Corrie Grafton – University of Bristol – *Analysis of the factors influencing butterfly diversity and abundance at Snows Farm, Gloucestershire*	Commended
University Department/ Programme of the Year Sponsored by: Countryside Jobs Service CJS	Level 3 Award in Wildlife, Ecology and Conservation – Kingston Maurward College	Winner
	BSc (Hons), Biological Sciences (Environmental Biology) – Nottingham Trent University	Highly Commended
NGO Impact Sponsored by: greenbelt ...green by nature	CRISEP 2021–2025 (Canal & River Invasive Species Eradication Project)	Winner
	Bat Conservation Trust – BatChat Podcast	Highly Commended
	Woodland Trust – State of UK Woods and Trees	Commended
Action 2030 Sponsored by: RSK biocensus EXPERTS IN ECOLOGY	Sarah Simons CEnv MCIEEM, Amey Consulting	Joint Winner
	WSP UK Net Zero/Biodiversity & Natural Capital Campaigns	Joint Winner
	Stantec: Inside SCOPE	Highly Commended
Promising Professional Sponsored by: WILDCARE Nationwide Ecology Supplies	Charlie Ward ACIEEM	Winner
	Aoife Joyce	Highly Commended
Member of the Year Sponsored by: WILDCARE Nationwide Ecology Supplies	Dr Martina Girvan CEcol MCIEEM	Winner
	Professor David Hill CEnv FCIEEM	Highly Commended
	Kat Stanhope CEnv FCIEEM	Commended
	Philip Colebourn MCIEEM	Commended
Best Practice – Small Scale Nature Conservation Sponsored by: Thomson environmental consultants	Spains Hall Estate – Spains Hall Estate and partners (including Atkins, Environment Agency, Essex and Suffolk Rivers Trust, Essex Wildlife Trust)	Winner

Best Practice – Large Scale Nature Conservation Sponsored by: Thomson environmental consultants	Solihull Habitat and Nature Improvements Project – Solihull Metropolitan Borough Council (SMBC)	Winner
	Making Space for Nature (Green Infrastructure for Growth & Green Infrastructure for Growth 2) – Cornwall Council and University of Exeter	Highly Commended
	Farming4Water and Severn Trent Environmental Protection Scheme (STEPS) – Severn Trent Water	Commended
Best Practice – Small Scale Mitigation Sponsored by: temple	Bushey Bank Offsite Compensation Site – Environment Bank, Earth Trust and Taylor Wimpey	Winner
	Water and Abandoned Metal Mines – Calaminarian grassland mitigation in the North Pennine Moor mines – JBA Consulting, JN Bentley Ltd, the Coal Authority and the Environment Agency	Highly Commended
	Otterbourne Hill – Ecological Planning and Research (EPR) Ltd	Commended
Best Practice – Large Scale Mitigation Sponsored by: temple	East West Rail Phase 2 – East West Rail Alliance	Winner
	Large Scale Reroofing in East Sheffield: Addressing The Impacts on Bats – Ecus Ltd in collaboration with Sheffield City Council	Highly Commended
Best Practice – Innovation Sponsored by: ARCADIS	BatCam: a novel trail camera for detecting tree-roosting bats – Gareth Lang, BSG Ecology	Winner
	Ash Dieback – Mott MacDonald and Conwy County Borough Council (CCBC)	Highly Commended
	Digital Environmental Assessment – Jacobs UK Ltd	Commended
	Improving coastal ecosystem resilience to climate change in Anguilla – Anguilla's Department of Disaster Management, Anguilla National Trust, Anguilla's Department of Natural Resources and Environment Systems Ltd	Commended
Best Practice – Stakeholder Engagement Sponsored by: ARCADIS	South Scotland Golden Eagle Project – South Scotland Golden Eagle Project Board/Southern Uplands Partnership	Winner (also winner of the Tony Bradshaw Award)
	NATURE Tool – NATURE Tool Partnership led by WSP	Highly Commended
Best Practice – Knowledge Sharing Sponsored by: ARCADIS	The Beautiful Burial Ground – Caring for God's Acre	Winner
	Lancashire Peatland Initiative – Lancashire Wildlife Trust	Highly Commended
	QGIS for Ecologists – QGIS for Ecologists	Commended
Consultancy – Small Sponsored by: MFL INSURANCE GROUP	DTA Ecology	Winner
	Burton Reid Associates	Highly Commended
	Environmental Gain Ltd	Commended
	Johns Associates	Commended

Consultancy – Medium Sponsored by: MFL INSURANCE GROUP	FiveRivers Environmental Contracting Ltd	Winner
	JBA Consulting Ltd	Highly Commended
	Environment Bank Ltd	Commended
	Ecological Planning and Research (EPR)	Commended
Consultancy – Large Sponsored by: MFL INSURANCE GROUP	RSK Biocensus	Winner
	Atkins	Highly Commended
	WSP	Commended
	Mott MacDonald Ltd	Commended

A special mention must be made of the winners of the Tony Bradshaw Award. Many members will be very familiar with the work of Professor Tony Bradshaw but may not be aware that he was instrumental in the founding of the-then Institute of Ecology and Environmental Management and our first President (1991–94). The award named in his honour is not presented every year, but is only awarded if, in the opinion of the judges, there is a truly exceptional project deserving of the accolade.

Each winner of the seven Best Practice Awards categories is eligible to be considered for the Tony Bradshaw Award. This year we were delighted that the judges felt the winner of the Best Practice – Stakeholder Engagement category, the South Scotland Golden Eagle Project, was a worthy recipient.

This national project is reinforcing the small, fragmented population of the golden eagle in south Scotland. Beginning in 2018 with the translocation of three juvenile golden eagles, the project is now in year four of six, and has to date translocated 19 young golden eagles (secured from the Scottish Highlands and Islands) to establish a population higher than recorded at any time in the last three centuries. Project partners include NatureScot, Scottish Forestry, RSPB Scotland, Scottish Land and Estates, and Southern Uplands Partnership.

It was a highly contentious project (potentially releasing a heavily persecuted bird of prey into a region where there was a history of illegal persecution of raptors), and the project partners had to address the risks extremely carefully. Effective engagement with landowners and land managers were used to build trust. Public engagement through a popular website and high-profile events and opportunities for local involvement have been instrumental to the success of this species recovery project. The Project has become a beacon for wider support for conservation management in rural communities.

Congratulations again to all those who were shortlisted – it was awe-inspiring to see what you have achieved and we would like to thank all of the entrants who took the time to submit a nomination. We would also like to extend our particular thanks to our sponsors, both returning and new, for their generous support, and to our judges for their time and expertise, without whom this special event would not have been possible.

Ethical Dilemmas

This is our series of problems and conundrums that can face members during their professional practice. The purpose of the feature is to encourage you to reflect on and explore scenarios that you may face during the course of your work and to consider the appropriate ways to respond to ensure compliance with the *Code of Professional Conduct*.

In the June 2022 issue of *In Practice* we described a scenario where you are running an environmental organisation which has a goal to become net zero. To help achieve that aim, you set an objective that all staff who use their own car for work (and claim costs) should use an electric car within a specified timescale. However, given the larger capital outlay required for electric cars compared with conventional ones, it soon becomes clear that this obligation is easier for senior, better paid staff than for junior staff.

We asked: Is this fair? Also, if any members of staff opt to retain their conventionally powered car, what should you do?

Our thoughts

Clarify at the outset that pool cars or hire cars will be available for staff to use in situations where public transport, cycling and walking for work journeys are not practical options. This requirement to use a zero-emissions vehicle does not apply to commuting journeys – just to journeys where staff are travelling to do their job.

Discuss with staff the net zero goal and the plan to encourage staff to use electric or other zero-emissions cars for work travel. Give the group and individuals the opportunity to raise general and specific issues (e.g. some staff may not be able to charge a vehicle at home or may have other reasons for retaining their conventionally powered car). Adapt the plan accordingly.

Give staff as much notice as possible – at least 5 years.

Commit to a review period, during which time the effect of the plan (on obtaining the net zero goal and on staff) will be monitored and, if necessary, revisions introduced.

Provide assistance with finding appropriate government or charitable grants/loans to offset the initial capital outlay.

If necessary, the organisation should consider providing loans for the capital outlay.

Provide ongoing incentivisation by providing free (ideally renewables-powered) charging points at work.

Provide ongoing incentivisation by gradually decreasing mileage payments for conventionally powered cars – say from years 5 to 7, so that by 2030 mileage expenses for conventional cars will only be paid in agreed, exceptional circumstances.

Explain that the difference between the mileage rate paid for use of zero-emissions vehicles and the lower rate for using conventionally powered vehicles will be used to fund an appropriate scheme to offset those work miles. The organisation will not be benefitting financially from paying reduced mileage rates for the use of conventionally powered vehicles.

If, by year 5, any member of staff opts to continue using their conventional car for work trips without agreed exceptional circumstances, the organisation may wish to pursue the following approach:

- Discuss the issue with the member of staff to better understand their reasoning.
- If there is no objective reason that compels the member of staff to retain their conventional car, remind them that in those circumstances mileage payments for conventional cars will decline gradually to zero by year 7. This period should be sufficient for the staff member to change their car.

The next dilemma

You are a newly promoted ecologist working under a new line manager. Not yet confident in your role, you are keen to impress and demonstrate your potential. In one of your first assignments, you undertake a Preliminary Ecological Appraisal (PEA) for a proposed development site. You find there are a combination of factors which would make it impossible to adequately avoid, mitigate or compensate for the direct and indirect impacts on protected sites and species. These are varied but include falling within very close proximity to a Special Protection Area, where the best available evidence suggests that impacts cannot be avoided. As a result, your PEA highlights the considerable constraints and clearly states that even with additional survey work, which would be necessary to inform any subsequent planning application, it may not be possible to identify measures sufficient to offset the impacts to the satisfaction of the decision-maker.

You submit your report to your manager for quality assurance and sign off, but your manager requests that you amend your report to focus on avoidance, mitigation and compensation suggestions, noting the need for additional surveys and removing some of the emphasis on the considerable constraints of the site. Your manager strongly disagrees with your suggestion to advise the client that it may not be possible to offset the impacts and indicates that they will not sign off a report with this conclusion. What should you do in this situation?

Complaints Through the Ages: Reflections on 10 Years with CIEEM's Professional Standards Committee

Ellie Strike
CEnv MCIEEM
Acting Head of Complaints, Investigations and Enforcement – Office for Environmental Protection

My CIEEM journey has been a little emotional of late. Whilst I excitedly embark on a new role with the Governing Board, I am sad to have stepped away from the Professional Standards Committee (PSC) after more than 10 years of involvement. It has been a hugely rewarding experience, but has not been without its challenges, and perhaps not surprisingly some of these relate back to our responsibilities for handling complaints against our members.

Given this transition it felt like a logical time to pause, reflect and play back some of my observations and thoughts, and those of some of my fellow PSC members.

There have been changes to both the number and nature of complaints we've seen over the years. And as a result, we have periodically had cause to review our processes and procedures in response to that. So here I will talk a little about some of the trends, our response to them and some reflections on the culture surrounding complaints too.

The numbers

When I joined PSC I remember hearing anecdotally that people were aware of our complaints process, but saw it as a rather toothless tool. Without the qualitative or quantitative evidence to give us deeper insight into what our statistics told us we were faced with a conundrum – were the low numbers of complaints indicative of a correspondingly low occurrence of issues that might give rise to complaints (i.e. professional misconduct)? Levels of awareness of our complaints process? People's faith in the process itself? The increase in our membership? Or was it a combination of some or all these factors… and probably some others too?

These are important questions. And they are important because, over the last few years (2021 in particular) we have seen an uplift in the number of complaints made against our members (Figure 1). To understand why this is the case, it is important to recognise that the number of complaints we receive is not a clear indicator of the state of our profession, or the quality of our members. It can, and most likely does, mean much more.

Every validated complaint is assessed by a Preliminary Investigation Panel (PIP), with members fielded from the Professional Standards Committee (PSC) and a wider pool of trained volunteers who assist in the preliminary investigation phase to help manage the workload.

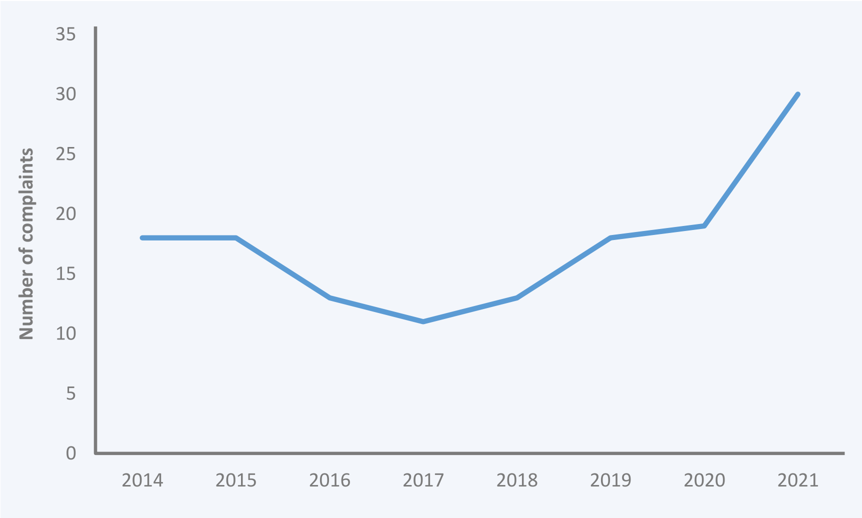


Figure 1. Number of complaints received by CIEEM. Note: prior to 2014 we did not collect/collate data in a way that allows for comparisons with the more recent data.

It is the job of the PIP to ascertain whether there is sufficient evidence of a possible breach of our Code of Professional Conduct to warrant further investigation of the complaint. If there is clearly insufficient evidence of a possible breach of the Code the complaint is dismissed. However, if the facts are not clear or there is evidence of a potential breach, and it is in the public interest to do so, the PIP will refer the case for a Professional Conduct Hearing.

The members of the Professional Conduct Hearing panels do not have access to the PIP assessments of each case. This ensures the Panel maximises objectivity and does not risk prejudicing the process. And it is reassuring that, through both these independent assessment processes, there is a strong degree of correlation. Over the last 8 years more than 83% of cases that were referred, were subsequently upheld at a Hearing.

In making a decision about whether a case should be referred, PIPs are mindful of a variety of factors. We are duty bound to consider the impacts to the subject and the complainant, the impacts to individual projects or initiatives that might be bound up in the case (e.g. what are the implications for a proposed development scheme that is currently going through a planning process?) and the level of public interest in taking the case forward (e.g. are the impacts of the alleged breach of our professional conduct such that they have caused, or could cause, significant harm, or are they at a level that would be better addressed through other means?). We also have to consider the resource implications of convening a full Professional Conduct Hearing. So, no referral is made lightly, nor is it based on any kind of precautionary principle – the weight of evidence must exist, and we must have agreement across all three PIP members before a case is referred.

So, the reason the correlation in Figure 2 reassures me is that it means we are not unduly referring cases that are subsequently found to have no merit, and there are enough cases where there is deviance (between the PIP assessment and subsequent findings of the Hearing), to show the value in having a two-tiered system.

Types of complaint

Whereas the number of complaints has changed over the years, there continue to be some common themes to the types of complaints we receive. Typically, we see a high number of complaints that relate to planning matters, and many of our complaints relate to the quality of ecological reports.

For these types of complaint we have to be mindful of a variety of factors. For one, we are aware that some of these complaints may be intended to frustrate decisions being made in relation to another process, for example, by attempting to discredit the ecological information used to inform assessments relating to planned development. I will touch a little more on the motivation of complainants below.

In respect of complaints relating to the quality of reports, we must also be mindful of our need to be proportionate in our response. Sometimes the quality of a report may be so poor as to present inaccurate or misleading information. And in these cases, there is the potential that they could directly lead to negative environmental impacts. In other instances, while there may be issues, they may be relatively superficial – and without a body of evidence to suggest that it is an endemic problem with the subject's work, it may be disproportionate, and really in nobody's best interests to pursue the matter through a full Professional Conduct Hearing.

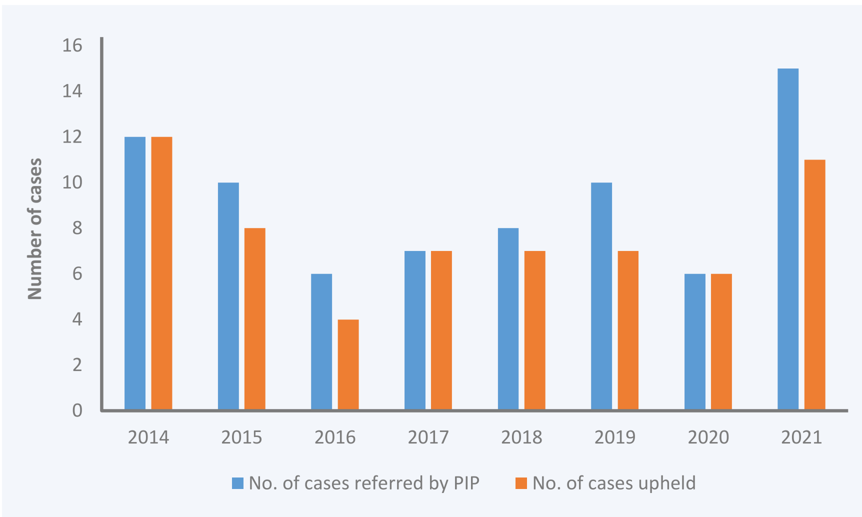


Figure 2. Number of cases referred by PIPs to a Professional Conduct Hearing, and the number of those cases where the complaint was subsequently upheld by the Hearing.

There are few other trends that can be drawn out in terms of the 'types' of complaints we receive. There was a brief period 5–6 years ago where we saw an increase in complaints relating to use of social media, and this did give us some cause for concern at the time as we saw the popularity of social media increase. We anticipated an increase in the number of complaints we might receive that related to social media, but interestingly this doesn't seem to have played out – perhaps as people have become more experienced and savvier in their use of these platforms.

The complainants

In the early days of our complaints process most complaints were from members, being made against other members. So, it very much existed in the professional realm for the professional realm. More recently this trend has shifted, and we are seeing increasingly more complaints from members of the public.

It is likely that this is because of increased awareness of our complaints process. In some quarters we are aware of local authorities highlighting our process to dissatisfied customers in the planning process. But it is also perhaps indicative of the greater level of interface that our profession now has with the public. And it may be reflective of the disconnect between our profession and how we engage with the public. Again, anecdotally, we hear of the perception that ecologists are 'in the pocket' of developers, and because they are 'on the payroll' for a development scheme this may bias their professional judgement. In respect of this last point, I can honestly say that this is not something which is regularly borne out by *our* complaints process, so it is not something that appears to have merit based on what we see.

Tone of complaints

One trend that both I, and my fellow PSC members, have noted is the increasingly emotive nature of some of the complaints we receive.

On the face of it, you might think that this relates to the previous point about complainants (i.e. that with more complaints being made by the public, they are not operating in a professional capacity, and therefore perhaps feel less obliged to check their tone, and sometimes language). But in truth, the emotive element is also seen in the rebuttals presented by the subject of the complaint – professional members of CIEEM.

Tone is so important. While we are duty bound to look at the facts and evidence as they stand before us, the way a subject engages with a complaint can be a significant indicator, and one that we do take into account. And our mandate for doing this is set out in our Code of Professional Conduct and the guidance supporting our complaints process. The following clauses of our Code are particularly relevant:

- Clause 5: act at all times with professional integrity and courtesy, avoiding or managing any conflicts of interest and avoiding actions that are inconsistent with my professional obligations.
- Clause 7: cooperate fully with, and provide full assistance to, CIEEM in any Professional Conduct Inquiry.
- Clause 8: not interfere with, frustrate or otherwise seek to compromise, whether through any act or omission, the due process of any Professional Conduct Inquiry Process undertaken under CIEEM's Professional Conduct Inquiry Procedures.
- Clause 10: accept responsibility for my professional actions and decisions.

Ownership, and taking responsibility for one's actions, is key and we advocate an approach where, if possible, we work more collaboratively to understand root causes of misconduct or poor practice so that we can all improve it together. This is only possible if a subject chooses to engage positively with the process, rather than fighting it at every turn.

Related to this, we also see complaints where it is apparent that options for informal resolution have not been fully explored. Instead, some people prefer to defer straight to the formal complaints process rather than making attempts to resolve the matter in a less contentious and emotive way. This in itself is inflammatory for those involved, if they feel they have not been afforded the courtesy of a right of reply before being subject to the level of scrutiny that our process involves.

Motivation

When looking at why people complain, there are numerous considerations and these exist at both the very individual level, and at a wider societal/cultural level. These are some of my reflections based on what I've seen over the years.

At the individual level

At the individual level when people make the decision to submit a complaint there are likely to be both practical and psychological elements at play. For the sake of ease, I think you could broadly categorise people's reasons for complaining into the following:

- ***Genuine concern*** – Where somebody has witnessed professional conduct that is so un-becoming of our profession as to make them feel duty bound to report it. Or that they have witnessed a 'harm' and are genuinely seeking to identify those responsible so they can be held to account.
- ***Personal or collective gain*** – This sounds more sinister than it sometimes is. For example, this may be somebody who wants to use our complaints process as a means of frustrating another process (such as a planning or permitting process), to safeguard something that has an intrinsic value – such as a local green space. It may, however, also be used to substantiate arguments around reasons for failure to pay fees or undertake additional survey work.
- ***Disruptive/malicious intent*** – In some instances a complaint may be made specifically and solely to cause disruption to a particular project, business or individual. This may be because of a personal or professional vendetta. And this is where we stray into the realms of complaints that are potentially vexatious or harassing in their nature.

Societal/cultural level

In addition to the circumstances surrounding an individual complainant (the practical and psychological), there are also wider contextual issues that may influence the recourse people choose. It would be almost impossible to list all of the potential externalities that may have an influencing effect but here are a couple of examples.

Political and media focus on environmental issues will have varying levels of influence, and the increased use of social media means people are much more aware of what is going on. And with this, issues of concerns receive a heightened level of public scrutiny and debate. It also means people are likely to have an increased awareness of the recourse options available to them.

We have also considered the extent to which the COVID-19 pandemic may have impacted more recently on the level of complaints. The impacts here may stem from a couple of things. Firstly, more people are likely to have been at home, with the potential to engage more with the media that will keep them informed of local issues. And secondly, there were observable increases in the extent to which people were out and about making greater use of their local spaces. This increased and direct exposure to issues on their doorstep may also be an influencing factor.

It is also possible that the evolution and improvements to our processes may have made an impact. And the increased visibility of outcomes of our complaints may have done something to convince people of the merits of complaining.

The relevance of motivation to our processes

Whereas all the above may be interesting, in terms of gaining a better understanding of 'why' people make complaints, and therefore what trends we may observe over time, it is equally important to note that when it comes to individual cases the motivation of the complainant actually has very little bearing.

As a quasi-judicial process, we have certain responsibilities, one of which is to maintain objectivity. When we are making our initial assessment of complaints (as the Preliminary Investigation Panels) we have to tread a line – between being 'motivation blind' and considering motivation to the extent that we can determine whether a complaint is vexatious or harassing in its nature. In other words, under normal circumstances we should not need to know what motivated the complainant, because we are solely concerned with the merits of the complaint as it is laid before us.

However, in some instances we may become so convinced that a complaint is intended to be vexatious or harassing to the subject that we may choose not to progress the complaint – and this decision is informed by a perception as to the complainants' motives.

To add further complexity to this, there are also instances where, while a complaint may be instigated for one reason (perhaps less positive in its motivation), we may subsequently find that it does have merit.

And fundamentally, although we need to be mindful of motivation, and the various pitfalls that come with it, we must also accept that we have limited influence over what motivates people.

Our complaints culture

As we delve into the detail of our complaints processes and the complaints we receive, it is all too easy to lose sight of why we have a complaints process in the first place.

Our role is to improve professional standards – not necessarily because of an overwhelming perception that professional practice is especially poor, but because continuous improvement should be central to the tenet of any profession. We operate in an ever-changing world, and so too must we evolve, adapt and improve in response to the change we see around us.

Of course, poor practice does exist, and as I have often reflected that we operate something of a 'carrot and stick' approach to tackling this. And it's worth noting that, through our training and development programmes, *In Practice* and numerous other member benefits, we invest significantly more into our 'carrot' offerings than we do our 'stick'. Essentially the complaints process is our backstop, the last resort for tackling poor practice and professional misconduct.

I also remain keen to stress, at every possible opportunity, we are not here to lambast and vilify people, or to give people a platform to torment or harass our members. Fundamentally, we are here to manage 'up' not 'out'. It is rarely our desire, or intention to manage people out of CIEEM – far from it! We are here to improve professional standards across our profession, and once someone leaves the Institute, we have lost our ability to influence their performance, and have lost another advocate for our wider cause, aims and objectives.

Evolution

Finally, I touched earlier on the evolution of our processes and procedures. And I have also talked about the need to evolve, adapt and improve. The same principles apply to our work in PSC. In my 10 years with the committee, I have been involved in and overseen numerous revisits of both our Code of Professional Conduct, and the principles, procedures and documents that underpin our complaints processes.

Every case we assess gives an opportunity to learn, and every time there is an important learning point we take the opportunity to review the way we do things. PSC, supported heavily by a committed and experienced secretariat, genuinely embeds the principles of continuous improvement in this area of work. And as a result of this we have a complaints process that not only stands up to external scrutiny but is considered to be one of the best in the professional body sector.

We will continue to evolve. And I hope that our membership continues to see the value in having a complaints process, which is ultimately there to protect us and our profession. Just know that it is very mindfully overseen by a group of dedicated people, who do it for all the right reasons – I shall miss them, and the world of CIEEM complaints.

About the Author

Ellie Strike MSc, BSc (Hons), CEnv, MCIEEM is currently Acting Head of Complaints, Investigation and Enforcement at the newly formed Office for Environmental Protection (OEP). Prior to that she has spent over 20 years working in the environment sector in public, private and charitable sector organisations. Ellie spent 10 years on the Professional Standards Committee, 6 of which were spent as Co-Chair. This year she has joined our Governing Board as Honorary Secretary.

Contact Ellie at: ellie.strike@theOEP.org.uk

Policy Activities Update

Amber Connett ACIEEM
Policy Officer, CIEEM

Summer recess is over and we are returning to lots of activity in environmental policy areas around the UK.

Despite delays to the biodiversity summit (COP15) which will now take place this winter, there have been continued talks to develop a new global biodiversity framework. This summer, we responded to a call for comments on the development of a long-term strategic approach to mainstreaming biodiversity and its associated action plan.

UK and England

In May, the UK Government introduced a Levelling Up and Regeneration Bill which introduces reforms to the planning system in England. One of the key reforms is the replacement of Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) with a new system of environmental assessment; Environmental Outcomes Reports (EORs). As the Bill stands at the time of writing, this will also affect the rest of the UK subject to consultation with devolved governments. We have written a short summary of measures in the Bill (www.cieem.net/what-is-the-levelling-up-and-regeneration-bill/).

We have written to the Department of Levelling Up, Housing and Communities to raise concerns that the new approach could remove opportunities to improve projects and plans as they are being developed, leaving only a retrospective assessment. We have also been engaging civil servants on the implications for the sector.

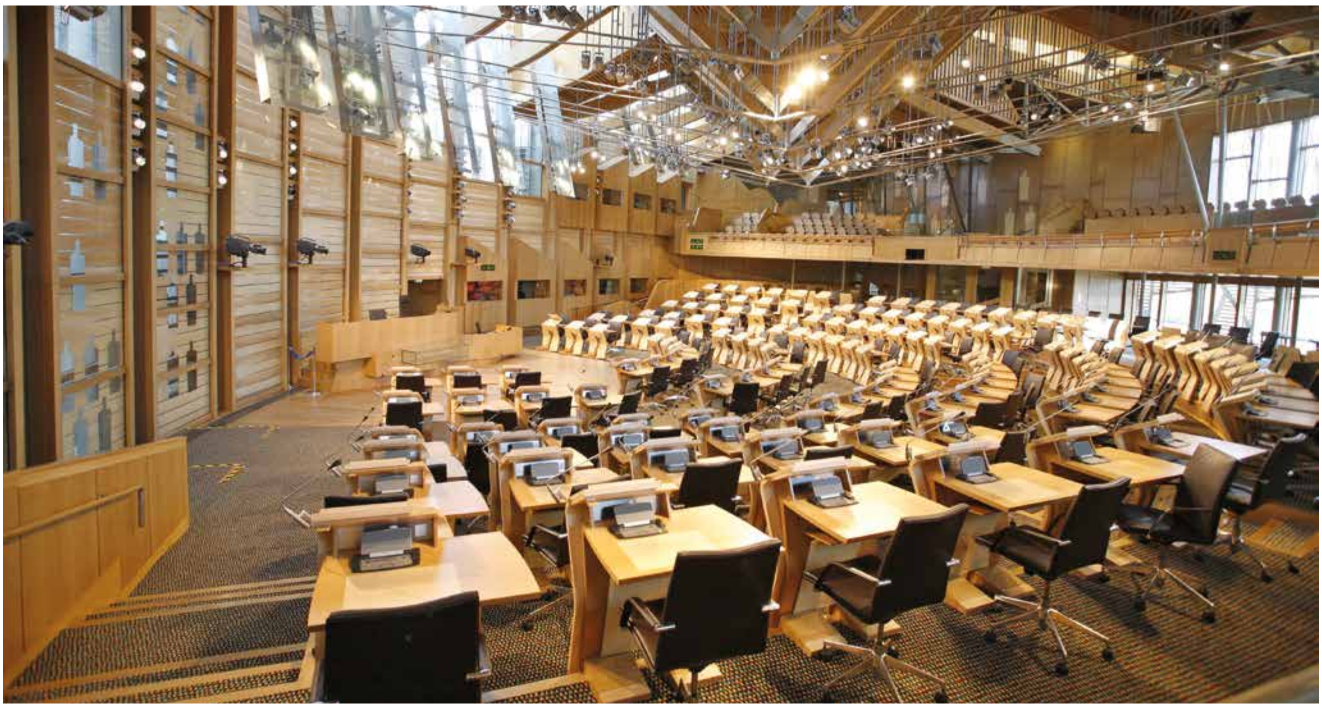
Back in the Spring, Ben Kite (Chair of CIEEM's Strategic Policy Panel) gave evidence to the House of Lords' Land Use in England Select Committee. The inquiry sought to determine whether there is sufficient capacity to deliver the Government's ambitions for climate and nature, and whether current systems support effective implementation of land use policies.

In August, our England Policy Group and marine experts from our wider membership responded to the Defra consultation on the principles of applying a mandatory Biodiversity Net Gain (BNG) to the marine environment.

We are delighted to have been invited to be a part of the UK Government's first ever dedicated group for creating green job opportunities, the Green Jobs Delivery Group. The group, co-chaired by Energy Minister Greg Hands, will support the delivery of up to 480,000 skilled green jobs by 2030 and will help ensure the UK has the skilled workforce it needs to build clean industries.

Scotland

A draft Biodiversity Strategy for Scotland was published in June, setting a new goal to end biodiversity loss by 2030 and restore biodiversity by 2045. We have been a member of the Biodiversity Strategy Development



Debating chamber, Scottish Parliament

Group and our Scotland Policy Group will be submitting a formal response to the consultation on the draft.

We have continued to promote the results of our survey of Local Planning Authority (LPA) capacity in Scotland by sharing a briefing with decision-makers that calls for sufficient training, access to expertise, and funding for LPAs to deliver biodiversity measures in NPF4 (Scotland's 4th National Planning Framework) and beyond.

In June, our Scotland Project Officer Annie Robinson met with Brian Whittle MSP for South Scotland to discuss Positive Effects for Biodiversity in planning and what is needed for Scottish Government to achieve it in a tangible, measurable way through NPF4. Brian Whittle is keen to engage with this issue and has raised questions in the Scottish Parliament.

Our Scotland Policy Group has also responded to Environmental Standards Scotland's draft strategy and we look forward to continuing to engage with the new organisation.

Wales

We recently published a briefing paper for ecologists and developers, setting out Welsh Government's approach to achieving 'Net Benefits for Biodiversity' in Wales and requirements for planning applications. We have continued to engage with Welsh Government on the issue of achieving tangible gains in biodiversity and ecosystem resilience.

As part of our membership of Wales Environment Link, we recently contributed to a briefing document setting out recommendations for the Ofwat Price Review 2024 calling for urgent action to protect and enhance freshwater and coastal systems, and restore our designated sites network. We have also contributed to a briefing on National Minimum Standards for farming and land management, and a letter to Lesley Griffiths on the same topic.

Ireland

Following our submission of a briefing document on the capacity crisis in the sector in Ireland to the Minister for Further and Higher Education, Research, Innovation and Science, Simon Harris, we were asked to send further information on how to address the issue. We are now calling for two key measures: the establishment of a Jobs for Nature Delivery Group, and funding to develop a training programme.

In June, we were approached by the Department of Agriculture, Food and the Marine to contribute to a Training Needs Analysis of the forestry licence applications process and we have now submitted our response..

Our Ireland Policy Group has recently responded to consultations on developing a Forestry Strategy and a Clean Air Strategy for the Republic of Ireland. They are continuing work in sub-groups on biodiversity in planning (including developing a briefing on Biodiversity Net Gain in Ireland), the climate emergency and biodiversity crisis, and agriculture and land use.

We are pleased to report we are now a member of Climate Coalition NI (CCNI). This group is a network of organisations and individuals working to facilitate cooperation between organisations working on climate change issues, locally and globally, in order to bring about appropriate action in Northern Ireland to tackle climate change.

Future priorities

Our priority for the coming months will be engaging with COP15 as an Observer organisation, and continuing to deliver proactive policy engagement on the green economy, natural capital, and data and evidence. Our Country Policy Groups will be responding to open consultations such as the Biodiversity Strategy in Scotland, and gearing up for forthcoming consultations on the Levelling Up and Regeneration Bill proposals.

All of our briefings and consultation responses can be found in our Resource Hub (www.cieem.net/resources-hub) under 'Policy Resources'.

Contact Amber at: AmberConnett@cieem.net

CIEEM is grateful to the following organisations for investing in our policy engagement activities:

ARCADIS Design & Consultancy for natural and built assets
RSK biocensus EXPERTS IN ECOLOGY
EPR
Stantec

Autumn and Winter Training Programme

Craig Willcock
Professional Development Manager, CIEEM

With survey season coming to an end, now is the ideal time to look at opportunities to upskill and further develop your knowledge and understanding in key areas. In support of this, the CIEEM training programme provides a range of courses at beginner, intermediate and advanced level which are delivered by a team of trainers with specialist skills and expert knowledge. The programme includes in-person field-based practical courses, classroom-based courses and courses delivered online.

Some upcoming highlights include:

- **Peregrine Falcon Ecology, Survey and Mitigation**
(21 September, Birmingham)
This course provides participants with the skills to undertake surveys, produce relevant and rational reports in line with national guidelines, and to advise on developments in respect of ecological constraints and mitigation measures.
- **Identifying and Managing Non-native Invasive Plant Species**
(5 & 6 October mornings, online)
An overview of what non-native, invasive and invasive non-native species are and why they may be a problem, then looking at the legislation listing these and control measures. For each taxon on the course will look at ecology and dispersal, survey techniques, sources of up-to-date information, reporting and devising mitigation measures. The course will also look at control measures, proposing on-site mitigation, writing and implementing management plans, and associated control measures on active sites.
- **Introduction to Nature Conservation Legislation in the UK (England)**
(12 & 19 October mornings, online)
An introductory level review of nature conservation legislation, looking at how the current framework translates to practical actions, and considering how effective it is in achieving its aims. Delegates will develop a strong practical understanding of the system of nature conservation governance in England, and how the new laws and policies impact the work on the ground.
- **Conifer Identification for Ecologists**
(19 October, West Midlands)
This course will help you recognise the major types of conifers, and start to separate the many species.
- **Winter Tree ID: Extending The Season in Ecological Surveys**
(7 December, Shrewsbury)
An introduction to winter tree identification, focusing on key characters to distinguish each species from similar looking plants.

For the first time since before the COVID-19 pandemic, we are now able to offer the **Train the Trainer for Ecologists** course which is being delivered on 4 and 5 October in London. This unique 2 day training course has been created to support ecologists and environmental professionals in developing techniques for designing and delivering field and classroom-based training courses. The training course is suitable for experienced trainers wishing to enhance their skills, as well as for those new to training wanting guidance in achieving a professional standard of tuition.

The training includes sessions on planning your learning objectives, matching a range of different learning styles, strategies to ensure tuition is learner focused, techniques for working effectively with mixed ability groups and ideas for checking delegates have met their learning goals.

Feedback from previous attendees has been positive:

- *"Train the Trainer was a very useful course. It equipped me with a range of practical techniques that help me ensure engagement and deeper learning for delegates." – Matt*
- *"Even after delivering training courses for over 15 years I found the Trainer the Trainer course very useful." – Hazel*

Other upcoming courses include: Biodiversity Metric V3.1 training, Beginners QGIS for Ecologists and Conservation Practitioners, Intermediate QGIS for Ecologists and Environmental Practitioners, Preliminary Ecological Appraisal, QField for Ecologists and Environmental Practitioners, Eurasian Beaver Ecology and Restoration, Ecological Report Writing, Developing Skills in Ecological Impact Assessment (EcIA) (England & Wales), Positive Planning for Biodiversity, Water Vole Mitigation, Introduction to Bat Ecology and Bat Surveys, Plant Identification and Botanical Keys, and more.

To view a full list of training courses we have to offer visit www.cieem.net/events

Contact Craig at: CraigWillcock@cieem.net

Do You Have What it Takes to be a Mentor?

Craig Willcock
Professional Development Manager, CIEEM

The role of a mentor

A mentor is someone who will encourage and support a person to make the most of their career and develop their skills. They do this by providing impartial, non-judgmental guidance and support. A mentor's role isn't to tell a mentee what to do, it is to act as a guide. Mentors aren't expected to have all the answers.

Who could become a mentor?

If you are a CIEEM member then you can sign up to become a mentor. You can be at any grade of membership, at the start of your career or even retired, in any role and from any sector. The main requirement is that you are able to commit time and effort in developing a relationship with a mentee.

Other qualities we are looking for are: helping others to reach their potential, a desire to make a difference, willingness to share your knowledge and experience, an approachable manner, and good listening, questioning and feedback skills.

What does the role entail?

- Exploring different scenarios with a mentee, widening their perspective and encouraging them to look at aspects they may otherwise not have considered before helping them to choose the most appropriate course of action for them.
- Acting as a sounding board for new ideas, listening and discussing personal and work issues that may be having an effect on their professional life.
- Asking probing and stimulating questions.
- Providing honest and constructive feedback and ongoing support and encouragement.

The time commitment can vary depending on the nature of the mentoring relationship and goal, but can be 30 minutes a week, an hour every 2 weeks, or even monthly. The duration and frequency would be agreed between you and the mentee at the start of the relationship to suit both parties. Meetings can be held online via the built-in video chat on the mentoring platform, or via MS Teams, Zoom, phone or even face to face if feasible.

Why we need your support

All CIEEM members are able to use the mentoring platform as part of their membership. However, the mentoring platform is only possible due to the support and dedication of our pool of mentors who volunteer their time to help others.

At present we have 120 mentors who are currently supporting 346 mentees, so we are keen to encourage more of our members to consider becoming a mentor. If we have more mentors available, then we can offer more of our members the opportunity to receive valuable support and advice. We are also looking to increase the range of expertise being provided to further develop the support available.

How you can help

We are looking for mentors from across the UK and the Republic of Ireland covering a range of specialisms including: becoming a Chartered Ecologist, people management, managing work/life balance, project management, business management, ecological impact assessment, upgrading membership and progressing/starting your career.

You can be from any sector, but in particular we would be keen for more mentors from academia, industry, consultancy, local government and NGOs.

We are keen to provide mentoring to final year and recently graduated members to help them with the transition from study to finding their first job. If you are a Qualifying or Associate member, then we do encourage you to sign up as a mentor as being at the early stage of your career you will be able to offer valuable support and advice to those joining the sector. More Fellows and Chartered members would also be welcomed to help provide support for those at mid and senior career stages.

How you can also benefit from being a mentor

- Develop your own problem solving skills
- Being able to pass on personal knowledge and experience
- Having the chance to give something back
- Gain the chance to work on new and exciting challenges
- Build new connections outside of your current organisation
- Feeling that you have been able to support someone else in their career
- Opportunity to develop your ability to empathise and build rapport with others
- Help with your own career progression as you will develop coaching, leadership and inter-personal skills

Do you think you have what it takes to be our next mentor?

If you are feeling inspired and would be willing to share your skills and experience with others, then why not take a look at our Mentoring Platform (https://cieem.net/i-am/continuing-professional-development/mentoring-platform/) to discover the support available and how to sign up.

Join us on 27 October for a special webinar to celebrate National Mentoring Day.

Contact Craig and the team at:
mentoring@cieem.net

Welcoming a New Fellow

The Governing Board was pleased recently to approve the nomination of Dr Graham Russell as a new Fellow.

Dr Graham Russell FCIEEM(rtd)

Graham Russell's CIEEM Fellowship has been awarded due to the extent to which his work has influenced the evolution of policies and legislation. Through his research portfolio, Graham became increasingly involved at the interface between scientific knowledge on the one hand and policy-making and implementation on the other.

He was co-leader of the quantitative modelling work package of the EU FP6 Integrated Project SEAMLESS and has also worked extensively in marine planning. Graham is currently the Planning and Environment Officer for RYA Scotland, and has also provided input to the National Marine Plan and, as part of the Clyde Marine Planning Partnership representing RYA Scotland, he has influenced the Clyde Marine Plan. Graham reviewed the RYA sustainability strategy to identify places where legislation and other matters were different in Scotland. This led to the RYA Scotland Sustainability Strategy and Action Plan, which he largely wrote.

Graham has worked with statutory agencies to share knowledge and is also a current member of the Forth Estuary Forum Management Committee, a former member of the Marine Strategy Forum of Marine Scotland, and a former member of the plenary group of the Scottish Coastal Forum. This latter stakeholder group advised Marine Scotland, from an operational perspective, on the development and implementation of policy relating to marine planning and licensing within a sustainable marine environment.

In addition, Graham has amassed over 50 years of experience in ecology and land use systems, mainly working in

academia, and has remained actively involved in environmental management since his retirement in 2009.

Do you know a CIEEM Full member who ought to be a Fellow? You may not know that it is now possible to nominate members for consideration for Fellowship of CIEEM. For more information visit www.cieem.net or contact the membership team: membership@cieem.net

From the Country Project Officers

Annie Robinson – Scotland Project Officer

Hello everyone

From speaking to members, it sounds like it has been a very busy summer season. From my days doing fieldwork I remember thinking – "wow I get paid to do this" when it was glorious sunshine to "thank goodness I get paid to do this" when it was blowing an absolute hoolie with horizontal rain. I hope the weather has been kind to you wherever you have been out and about across Scotland. I love seeing your pictures on LinkedIn and Twitter.

It was great to get back to in-person Member Network events with a visit to Black Law Windfarm looking at 10 years of peatland restoration. Thanks to Rachel Short and Peter Robson from ScottishPower Renewables. Prior to that we held the brilliantly entitled Member Network event – 'Can you hear me? Oh, I'm muted!' Thanks to Ashleigh Kitchiner and Claudia Gebhardt for giving us a fascinating insight into bioacoustics and echolocation by cetaceans and bats. See Member Network news (page 79) for write-ups from both events. We are busy planning lots of events for our Scottish members this autumn/winter so hope to see you there.

Our Scotland Policy Group members have been busy inputting to consultation responses on Environmental Standards Scotland Draft Strategic Plan and Scotland's Biodiversity Strategy consultation.

We are looking forward to seeing you at the CIEEM Autumn Conference – Delivering a Nature Positive, Carbon Negative Future – in Edinburgh on 23 and 24 November 2022. Find out more at www.cieem.net/events.

Thanks, Annie

Contact Annie at:
AnnieRobinson@cieem.net

Elizabeth O'Reilly – Ireland Project Officer

Hello CIEEM members

I hope you all had a good survey season and that quieter times are ahead. CIEEM has recognised the additional strains on you at the minute as the sector experiences a capacity crisis across all nations. Here in Ireland, we have been making some efforts towards addressing this. We have written to Minister Varadkar to request ecologists and environmental managers are added to the Critical Skills List, and have been working with other organisations on the possibility of establishing an apprenticeship for the sector. In addition, we have been communicating with the Department of Further and Higher Education, Research and Science on other support that we can access. We hope to have further details on these activities by the next edition, but don't hesitate to get in touch with me if you have any questions or input.

In addition to this, we have been working on pulling together some events and activities for our Irish members this autumn. Our Lunchtime Chat Series will return at the end of the month, and we are looking forward to hosting more in-person events before the year is out.

As the Irish Section grows, we look forward to working with our members to support and build a stronger sector in Ireland.

Until next time, goodbye from Ireland,

Liz

Contact Elizabeth at:
Elizabeth@cieem.net

Mandy Marsh – Wales Project Officer

S'mae pawb/Hello everyone

The bryophyte and lichen theme of this edition of *In Practice* reminded me that in 2009 I was briefly part of the Lichen Apprentice Scheme Wales. This was set up by Welsh Government following a suggestion by Ray Woods of Plantlife, as a solution to the dearth of expert (and younger!) lichenologists, not just in Wales but generally. Some went on to become experts, others gained a general grounding in the importance of lichens. We know that there is a skills shortage in ecology and environmental management and that many of our members have been extremely busy over the summer season. It's worth looking at the Welsh Government's apprenticeship scheme, covering all professions, with a view to training up the next generation. Find out more at https://gov.wales/apprenticeships.

With so many of our volunteers, both organisers and speakers, busy surveying throughout the summer, there's been a lull in Member Network events. Keep an eye out on the website for a renewed Autumn and Winter programme, and don't forget that CIEEM members can access all past recorded talks via the My CIEEM section of our website. We also have many publicly available talks on our YouTube channel – just search for CIEEM.

Our Wales Policy Group members continue to input responses to the Welsh Government's Deep Dive into Biodiversity, the Ofwat Price Review 24 process, and the Sustainable Farm Scheme and National Minimum Standards proposed by the Agriculture Bill. The Bill is expected to be laid by the end of September.

Hwyl, Mandy

Contact Mandy at:
MandyMarsh@cieem.net

British Ecological Society

The Interdisciplinary Future of Ecological Forecasting

Charlotte Harrison-Littlefield

Bringing together ecologists and climate scientists has always excited Dr Vicky Boult. With the climate and ecological crises looming, now is the time to unite these historically separate disciplines.

The fields of climate science and ecology are clearly interconnected: climate affects the presence and abundance of species in an ecosystem, while ecological processes feed back into the climate. Yet these disciplines have been kept apart in the past. A joint meeting between the British Ecological Society (BES) and the Royal Meteorological Society (RMetS) in May provided a new opportunity to establish interdisciplinary connections between ecologists, meteorologists and climate scientists. Researchers and practitioners united under one roof to discover a way forward for this emerging field.

Dr Vicky Boult, Knowledge Exchange Fellow from the University of Reading's Meteorology Department, was one of the conference's pivotal organisers. She shares her passion for incorporating climate science modelling into ecological forecasting.

"Anyone interested in the future of ecology and biodiversity should put ecological forecasting on their agenda," she says. "Funding is moving towards applied science, science with impact. Now is the opportunity to bring together these interdisciplinary networks."

The journey so far

The power of ecological forecasting is elevated when fed with the knowledge and expertise of climate scientists, Vicky explains. "In the USA, harmful algae blooms are an increasing concern for lake management," she says. Sophisticated forecasting models have been developed to predict the

BES 2022 Symposium, Climate Science for Ecological Forecasting. Photo credit Grace Foulds.

emergence, flow and movement of blooms. The models consider temperature and ocean currents as well as the impacts of environmental conditions on ecological factors. "The predictive model provides an early warning system to forewarn visitors of the dangers of swimming during bloom events."

Having always been interested in ecological forecasting and predictive ecology, Vicky explains the opportunities that interdisciplinary collaboration brings. "Climate science has been doing this for decades: weather forecasting informs everyday decisions we all make, while climate projections are increasingly used in decision-making, planning and conservation."

"When I first moved into a meteorology department it was a massive learning curve. I had no idea these data were available. As a PhD student in ecology, I used some climate projections for modelling elephants, but there was so much more I could have done that I didn't know was even possible. There is a real need to share knowledge and data across disciplines."

Facilitating interdisciplinary research

Interdisciplinary science, bringing people with diverse backgrounds together, has enormous potential to improve our understanding of the world. Yet it is often seen as a challenge. There was little history of collaboration between climate scientists and ecologists – the Climate Science for Ecological Forecasting conference had to be pulled together from scratch. So how did Vicky and the other organisers set about bringing communities together to kickstart conversations and breakdown barriers? Part of the answer is drawing on the power of societies like the BES to bring people together and increase the reach of such efforts.

At the BES annual meeting last year, Vicky and colleagues ran a workshop to identify the main barriers preventing collaboration. "Going into that first experience it's crucial not to make any assumptions, you must be open to listening," she says. "One of the big barriers that comes out is language. We are all talking different languages and throwing around different fragments of scientific jargon."

Since the May conference with RMetS, work is underway to address these barriers through the development of an introductory seminar series, glossaries of key terms, and a 'database of databases' to improve access to the decades of knowledge and data available in both ecology and climate forecasting.

"Ecological forecasting has value in practical ecology," says Vicky. "We're already seeing the impact of climate change and increasing extreme weather events on species around the world. A better understanding of the forecasting models and data available will be increasingly valuable to ecologists in ensuring the best mitigation and management strategies are in place."

By joining these discussions, researchers and practitioners can play a crucial part in bringing ecological forecasting to the forefront of future management and policy decisions.

Find out more about Vicky and her work at: https://vickyboult.com/

By Members ForMembers

Election season in approaching, and Member Networks need your help. Be part of something amazing!

Our CIEEM Member Networks and Special Interest Groups require enthusiastic and proactive CIEEM members to remain active in supporting members and influencing the sector. This autumn, please take an active part in the Member Network regional elections, and be the spark that inspires your local CIEEM group to go further!

Volunteering for your regional or national CIEEM Member Network can deliver a great number of advantages for you personally including contributing towards your CPD requirements, helping you stand out from the crowd when looking for employment opportunities, as well as providing you with the chance to get involved with lots of great initiatives and projects. There will be opportunities to share your knowledge and learn new skills along the way. You will be able to network with lots of different people involved in many areas of ecology and environmental management, and also be able to help influence the future of CIEEM and the ecology and environmental management profession.

CIEEM Member Networks are a vital part of the Institute's work because they enable networking between professionals in the sector linked together by region/country. Member Networks can showcase the very best case studies illustrating positive work on specific species, habitats and hot topics within ecology and environmental management, through the medium of webinars, workshops and site visits. They can influence the next generation of ecologists and environmental managers by engaging with universities, delivering talks to students and having 1:1 discussions at careers fairs about life in the sector. They can even get involved with policy work with assistance from the Secretariat, and share their passion for specific topics with members via *In Practice* magazine and writing online blogs for the CIEEM website.

Does the above sound good to you? If so, please do not hesitate to take part in the autumn elections this year to recruit new members to your local Member Network committee. Remember, as a committee member, you will be able to take an active role in the work of the committee in the subjects and focus areas that are most important to you. To discover which Member Network roles are available in your area, please visit the Volunteer Opportunities page in the My CIEEM area of our website.

North East England Geographic Section

Woodland Creation Challenges

Back in April 2022, held in conjunction with the Institute of Chartered Foresters, the North East England Section held a successful event delivering relevant presentations and visits to two large-scale productive woodland creation projects in the Rothbury area of Northumberland, to foster a healthy discussion on meeting the Government's tree planting targets while also meeting environmental constraints. The area hosts multiple Sites of Special Scientific Interest (SSSIs), particularly due to the wealth of rare flora found there.

The day provided an opportunity to debate the current situation, for members of both organisations to air their perspectives on the issue of creating both a biodiverse and commercially viable forestry, and help build constructive working relationships so that such schemes can also meet the challenge of the climate crises.

Scotland Geographic Section

Can you hear me? Oh, I'm muted!

At this Scotland Member Network event, we heard from experts examining bioacoustics and echolocation by cetaceans and bats. It focused on the process and mechanisms of echolocation, and the impacts that anthropogenic activities may have on these fascinating creatures.

The group was treated to an excellent talk by Claudia Gebhardt, the Scottish Bat Officer with the Bat Conservation Trust. In her role as Scottish Bat Officer Claudia is supporting bat groups in Scotland, providing training for bat surveys skills, as well as enthusing and engaging people about bats and taking part in bat surveys.

They also heard from the brilliant Ashleigh Kitchiner, a Senior Marine Mammal Consultant at APEM Ltd. Ashleigh works with many organisations to create marine mammal risk assessments, monitoring survey plans, mitigation protocols and much more.

Noctule bat (*Nyctalus noctula*)

Ten years of peatland restoration at Black Law Windfarm

The Scottish Section welcomed back the opportunity for in-person events again with a much overdue visit to Black Law Windfarm to see the results of peatland restoration carried out there over 10+ years. The site visit was very informative and a big thanks to Peter Robson for talking us through the various operations, results and research undertaken at the site. Having seen the ex-forestry sites in such poor condition prior to restoration, I thought the results were particularly impressive over a relatively short space of time. In addition to the technical discussions, I heard comments from various attendees at how good it was just to be back mixing and networking with like-minded people and that is such an important part of these events.

Thanks to everyone who attended and a big thanks to Peter, Rachel Short and the other ScottishPower Renewables staff for hosting our first in-person event for over 2 years.

Matt Pannell, Scotland Committee Convenor

East Midlands Section

A summer stroll through Bunny Old Wood

The East Midlands Member Network met up at Bunny Old Wood, Nottinghamshire, for an evening walk on one of the hottest days of the year! Bunny Wood is an ancient, coppiced woodland referred to in the Domesday Book and was probably used by Saxon settlers as a source of wood. In 1487, Henry VII and his army camped nearby on their way to the Battle of East Stoke.

It was an insightful evening walk with a fantastic opportunity for sharing knowledge, networking, learning about woodland management and enjoying the beautiful surrounds. The Member Network were joined by Dr Chris Terrell-Nield, who manages the woodland on behalf of Nottingham Wildlife Trust. Chris shared the history of the woodland as well as how the woodland is managed in the present day. Great and lesser spotted woodpeckers are among the 50 bird species recorded at the site, while field maple, dogwood, foxglove and bluebell make up some of the diversity of flora of the woodland.

From the CIEEM Patrons

Creative Cultural Encounters Towards a Collaborative World

Judy Ling Wong
Painter, Poet and Environmental Activist

There is no such thing as a purely environmental initiative. A so-called purely environmental initiative is one that has rejected its social, cultural and environmental context. When we think locally and globally, issues of diversity, equality and inclusion necessarily come to the fore. There are issues of diversity, equality and inclusion within nations, and there are issues of diversity, equality and inclusion set within the relationship between nations. Purposeful cultural encounters can contribute to building better multicultural collaboration nationally and internationally, fueling innovative and culturally appropriate sustainable solutions.

There is a world of diversity in every country. The people that we call ethnic minorities in the UK are in continuity with global ethnic majorities. White people make up only 11% of the world population. By giving a focus to cultural encounters and building working relationships with ethnic communities, members of dominant populations can look forward to acquiring an ease of cultural contact, and gaining intercultural skills that can facilitate the effective negotiations and collaborations that we wish to see locally and on the world stage. Our ethnic minorities are like the living world news. Their stories are told from a place of heart, through day-to-day connections with family and colleagues across the world. These can bring us closer to what we need to know in order to work well cross-culturally.

Besides bringing all of us closer to the world-wide lived experiences that can move us and help us to work from a place of identification, there is also the inspiration of cultural visions of nature that can inspire us to work from a place of deep visceral, emotional and spiritual connections. In the early days of Black Environment Network, a group of Bangladeshi women asked us to look for a space for them to grow some vegetables. At the end of the project, there was the usual evaluation and we asked, "What is the best thing about this project?" Typical answers would have been the pleasure of fresh food, being in the outdoors or making friends, but their answer blew me away. They said, "The best thing is that our bare feet are once more upon our Mother, the Earth." A few years ago, when I was in Mexico, I met people from the Huichol tribe and one of them said to me, "In the West you talk about Mother Earth, seeing her as mother just because she is seen to feed you, but for us, there is also Grandmother Moon. There is Father Sun and Brother Deer…. When we take care of the environment, we are only taking care of our family." Many cultural visions of nature carried by our ethnic minorities inspire and challenge us to rethink our connection to nature. The impact of cultural visions is not about receiving something completely new. It is more about reawakening something we too felt a long time ago on our developmental journey and that we have lost as society in the Global North has become more mechanistic and science-based.

We can invest in cultural encounter and in the building of working relationships between environmental professionals and ethnic minorities, paying particular attention to supporting both parties' capacity for creativity. Creativity opens out expression, communication and the ability to re-imagine scenarios. Bringing in creatives to work alongside environmental professionals can help to unlock the power that may be released when those who are affected are included, supported and enabled to contribute from their lived experience towards the transformative solutions that we need to address climate change.

I look to environmental professionals to purposefully engage with ethnic minorities, building capacity and shaping the processes, to create a quality of energy that moves us within a multicultural context, so that we can re-imagine the world together, moving it towards the culturally informed transformative ideas that we need so much right now, locally and globally, for meaningful collaboration. When we are richly engaged, we are inspired to work hard together towards a sustainable green future for all of us.

About the Author

Judy is a painter, poet, environmentalist and expert advisor on multicultural environmental participation. She is probably best known as the Honorary President of Black Environment Network (BEN). For 27 years she was the UK Director of BEN, with an international reputation as the pioneer and creator of the field of multicultural environmental participation in the built and natural environment. Judy is a major voice on policy and practice towards social inclusion. She is recognised as a visionary advocate for diversity and equality. She was awarded an OBE for pioneering multicultural environmental participation in 2000, and a CBE for services to heritage in 2007. Recently, she was included in the BBC Power Women List 2021, and the Forbes List of 100 Leading Environmentalists in the UK 2021, Climate Reframe List of 100 best-known UK BAME activists.

Foot in the Door: Step into the Sector

Drew Lyness
Volunteer Engagement Officer, CIEEM

In late June, CIEEM were pleased to host a student and early career webinar, focusing on top tips for applying for jobs in the sector. Members of the CIEEM Secretariat – Krystie Hamilton, Drew Lyness and Saz Hayward – were joined by professional recruiter Catherine Bunting, from Hill and Jago Recruitment, who specialise in the environment sector. Usually focusing on more senior level positions, Catherine works with leading small- to medium-sized environmental consultancies across the UK. She is a passionate environmentalist who enjoys supporting graduates and early careers professionals with careers advice and coaching. Here is a summarised version of the advice that Catherine and CIEEM provided during the webinar, to help driven individuals to break into the ecology and environmental management sector.

Finding the perfect opportunity

Before taking any of the processes below any further, it is vitally important you consider what you want from a career. Think about practicalities and potential impacts on your life outside of work. Choose the correct working environment for you. Work may involve reaching remote outdoor locations, nature reserves or remaining office-based, at home and everything in-between. Some roles may require working anti-social hours and considerable travel time, so before committing to anything, consider whether this fits with your weekly life. Talk to lecturers and course leaders at your higher education institution, as they can provide insight into life in the sector, or put you in touch with those who know about specific areas and career types.

Once you have decided, do your research into which organisations and companies are based in your desired area. You can often reach out to them through LinkedIn, or if not, contact them by email to find out more about them and their mission. Seek further information about a specific role if you have one in mind. Focus on how the role might fit into the bigger picture. You could search for past and present employees on LinkedIn too, to ascertain opportunities for development. You may even get an idea of staff turnover.

Attracting attention: all eyes on you

When applying for a job, take time to ensure your CV stands out from the crowd. Remember, all graduates have a degree. Think about what sets you apart, and what drives you to pursue a particular job. Keep your CV concise (two pages at the most) and split into clear sections. Recommendations for structuring a CV can be found in the CIEEM Resource Hub. Writing a cover letter is strongly advised, even if the application does not specifically require one. Your letter and CV should be structured to answer why you are getting in touch, why you are suitable for the job and what you feel you can bring to the company/organisation. At the end, reiterate how your ambitions link to the mission of the role being applied for.

While being able to demonstrate impactful volunteering for a related organisation or project is highly valuable, not everyone has the time or resources to do this. Remember to consider transferrable skills from paid jobs which may apply, and mention these in your application. If you are able to volunteer, be wise about where you do this and how it might help you build a network of useful connections or gain new skills. Volunteer for something you are passionate about! This will help you remain interested and motivated. Organisations will recognise high motivation, and that may lead to an offer of paid employment down the line.

Stay focused, stay true

Be organised when applying for jobs. Keep a log of roles you have applied for. If you can, find out who key decision-makers might be, and add them to your LinkedIn profile if you have one. If you don't hear a response from an organisation, follow up and find out why. Remember to tailor your CV and covering letter to each role, so that it remains targeted and relevant. Call

companies to ensure your application has been received, if applying online. Personal communication gets you noticed and illustrates a proactive approach. If an application is rejected, don't let it get to you! Each rejection just means you are one step closer to the role that you want. If you need further advice as you feel you might be getting something wrong, seek further help and guidance. In the sector we are all one team and will support each other when asked.

Thriving under interview

If your interview is online, ensure you have a strong internet connection. Keep your background clear so attention can be kept on you. Complete your research on the organisation interviewing you. Be aware of what you can bring to the table, and also what you might like to get out of the role. Think about relevant scenarios where you have demonstrated the skills required on the role profile, especially where a positive impact can be shown. Think about how your examples show an ability to learn and adapt. At the end of the interview, confirm you are still interested in the role (assuming you still are) and ask the interviewers what the next steps will be.

Honest review post-interview

Before you hear back, send an email to interviewers to thank them for their time. If you receive a job offer, fantastic! Take the time to read through the terms of the role, and ensure you understand everything you need to know before responding. If you receive a rejection, don't be disheartened. Contact the organisation to ask for feedback, and (if you can) find out what made the chosen candidate stand out. Keep going, but make sure you take an occasional day off so you can relax and check in with yourself. If you are still struggling after several applications, ask for further advice from experts in the sector. Consult with the careers service at your university or college (if you have one) as they may be able to provide further useful information.

Further support from CIEEM

Make use of CIEEM's Continuing Professional Development (CPD) tool, and keep track of the skills and knowledge you build from training, volunteering and other activities. CIEEM can offer great opportunities for networking, so be sure to get involved with regional Member Networks and Special Interest Group activities. You could also get involved with CIEEM's mentoring scheme as a mentee, where you would be matched with a suitable volunteer mentor based on your personal and professional development goals (for more about the mentorship scheme, see page 75 of this issue). Additionally, if you are a student CIEEM member, you can apply to receive one of five free places to attend a national CIEEM conference. There are lots of opportunities here, so don't miss out. Once you've taken the first step on the career ladder, do join up with the newly created CIEEM Early Careers Special Interest Group. This group exists to support you as you settle into life in the sector, so do get involved where you can.

About the Author

Drew develops and assists CIEEM's brilliant volunteer community, so that they can continue to make positive impacts in all areas of our Institute. Drew is an Ecology BSc(hons) graduate from UEA and has previously worked for the RSPB supporting its volunteers and community groups in Eastern England. He is a highly passionate birder and naturalist, based in Norfolk.

Contact Drew at: DrewLyness@cieem.net

BOOKS, JOURNALS AND RESOURCES

Compiled by the Academia Special Interest Group

Paper Review OPEN ACCESS

Nutrient fertilization by dogs in peri-urban ecosystems

De Frenne, P., Cougnon, M., Janssens, G.P. and Vangansbeke, P.

Ecological Solutions and Evidence, 2022, 3(1): e12128

https://doi.org/10.1002/2688-8319.12128

These authors calculated the nutrient input from the dogs visiting four peri-urban nature reserves around the city of Ghent in Belgium over an 18-month period. The research was prompted by the recent dramatic increase in dog ownership combined with the access to nature agenda acknowledging the health benefits of outdoor exercise. The research involved observing the number of dogs visiting the areas combined with data in the literature urinary and faecal output to calculate that nutrient input could be as high as 11 kg nitrogen and 5 kg phosphorous per hectare per year, with the later mostly from solid waste. The potential impact on vegetation, with this input additional to atmospheric nitrogen, is significant although deposition is not evenly spatially distributed but likely to be concentrated along pathways and in high-use areas. The authors stress the importance of considering this issue in management plans and discuss the implications for management. If dogs are kept on the lead rather than allowed to roam freely the likelihood of owners collecting poo and disposing of it responsibly is increased and this is estimated to remove over 50% of the nitrogen and 97% of the phosphorus. Communicating the implications of failing to do this for wildlife, rather than the health and hygiene messages commonly used, may be a more effective encouragement.

Paper Review OPEN ACCESS

Principles for the production of evidence-based guidance for conservation actions

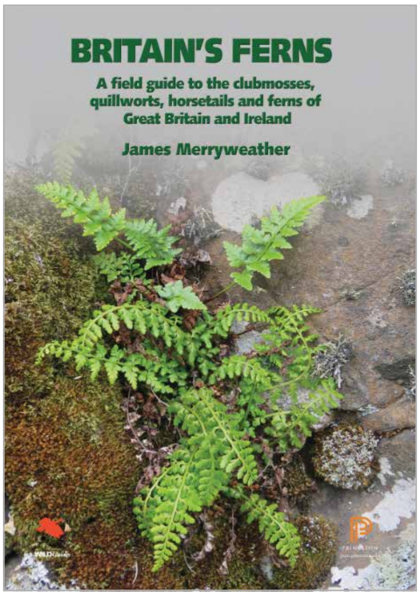
Downey, H., Bretagnolle, V., Brick, C. *et al*

Conservation Science and Practice, 2022, 4: e12663

https://doi.org/10.1111/csp2.12663

Conservation guidance documents can offer consolidated advice, and its adherence can often form part of licensing or other aspects of regulatory compliance in relation to protected species or habitats. This research involved a review of conservation guidance for mitigation and management of species and habitats in the United Kingdom and Ireland. The study identified and reviewed 301 examples of guidance, of which only 29% provided a reference list, and only 32% (9% of all the guidance reviewed) had references that were relevant to justify the recommended actions. Much of the guidance also lacked methodology for production, did not list uncertainty of, or lack of evidence and was often outdated. The review concludes that a lack of up-to-date and evidence-based guidance can lead to misguided and ineffective conservation action and policy as well as poor decision making and wasted resources. To combat this and enable more effective conservation practices, the paper presents a set of principles to follow that would ensure relevant evidence is incorporated into future conservation guidance.

Book



Britain's Ferns: A Field Guide to the Clubmosses, Quillworts, Horsetails and Ferns of Great Britain and Ireland

Merryweather, J., 2020. (Vol. 15).

Princeton University Press, Woodstock.
ISBN: 978-0-691-18039-7

A useful field guide for those interested in identification of British and Irish ferns and their allies. This book includes attractive illustrated keys and a significant range of coloured photographs, often showing morphologically similar species side by side and tabulating critical features. For anyone who has struggled with identification of *Dryopteris* species, the text offers psychological support in the justification of 'walk on by' specimens, individual ferns that through apomixis and hybridisation may defy identification. In biology, not everything can be readily determined but it is rare to see that admitted in a field guide. Such honesty makes it easy to warm to this book; it offers encouragement. Coverage of seasonal variation and unusual habitats such as drainpipes also make this guide fun to read.

Paper Review OPEN ACCESS

Nature's contributions to people and peoples' moral obligations to nature

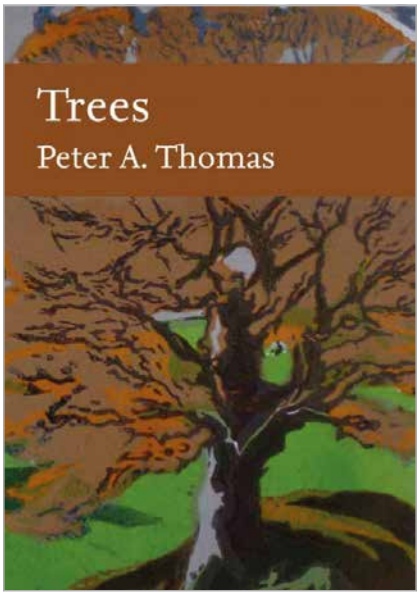
Piccolo, J.J., Taylor, B., Washington, H. *et al*

Biological Conservation, 2022, 270, 109572

https://doi.org/10.1016/j.biocon.2022.109572

In this timely article the authors reflect on the second session of COP15 (now confirmed for December 2022), which aims to implement ambitious measures to stop biodiversity loss with the ultimate goal of establishing harmony between humans and nature by 2050. They argue that achieving these aims is currently hampered by the separation of humans from nature, citing conservation scientists as responsible for continuing this paradigm. They are specifically critical of the ecosystem services approach, challenging the notion that this helps to make conservation activities more socially and culturally inclusive. They argue that in order for conservation initiatives to move forward and effectively address the extinction crisis neither technical advances nor policy measures will be enough without challenging anthropocentric assumptions and radically changing the way we view and value nature and other species. While most of us will agree wholeheartedly it was perhaps surprising – and illuminating – to be reminded just how embedded anthropogenic values are in high-level organisations. The authors concluded by urging the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), to address this issue in future work and focus on promoting a more inclusive approach based on intrinsic values and ecocentrism. For those without the time to read the full article a summary has been published in *The Conversation,* available at https://theconversation.com/conservation-science-still-rests-on-how-animals-can-benefit-humans-184671.

Book



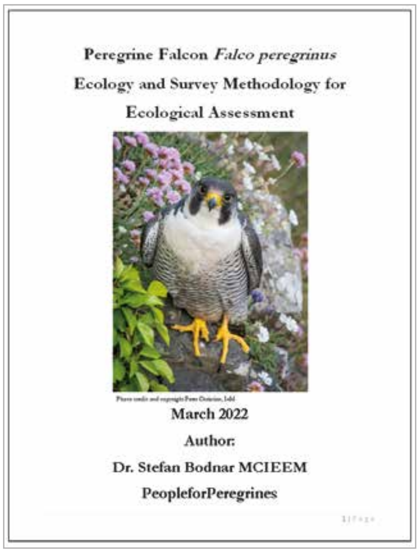
Trees

Thomas, P.A., 2022.
(The New Naturalist Library #145)

HarperCollins. ISBN: 9780008304539 (pbk), 9780008304515 (hbk)

This much awaited latest edition of the New Naturalist Library follows on from Rackham's (2006) Woodlands (book #100). In Chapter 1 'setting the scene' Thomas explains the inclusive approach of the book, which includes shrubs and non-native species from outside of Britain. The text is accessibly written, amassing a huge wealth of new published research (sources are given), accompanied by tables of data, diagrams and colour photographs of trees. The core of the book loosely follows a tree's journey through the seasons (spring flowers, summer droughts, autumn seeds, winter storms), with break-out chapters examining tree biology in more depth, such as how a tree defends its wood (Chapter 8) and gets to be 5000 years old and 100 m tall (Chapter 12). The book closes with an assessment on 'what is the future of trees' (Chapter 16), highlighting the need to slow deforestation and improve forest quality to counteract the 32% of the world's forests we've lost since the industrial era and that 40% of what is left is high in quality and without human modification. Thomas is optimistic and hopeful that this can be done in a variety of local to global ways, such as the Tree-lined Streets Bill currently passing through the House of Commons that would require new developments to have tree-lined streets. Throughout the whole book there are fascinating case studies. For example, in Chapter 2 on 'the value of trees', Thomas reports on how trees can be used to protect cities from terrorist bombs, with accompanying images showing intact *Thuja* hedges (smaller leaves) and ripped-apart cherry laurel (large leaves). It's this kind of information that makes this book a must-read for those involved in land management and it provides some great anecdotes for tree enthusiasts. This is the definitive book on trees!

BOOK REVIEW



Peregrine Falcon *Falco peregrinus*
Ecology and Survey Methodology for
Ecological Assessment

March 2022
Author:
Dr. Stefan Bodnar MCIEEM
PeopleforPeregrines

New Guidance for Survey and Mitigation for Peregrine Falcon

The new guidance *Peregrine Falcon Falco peregrinus Ecology and Survey Methodology for Ecological Assessment*, written by Stefan Bodnar MCIEEM, provides comprehensive and up-to-date guidance for surveys and mitigation for developments.

Introduction

The peregrine falcon, *Falco peregrinus*, is now a familiar and iconic bird of inner cities and towns in the UK, with an expanding population. The peregrine is renowned for its speed, reaching over 320 km/h during its characteristic hunting stoop (high-speed dive). In the 1950s and 1960s, the population suffered a catastrophic decline from the effects of pesticide contamination in its food chain and neared extinction. Its rarity as a breeding bird was the reason for its inclusion on Schedule 1 of the Wildlife and Countryside Act (1981) as amended. Following certain pesticides being banned and increased legal protection for the birds, the recovery of the peregrine is a conservation success story. The population is now estimated to be more than 1505 breeding pairs in the latest national survey by the British Trust for Ornithology.

Development

Once a species that was rarely (if ever) encountered by most ecological consultants, with continued expansion of the peregrine population, particularly in urban areas, there is increased need for survey and appropriate assessments in terms of development. However, there has been limited guidance on surveying and mitigation available, and the related behavioural and ecological information for this species is fragmented, difficult to find and, at times, out of date.

This guidance brings together the body of research and evidence in relation to timings of breeding, causes of disturbance, the process of site colonisation and the degree of post-fledging dependence.

The guidance provides detailed advice for professional ecologists undertaking surveys in different habitats, assessing the impacts of development and appropriate mitigation. It bridges the gap between practical conservation work of peregrine groups and research evidence on behaviour and ecology and focused advice for ecological consultants. The aim was to create a coherent, accessible resource of all relevant information on peregrine status and ecology. The guidance develops and describes best practice for consultant ecologists in relation to development. Where appropriate, existing guidance has been incorporated, amended, developed and expanded based on more recent data and experience. In particular, the focus is urban situations, which is where professional ecologists are most likely to encounter the species. It covers such issues as potential disturbance and licensing, when to recommend boxes and other mitigation structures and the potential impacts of new developments on resident birds, and it aims to provide appropriate approaches and, where possible, offer pragmatic and realistic solutions.

Content

The guidance is 94 pages long, and contains nine chapters split into two main sections. The first (Chapters 1–3) deals with peregrine falcon identification, conservation status and ecology in relation to surveying and mitigation. The second section (Chapters 4–9) comprises desk and field survey guidance, the planning process and development/mitigation, including the creation and efficacy of artificial nest sites. Lastly there are comprehensive appendices of legislation, recommended reading and references. The text is illustrated throughout with tables and images for clarity.

Future and availability

In publishing this guidance, the aim is to improve on our collective knowledge through the learned experiences of others. It is our intention to revise the text regularly and amend the guidance in the light of further knowledge and experience. To obtain the document, please contact the author at the email address given below.

Thanks

As with all such endeavours, we stand on the shoulders of others in developing this guidance and it is the sum of our collective knowledge, developed by many experts and enthusiasts alike, who are gratefully acknowledged here. I have met many peregrine workers who have shared their knowledge and insights and have helped to fill in any omissions or errors. In addition, useful comments and observations on the draft guidance was provided by the London Peregrine Partnership, Ed Drewitt, Keith Betton, Richard Foss and the Professional Standards Group of CIEEM, to whom I am grateful. Photographic images were provided by several talented individuals and are reproduced with their kind permission and their copyright acknowledged.

About the Author

Stefan Bodnar MCIEEM runs an independent ecological consultancy, having previously worked for a range of statutory and voluntary sector conservation organisations. His interest in peregrines involves holding a Schedule 1 licence and being a founding member of PeopleforPeregrines.

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stefan.bodnar01@googlemail.com


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Forthcoming Events

For information on these events and more please see http://cieem.net/training-events.

Conferences
Training Courses

05 September **Introduction to Fern Identification** South West England	07–09 September **Working with Crayfish: Survey Methods, Ecology, Mitigation, Licensing and Invasive Species** Yorkshire and Humber	08–09 September **Water Vole Ecology and Surveys (online with field visit)** Online and South West England	13 September **Fern Identification for Botanical Surveying and Habitat Classification** West Midlands
14–15 September **Undertaking Dusk/Dawn Bat Roost Surveys** South East England	15–16 September **UK Habitat Classification for Practitioners** Online	21 September **Peregrine Falcon: Ecology, Survey and Mitigation** West Midlands	28 September **Eurasian Beaver Ecology and Restoration** Online
03–04 October **Water Vole Mitigation** Online	04–05 October **Train the Trainer for Ecologists** South East England	05–06 October **Identifying and Managing Non-native Invasive Plant Species** Online	06–07 October **Plant Identification and Botanical Keys** Online
11 & 12 October **Introduction to Bat Ecology and Bat Surveys** Online	11–14 October **Beginners QGIS for Ecologists and Conservation Practitioners** Online	12 & 13 October **Ecological Report Writing** Online	12 & 19 October **Introduction to Nature Conservation Legislation in the UK (England)** Online
17–19 October **Bats: Assessing the Impact of Development on Bats, Mitigation & Enhancement** Online	18, 19 & 21 October **QField for Ecologists and Environmental Practitioners** Online	19 October **Conifer Identification for Ecologists** West Midlands	20–21 October **Using UKHab for Biodiversity Net Gain** Online
03 & 04 November **Developing Skills in Ecological Impact Assessment (EcIA) (England & Wales)** Online	03 & 04 November **Eurasian Beaver Ecology and Restoration** Online	07—09 November **Intermediate QGIS for Ecologists and Environmental Practitioners** Online	23–24 November **2022 Autumn Conference: Delivering a Nature Positive, Carbon Negative Future** Edinburgh

https://www.bto.org/learn/about-birds/birdfacts/yellow-wagtail

Yellow Wagtail

Motacilla flava

Introduction

The Yellow Wagtail is a summer visitor, breeding primarily in southern and eastern Britain.

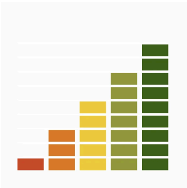
This is a strongly migratory species, wintering in trans-Saharan Africa and returning from early April to breed in grassy habitats, particularly in proximity to cattle. There has been a major decline in numbers since the 1970s, albeit with more stability over the last decade. The decline appears strongly linked to agricultural intensification.

Along with the decline in numbers, the Yellow Wagtail has also undergone range contraction. Most of our breeding birds are now found in central and northern England. It is extinct as a breeding bird on the island of Ireland, where is now only found while on passage.

- Our Trends Explorer gives you the latest insight into how this species' population is changing.

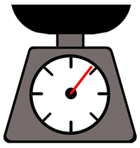
Key Stats

Status



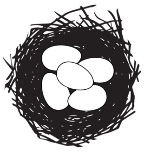
Common

Weight



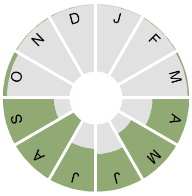
17.6g

Eggs



5-6

Seasonality



3%

BTO Records

180k records

Publications

1

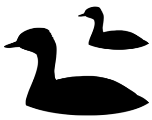
Population and distribution stats for:

Breeding

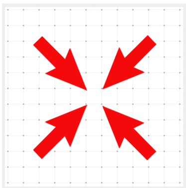
Winter

Population Change

Population Size



Distribution Change



78% decrease 1967 to 2023 | 20k territories | -32.3% contraction

Identification

Curated resources to aid in the identification of Yellow Wagtail

ID Videos

Close ×

This section features BTO training videos headlining this species, or featuring it as a potential confusion species.

Yellow-coloured wagtails

BTO Bird ID - Yellow-coloured wagtails

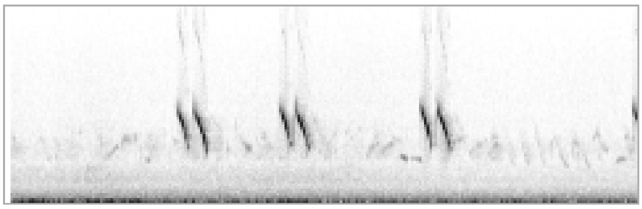
Songs and Calls

Close ×

Listen to example recordings of the main vocalisations of Yellow Wagtail, provided by xeno-canto contributors.

Song:

xeno-canto XC181578

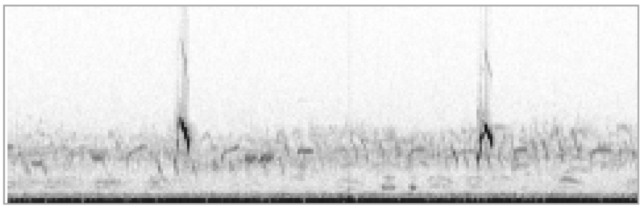


0:00 1:04

Western Yellow Wagtail Motacilla flava · call
david m
Ryedale District (near Helperthorpe), North Yorkshire, England, Unit…

Call:

xeno-canto XC123031

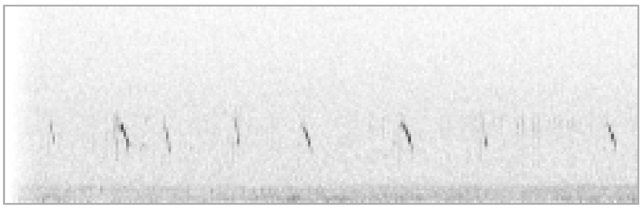


0:00 3:19

Western Yellow Wagtail Motacilla flava flavissima · call
david m
Ryedale District (near Helperthorpe), North Yorkshire, England, Unit…

Flight call:

xeno-canto XC673439



0:00 0:15

Western Yellow Wagtail Motacilla flava · flight call
David Pennington
Harden Quarries, Penistone, South Yorkshire, England, United Kingd…

Status and Trends

Population size, trends and patterns of distribution based on BTO and partnership surveys and atlasses with data collected by BTO volunteers.

Conservation Status

Close ×

This species can be found on the following statutory and conservation listings and schedules.

UK Birds of Conservation Concern: Red listed

Species of European Conservation Concern: Least Concern

IUCN Red List of Threatened Species (global): Least Concern

Schedule 1 Licence required (to disturb)*: No

Birds Directive Annex 1: No

Listed on the Annexes of*: Bern(III), NERC (41)

* A guide only. Check details with the original legislation, especially those marked with an asterisk. See About BirdFacts for more information.

Population Size

Close ×

UK (breeding): 20 thousand territories (2016), Source

BOU Category: A, Source

First Record*: c. 1600

* First documented occurrence. Most species undoubtedly occurred before this. See About Birdfacts for more information.

Population Change

Close ×

UK breeding population: -78% (1967 to 2023), Source

Britain holds almost the entire world population of the distinctive race *flavissima*, so population changes in the UK are of global conservation significance. Yellow Wagtails have been in rapid decline since the early 1980s, according to CBC/BBS and especially WBS/WBBS and, after a shift from the green to the amber list in 2002, the species was moved to the red list in 2009 (Eaton *et al.* 2009). Gibbons *et al.* (1993) identified a range contraction towards a core area in central England, concurrent with the early years of decline. Further range contraction has occurred extensively since then, especially in the west and south and in parts of East Anglia (Balmer *et al.* 2013). The European trend, which comprises several races of the species, has shown a decline since 1980 (PECBMS: PECBMS 2020a>).

Visit our Trends Explorer **for trend graphs and country statistics.**

Distribution

Close ×

The majority of the UK's Yellow Wagtails now breed in England, with none breeding in Ireland and only a few squares occupied in Wales and Scotland during 2008–11. Densities are highest in East Yorkshire, Lincolnshire, the Fens, Broadland and the Essex and Kent coastal marshes.

Occupied 10-km squares in UK

These figures come from *Bird Atlas 2007* and indicate how widespread a species is.

No. occupied in breeding season: 785

% occupied in breeding season: 26%

No. occupied in winter: 11

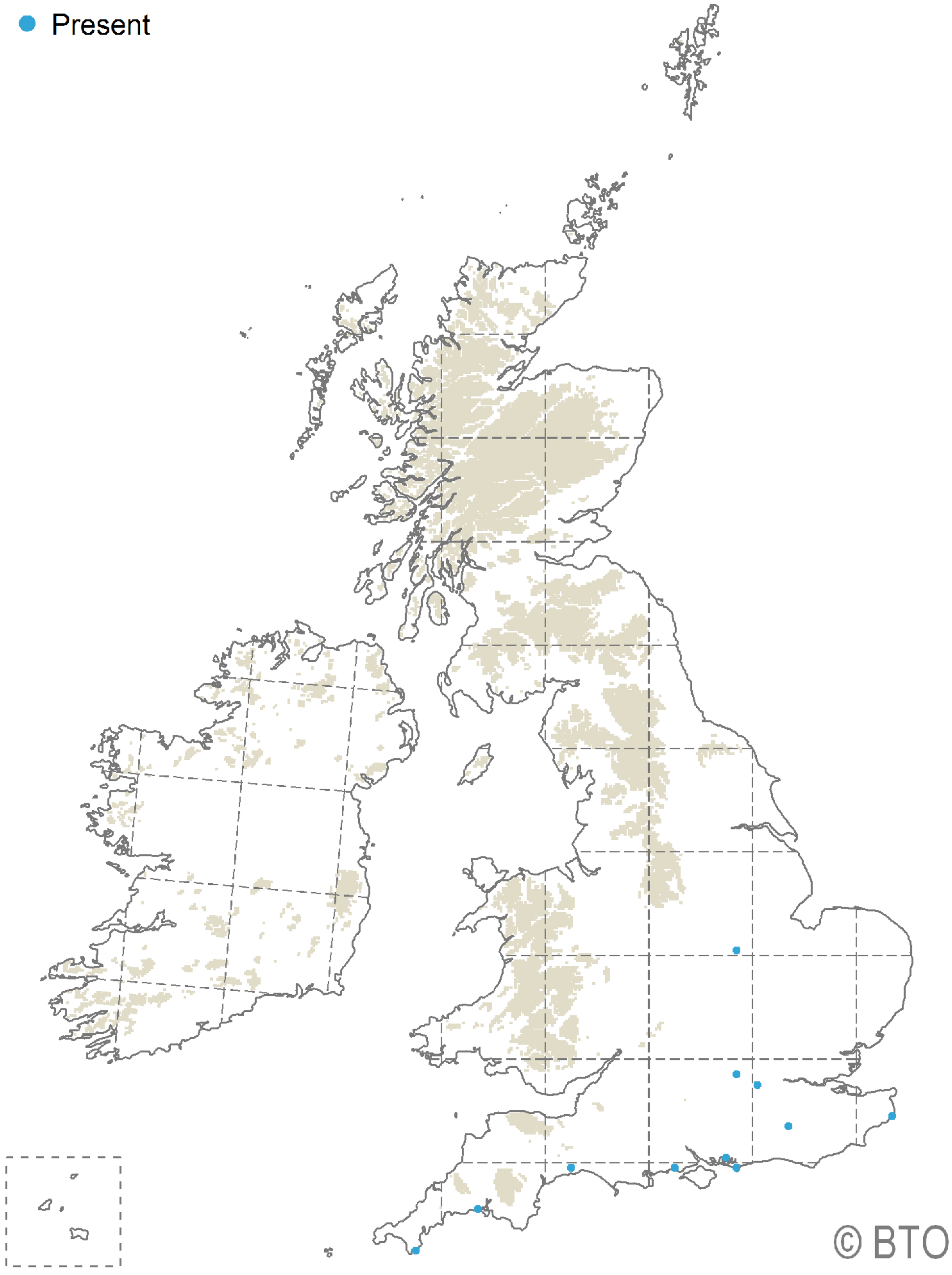
% occupied in winter: 0.4%

Visit our Trends Explorer **for trend graphs and country statistics.**

Bird Atlas distribution maps show where bird species breed or winter in Britain and Ireland. For breeding maps, larger dots indicate higher certainty the species bred in that area.

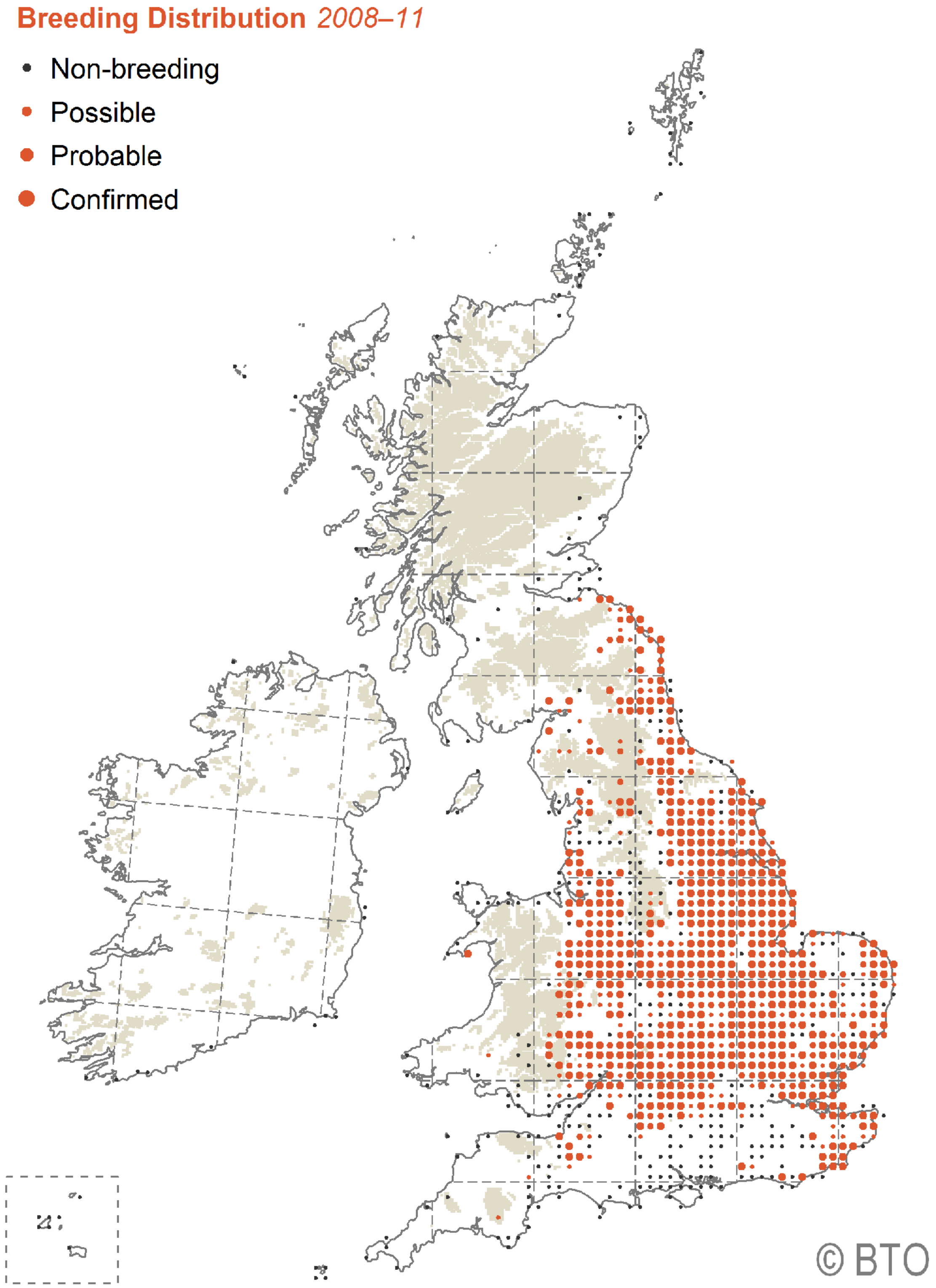
Winter distribution
2007/08–10/11

Winter Distribution *2007–11*



Click the map to enlarge,
or view it on Bird Atlas Mapstore.

Breeding distribution
2008–11



Click the map to enlarge,
or view it on Bird Atlas Mapstore.

To view and download up-to-date distribution information aggregated from across BTO and partnership surveys and schemes, see our data holdings on the NBN Atlas.

European Distribution Map

European Breeding Bird Atlas 2

Distribution Change

Close ×

Breeding Yellow Wagtails have been lost from many parts of southern England, northwest England, Wales, the Scottish Borders and the Central Belt. In the remaining range relative abundance has decreased with only East Lincolnshire and East Yorkshire showing signs of growth.

Change in occupied 10-km squares in the UK

These figures come from *Bird Atlas 2007-11* and indicate by how much occupied areas have expanded or contracted over recent decades.

% change in range in breeding season (1968–72 to 2008–11): -32.3%

% change in range in winter (1981–84 to 2007–11): -85.7%

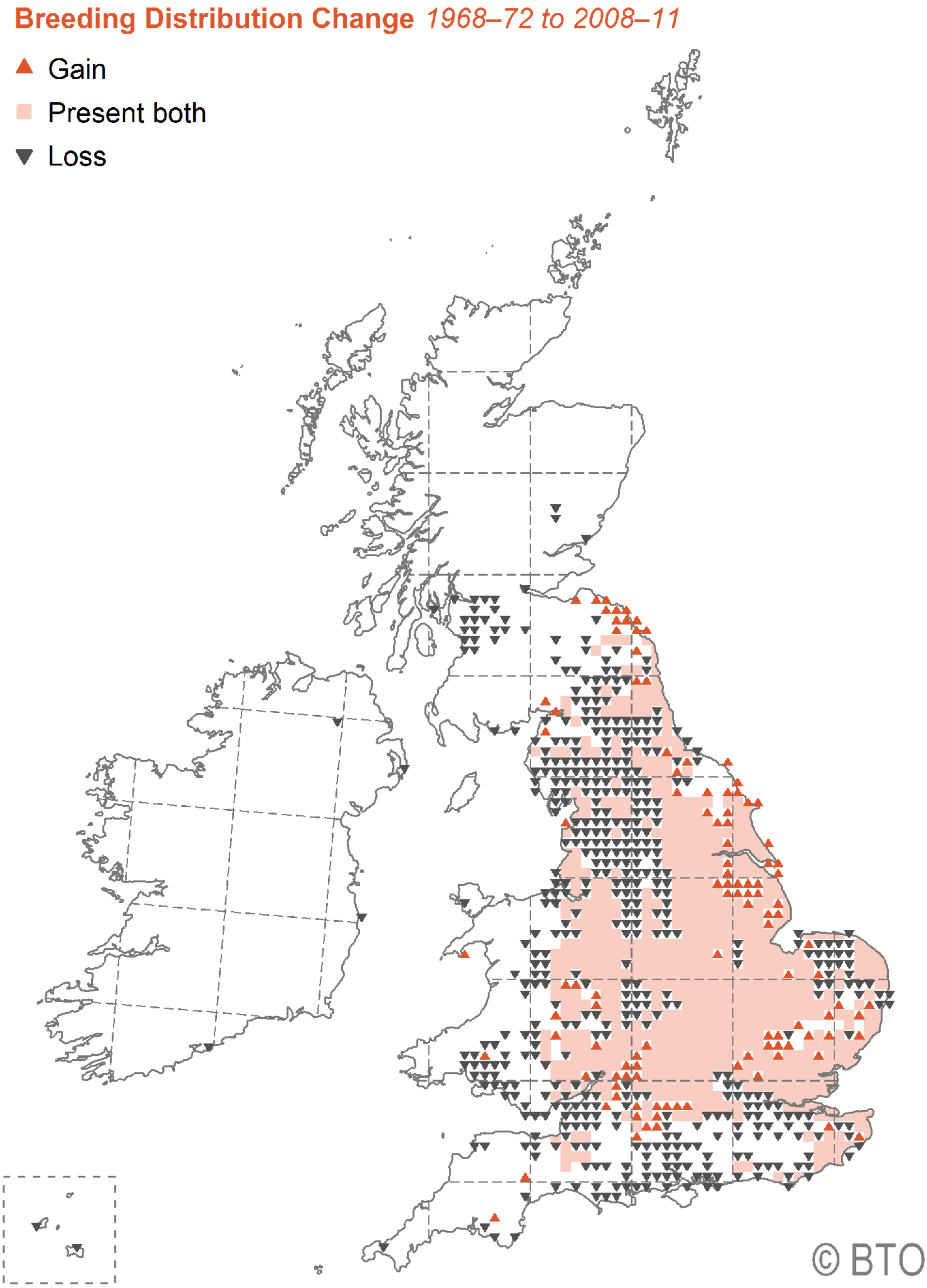
Visit our Trends Explorer **for trend graphs and country statistics.**

Bird Atlas distribution change maps show how bird distributions have change through time. Coloured upward-pointing triangles show places apparently colonised over the period; grey downward-pointing triangles show places apparently vacated. Shading shows squares occupied in all periods.

Winter distribution change
from 1981–84 to 2007–11

Click the map to enlarge,
or view it on Bird Atlas Mapstore.

Breeding distribution change
from 1968–72 to 2008–11



Click the map to enlarge,
or view it on Bird Atlas Mapstore.

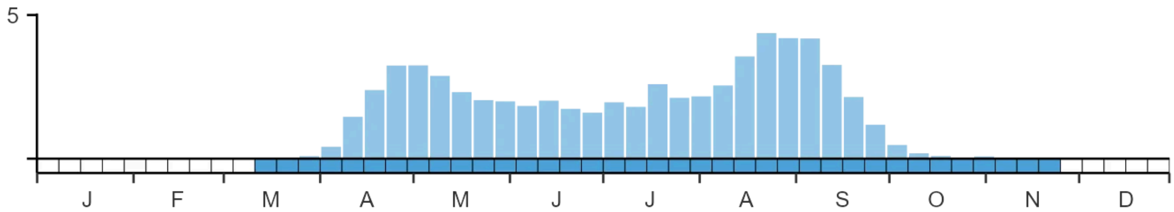
Seasonality

Close ×

Yellow Wagtail is a localised summer migrant, arriving in April; can be seen more widely during autumn passage, often at wetlands, but most have departed by October.

Weekly pattern of occurrence

The graph shows when the species is present in the UK, with taller bars indicating a higher likelihood of encountering the species in appropriate regions and habitats.



Weekly occurrence patterns (shaded cells) and reporting rates (vertical bars) based on BirdTrack data. Reporting rates give the likelihood of encountering the species each week.

Habitats

Close ✕

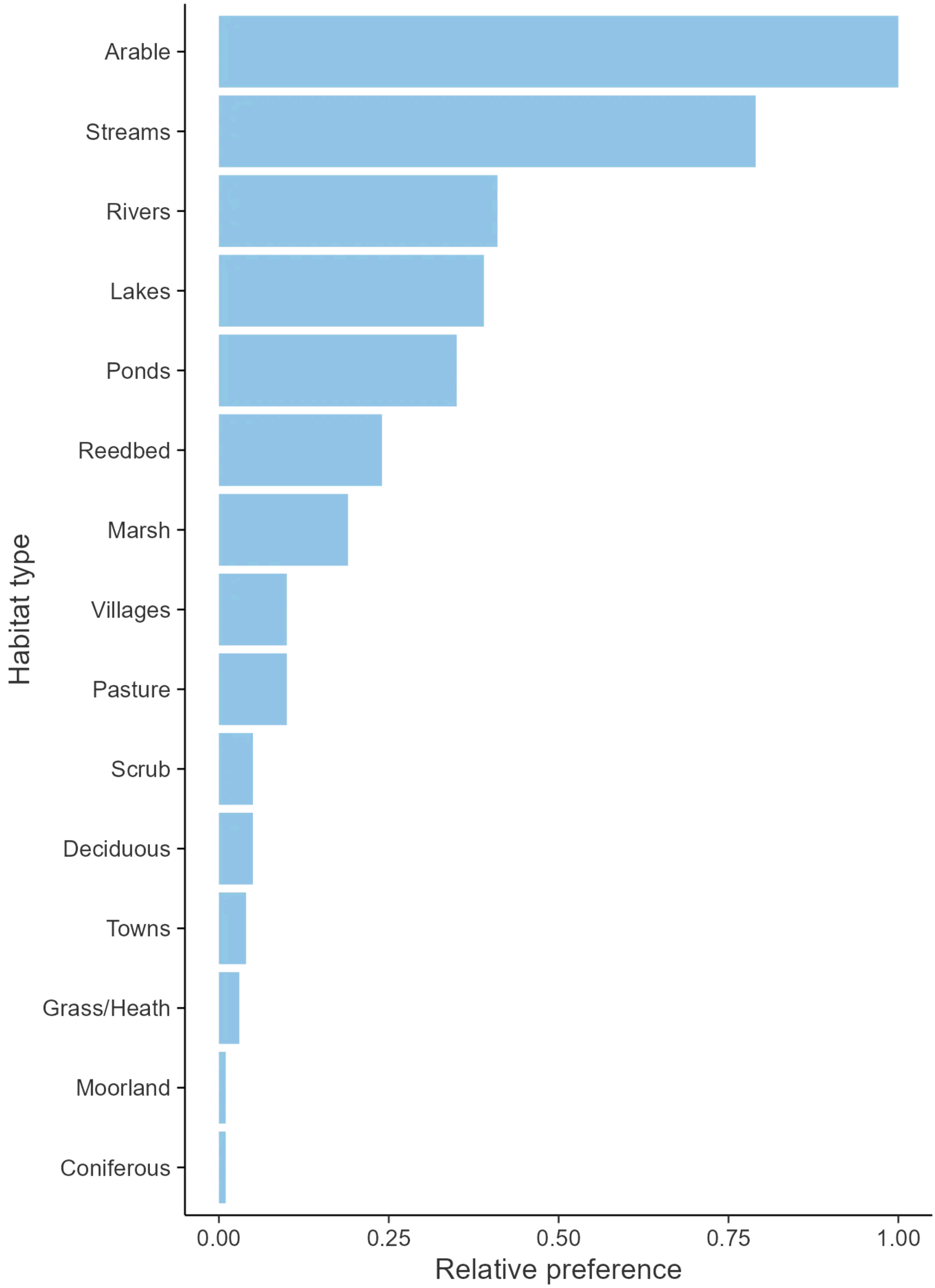
Breeding season habitats

Most frequent in: Arable Farmland, Estuaries

Also common in: Along Streams

Relative frequency by habitat

The graph shows the habitats occupied in the breeding season, with the most utilised habitats shown at the top. Bars of similar size indicate the species is equally likely to be recorded in those habitats.



Relative occurrence in different habitat types during the breeding season based on the BTO/JNCC/RSPB Breeding Bird Survey. Bars are scaled relative to the habitat in which the species is most commonly detected.

Movement

Information about Yellow Wagtail movements and migration based on online bird portals (e.g. BirdTrack), Ringing schemes and tracking studies.

Britain & Ireland movement

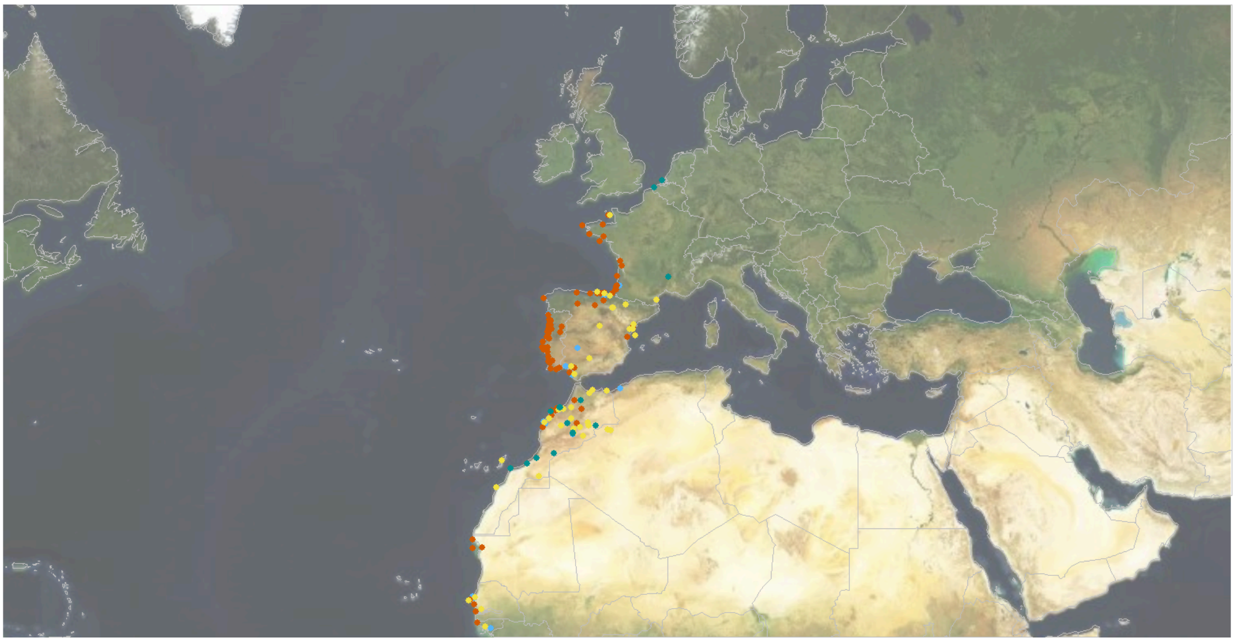
Close ×

View a summary of recoveries in the Online Ringing Report

Foreign locations of birds ringed or recovered in Britain & Ireland

Dots show the foreign destinations of birds ringed in Britain & Ireland, and the origins of birds ringed overseas that were subsequently recaptured, resighted or found dead in Britain & Ireland. Dot colours indicate the time of year that the species was present at the location.

Winter (Nov-Feb) Spring (Mar-Apr) Summer (May-Jul)
Autumn (Aug-Oct)



European movements

Close ✕

EuroBirdPortal uses birdwatcher's records, such as those logged in BirdTrack to map the flows of birds as they arrive and depart Europe. See maps for this species here.

The Eurasian-African Migration Atlas shows movements of individual birds ringed or recovered in Europe. See maps for this species here.

Biology

Lifecycle and body size information for Yellow Wagtail, including statistics on nesting, eggs and lifespan based on BTO ringing and nest recording data.

Productivity and Nesting

Close ✕

Nesting timing

Average (range) fo first clutch laying dates: 24 May (7 May-3 Jul), Source

Typical (exceptional) number of broods: 1–2, Source

Egg measurements

Typical length x width: 18×14 mm

Mass (% shell): 1.8g (6%)

Source

Clutch Size

Typical number: 5-6 eggs

Average ±1 standard deviation: 5.24±0.88 eggs

Observed minimum and maximum: 3-7 eggs

Source

Incubation

Incubation by: Female

Typical duration: 14 days, Source

Observed average ±1 standard deviation: 13.59±1.27 days

Observed minimum and maximum: 11-16.5 days

Fledging

Type of chick: Altricial, downy

Typical duration: 13-15 days, Source

Observed average ±1 standard deviation: 13.94±1.21 days

Minimum and maximum: 12-15.5 days

N=425, -Source

Visit our Trends Explorer for trend graphs and country statistics.

Survival and Longevity

Close ×

Survival is shown as the proportion of birds surviving from one year to the next and is derived from bird ringing data. It can also be used to estimate how long birds typically live.

View number ringed each year in the Online Ringing Report.

Lifespan

Typical life expectancy of bird reaching breeding age: 3 years with breeding typically at 1 year, Source

Maximum age from a ringed bird: 7 years, 1 month, 14 days (set in 1982), Source

Survival of adults

All adults: 0.533±0.031

Source

Survival of juveniles

All juveniles: 0.463±0.041 (in first year), Source

Visit our Trends Explorer for trend graphs and country statistics.

Biometrics

Close ×

Wing length and body weights are from live birds (source).

Wing length

Average ±1 std deviation; range and sample size in brackets.

Juvenile: 81.2±2.6 mm, (77-85 mm, N=999)

All adults: 81.6±3 mm, (76-86 mm, N=295)

Female: 79.3±2.8 mm, (75-84 mm, N=82)

Male: 82.8±2.5 mm, (79-86 mm, N=176)

Body weight

Average ±1 std deviation; 5th and 95th percentiles and sample size in brackets.

Juvenile: 17.9±1.7 g, (15.5-21 g, N=869)

All adults: 17.6±1.7 g, (15.3-20.4 g, N=270)

Female: 16.9±1.8 g, (15-21.3 g, N=77)

Male: 17.7±1.5 g, (15.5-19.9 g, N=159)

Visit our Trends Explorer for trend graphs and country statistics.

Ring Size: A

Classification, names and codes

Taxonomy, names and species codes for Yellow Wagtail

Classification and Codes

Close ×

- Order: *Passeriformes*
- Family: *Motacillidae*
- Scientific name: *Motacilla flava*
- Authority: Linnaeus, 1758
- BTO 2-letter code: YW
- BTO 5-letter code: YELWA
- Euring code number: 10170

Alternate species names

Close ×

Catalan: cuereta groga
Czech: konipas lucní
Danish: Gul Vipstjert
Dutch: Gele Kwikstaart
Estonian: hänilane
Finnish: keltavästäräkki
French: Bergeronnette printanière
Gaelic: Breacan-buidhe
German: Schafstelze
Hungarian: sárga billegeto
Icelandic: Gulerla
Irish: Glasóg Bhuí

Italian: Cutrettola
Latvian: dzeltena cielava
Lithuanian: geltonoji kiele
Norwegian: Gulerle
Polish: pliszka zólta
Portuguese: alvéola-amarela
Slovak: trasochvost žltý
Slovenian: rumena pastirica
Spanish: Lavandera boyera
Swedish: gulärla
Welsh: Siglen Felen

Research

Interpretation and scientific publications about Yellow Wagtail from BTO scientists.

Causes of Change and Solutions

Close ✕

Causes of change

Agricultural intensification is the ultimate cause of population declines. However, the mechanisms underlying the decline remain unclear.

Further information on causes of change

Changes in agricultural practices have been proposed as the main reason for declines via their impact on the quality of foraging and breeding habitats. The magnitude of Yellow Wagtail decline appears to vary between habitats, being strongest in wet grassland and marginal upland areas (Henderson *et al.* 2004, Wilson & Vickery 2005). Chamberlain & Fuller (2000, 2001) found that there were greater range contractions in regions dominated by pastoral agriculture. The decline in pastoral habitats has been proposed to be due to agricultural intensification, specifically farmland drainage, the conversion of pasture to arable land, changes in grazing and cutting regimes, the loss of insects associated with cattle and changes to grassland ecosystems in marginal upland areas (Gibbons *et al.* 1993, Chamberlain & Fuller 2000, 2001, Flyckt 1999, Vickery *et al.* 2001, Nelson *et al.* 2003, Bradbury & Bradter 2004, Henderson *et al.* 2004). Such changes are likely to have reduced the quality of grasslands as a nesting and foraging habitat.

Data from eastern England suggest a strong avoidance of grassland and preference for spring-sown crops (Mason & Macdonald 2000), though breeding can also be successful in landscapes dominated by winter cereals (Kirby *et al.* 2012). A detailed autecological study by Gilroy *et al.* (2008) provides good evidence that, on arable land, soil penetrability had a significant influence on the abundance of Yellow Wagtails, together with crop type and soil type, as these influenced invertebrate capture rates. There was a strong relationship between Yellow Wagtails and soil penetrability, suggesting a potential causative link between soil degradation and population decline (Gilroy *et al.* 2008). Breeding-season length may also be limited in cereal-dominated areas, as Yellow Wagtails avoid autumn-sown cereals late in the season (Gilroy *et al.* 2009, 2010). Predation was also considered and it was found that predation rate was closer nearer to tramlines and field-edges (Morris & Gilroy 2008). It is uncertain how important nest predation in tramlines is as a limiting factor for Yellow Wagtail populations but no studies have reported predation as a major driver of population decline for this species. Work carried out by Benton *et al.* (2002) showed that, in Scotland, arthropod abundance was significantly related to agricultural change and that this was also linked to measures of farmland bird density. Although Yellow Wagtail does not breed on Scottish farmland, it is an obligate insectivore, so this evidence adds support to the hypothesis that reduced food availability due to agricultural change may have contributed to the declines in this species.

Yellow Wagtails are long-distance migrants, moving to wintering grounds in western Africa south of the Sahara. Factors relating to conditions on the wintering grounds may also play a role (Bradbury & Bradter 2004, Heldbjerg & Fox 2008, Stevens *et al.* 2010) but evidence for this is lacking.

Information about conservation actions

The decline of the Yellow Wagtail since the 1980s is believed to be driven by agricultural intensification and resultant habitat changes, although the exact mechanism behind the decline is unclear and therefore specific evidence-based conservation actions to reverse the decline are limited. However, there is good knowledge about breeding habitat preferences.

The research suggests that changes to cattle farming and associated grassland may have reduced quality and food availability; hence actions which enable low intensity pastoral farming may benefit Yellow Wagtails, including a reduction in the use of fertilisers, herbicides and pesticides to provide more diverse semi-natural grasslands. A detailed study of Yellow Wagtail breeding ecology by Bradbury and Bradter (2004) provided good evidence of the species' breeding requirements on grassland. Territories were associated with a greater proportion of bare earth in the sward, the presence of shallow-edged ponds or wet ditches in the field, and a greater probability of a prolonged winter/spring flood, although the relative importance of these and how they impact on demographic processes was indecipherable.

Where Yellow Wagtails nest in arable fields, providing spring sown crops may help improve breeding productivity by extending the breeding season (Mason & McDonald 2000). Alternatively, providing a mosaic of crops may enable Yellow Wagtails to raise early broods in autumn sown cereal fields but switch to other crops (e.g. potatoes) for later broods (Gilroy *et al.* 2010).

Publications (1)

Close ×

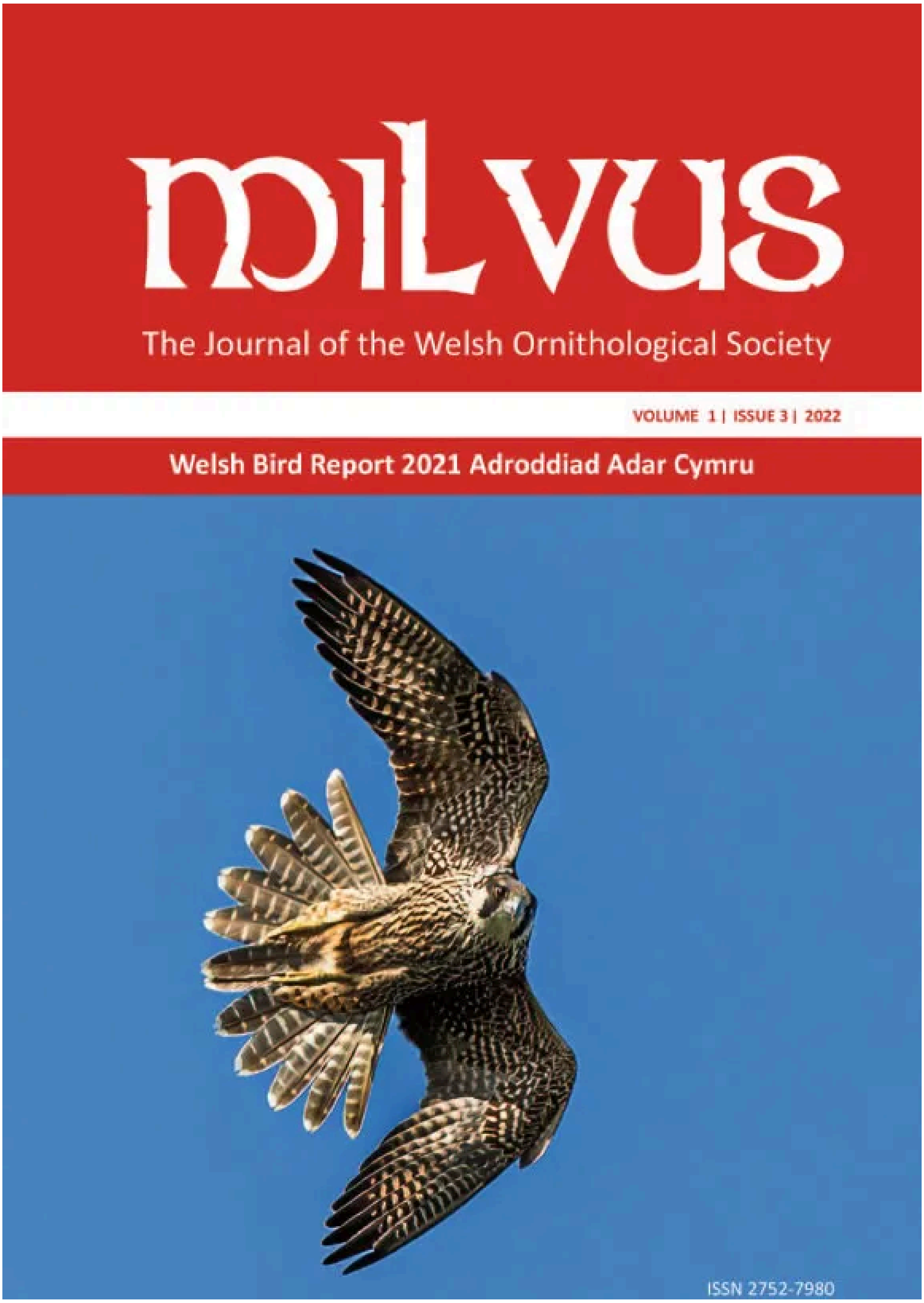
Birds of Conservation Concern Wales 4: the population status of birds in Wales

The latest review of the conservation status of birds in Wales. The report assessed all 220 bird species which regularly occur in Wales. There are now 60 species of bird on the Red List, with 91 on the Amber List and just 69 - less th...

06.12.22

Reports   Birds of Conservation Concern

View a summary report



More Evidence

More evidence from Conservation Evidence.com

- Seed shed in the making of hay from mesotrophic grassland in a field in northern England: effects of hay cut date, grazing and fertilizer in a split-split-plot experiment
- The effectiveness of land-based schemes (incl. agri-environment) at conserving farmland bird densities within the UK. CEE Review 05-005
- Broedvogels van de buitenkaadse Oostvaardersplassen in 1997, 2002 en 2007
- Bird use of cultivated fallow 'lapwing plots' within English agri-environment schemes
- Evaluating the English Higher Level Stewardship scheme for farmland birds

There are a total of 8973 individual studies.

Partners

Birdfacts is based on data collected by volunteers participating in surveys that are organised and funded by BTO, RSPB, Esmée Fairbairn Foundation, JNCC and other partners.

BTO

Esmée Fairbairn Foundation

JNCC

RSPB

Citing BirdFacts

If you wish to cite particular content in this page (e.g. a specific value) it is best to use the original sources as linked in the page. For a more general citation of the whole page please use: BTO (20XX) BirdFacts Species: profiles of birds occurring in the United Kingdom. BTO, Thetford (www.bto.org/birdfacts, accessed on xx/xx/xxxx).

Find a Species

Search by common or scientific name

Find a species

Go

Solar Energy UK

Solar Habitat 2025:

Ecological trends on solar farms in the UK

Solar Energy UK

is an established trade association working for and representing the entire solar and energy storage value chain. Solar Energy UK represents a thriving member-led community of more than 430 businesses and associates, including installers, manufacturers, distributors, large-scale developers, investors and law firms. Our underlying ethos has remained the same since our foundation in 1978 – to be a powerful voice for our members by catalysing their collective strengths to build a clean energy system for everyone's benefit. Our mission is to empower the UK's solar transformation.

Clarkson & Woods

provide a full range of ecological survey and consultancy services in respect to planning and land management. We are a leading consultancy in the survey, assessment and design of proposed and existing photovoltaic solar developments of all scales, from community owned to nationally significant projects.

We provide a range of services including survey and ecological assessment of solar and battery projects, development of bespoke management plans for solar farms and ecological monitoring of operational solar farms. We have a particular interest in furthering our understanding of the interactions between solar farms and ecology and have co-developed guidance in this area as well as embarking on pioneering research and collaboration with academic institutions.

Lancaster University

is a northern powerhouse of research excellence nested within a context of social and environmental sustainability. In the 2021 Research Excellence Framework, 91% of our research was independently rated as 'internationally excellent' or 'world leading'. We are ranked 7th in the UK for social and environmental sustainability.

The Energy Environment Interactions team focus on improving understanding of the implications of the energy transition on the environment, and how land use change for energy can be done in a way that delivers ecological, as well as climate, benefits. They sit within Lancaster Environment Centre, a 400-strong community of high-achieving students, world-class environmental researchers, government scientists and enterprises working together to address today's biggest environmental challenges, cutting across the physical and social sciences.

Wychwood Biodiversity

works with solar asset owners and managers to improve biodiversity on their land. Our team of ecologists is passionate about biodiversity and our core strengths lie in the planning, creation and management of bespoke wildlife habitats.

We've developed a range of services to support organisations at all stages of the project cycle, from pre-planning through to the long-term management of solar farms. We provide technical services to support planning applications, development of site management plans and ecological monitoring. We offer tried and tested means to achieve biodiversity gains for single sites or entire portfolios. We've worked with our project partners to produce guidance on biodiversity management for the entire solar industry.

Bumblebee, Wychwood Biodiversity

Contents

Front cover photo: White-tailed bumblebee, H. Blaydes, Lancaster University

Yellowhammer, Wychwood Biodiversity

Summary and highlighted findings

The 2025 Solar Habitat report reinforces our understanding of the positive impact of well-managed solar farms on biodiversity. The findings support best practices for ecological monitoring and land management, emphasizing that solar farms can function as valuable habitats while contributing to renewable energy goals.

The data from ecological monitoring on 124 sites conducted throughout 2024 was received for this year's report, representing around 11% of sites across the UK. This is another jump in the number of sites, from 87 last year, and brings the total number of sites surveyed in Solar Habitat reports between 2023 and 2025 to 248. The sites included within this report were found to be generally representative of solar farms across the UK in terms of age, output and geography.

The data is collected according to the Standardised Approach to Monitoring Biodiversity on Solar Farms[1]. A methodology made up of nine key components to be included in each survey and a list of nine optional components. Most surveys conducted included the key elements plus additional surveys for invertebrates, birds, soils and hedgerows (Figure 1.).

Following guidance in the Standardised Approach, sites are arranged into overall management categories based on their focus on biodiversity. Some sites have been further categorised by management for grassland, site margins and hedgerows. Analysis of overall management categories and survey data shows that sites managed for biodiversity support greater mean plant species richness, greater invertebrate species richness, and greater bird species richness. Key highlights have been outlined on the next page.

Grassland

- **More than 2,000 quadrats were used to assess grassland habitats across 124 solar farms.**
- **A total of 314 plant species were recorded across all quadrats, with an average of six species per quadrat.**
- **Greater numbers of plant species were recorded where efforts were made to enhance biodiversity.**

Hedgerows

- **Hedgerows were assessed at 29 solar farms, and a total of 44 different woody plant species were recorded.**
- **The majority of hedgerows were reported as in good condition.**
- **More plant species were recorded in hedgerows that were being managed with a biodiversity focus.**

Invertebrates

- **A total of 764 transects were walked across all solar farms.**
- **Almost 3,000 butterflies and bumblebees, comprising 29 different species, were observed across 64 solar farms on which transects were walked.**
- **Butterflies were around ten times more abundant than bumblebees, with one species of conservation interest recorded.**
- **Invertebrate biodiversity varied depending on transect location and solar farm management, with more individuals and species recorded in margin or enhanced areas and at sites with more biodiversity-focused management.**

Birds

- **Around 7,500 individual birds were counted as part of surveys undertaken at 63 solar farms, including a total of 94 different species.**
- **Of the species recorded, 28% were Amber Listed and 20% were Red Listed, with several exceptional species observed, including nightingale and cirl bunting.**
- **Bird biodiversity varied with solar farm management, with more individuals and species recorded at solar farms managed with a greater biodiversity focus.**

Mammals

- **Although targeted mammal surveys were not undertaken, incidental observations were made at 22 solar farms.**
- **Eight species of mammal were recorded, including water voles at one solar farm.**

Soils

- **Soil samples collected at 35 solar farms were analysed for a range of soil properties.**
- **Soil properties can provide insights into soil health and help to inform future solar farm management.**

Glossary

Amber Listed (birds) – bird species with an unfavourable conservation status in Europe, whose population/range has declined moderately in recent times or has a historically declining population but has made a recent substantial recovery, rare breeders and species for which the UK holds internationally important populations, as categorised by the British Trust for Ornithology1.[2]

Arisings – vegetation cuttings often left in situ after management.

Biodiversity Net Gain (BNG) – an approach to development that aims to deliver measurable improvements for biodiversity by creating or enhancing habitats.

Birds of Conservation Concern – British Trust for Ornithology Amber or Red Listed species[2].

BTO – British Trust for Ornithology.

Botany – relating to plants.

Broadleaf – a group of plants with relatively broad, flat leaves.

Climber - a group of plants that use twining stems, tendrils or sticky pads to cling to surfaces.

Ferns - a group of plants that reproduce using spores and do not have seeds or flowers.

Graminoid – grass, sedge or rush.

Green Listed (birds) – bird species that are of least conservation concern, whose population is stable or increasing, as categorised by the British Trust for Ornithology[2].

Incidental (observations) - biodiversity sightings outside of structured surveys.

Injurious weed – a plant that can damage crops, habitats or ecosystems, as prescribed in the Weeds Act 1959.

Least Concern (butterflies) – butterfly species that widespread and abundant, as categorised by Butterfly Conservation[3].

Quadrat – a square plot of land marked out for botanical assessment.

Red Listed (birds) – bird species that are globally threatened, whose population/range has declined rapidly in recent times or that have declined historically and not shown recovery, as categorised by the British Trust for Ornithology[2].

Strings (of panels) – a row of panels that are wired together.

Sward – a grassland area.

Transect – a walked line through a habitat used to make measurements or observations.

UK Habitat Classification System (UKHab) – a system for classifying vegetation in the UK, required for Biodiversity Net Gain.

Vulnerable (butterflies) – butterfly species that are considered to be facing a risk of extinction in the wild, as categorised by Butterfly Conservation.

Woody plants – a group of plants whose stems/roots are reinforced with wood (typically trees and shrubs).

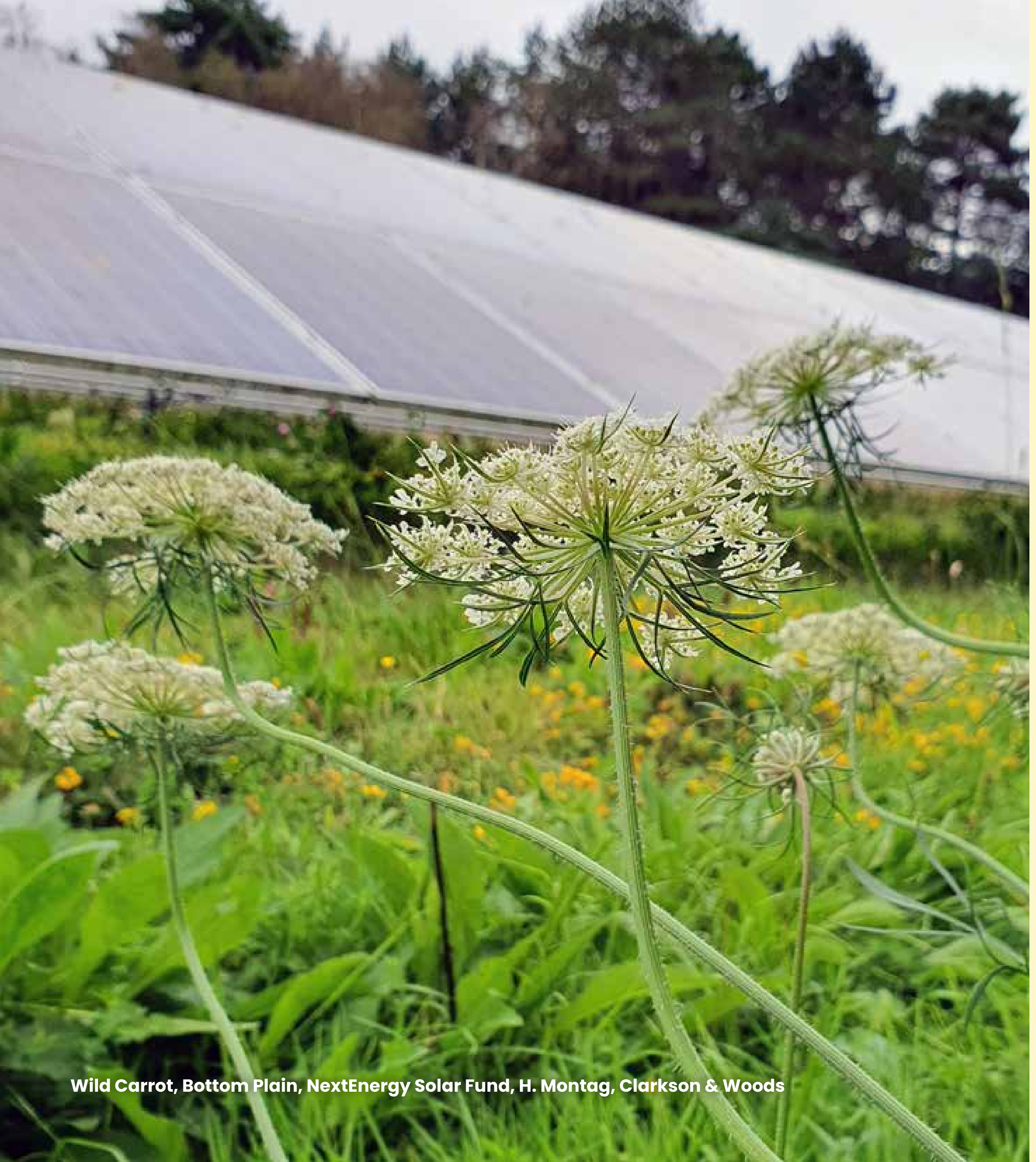
Introduction

Solar Energy UK, in collaboration with Clarkson & Woods, Wychwood Biodiversity and Lancaster University are pleased to present the third Solar Habitat report, highlighting ecological trends on solar farms in the UK. This report follows on from the pilot Solar Habitat published in 2023 and the second report published in 2024. The Solar Habitat reports are based on data collected from solar farms using the Standardised Approach to Monitoring Biodiversity on Solar Farms[1] methodology. The scope of data collection has expanded significantly over the years, increasing from 37 solar farms monitored in 2022 to 87 in 2023, and reaching 124 sites in this 2024 report.

Solar Habitat reports focus on botany, invertebrates, birds, soil and mammals found on solar farms, alongside case studies giving the context of ecological monitoring on solar farms, highlighting innovative ecological practices and exploring research being undertaken on the impact solar farms have on biodiversity.

The case studies in Solar Habitat 2025 aim to give the reader a perspective on the practice and potential costs of ecological monitoring. Three case studies look at managing and monitoring a solar farm to promote greater biodiversity. Three further case studies discuss research and innovation, including a study of birds on solar farms, promoting soil carbon, and innovations in ecological monitoring technology.

Skipper butterfly, H. Blaydes, Lancaster University


Wild Carrot, Bottom Plain, NextEnergy Solar Fund, H. Montag, Clarkson & Woods

Monitoring ecology

Monitoring ecology on solar farms

The motivation to conduct ecological monitoring on a solar farm can come from a planning requirement, or to check that new habitats are establishing well, or to better understand the impacts of solar farms on biodiversity. Further, some level of biodiversity monitoring will be required as sites receive planning permission under BNG.

Solar Habitat takes the data collected during the past monitoring season, whatever the motivation, and analyses data to identify trends, most notably the impact of management on botany, invertebrates and birds and how these relate to each other. This helps us to better understand how solar farms can support biodiversity and to guide the management of solar farms moving forwards.

Solar Habitat data

Solar Habitat is an annual report, providing a snapshot of ecology on solar farms in the year data was collected. Across three reports there have been a handful of sites which have been monitored each year, but the majority have been unique.

The trends identified suggest that well managed solar farms can support biodiversity and are in line with previous Solar Habitat reports. As the data set grows and an increasing number of sites are monitored regularly, long terms trends will hopefully become an additional feature of the report.

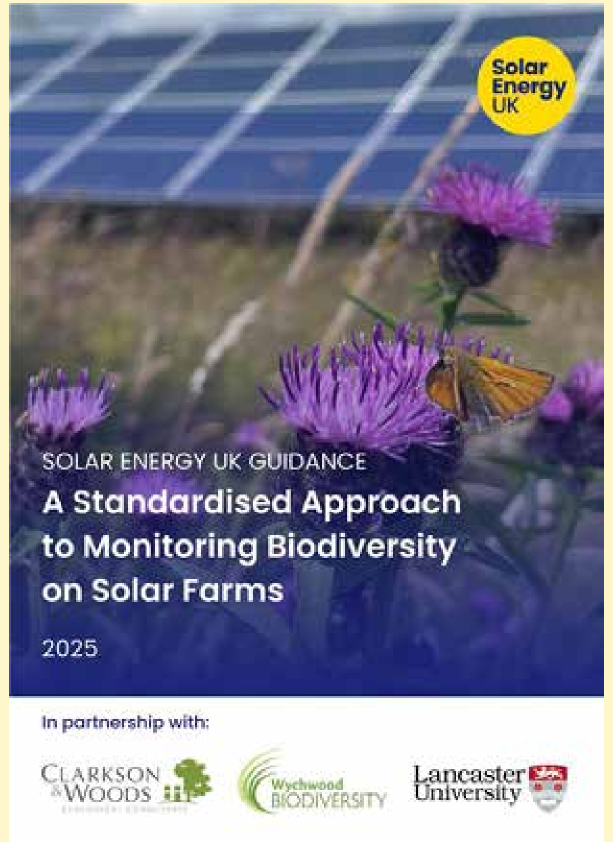
Update to the Standardised Approach

The Standardised Approach to Monitoring Biodiversity on Solar Farms[1] is designed to establish a common standard which enables the comparison of data from solar farms across the entire country.

The methodology was designed to be conducted over a one-day period by a generalist ecologist however, as sites have grown in size this has become more difficult. In the updated methodology an approximate time on site is given for each element, including the five core elements as well as the additional elements. This helps to estimate the required time on site for monitoring a solar farm and to give an indication if the monitoring might take more than a single day or visit. Additionally, methodologies for soil sample collection and management scores have been revised. To understand more the methodology please access the methodology on the Solar Energy UK website.

Third-party monitoring data

In the first two editions of Solar Habitat all data was provided by two ecological consultants, Clarkson & Woods and Wychwood Biodiversity, project partners in both developing the methodology and in authoring the Solar Habitat reports. In Solar Habitat 2025, for the first time some of the data has been provided by a third-party ecological consultant, Envance. They provided data for five sites using the Standardised Approach which have been included within the report. It is hoped that a growing number of consultants will submit data to support future reports.



View this report at solarenergyuk.org/resource

Or scan the QR code to access this guidance.

Case Study

What is solar monitoring?

Ecological monitoring on solar farms may be a requirement under a management plan, but it is also a useful tool to ensure that any problems can be detected early such as the spread of unwanted weeds or failure of planting or seeding. In addition, companies may want to participate in the collection of data to broaden their understanding of how solar farms interact with nature.

Most ecological consultancies can offer this service and a Standardised Approach has been developed to ensure the same type of information is collected in the same way. The Standardised Approach has been designed on a sliding scale so that as a minimum, key components can be collected at low cost (often under £2,000 for smaller sites, increasing with site size and complexity). Additional elements can be added where there is interest or requirements given the characteristics of the site.

Habitat survey

This entails the mapping of habitats using the UK Habitat classification system, as well as collection of botanical quadrat data. Quadrats are 1 m by 1 m squared which are laid out in specific areas so that all plants within it can be measured (species and percentage cover). The quadrats are surveyed between the panel rows, underneath the panels, at the edge of the site and in any areas of enhanced biodiversity (if applicable), so that differences in botanical composition and diversity can be identified. Such differences can provide insight into our current understanding of what kind of habitats can feasibly be created and maintained across the different areas of a solar farm.

Soil sampling

Collecting soil samples for analysis can be helpful to track nutrient levels, guide management and inform seed mixes to be used on a site. Soil sampling is done by collecting shallow cores of soil, mixing them together and sending a subsample to a laboratory.

Fixed point photographs

Photographs are taken at the same position each visit providing a useful visual guide to track site changes over the years.

Incidental sightings

Ecologists employ a investigative approach, examining signs for animal sighting such as hairs, footprints, pellets, and scat. Any interesting plants and animals are recorded during the survey to build up a picture of the range of wildlife that are using the site.

Further surveys

On top of the core surveys described above, specific data can be collected on various other aspects of biodiversity, including butterflies, bumblebees, birds, bats, reptiles, as well as environmental data. An ecologist can help determine which further surveys would be suitable on a specific site depending on the habitats and species present in the local area.

Overview of solar farms

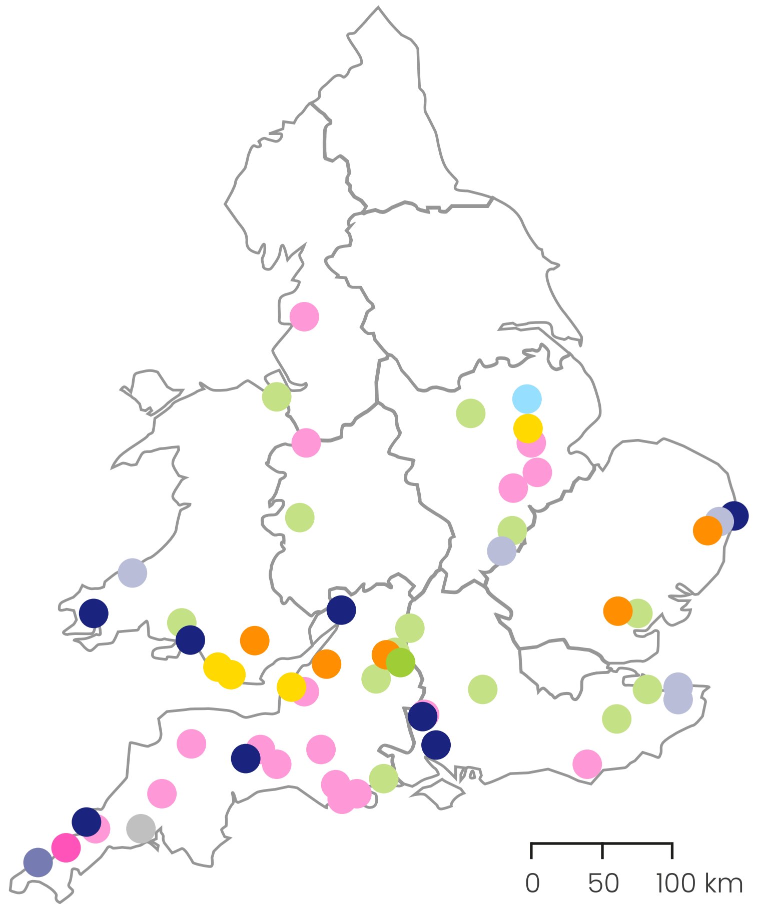
In 2024, data collected from 124 solar farms were submitted for inclusion in the Solar Habitat report, which is around 11% of the total number of sites across the UK[4]. The majority of these solar farms were new to Solar Habitat (106 sites; 85%), with only 18 sites (15%) included in previous reports. A range of data were collected across the solar farms, focusing on botany, hedgerows, invertebrates, birds and soils (Figure 1).

Most solar farms in the Solar Habitat sample were located in England (89%; 110 sites), with the majority in the South West (42%), the South East (16%) and the East Midlands (12%), broadly mirroring the national distribution of sites. At the county level, Devon and Somerset contained the greatest number of solar farms that submitted data to Solar Habitat, with 11% and 8%, respectively. Around 11%, (14 sites) of solar farms were in Wales, which matches the distribution of all solar farms in the UK. Although past Solar Habitat reports have included sites data from solar farms in Scotland and Northern Ireland, no monitoring data were submitted to this report.

Solar farms included in this Solar Habitat report varied in terms of their age, area and capacity, but were broadly representative of solar farms across the country. The average age of solar farms in the Solar Habitat sample was nine years (ranging from two to twelve) which is the same as the national average (calculated using the Renewable Energy Planning Database[4]). The average area of sites included in the sample was 16 hectares (ranging from one to 79 hectares), which is slightly larger than the national average of 14 hectares. In terms of the capacity, solar farms in the Solar Habitat sample had an average capacity of 9 MW (ranging from 1 to 46 MW), which is similar to the national average of 8 MW.

Most solar farms monitored in 2024 were assessed in terms of how habitats on site were managed and were assigned an overall management category based on the focus on biodiversity (91%; 113 sites; Table 1). More than half of all solar farms were assigned to Category 3 (58 sites, 51%), indicating some consideration of biodiversity. Some solar farms were assigned to Category 2 (30%; 34 sites), suggesting management with a greater focus on biodiversity and the remaining sites were placed into Category 4 (19%; 21 sites), indicating less consideration.

The reason that no solar farms reached the criteria for Category 1 is most likely attributed to the challenges of cutting and collecting grass arisings; specialist machinery is often needed and this is explored in the case study: cutting and collecting arisings at solar farms, on page 16. Removing arisings repeatedly ensures that biomass and the nutrients that they contain are also removed from the grassland, and over time, this typically encourages a more diverse plant community[5,6].



	Botany	Hedgerow	Invertebrates	Birds	Soil	Count
	X		X	X		42
	X					21
	X	X			X	16
	X	X				12
	X		X	X	X	11
	X			X		7
	X		X		X	6
	X		X			5
	X	X		X		1
	X	X	X	X		1
	X				X	1
	X			X	X	1

Figure 1: Locations of solar farms that submitted monitoring data to Solar Habitat in 2024. Dots are coloured according to the surveys undertaken at that site. The table shows the combinations of surveys carried out at solar farms, ordered by count (i.e. the number of solar farms where this combination took place).

Table 1: Site management categories. Categories defined as in the Standardised Approach to Monitoring Biodiversity on Solar Farms.

1	Optimal management for biodiversity with conservation cutting/grazing and no herbicide use. Arisings are removed from the site. A range of habitats (e.g. meadows, tussocky grassland, woodland planting, hedgerow planting) are present.
2	Conservation cutting or grazing takes place on site. Arisings are left on the site with signs of thatch of vegetation in places. A range of habitats are present. Herbicides may be used, but spot treatment only.
3	Site is cut or grazed throughout the year leading to a short sward in the summer months. Some other habitats are present, such as tussocky margins or planted hedgerows/woodland. Use of herbicides are apparent (e.g. blanket spraying beneath the solar panels).
4	Site is cut or grazed throughout the year leading to a short sward in the summer months. No other habitats (e.g. tussocky margins, new hedgerows or woodland) are present. Use of herbicides is apparent (e.g. blanket spraying of fields or beneath the solar panels).
5	Site is unmanaged or "other".

As a trial of a new management categorisation system to add depth to the analysis of on site management, additional site management information was collected on some solar farms. It was possible therefore to categorise sites based on how different habitats within the site were managed (Table 2). Categories focused on the (1) grassland around the solar array (information was available for 45 sites), (2) grasslands or field margins outside of the array (but within the lease area; information was available for 42 sites) and (3) hedgerows (information was available for 32 sites).

The majority of grassland directly around the solar arrays were assigned to Categories 3 (40%; 18 sites), or 4 (51%; 23 sites), with two sites placed into Category 2 (4%) and two sites placed into Category 1 (4%; Figure 2). However, most grassland outside of arrays/field margins were less intensively managed and assigned to Category 2 (55%; 23 sites), with some placed into Category 1 (19%; eight sites), with a smaller proportion assigned to Category 3 (26%; eleven sites) and none placed into Category 4 (Figure 2). This is likely because grasslands and field margins away from solar panels do not need to be kept short to avoid panel shading.

Table 2: Site management categories, split by solar farm habitat type. Information for individual habitats were only available for a subset of the solar farms that submitted data to Solar Habitat in 2024.

Grassland around the solar array	1	Grassland managed through hay cut (after late July) and arisings are collected.
	2	Grassland is conservation cut or grazed (e.g. sheep are removed for at least two months over the summer). Arisings may not be collected.
	3	Grassland is managed at a low intensity resulting in variable sward height.
	4	Grassland is cut or grazed intensively resulting in a short and uniform sward.
	5	Grassland is unmanaged or "other".
Grasslands or field margins outside of the array (but within the lease area)	1	Grasslands or field margins are managed for biodiversity (e.g. conservation management, seeded or other specific interventions).
	2	Grasslands or field margins are managed at relatively low intensity, resulting in variable sward height.
	3	Grasslands or field margins are cut or grazed intensively, resulting in a short and uniform sward.
	4	Grassland or field margins are unmanaged or "other".
Hedgerows	1	Most hedgerows within the site are managed for biodiversity (e.g. bushy, cut every two years or less, at least 2 m tall, good margins etc.)
	2	The management or condition of hedgerows across the site varies.
	3	Most hedgerows within the site are not managed for biodiversity.
	4	Hedgerows are unmanaged or "other".

At many solar farms, hedgerows appeared to be managed with some consideration for biodiversity (66%; 21 sites). Management for biodiversity can involve allowing hedgerows to increase in height and width through less intensive cutting regimes (e.g. trimming every couple of years, rather than annually), among other practices[7]. Hedgerow management seemed to vary at some sites (28%; nine sites) and there appeared to be no management for biodiversity at two sites (6%; Figure 2). As there is no national database containing details of how solar farms are managed, it is not possible to tell if sites included in the Solar Habitat sample are representative of site management across the UK.

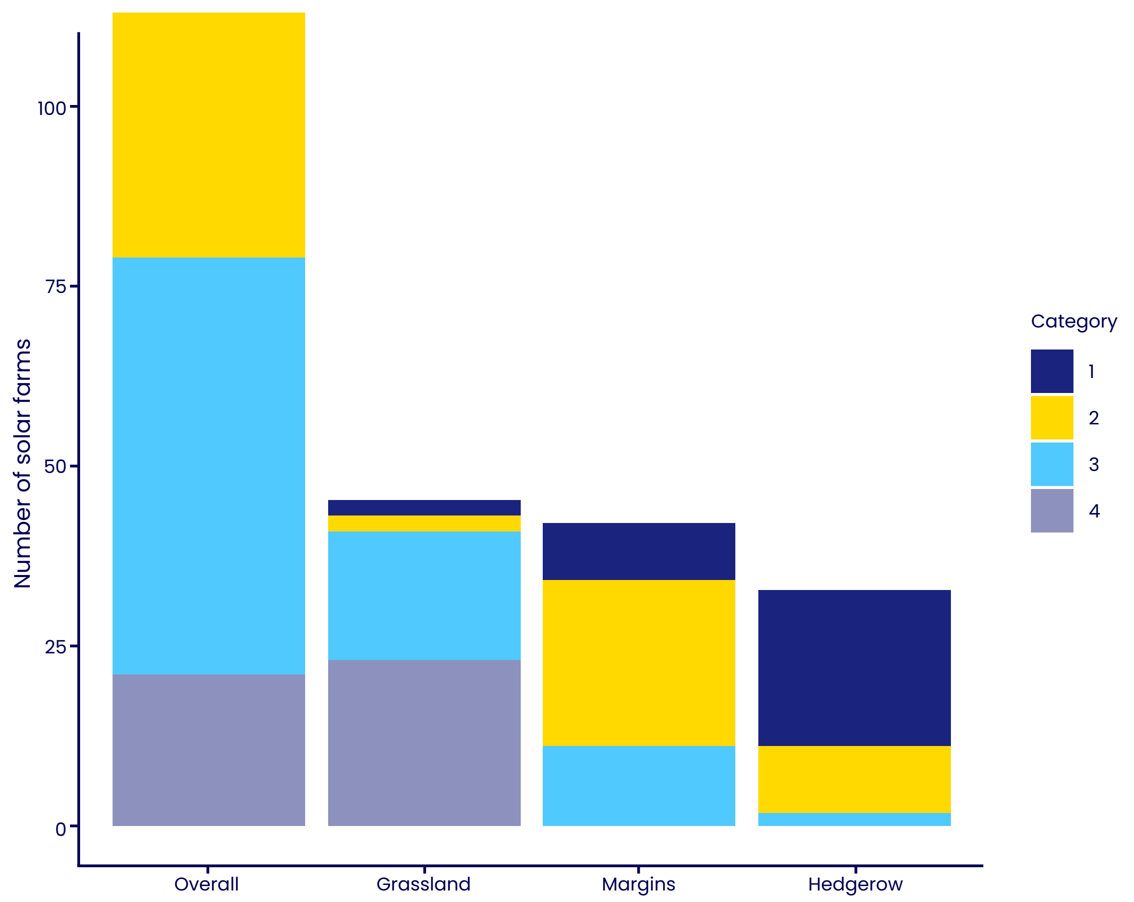


Figure 2: The number of solar farms placed into each management category. Categories are split into those for solar farms overall ("overall"), based on the Standardised Approach, and three habitat types, outlines in Table 2; grasslands around the arrays ("grassland"), grasslands or field margins outside of the array ("margin"; but within the lease area) and hedgerows ("hedgerow").

Wild flower meadow, H Blaydes, Lancaster University

CASE STUDY: Southill solar farm

Southill solar farm is a 5 MW site constructed in West Oxfordshire in 2016. It is owned by Southill Community Energy and the land is managed by Wychwood Biodiversity. The site's Biodiversity Management Plan specifies cut and collect within the solar farm security fence line to encourage wildflowers into the fine grass sward. The whole site (including around the solar panels) was cut and collected in 2023 and 2024 using an Iseki 237 box mower. The cuttings were loaded into a box trailer using the high-lift box of the Iseki and exported offsite for cattle bedding.

Time taken:
two full days

Cost of mower and operator:
£2,208

Cost of trailer and disposal:
£600

Additional labour, site access etc:
£400

Total cost:
£3,208 for seven hectares

Cost per land area: approximately £460 per hectare / £185 per acre

Case Study

Cutting and collecting arisings at solar farms

'Cut and collect' is a somewhat contentious approach to grassland management on solar farms, with many ecologists favouring the approach and many Operation and Maintenance teams finding it difficult or impossible to fulfil. This case study explores the costs and benefits of cut and collect using insight from a solar farm in Oxfordshire which has been implementing this technique around the solar arrays for the past two years.

Why are ecologists so keen on cut and collect?

The simple answer is that most grass cutting does not result in positive conservation outcomes. Cutting the grass conventionally leaves a layer of cuttings which smother the existing grass and creates dead patches.


Wild flowers, Southill solar farm

Further, the cuttings break down and nutrify the soil. This encourages the faster growing agricultural grasses such as cock's foot (*Dactylis glomerata*), Yorkshire fog (*Holcus lanatus*) and rye grass (*Lolium perenne*), and discourages slower growing grasses such as fescues and bents (often referred to as 'fine grasses') and wildflowers.

Conversely, 'cut and collect' is an approach whereby the grass cuttings are removed after cutting, either immediately with a box collector, or after cutting with a baling machine. Removal ensures there is no layer of cuttings left behind to smother the grass and nutrify the soil, and this can result in lower nutrient conditions which favour fine grasses and wildflowers. Traditional hay meadows are managed this way and over many years they can become very botanically rich.

Considerations

1. Cut and collect is designed to encourage fine grasses and wildflowers and therefore should only be used where there is potential for these to develop on a site.
2. There must be a plan for the disposal of large quantities of cuttings. Piles of cuttings should not be left heaped on site as they may present a fire risk and can cause nutrient run-off into watercourses.
3. Cut and collect machines can be larger than conventional mowers owing to the collector box and so may be less suited to tighter row spacing and confined areas.
4. To have a positive effect upon grassland, cut and collect needs to be undertaken for a minimum of 2-3 years. In addition, for maximum benefit, the cutting must be done at the end of the main flowering season (i.e. avoiding April – July inclusive). Further, other management activities, (e.g. weed control), must be designed to support wildflowers.
5. Cut and collect requires specialist equipment which is more expensive to hire or purchase. Further additional time will be needed to manage the cuttings.

Alternatives to cut and collect

If cut and collect is not possible on a site several alternatives could be tried:

- Cut and mulch – using a machine that cuts and mulches the grass is better than conventional mowers as it cuts the grass cuttings into tiny pieces, reducing the thickness of the cut grass layer. However, the soil will still be nutrified as the cuttings break down.
- Cut and aftermath grazing – sheep are introduced to the site immediately following cutting. The sheep will eat some of the cuttings, and trample the rest, so a thick layer is avoided. Nutrient input to the soil is reduced as some cuttings are eaten and deposited as sheep dung.

Conclusions

Cut and collect is possible on solar farms. It is more expensive than conventional cutting, but the specialist equipment is becoming more readily available. The advantages of cut and collect is that it encourages wildflowers and fine grasses, which can be management priorities for some sites. It also reduces nutrients on site and over time this will reduce grass vigour, meaning less need to cut.

Given the costs are higher, cut and collect is most appropriate for sites where wildflowers are already present or where they are specified in the management plan. Where cut and collect is not viable, it may be valuable to explore mulching mowers or aftermath grazing as a less effective but lower cost alternative to cut and collect.


Iseki cut & collect mower

Pyramidal orchid, H. Blaydes, Lancaster University

Botany

Botanical surveys within solar farms focused mainly on grassland habitats, which represent the largest habitat within a site. Grasslands are important because they can be rich with many different species of wild plant, which can support other biodiversity groups. Grasslands also provide a range of ecosystem services important for humans and wildlife, including water regulation and soil preservation. However, grasslands are among the most threatened habitats in the UK, with much of their loss attributed to agricultural development[7]. The intensification of pasture, driven by the sowing of less diverse, highly competitive palatable grasses and heavy fertiliser use to maximise yield has replaced traditional meadow grazing methods. Traditional approaches to management, which involve lower fertiliser inputs and do not require periodic reseeding, support significantly higher biodiversity.

Due to their less intensive management, solar farms offer an excellent opportunity for grassland restoration, allowing diverse plant communities to thrive without the need for fertilisers or intensive regimes. Additionally, they can still accommodate grazing animals, which when introduced in lower numbers or managed through conservation grazing, contribute to maintaining and enhancing species-rich grasslands.

Botanical quadrats

Botanical quadrats were used to assess grassland habitats within all solar farms, with a total of 2,146 surveyed across the 124 sites. Most quadrats were 1 m x 1 m in size (1,296 quadrats), others were 2 m x 2 m in size (790 quadrats) and the size of 60 quadrats was unknown. Quadrat size differed across ecological consultancies that carried out the surveys, but previous statistical analyses showed minimal impacts on results, making it possible to compare data across quadrat sizes.

Quadrats were used within different areas of the solar farm, including directly beneath solar panels ("under"; a total of 697 quadrats), between the rows of solar panels ("between"; a total of 707), in areas outside of the main footprint of the solar panels such as field margins which may be inside or outside of the security fencing ("outside"; a total of 553 quadrats) and in areas managed or enhanced specifically for biodiversity ("enhanced"; a total of 189 quadrats).

At many sites, five quadrats were assessed under the solar panels, five were assessed between the rows of panels and five were assessed in field margins or other habitats. Enhanced areas were surveyed where they were present. On average, 15 quadrats were assessed at each solar farm, but there was much variation, with the number of quadrats per site ranging from four to 65. More quadrats tended to be surveyed at larger solar farms and those with more variation in habitat types.

Solar farms have generally increased in size over time[8] and this trend is set to continue, especially given the number of Nationally Significant Infrastructure Project solar farms recently approved. As solar farm area increases, it becomes more costly to collect data that are representative of the site, risking not capturing biodiversity across the site. Some areas of a site may be homogenous and only need a few quadrats to characterise them, whereas others may be more diverse and need a higher density of quadrats. The key thing is to ensure the site's diversity has been captured.

Botanical species richness

Within each quadrat, the number of plant species and the percentage of the quadrat they occupied were recorded. Across all solar farms, a total of 314 plant species were observed. Most of these species were broadleaf plants (221 species), but many graminoids were also recorded (72 species), along with a variety of other species including woody plants, climbers, ferns and agricultural plants (21 species).

The most frequently recorded plant type was graminoids, with Yorkshire fog (*Holcus lanatus*) present in 71.8% of all quadrats, followed by common bent (*Agrostis capillaris*) found in 43.2% and rough meadow grass (*Poa trivialis*) recorded in 29.8% of quadrats. The most frequently recorded broadleaf species was creeping buttercup (*Ranunculus repens*) found in 20.0% of quadrats, followed by creeping thistle (*Cirsium arvense*) found in 14.8% of quadrats and white clover (*Trifolium repens*) recorded in 13.3%. Both creeping buttercup and white clover are species indicative of nutrient enrichment in the soil.

A number of interesting plant species were recorded inside quadrats, including four species of orchid. Bee orchid (*Ophrys apifera*) was recorded in one quadrat, common spotted orchid (*Dactylorhiza fuchsii*) in one quadrat, pyramidal orchid (*Anacamptis pyramidalis*) in five quadrats (across three different solar farms) and southern marsh orchid (*Dactylorhiza praetermissa*) in one quadrat. Orchids can be good indicators of healthy grassland ecosystems.

The average number of plant species recorded inside a quadrat was six, but this was variable and ranged from one to 21. There were differences in the number of plant species recorded inside quadrats depending on their location within the solar farm. On average, quadrats assessed in enhanced areas contained the highest number of plant species, followed by those in outside areas, margins, between the rows of panels and under the solar panels (Figure 3).

Botany continued

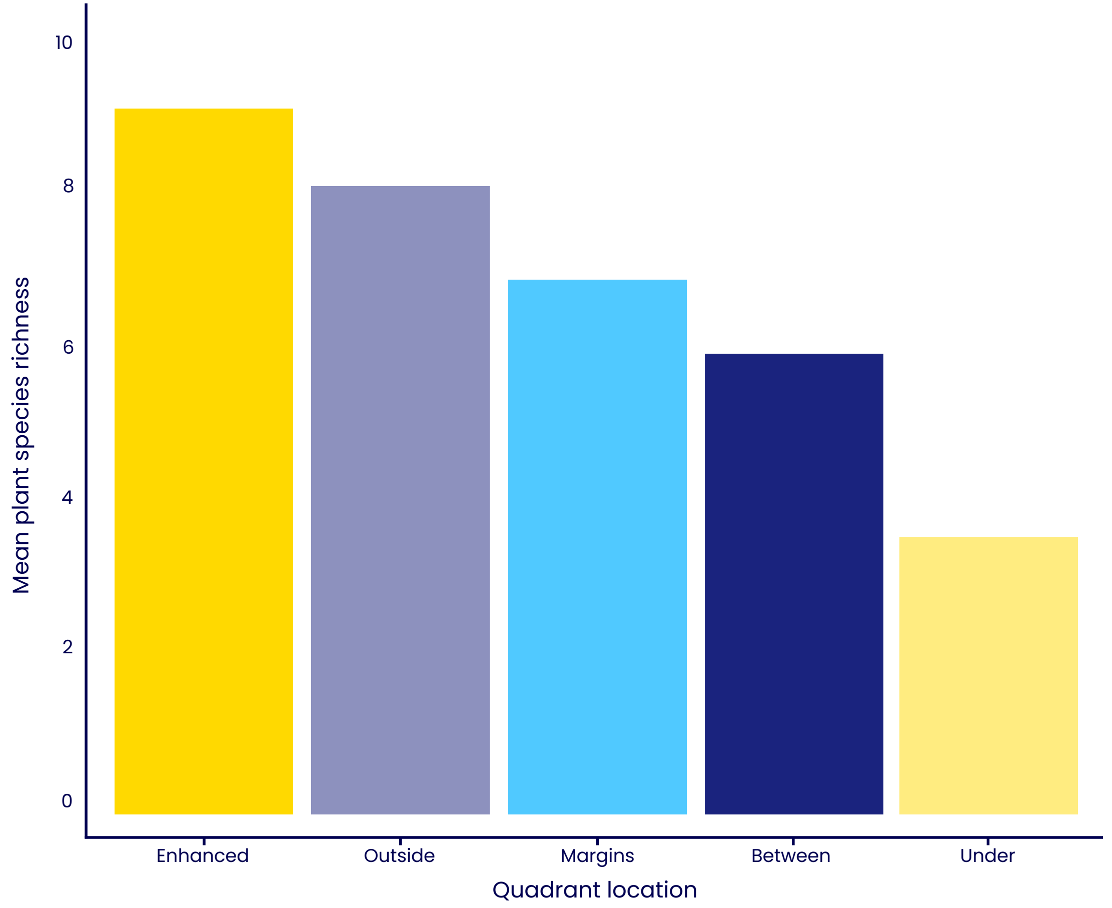


Figure 3. Average plant species richness by quadrat location. The mean number of plant species recorded inside quadrats surveyed in different locations within solar farms.

Plant species richness also varied at the site level, ranging from four to 66 species recorded, incorporating quadrats surveyed in all areas of the sites. The number of plant species observed varied with how the solar farm was managed, with an average of 31 species recorded at solar farms placed into overall management Category 2, 28 species at solar farms placed into Category 3 and 23 species at those considered to be in Category 4 (Figure 4).

Incidental observations

Alongside botanical quadrats, plant species were recorded as part of incidental observations at some solar farms, where ecologists recorded plants they identified whilst moving around the site or conducting other surveys. A total of 154 observations were made across 21 sites. Most observations focused on broadleaf species (77%), as they are typically more noticeable, but some observations of graminoids (18%) and other species (5%) were also made. A total of 102 plant species were identified, 23 of which were not recorded in quadrats as part of structured surveys.

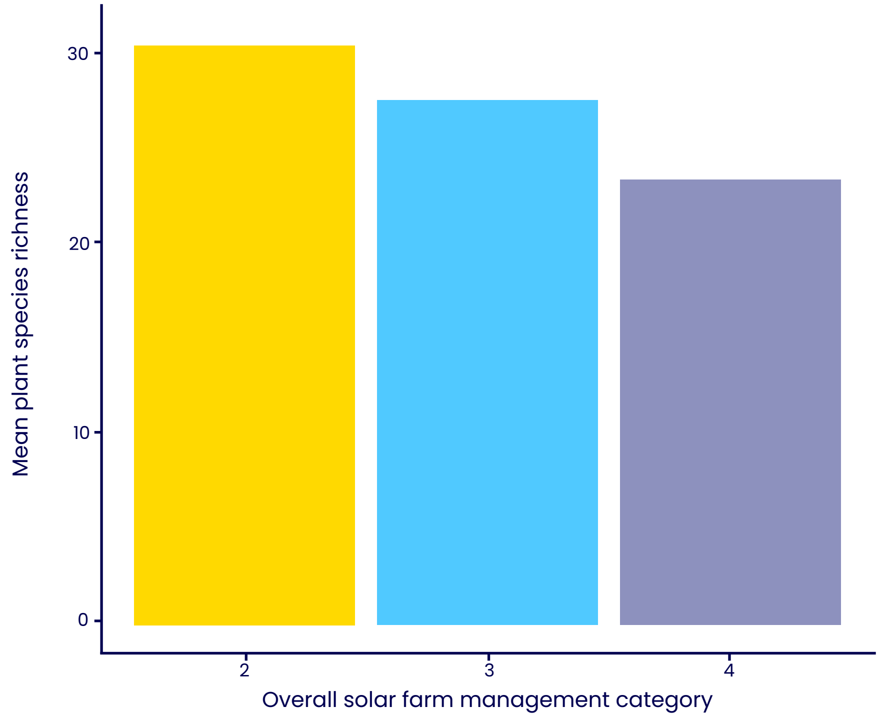
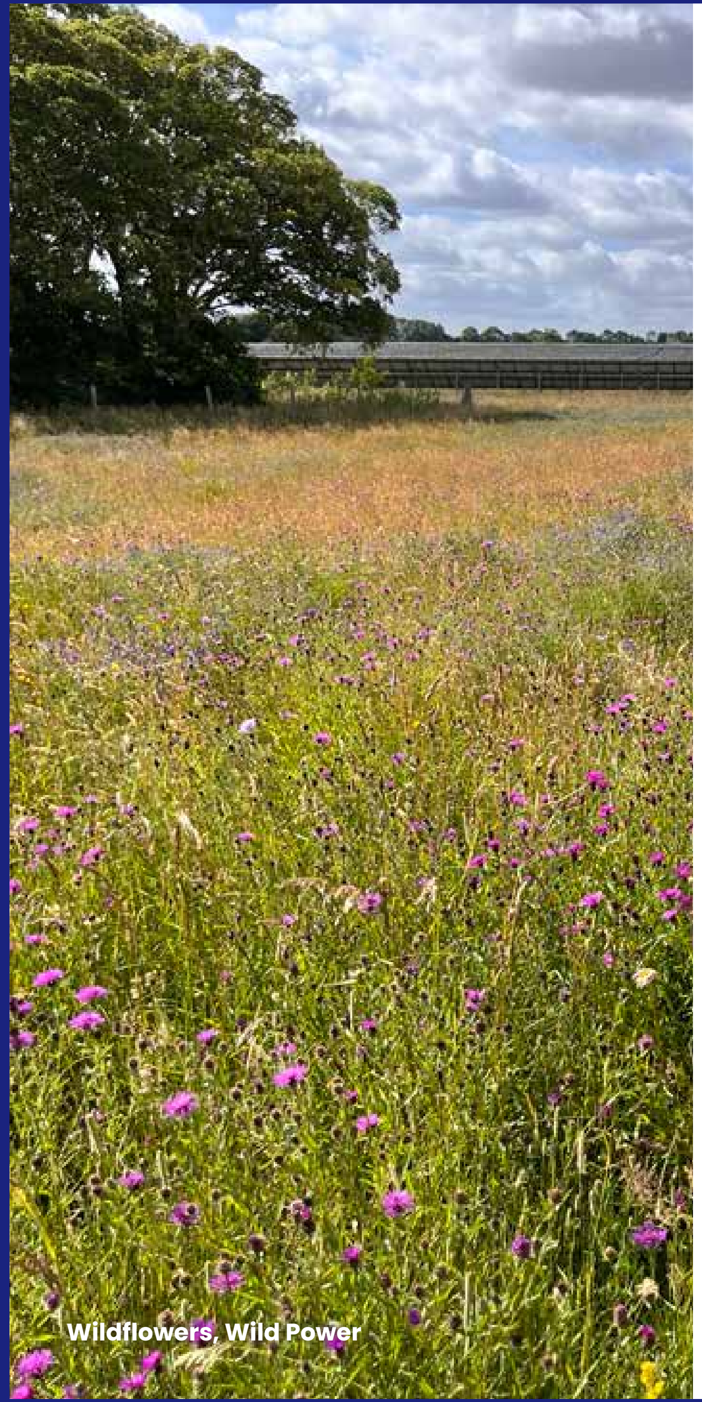


Figure 4. Average plant species richness by solar farm overall management category. The mean number of plant species recorded at the solar farm scale by solar farm management category.

Oxeye daisy, H. Blaydes, Lancaster University



Wildflowers, Wild Power

Case Study

Wild Power Certification for West Raynham Solar Farm

A way to measure, validate and verify biodiversity

The Wild Power Solar Biodiversity Scorecard integrates habitat creation, extent and condition, connectivity, biodiversity, ecosystem services and management actions to provide a holistic view of a site's contribution to biodiversity and is the basis for the Wild Power Certification scheme[9]. Over 50 UK solar farms have been surveyed using the Scorecard during Wild Power's calibration phase and the first Wild Power certification was issued to Bluefield Solar Income Fund's West Raynham Solar Farm in May 2024.

◄ Wildflowers at West Raynham Solar Farm now cover an area of approximately 40 acres, providing habitat and foraging for pollinators and birds. This area is managed following a conservation sheep grazing regime.

CASE STUDY: West Raynham Solar Farm

West Raynham Solar Farm occupies approximately 91 hectares of a disused airbase. The land had previously been dominated by extensive areas of open, sheep grazed, semi-improved grassland, former runways and two parcels of arable land. As such the site presented considerable opportunity for biodiversity enhancement, which has been realised under Bluefield's stewardship.

Selected site features:

- Microhabitats have been installed throughout the site, with bird boxes (including barn owl boxes), bat boxes and log piles.
- Hedgerows, planted at construction, augment existing perimeter features to provide habitat, connectivity and foraging for local fauna.
- Invasive and injurious weeds have been identified and management plans enacted.
- Comprehensive biodiversity monitoring plans are in place for the site, including a number of biodiversity indicators (transects, breeding bird surveys, quadrats) and a fixed photo point monitoring programme. These have shown increasing wildflower diversity over time, Schedule 1 bird species, and farmland bird species of interest such as skylarks (*Alauda arvensis*).

Wild Power Certification

The measures highlighted above alongside a commitment to planning, creation and delivery of a thorough Biodiversity Management Plan contributed to West Raynham Solar Farm achieving Wild Power Gold status, Wild Power's highest level of certification. West Raynham Solar Farm is stated to be operational until 2055. Over this time, as a result of the efforts that Bluefield has put into enhancing biodiversity at the site, West Raynham Solar Farm will provide habitat and be a haven for nature concurrent with the benefits associated with renewable energy production.

wild power

WILD POWER CERTIFIED — NATURE FRIENDLY ENERGY

A five-acre tree planting area at the north of the site offers screening along with associated ecosystem services benefits such as additional habitat types, food sources, structural variation, soil and water control, carbon capture, and air purification. ►

Planting area, Wild Power

Hedgerows

In addition to grasslands, hedgerows are another important habitat for biodiversity at solar farms. Hedgerows can provide food and shelter for a range of biodiversity groups including invertebrates, birds and mammals. Hedgerows can also facilitate species movement across landscapes, acting as wildlife corridors, which are especially important for those that struggle to cross large, open areas, such as agricultural fields[10].

Hedgerow surveys

In 2024, hedgerows were assessed at 29 solar farms where ecologists recorded their condition (using Biodiversity Net Gain condition criteria), characteristics and species present. A total of 172 individual hedgerows were surveyed, with an average of four hedgerows assessed at each site (ranging from one to 19). Most hedgerows were noted as being in good condition (66%), with many in moderate condition (23%), a small number in poor condition (3%) and the condition of some hedgerows were not recorded (8%). Hedgerow condition scores are determined using the Biodiversity Net Gain methodology, assessing key traits including height, width, ground disturbance, damage, nutrient input and the presence of invasive species.

In total, 44 plant species were observed within hedgerows and the most commonly recorded was hawthorn (*Crataegus monogyna*; recorded in 83% of hedgerows), followed by blackthorn (*Prunus spinosa*; recorded in 78%) and field maple (*Acer campestre*; recorded in 34%). It is not surprising that these species were frequently recorded as blackthorn and hawthorn generally form the highest percentage of hedgerow whip mixes as they provide structure. Hedgerow habitats offer shelter and additional foraging habitat to the grassland on a solar farm and demonstrates how the inclusion of this important habitat within sites can introduce a suite of different species (namely woody plants).

On average, five plant species were recorded per hedgerow, but this ranged from one to eleven species. The number of species recorded varied with how the hedgerows were managed (Figure 5). Hedgerows at solar farms that were assigned to Category 1 (in terms of hedgerow management, as shown in Table 2) contained an average of six species, compared to five species at sites assigned to Category 2 and four species at sites in Category 3.

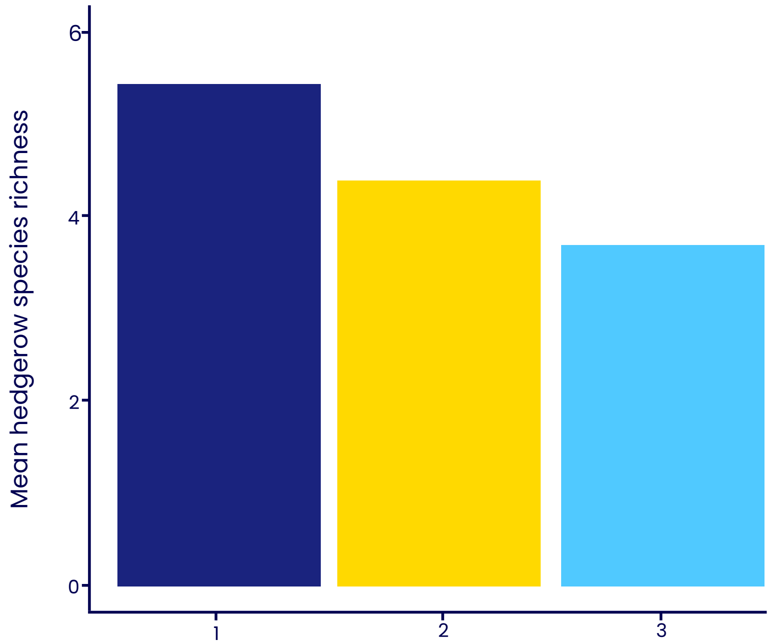


Figure 5. Average hedgerow species richness by hedgerow management Category 1. The mean number of species recorded in hedgerows at solar farms across hedgerow management categories.

Peacock butterfly, Wychwood Biodiversity

Invertebrates

Invertebrates provide a range of services beneficial to humans and wildlife, including the pollination of wild and agricultural plants. A key element of food chains, invertebrates are also a major source of food for biodiversity groups such as birds and bats. However, many invertebrate species have become less abundant and widespread over decades, with flying insects potentially declining by as much as 60% between 2004 and 2021 across the UK[11]. Preliminary data suggest that 2024 may have been the worst year on record for some groups such as butterflies, with low numbers attributed to poor weather conditions, set against the backdrop of other challenges that invertebrates face such as habitat loss, degradation, fragmentation and climate change[12].

Managing solar farms to provide suitable habitat for invertebrates could contribute to alleviating some of these challenges. For example, solar farms can be managed to provide critical food, nesting sites and microclimatic niches for invertebrates, as well as enhancing landscape connectivity[13] and appropriate management has shown to support greater invertebrate biodiversity within solar farms[14].

Transect walks

At 64 solar farms (52% of sites), butterflies and bumblebees were surveyed by ecologists walking transects. Transects focused on these invertebrate groups as they are identifiable in the field, unlike other groups which can require samples to be collected and examined under a microscope to identify species. Butterflies and bumblebees are also relatively large invertebrates, making them easier to spot when surveying, and they can act as indicators for the biodiversity of other invertebrate groups and environmental change[15].

Transects were generally 100 m in length and any butterfly or bumblebee within an imaginary 5 m x 5 m box around the surveyor was counted and identified to species level in most cases. A total of 764 transects were walked across all solar farms, either between the rows of solar panels ("between"; 396 transects) or in margins, open areas or areas enhanced for biodiversity ("outside"; 368 transects). On average, ten transects were walked at each solar farm, but this ranged from nine to 22.

Invertebrates continued

Butterflies and bumblebees recorded along transects

A total of 2,913 individual butterflies and bumblebees were counted along all transects, comprising 29 different species (23 butterfly and six bumblebee species). Butterflies were almost ten times more abundant than bumblebees, with 2,633 individual butterflies counted compared to 280 bumblebees. Butterflies may be more abundant as many of the species recorded are reliant on grasses, which are fed on by caterpillars and are therefore critical to complete their life cycle[16]. In contrast, bumblebees may instead be looking for flower rich areas, rather than areas of long grass, which may only be present where management is targeted to create such habitats at solar farms.

The most commonly recorded butterfly species was the meadow brown (*Maniola jurtina*), making up almost 60% of the total invertebrate count (1,717 individuals were recorded). Gatekeeper (*Pyronia tithonus*) and marbled white (*Melanargia galathea*) were also abundant, with 243 and 170 individuals counted, respectively. Almost all of the butterfly species recorded are classified as Least Concern, although one Vulnerable species was recorded: the small heath (*Coenonympha pamphilus*). Small heath were sighted at 15 solar farms, with 75 individuals observed across all of these sites. This species is classified as Vulnerable because although small heath is widespread throughout the UK, their distribution has declined significantly since the 1970s and due to their low dispersal ability, it is unlikely that populations of small heath from continental Europe could recolonise and help to expand the UK population[17].

In terms of bumblebees, the most frequently recorded species were the white-tailed bumblebee (*Bombus lucorum*; 127 individuals), the red-tailed bumblebee (*Bombus lapidarius*; 79 individuals) and the common carder bee (*Bombus pascuorum*; 34 individuals).

On average, one butterfly or bumblebee species was recorded along each transect (per 100 m), but this varied from zero to ten. In term of number of individuals counted per 100 m, the average was four but ranged from zero to 49. However, both the number of species and the number of individuals recorded along transects varied depending on where transects were walked. The number of individuals and species of butterflies and bumblebees collectively was greater in outside areas compared to between the rows of solar panels (Figure 6). On average, one species was observed along transects walked between the solar panels, compared to two walked in margins, open areas or areas enhanced for biodiversity (Figure 6). In terms of the number of individuals counted, an average of two individuals were sighted between the rows of solar panels, compared to six individuals in other areas (Figure 6).

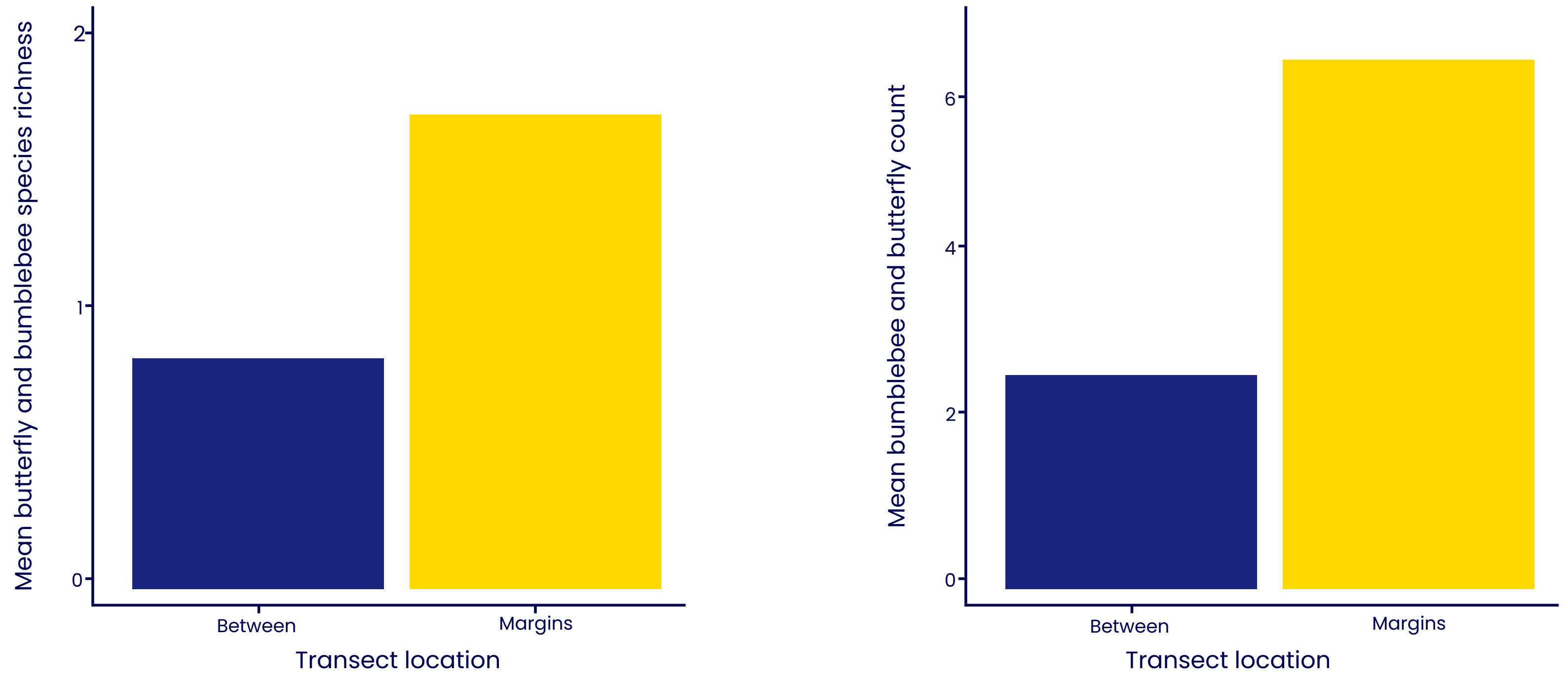


Figure 6. Butterfly and bumblebee biodiversity by transect location. The mean number of butterfly and bumblebee species (left) and count of individual butterflies and bumblebees (right) recorded along 100 m transects walked between the rows of solar panels ("between panels") and in margins, open areas or areas enhanced for biodiversity ("margins").

Invertebrates continued

Butterfly and bumblebee diversity also varied at the site level. The average number of species recorded was five, but this ranged from zero to twelve. The average number of individuals counted was 46, ranging from zero to 281. Solar farm butterfly and bumblebee species richness and counts varied according to how sites were managed, with the greatest numbers of species and individuals recorded at solar farms assigned to Category 2, followed by Category 3 and then Category 4 (Figure 7).

Whilst both transect location and site management appear to affect invertebrate biodiversity at solar farms, it is important to note that many other factors influence invertebrate biodiversity in this context. A positive relationship between plant and invertebrate species richness was observed (Figure 8), but other factors including landscape context, weather and climatic variables are likely to have an influence[18]. This is particularly true for the surveys undertaken in 2024, when the numbers across the country were extremely low due to weather conditions.

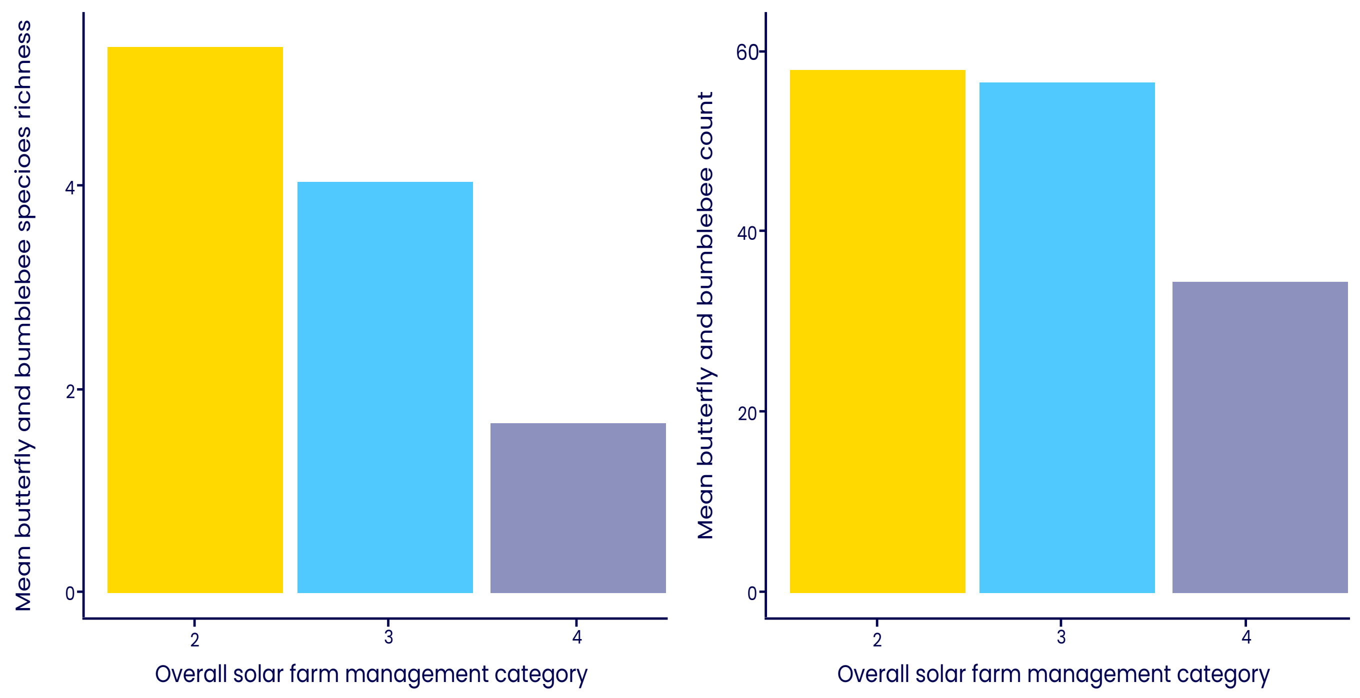


Figure 7. Butterfly and bumblebee biodiversity by solar farm overall management Category 2. The number of species (left) and individuals (right) of butterflies and bumblebees recorded at solar farms by overall management category.

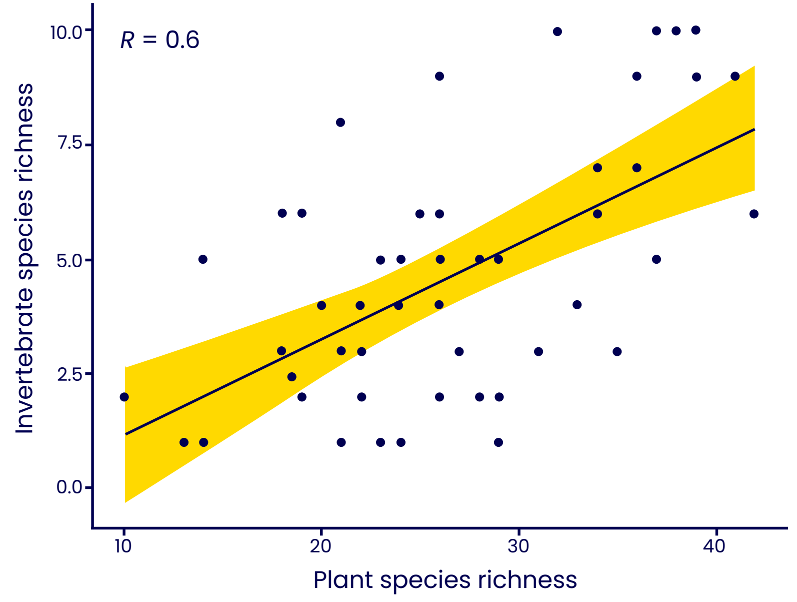


Figure 8. The relationship between plant and invertebrate (butterfly and bumblebee) species richness at the solar farm scale. The black line represents the trend line and the shaded areas represent 95% confidence intervals. The R value is the Pearson correlation coefficient.

Other invertebrates recorded along transects

Although transects were focused on butterflies and bumblebees, a total of 104 other invertebrates were recorded, comprising eight different species. Most individuals counted were honeybees (*Apis mellifera*; 68 individuals) and six-spot burnet moths (*Zygaena filipendulae*; 20 individuals). Other moth species recorded included five-spot burnet moths (*Zygaena lonicerae*; four individuals) and cinnabar moth (*Tyria jacobaeae*; one individual), along with odonates including common blue damselflies (*Enallagma cyathigerum*; five individuals), emperor dragonflies (*Anax imperator*; three individuals) and a broad bodied chaser (*Libellula depressa*; one individual). European hornets (*Vespa crabo*) were also recorded on two occasions.

Incidental observations

A total of 1,504 invertebrates were also observed at solar farms outside of structured transect walks. Such observations were made at 35 solar farms, including sites where structured surveys were not undertaken, and 42 species were recorded. These included 20 butterfly species, five bumblebee species, eight odonates and a range of other invertebrates including beetles, crickets, grasshoppers, hornets, moths and spiders.

Birds

Birds are a much-valued component of the UK's biodiversity, and their populations provide an indication of the broader state of wildlife as they occupy a wide range of habitats and respond to environmental pressures that affect other biodiversity groups. However, wild bird numbers across the UK are falling and since 2018 many bird species have suffered population declines19. The worst affected groups are farmland and woodland birds, which have declined by 61% and 35% since 1970[19]. However, there is emerging evidence that solar farms can support some bird species in agricultural landscapes by increasing structural diversity[20] and providing safe breeding areas[21].

Bird surveys

A total of 78 bird surveys were undertaken across 63 solar farms, with some sites being surveyed once (76% sites) and others twice (24% sites). Surveys involved a walked transect across each solar farm so that all habitats within 50 m of a transect were covered and all birds that were heard or seen were recorded.

Birds recorded as part of surveys

A total of 94 bird species were recorded as part of surveys and most were BTO Green Listed (49%; 46 species), although a significant proportion were Amber (28%; 26 species) or Red (20%; 19 species) Listed Species of Conservation Concern. There were also three species (3%) recorded which had no status, representing those which are not categorised by the BTO, as they are introduced species (e.g. little owl, *Athene noctua*) or game bird species (e.g. common pheasant, *Phasianus colchicus* and red legged partridge, *Alectoris rufa*).

In terms of bird count, a total of 7,459 individual birds were recorded. The most abundant Green Listed species was blue tit (*Cyanistes caeruleus*; 485 individuals), closely followed by goldfinch (*Carduelis carduelis*; 447 individuals).

The most abundant Amber Listed species was wood pigeon (*Columba palumbus*; 645 individuals), followed by wren (*Troglodytes troglodytes*; 589 individuals). It is unsurprising that these species were abundant and frequently recorded at solar farms given both woodpigeon and wren are generalist species that thrive in a variety of habitats. Although wren is on the Amber List, they are the most abundant species in the UK and were recorded during almost all bird surveys undertaken at solar farms (Figure 9). It is likely that they are attracted to the hedgerows and tussock grassland associated with solar farm boundaries.

The most abundant Red Listed species (in terms of the number of individuals counted) was starling (*Sturnus vulgaris*; 333 individuals), followed by linnet (*Linaria cannabina*; 223 individuals). When considering how frequently species were recorded (in terms of in how many surveys they were observed), starling were seen within around a third of all bird surveys (32%; Figure 9) and linnet were recorded within around half (49%; Figure 9). However, the most frequently observed Red Listed species was skylark (*Alauda arvensis*), recorded during 59% of all bird surveys undertaken (Figure 9).

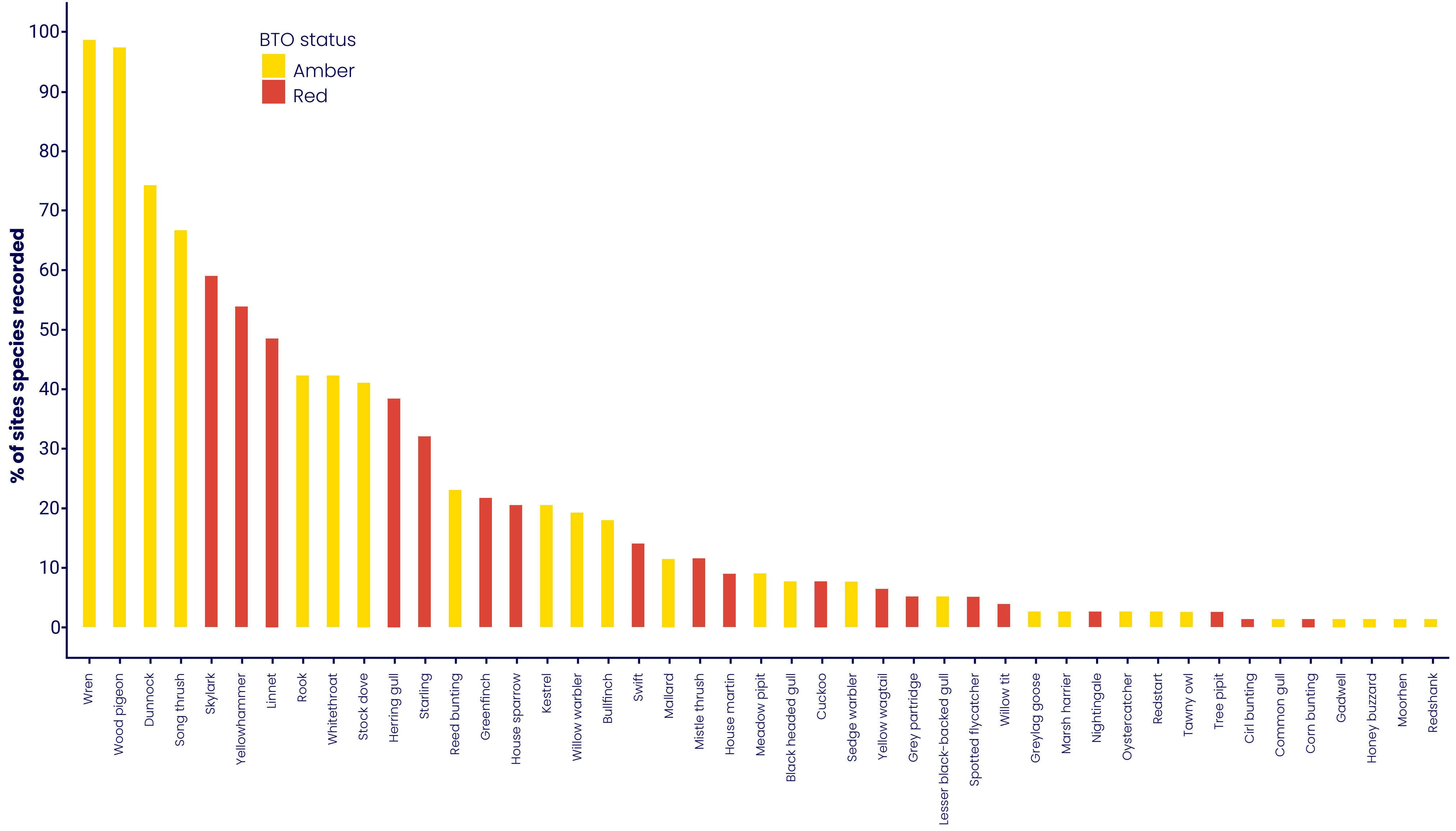


Figure 9. Observation frequency of Birds of Conservation Concern. The percentage of individual bird surveys during which each BTO Amber or Red Listed bird species was observed, arranged by most to least frequently recorded.

Birds continued

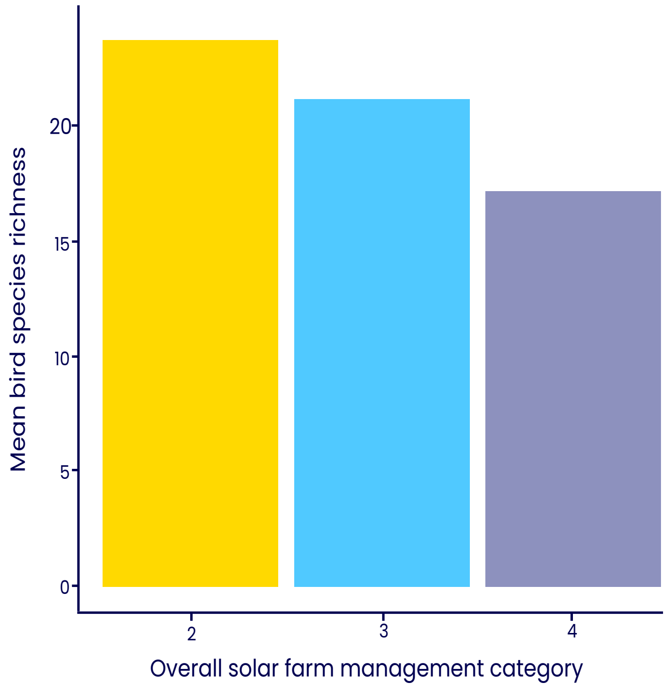
Particularly Interesting species recorded during bird surveys included nightingale (*Luscinia megarhynchos*), observed during two surveys at one solar farm and reported as possibly breeding on site. Nightingale is a Red Listed species which have declined in number (42% reduction in population between 1995 and 2022) and range over time and are now only found in small areas in southern and eastern England[22].

Another notable Red Listed species recorded was cirl bunting (*Emberiza cirlus*), observed during one survey at one solar farm. This species also has a restricted range, which contracted by almost 85% between 1968-72 and 2008-11, and is now generally limited to southwest England[23].

On average, 86 individual birds were recorded per survey, but this ranged from eleven to 238. In terms of number of bird species, 22 were sighted per survey, on average, ranging from eight to 39.

There was also variation in bird biodiversity observed at the site level. On average, 93 individual birds were recorded per solar farm, but this ranged from 28 to 238. The number of species sighted also varied, with an average of 22, but ranging from nine to 39. Solar farm scale numbers include only values from one bird survey per site; the second bird survey at solar farms that were visited twice was excluded.

There was some variation in bird diversity with solar farm management, with more individuals and species recorded during surveys at solar farms that were managed with a greater focus on biodiversity (i.e. assigned to Categories 2 or 3; Figure 10). On average, 24 species were sighted at solar farms in Category 2, 21 species at sites in Category 3 and 17 species at solar farms assigned to Category 4. A similar pattern was observed with the number of individuals, with 97 birds observed at solar farms assigned to Category 2, 95 at sites in Category 3 and 58 at those in Category 4, on average (Figure 10).



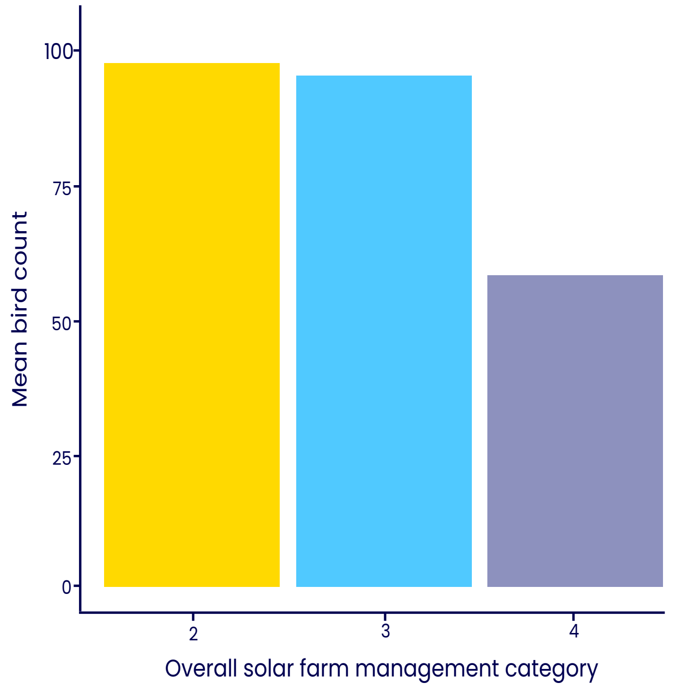


Figure 10. Bird biodiversity by solar farm overall management category. The number of bird species (left) and individual birds (right) recorded during structured bird surveys walked at solar farms assigned to different management categories. Where multiple bird surveys were undertaken at solar farms, only data from the first survey were included.

Incidental observations

Birds were also observed outside of structured bird surveys and incidental observations were noted down by ecologists at 28 solar farms (sometimes alongside structured surveys, but not in all cases). As part of incidental observations, 426 birds were recorded, comprising of 46 different species. As with structured surveys, most species recorded were Green Listed (50%; 23 species), although Amber and Red Listed (both 22%; ten species) were also recorded, as were those which are non-native and so have no status (6%; three species). All species recorded as part of incidental observations were also observed in structured bird surveys, apart from Canada goose (*Branta canadensis*).

Meadow Pipit,
H. Knight-Smith, British Solar Renewables

Stonechat, J. Coppin, RSPB

Case Study

Solar farms managed for nature can boost bird numbers

RSPB

UNIVERSITY OF CAMBRIDGE

Centre for Landscape Regeneration

The possibility that solar farms managed for biodiversity could support birds has been evidenced by a recent study undertaken by the RSPB and the University of Cambridge[24]. Bird populations on six solar farms in the East Anglian Fens were explored by conducting field surveys at solar farms managed in different ways (Table 3) and in nearby arable farmland. Across the entire study, more than 35 km of transects were walked, with 830 individual birds from 44 different species recorded.

Category	Definition
Simple habitat solar farm	Solar farms that were intensively managed, with the grass around the solar array cut or grazed, leading to a short sward throughout the summer.
Mixed habitat solar farm	Solar farms that were less intensively managed and as a result contained more complex habitats, allowing greater sward height and establishment of wildflowers. Woody features, such as hedgerows, were also present.

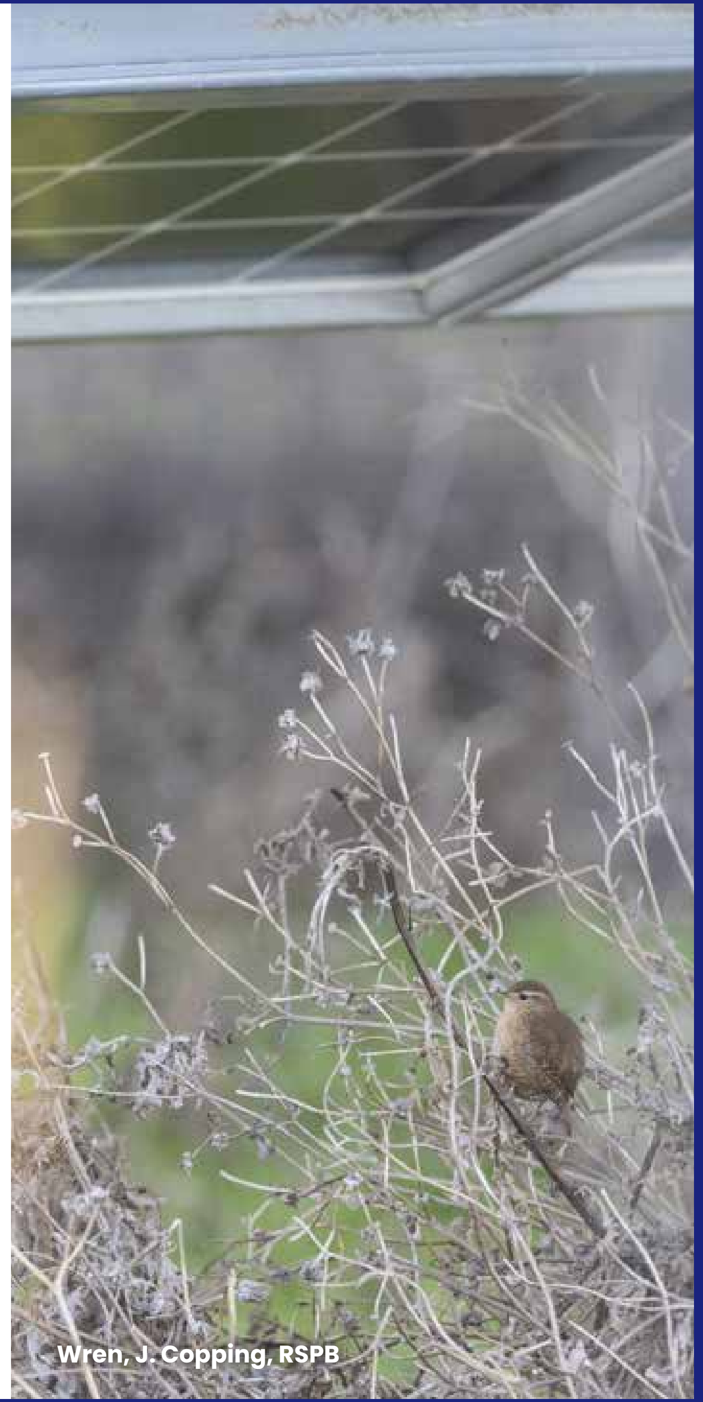
Table 3: Categories into which solar farms were split, based on management, in this study across six sites in the Fens.

Bird abundance and species richness was reported to be greater inside mixed habitat solar farms, i.e., those managed less intensively. This trend was reported across most of the bird species studied and was also clear when birds were split into different groupings, including for farmland and woodland birds, and for threatened species classed as Red/Amber listed Birds of Conservation Concern.

Thinking about the drivers behind these trends, the researchers suggest that well managed solar farms could support bird biodiversity because they have increased floral diversity compared to intensively managed sites or arable land, which provide food resources for birds via seed and invertebrate prey. Alternatively, solar farms may support birds because their presence in certain landscapes can add structural variation via semi-natural habitat features which provide cover and perches for birds. The researchers highlight that the impact of solar farms may differ depending on wider landscape context and sites developed in landscapes dominated by intensive arable agriculture might be more beneficial to biodiversity than those deployed in landscapes that already contain diverse grasslands or other natural habitats.

Careful landscape-scale planning is still needed to ensure solar farms are developed in suitable areas, away from nature-sensitive areas. However, if managed with biodiversity in mind, this study echoes the notion that solar farms can provide relief for birds from the impacts of intensive agricultural practices in the surrounding landscape.

To help realise these benefits on the ground, the RSPB is working in partnership with solar businesses Lightrock Power, Econergy and Elements Green to help ensure a positive outcome for nature and to support the integration of best practices for nature into the management of their sites.



Wren, J. Copping, RSPB

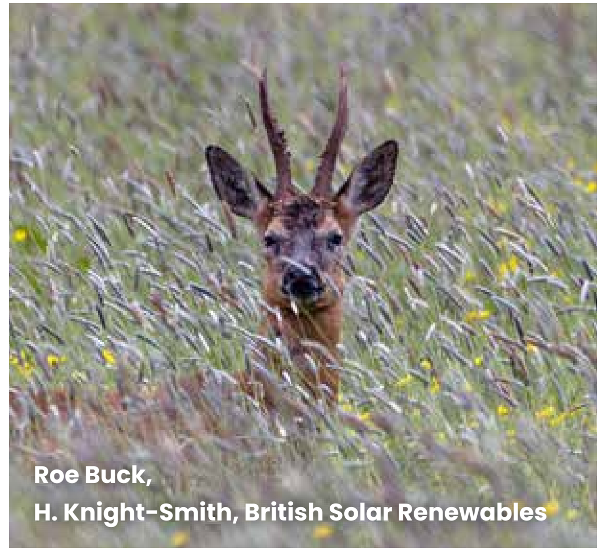
Roe Deer, H. Knight-Smith, British Solar Renewables

Mammals

Incidental observations

Although targeted surveys for mammals were not undertaken at most solar farms, ecologists noted down any mammals they observed, or saw signs of (such as scat, footprints or feeding remains), whilst carrying out other surveys. Mammal observations were made at 22 sites (18%), with eight species observed or signs of their presence recorded. These included badger (*Meles meles*), fox (*Vulpes vulpes*), brown hare (*Lepus europaeus*), rabbit (*Oryctolagus cuniculus*) and common shrew (*Sorex araneus*). Muntjac (*Muntiacus reevesi*) and roe deer (*Capreolus capreolus*) were also sighted. At one solar farm, droppings and feeding remains of water vole (*Arvicola amphibius*) were noted, which is listed as endangered on the Red List for British Terrestrial Mammals because of population declines over time[25].

Incidental observations provide only a snapshot of the mammal biodiversity that can exist within solar farms and to gain a better understanding, targeted approaches are needed.



Roe Buck,
H. Knight-Smith, British Solar Renewables

Soils

Soil conditions and properties reflect the types of habitats that can be supported above ground. Soil samples can be collected to track any changes in nutrient levels and general soil health over time. High nutrient levels can be a limiting factor to habitat creation (e.g. wildflower meadow creation) and can guide appropriate management to work towards creating suitable conditions prior to applications of expensive seed mixes. If soil properties and conditions are known this can also inform an appropriate seed mix and support a site-specific approach.

Soil sampling

Soil samples were taken at 35 solar farms, and this typically involves using a soil corer to collect samples within one of the fields.

Several challenges were identified when collecting soil samples. On some sites, samples were not taken due to concerns about underground wiring damage. Where samples were taken, the corer was only utilised between panels due to health and safety concerns associated with taking samples under panels or in the edges of the site (where security camera cables can be buried). Additionally, the sampling methodology is designed to be focussed on a single field so in many cases, the entire site was not sampled.

Laboratory analysis

Once soil samples have been collected by ecologists, they are sent off to external laboratories who run a range of tests to assess soil properties. For most solar farms, a range of data were available which can inform future management and provide insights into soil health (Table 4).

Soil property	Application
pH	Can be used to inform future seeding or planting.
Phosphorous content	A key limiting nutrient when establishing a diverse grassland.
Potassium content	A key limiting nutrient when establishing a diverse grassland.
Magnesium content	Useful to inform grazing regimes.
Total nitrogen	A very variable nutrient which can also limit plant diversity when levels are high.
Organic matter	An overall measure of soil health.
Total organic carbon	An overall measure of soil health.
Carbon nitrogen ratio	Higher ratios are typically associated with more soil fungi and slower decomposition of organic matter.
Soil texture	Insights into the proportion of sand, silt and clay can be useful to inform seeding and planting.

Table 4. Soil properties and how they can inform solar farm management. Soil properties that can typically be assessed after running laboratory tests and their applications for use when managing solar farms.

Soil, H. Blaydes, Lancaster University

Case Study

Promoting soil carbon on solar farms

Land use change has resulted in substantial losses of soil organic carbon (SOC) globally, and the current drive to convert agricultural land to ground-mounted solar farms offers risks and opportunities to enhance soil's role in climate, food, and human security. The goal of increased SOC storage to combat climate change has received much attention in recent years, partly due to its other known benefits (e.g. water quality, food security).

Solar farms can play a crucial role in addressing global soil issues by promoting healthy soils and, in particular, SOC storage and sequestration, which are essential to mitigate climate change, support food production, and promote biodiversity.

Despite the significant impact solar panels may have on plant biomass production and soil carbon[26], solar farms can promote SOC through a range of design, construction, and management options that are fully compatible with solar farm development and operation.

A recent review of the scientific evidence from the UK and Ireland[27] has revealed land management practices that offer potential to deliver net soil carbon gains within solar farms in the UK:

1. **Designing solar farms to deliver positive outcomes for plants and soils** (e.g. by increasing the height of solar panels or the proportion of areas not over-sailed by panels to reduce the negative effects of shading on plant productivity). However, these would likely result in increased land take for solar farms, with overall outcomes dependent on the type of land use being converted.
2. **Adopting construction practices that minimise impact on soils** (e.g. by favouring the use of low-impact vehicles to minimise soil compaction during construction and operation).
3. **Increasing plant species richness and the diversity of plant functional groups**, including those commonly associated with increased soil carbon sequestration (e.g. legumes) and those tolerant to shading (to cope with conditions found underneath solar panels).
4. **Improving grazing management through low-to-moderate intensity grazing and rotational grazing** (i.e. rotating livestock to allow the land to rest).
5. **Applying organic fertilisation tailored to site conditions**. Moderate levels of organic nutrient addition, particularly cattle slurry and biosolids, often results in positive outcomes for grassland soil carbon storage in the long term, especially if combined with other management options (e.g. rotational grazing), however, higher nutrient contents can promote lower plant diversity.

The wide temporal and spatial variability in soil conditions in agricultural systems, as well as the highly contextual nature of the effects of land management on soils, make devising general recommendations challenging. Therefore, design, construction, and management strategies must be optimised for each solar farm to accommodate site specific conditions. Positive results will most likely be realised if conversion is from degraded agricultural land or brownfield sites.

Importantly, regular monitoring using standardised approaches[28] will be key in evaluating the success of any intervention to support healthy soils, and help inform scientific research, land use frameworks, policy development[29], and industry best practice.

Soil sample, H. Blaydes, Lancaster University

Looking ahead

Solar Habitat 2025 marks the third annual edition of the Solar Habitat report, reaffirming that well-managed solar farms can positively contribute to biodiversity. Whilst the importance of substantiating this conclusion with evidence each year remains, the industry is committed to continuously enhancing the depth of our analysis by exploring new ways to strengthen the insights from the data collected.

Methodology update

The Standardised Approach to Monitoring Biodiversity on Solar Farms has been applied on 248 occasions across three years, according to the data submitted for analysis in Solar Habitat, and may well have been used more widely. Building on their experience in the field and looking at how solar farms are changing the authors have identified ways that the methodology can be improved and adapted to an evolving industry. As the data sets grows, we anticipate further research, including examination of temporal trends.

Site numbers and third parties

The number of sites surveyed each year has grown from report to report. In the first and second Solar Habitat however, though data was collected on sites representing multiple site managers and owners, the ecologists conducting the monitoring and submitting the data has been the two ecological consultants involved in both developing the Standardised Approach and authoring Solar Habitat. For the number to continue to grow and cover a greater share of active sites across the country it will be necessary for additional ecological consultants to use the methodology and submit data to the report. This year, data has for the first time been supplemented by a third party ecological consultant, Envance.

The Standardised Approach was developed for industry-wide use, and we strongly encourage all consultants conducting ecological monitoring on solar farms to adopt it. We look forward to increased participation from ecological consultants in the future.

Identifying deeper trends in the data

Lancaster University have been conducting a deeper analysis of the data from 87 sites collected in 2023. It is hopeful that this analysis could identify relationships and management types which have been effective in promoting biodiversity on solar farms which have not been picked up in the regular analysis in the report. As well as that we hope that this will identify areas of analysis which could add depth to future Solar Habitat reports. As the data sets grows, we anticipate further research, including examination of temporal trends.

Citizen science

Over the past year the project partners have held discussions with Non Government Organisations (NGOs) engaging volunteers to conduct monitoring of birds and invertebrates. Enabling volunteers to access sites to conduct in depth bird or invertebrate studies on solar farms, potentially including more than one visit in a year, could add clarity to our understanding of how they behave on solar farms. The project partners will continue to discuss how this could be achieved and aim to pilot a volunteer monitoring scheme on a solar farm.

Exemplar solar farms

The authors have discussed the possibility of developing a small number of 'research intensive' sites. This would enable more extensive biodiversity assessments and allow ecologists to target sampling days suitable for certain groups. Moreover it would enable more groups to be assessed and multiple visits in one year to capture known variations in species throughout the year. Such sites impact of seasonal and daily weather fluctuations on the usual one-day surveys, by conducting longer, targeted studies, possibly with multiple visits in the year to test out the trends identified in the larger data set. Such sites could also be suitable places to test innovations in monitoring techniques, such as automated monitoring technologies.

Kestrel, H. Knight-Smith, British Solar Renewables

AgriSound Polly, H. Blaydes, Lancaster University

Case Study

Automated monitoring of biodiversity at solar farms

Novel technologies are emerging that can be used to monitor biodiversity which are less time demanding than traditional surveys and capture data at much more frequent intervals. Often using acoustics or image-based analyses, devices can be deployed in an area of interest, such as a solar farm, and left to collect biodiversity data. Compared to one day field surveys, which are often only able to capture a snapshot of biodiversity present on a single day, continuous monitoring that collects data over longer periods can provide different insights into biodiversity. Monitoring over longer periods of time also means that results are less likely to be impacted by weather conditions, which can strongly influence outcomes of single visit field surveys.

AMI trap, H. Blaydes, Lancaster University

A range of automated monitoring techniques have been trialled at Westmill Solar Park in Oxfordshire to assess the activity of invertebrates, birds and bats, in a study led by Lancaster University.

Although similar techniques have been used in agricultural settings, this is the first time that this combination of technologies have been deployed in tandem in a renewable energy setting. It is hoped that these technologies will help to further understanding of biodiversity response to solar farms habitats.

The study was supported by Low Carbon and the UKRI Engineering and Physical Sciences Research Council.

The different technologies used were:

AgriSound Pollys

These devices use acoustics (based on the wing beat frequency of invertebrates) to assess bee and hoverfly activity[30].

Automated Monitoring of Insect systems

Developed by the UK Centre for Ecology & Hydrology, these traps use lighting to attract moths along with a high-resolution camera to assess moth activity and biodiversity based on the images captured[31].

SongMeters

Acoustic devices with multiple microphones that record bird and bat calls, giving insights into activity and species present[32].

Songmeter, H. Blaydes, Lancaster University

Contributors

Monitoring data for Solar Habitat 2025 was provided by:

We would like to thank the following asset owners and managers for contributing monitoring data and case studies:

Resources and Footnotes

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