Review
of 2023

A full report of the activities of the Game & Wildlife Conservation Trust

gwct.org.uk

Game & Wildlife Conservation Trust

Leave a gift that lasts for generations

What made you fall in love with the British countryside? Whether it was the call of a curlew or a day spent with a loved one that sparked your love for the countryside, your gift will ensure that future generations can experience the same joy and wonder.

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Game & Wildlife
CONSERVATION TRUST

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REVIEW OF 2023

Game & Wildlife Conservation Trust

Issue 55

A full report of the activities of the Game & Wildlife Conservation Trust (Registered Charity No. 1112023) during the year

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GAME & WILDLIFE CONSERVATION TRUST CHARITABLE OBJECTS

- To promote for the public benefit the conservation of game and its associated flora and fauna.
- To conduct research into game and wildlife management (including the use of game animals as a natural resource) and the effects of farming and other land management practices on the environment, and to publish the useful results of such research.
- To advance the education of the public and those managing the countryside in the effects of farming and management of land which is sympathetic to game and other wildlife.
- To conserve game and wildlife for the public benefit including: where it is for the protection of the environment, the conservation or promotion of biological diversity through the provision, conservation, restoration or enhancement of a natural habitat; or the maintenance or recovery of a species in its natural habitat on land or in water and in particular where the natural habitat is situated in the vicinity of a landfill site.

Game & Wildlife CONSERVATION TRUST

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as of 1 January 2024

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Names in brackets were chairmen that stepped down during 2023

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Barn owl. © Laurie Campbell

Game & Wildlife CONSERVATION TRUST

Welcome

A thriving countryside rich in game and wildlife

Broadening our reach and expanding our impact

The GWCT's research into wildlife has expanded over the last 20 years. © Laurie Campbell

Teresa Dent CBE,
Chief Executive

- The core of the GWCT's work has not changed: robust research which is 'applied' to our three Ps of practice, policy and public awareness.
- We have increased our policy and communication work, broadening our reach and expanding our impact.
- Our research can achieve conservation outcomes alongside economic land use.
- Thank you to all the staff, trustees, donors and supporters for their hard work and ongoing loyalty.

This will be my last contribution to our annual *Review* as when the *Review of 2024* is written, the GWCT will have a new CEO; I will be retiring in December 2024. I took over from the late Dr Dick Potts, the 'global' grey partridge expert, in January 2002 at the end of the 2001 Foot & Mouth year, which had caused awful havoc in the countryside. Since its start in 1930 the GWCT has only had five CEOs: Major Eley himself, Charles Coles, Richard van Oss, Dick and then me. I have very fond memories of the day the picture below was taken at Burgate, together with the wonderful Wendy Smith, personal assistant to all five.

The core of the GWCT is unchanged: robust research which is 'applied' to our three Ps of practice, policy and public awareness. I coined that phrase in my first few months and its relevance persists. Beyond that there have been many changes. The big two are policy and communications; broadening our reach and expanding our impact.

(L-R) Wendy Smith, Richard van Oss, Charles Coles, Dick Potts and Teresa Dent.

In 2002 we had one press officer and did virtually no policy work; the idea was that GWCT did the research and others took it into policy. Our research has much more impact when we do that ourselves and now we have seven staff regularly involved in policy work, directors like Roger Draycott and Alastair Leake advise Defra at the highest level with similar input happening in Wales and Scotland. Our communications, marketing and membership teams are now combined with a strength of 15.

The name change in 2007 was an overdue acknowledgment of the GWCT's work with wildlife beyond game; on farmland, in the uplands and freshwater fisheries. The list is now long: from *Ranunculus* to *Sphagnum*; rare arable weeds to soil organisms; water voles to hedgehogs; curlew to yellowhammers; hen harriers to little terns. In 2013 we invented Farmer Clusters, a concept that was immediately supported by Defra and Natural England and in which there are now around 5,000 farmers in England.

GWCT's vision is a thriving countryside rich in game and wildlife. We have much greater impact now in achieving that than 20 years ago. Not only the accumulation of another 20 years of research into achieving better conservation outcomes alongside economic land use, the inspiration of 30 years of the Allerton Project, but also working with gamekeepers, farmers and moorland managers (who we call Working Conservationists). This is now expanding again through Environmental Farmer Groups in both lowlands and uplands with 600 farmers and moorland managers either joining or expressing interest in joining at the time of going to press.

The drivers for all this are committed trustees, knowledgeable, hardworking staff who have been an honour and pleasure to work with, and finally supporters and donors whose love of game and wildlife have helped us increase income from £4.6m in 2001 to £11m in 2023.

Thank you for your support

Highlighting some of our incredible achievements

Sir Jim Paice
GWCT Chairman

If you are reading this – thank you. I am forever perplexed by how little many of our members know about what we do. I know that I am speaking to the converted, but please do draw the attention of your friends to this *Review* and our members magazine *Gamewise* to demonstrate how much we do for your subscription and why it is so necessary. I say this because in Teresa Dent's introduction she refers to her impending retirement by Christmas. As always, she is reticent about what she has done for the GWCT in her 21 years as our Chief Executive, but her article highlights some of the incredible achievements of the Trust under her leadership. While the role of game management remains a cornerstone of our work, it is part of the wider countryside. Whether it is predation control, loss of our salmon, soil science, wader conservation or agricultural policy post-Brexit, we are in there with our science lobbying for what we believe in.

As I write we are engaged in finding Teresa's successor; not an easy task. There is no doubt that effective communication is a critical part of the job whether with Ministers, civil servants, other conservation bodies or increasingly the general public. Trustees have already determined that they want to see an increase in our communication across the board. By the time our new Chief Executive is in post we will probably have a new Government with new priorities, so upping our game will be vital.

That leads me to my final point. All shooting organisations now own the Shoot Assurance scheme but in addition they have produced their own set of shoot standards. There is lots of talk about 'last chance saloons' but there is little doubt that time is against us to prevent further regulation. No shoot, large or small has any excuse for not constantly improving their standards. Next year I will write in my last *Review* before stepping down and I do not want it to be reflecting on why we did not act when we had the chance.

Policy

Advising policymakers in Government

Shaping legislation with proven effective research

The threat of wildfire is increasing due to climate change and so how we manage and 'plant' the landscape to reduce potential fuel availability will be important in its mitigation. © Richard Whitcombe

Ross MacLeod,
Head of Policy, Scotland

SCOTLAND

The grouse moor management legislation dominated Scottish policy work

The Wildlife and Muirburn Management Bill was published last March, introducing the prospect of grouse shoot and muirburn licensing in Scotland. GWCT gave evidence to the Rural Affairs and Islands (RAI) Committee in June on both aspects, covering regulatory practice, wildfires and the need for a flexible approach to muirburn.

In August, Scottish Government announced a proposal to ban all snares through the Wildlife Management and Muirburn Bill. After delays to meetings earlier in the year, discussion on modern humane cable restraints (HCRs) was finally convened with the Minister for Environment in September, when land management organisations put their case for retention of HCRs under licence.

The same organisations then gave evidence to the RAI Committee in early November. GWCT stressed the need to balance welfare with conservation of vulnerable ground-nesting birds. However, when the Stage 1 debate on the Wildlife Management and Muirburn Bill commenced in late November, it became clear that a ban on all snares was likely to prevail. The Bill is set for introduction in 2024.

Building GWCT's profile on agricultural policy matters

GWCT made progress building policy profile on agriculture during 2023, helped by research work at the Game & Wildlife Scottish Demonstration Farm in Aberdeenshire (see pages 62-65). We responded to the RAI Committee consultation on the Agriculture Bill and were invited to give evidence on farm nature restoration, climate mitigation and adaptation. We maintained dialogue with the Scottish Government throughout 2023 on the need to support Farmer Cluster development within the Bill. GWCT continues to sit on NatureScot's external 'farming with nature' advisory group.

Opportunities to develop Natural Capital work in Scotland

We continued tracking the development of Nature Finance during the year. A report on biodiversity metrics submitted to Scottish Government by SRUC (the Scottish Agricultural Colleges) in September indicated that elements of the Defra Metric could be adopted in a suite of measures to cover distinctive habitats in Scotland, broadly like England. Implementation being taken forward by NatureScot in 2024 will assist development of GWCT biodiversity assessment and Natural Capital Advisory work in Scotland.

ENGLAND

Alastair Leake,
Director of Policy and Parliamentary Affairs

Getting into the detail

The Westminster domestic policy landscape continues to evolve with consultations, inquiries and liaison with Government officials and advisory bodies increasingly focusing on detail. Given the 30by30 targets the Government has set in legislation, this focus is needed.

We are concerned that proven, effective conservation tools are still not being adopted into policy. In 2023 we continued to emphasise the importance of predation management as a tool to reverse the decline of some species (usually red-listed), and the need for 'managed' wildlife measures to co-exist alongside sustainable food production. In the misguided belief that habitat creation alone can reverse population declines, management is becoming sidelined. Yet management, or perhaps we should say targeted interventions, is vital if we are to balance environmental goals with food production.

Watching out for wildfire

In January 2023 we held a Wildfire workshop, chaired by Lord Deben, then chair of the Climate Change Committee, to raise awareness of the increasing wildfire risk on semi-natural habitats. It was attended by members of the Climate Change Committee, Defra, Natural England, NatureScot, Natural Resources Wales, the Cabinet Office, the UK Health Security Agency, Fire & Rescue Services (FRS) and scientists involved in wildfire research. The threat of wildfire is increasing due to climate change and so how we manage and 'plan' the landscape to reduce potential fuel availability will be important in its mitigation, something human inhabitants of fire-risked environments elsewhere on the planet have practised for millennia.

Providing the evidence

We also responded to Select Committee inquiries on, among other topics, soil health, species reintroductions and insect declines, and submitted evidence to the Dartmoor site management review, a consultation on hedgerow regulations and on nature-based solutions. Our CEO, Teresa Dent, also appeared before the Environmental Audit Committee to give evidence on the role of natural capital in the green economy; an excellent opportunity to highlight the success and expansion of the Environmental Farmers Groups (EFG) around England.

The Office for Environmental Protection undertook calls for evidence in 2023, to aid their monitoring of progress in measuring changes in the natural environment. We contributed to the Improving Nature and the Protected Sites calls for evidence, making the point that bottom-up collaborative approaches based on evidenced interventions at scale (like EFG) are required to address nature recovery and that a focus on protection through designation, a passive action (if that is not a tautology), is not enough.

We need to balance environmental goals with food production. © Joe Stanley/GWCT

Vulnerable species under pressure

Highlighting our concerns using proven GWCT science

Matt Goodall,
Head of Education and Advisor for Wales and NW England

WALES

NRW's proposed approach to regulating the release of gamebirds in Wales

Natural Resources Wales (NRW) opened a consultation in March 2023 which introduced proposals to add common pheasant and red-legged partridge to Part 1 of Schedule 9 of the Wildlife and Countryside Act 1981. NRW then proposed to allow the release of these species following conditions outlined in General Licences, and specific licences for sensitive designated sites. The initial proposals were planned for the 2024-25 season. However, following pushback from the sector, NRW conceded that any changes would need to be delayed until the 2025-26 season.

Although the GWCT was satisfied that NRW was following our science and recommendations for sustainable gamebird release, we remain strongly opposed to the proposals, which could severely damage released gamebird shooting in Wales and curtail conservation efforts across the sector. The proposed licenses would remove the security required for shoot owners to invest in land management and would remove job security for gamekeepers in Wales.

In November 2023, despite concerns raised during consultation (which received more than 42,000 responses), NRW advised the Welsh Ministers to follow the initial proposals. The Welsh Ministers are yet to confirm how they will act.

Welsh Government and Natural Resources Wales restrict predation management

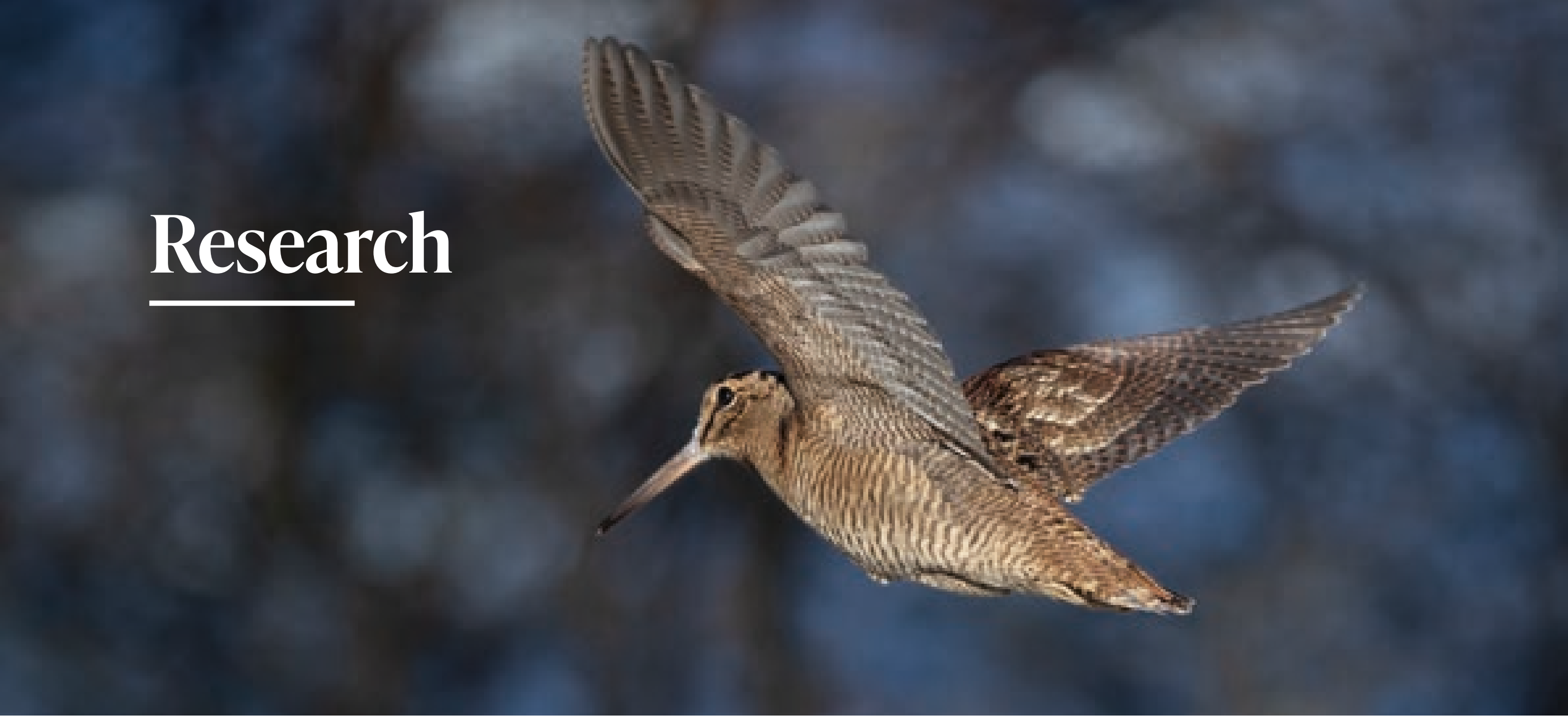
Welsh Government refused to listen to the science surrounding the use of snares in Wales and specifically the use of Humane Cable Restraints which have been proven to surpass international humaneness standards for restraining traps. By banning the use of snares and any cable restraint in Wales in November 2023, the Welsh Government has inadvertently restricted the capabilities of those wishing to manage foxes to protect vulnerable ground-nesting birds in locations where shooting and other methods of control are inefficient or unpractical.

In a blow to farmers, NRW removed magpie as a species which could be controlled to protect livestock in Wales. NRW had previously stopped magpie control to conserve vulnerable bird species and anyone needing to control magpies in Wales can now only do so under a specific licence.

Welsh Government appeared to not be listening to farmers concerns in 2023

GWCT has highlighted the need for a broad and shallow entry level for the new Sustainable farming Scheme (SFS) which encourages farmer participation. We have highlighted our concerns to Welsh Government that its 2023 proposals for 10% woodland and 10% habitat will isolate many farmers and we continue to highlight efficient, effective ways to recover wildlife alongside productive, profitable farming. The next SFS consultation will be in early 2024. Read our consultation response here: gwct.org.uk/wales-sfs.

In Wales, curlew have declined by approximately 80% since 1990 and are forecast to be extinct as a breeding bird in Wales by 2033. As with the rest of the UK, they are rated as the bird of highest conservation concern. © Anne Coatesy



Research

Informing management through research

Addressing knowledge gaps and seeking solutions

- **Grouse moor management benefits ground-nesting birds and can inform conservation of declining species.**
- **The PARTRIDGE project shows that locally adapted management plans can be effective in recovering farmland wildlife.**
- **Practitioner engagement in surveys and use of technology will increase our capacity to address management questions.**

The third national survey showed signs of slowing of the decline in our resident woodcock in most regions over the last 10 years. © Helge Sørensen

© Karen Haysom

Andrew Hoodless
Director of Research

Our research projects are all either addressing knowledge gaps in our understanding of complex issues or are seeking solutions to known management problems. During 2023, we completed a project on merlin which arose from concern over declining breeding numbers in northern England. Merlin breeding distribution is closely associated with heather moorland managed for driven red grouse shooting. Despite suggestions that increased heather burning in recent decades might have contributed to merlin declines, our study showed that merlin bred successfully in very small (<0.1 hectares) patches of taller heather, and that merlin breeding distribution was not limited by the amount of heather suitable for nesting nor by the availability of meadow pipits and skylarks (see page 38-41). We also published a study documenting the difference that predator control on grouse moors makes to curlew breeding success, showing that without it too few chicks were fledged to maintain a stable population (see page 42-43).

The seven-year PARTRIDGE project, run in partnership with 12 European organisations, concluded in 2023. Using a bottom-up approach, it demonstrated that where farmers and hunters managed 14% of arable farmland as high-quality wildlife habitat tailored to grey partridge conservation, numbers of grey partridge, brown hare, breeding farmland birds and seed-eating wintering birds were significantly higher than at comparable unmanaged reference sites. This was even the case in areas where efficient lethal predator management was not feasible (see page 28-29).

We have partnered with the British Trust for Ornithology for 21 years now to monitor breeding woodcock. In 2023, we conducted the third national survey, which achieved the best coverage to date and showed signs of slowing of the decline in our resident woodcock in most regions over the last 10 years (see page 20-21). The success of the Breeding Woodcock Survey lies in the engagement of dedicated volunteers across the UK and the GWCT is increasingly exploring practitioner-collected data and the use of technology to obtain and process species records. I have recently extracted results from 10 years of the GWCT's Big Farmland Bird Count and see great scope for gaining valuable insights into the effects of changes in land use and management techniques through expanding our engagement with farmers, gamekeepers and land managers.

Engaging with Defra

GWCT science comes to the fore in a challenging period

Roger Draycott,
Director of Advisory & Education

- **The GWCT has engaged with Defra throughout 2023 to provide scientific and practical advisory input to help Defra introduce an effective licensing regime.**
- **There is increasing value of 'practitioner evidence' which can rapidly help inform policymakers.**

The past few years have presented significant challenges for the game management sector. Covid impacted shoots during the 2020-2021 season with many days rolled over to 2021-2022. Then, in 2022 with Highly Pathogenic Avian Influenza (HPAI) causing significant problems across Europe in both captive flocks of birds and in wild birds, there was a shortage of supply of poults for release in 2022. We were hopeful that 2023 would bring some stability back to the shooting sector, albeit within the context of rising prices across the board owing to increased energy, labour and feed costs.

While many shoots were able to get back to normal, a large number were seriously negatively impacted by last minute changes to the General Licensing system on or near Special Protection Areas (SPAs, which are designated for their important bird life) because of a perceived risk of transmission of HPAI from gamebirds to certain (designated) wild bird species. The particular species vary across SPAs and regions, but examples included hen harrier, stone curlew and golden plover. We estimated that around 200 shoots were affected by these last minute changes, throwing game management activity into chaos and leaving many gamekeepers at risk of losing their livelihoods and with that the positive conservation outcomes arising from their work. Ironically, it was the designated species themselves, that the changes were supposed to protect, that could have been impacted the most by the proposed changes.

During summer 2023, Defra asked the GWCT to provide independent, specialist technical advice on the ecology and management of gamebirds in and around SPAs to help Defra make informed, evidence-led decisions on licence applications in relation to risks and mitigation strategies around HPAI. Ultimately, many shoots received licences with additional conditions to minimise risks associated with transmission of HPAI – the net result being that the important work that game managers undertake to conserve wildlife could carry on.

The GWCT has continued to engage with Defra throughout 2023 to provide

scientific and practical advisory input to help Defra introduce an effective licensing regime for 2024. This ensured that the risks of HPAI are minimised while retaining the significant conservation benefits to designated species that sustainable game and wildlife management can deliver.

Having a significant track record in producing high quality peer-reviewed science in gamebird ecology and management, alongside a sector-leading independent, practical, science based Advisory Service, meant that the GWCT was in an excellent position to help Defra during a challenging period for both policymakers and practitioners.

While peer-reviewed science should always be the foundation of good policy development, when new issues arise such as a significant outbreak of HPAI and Governments need to determine the risks associated with continuing or stopping an activity (eg. gamebird releasing and management) at short notice, then making evidence-led decisions can be very challenging. This is where we see the value of 'practitioner evidence'. These are data collected by land management professionals (farmers, keepers, wildlife rangers) on their own patch of ground. These data, collected at scale, can rapidly help inform policymakers of the consequences of a particular policy decision.

Over the past couple of years, despite there being no scientific evidence to indicate that gamebirds present a significant risk to transmission of HPAI among wild birds, there have been calls from certain conservation organisations and commentators to the Government for a ban on gamebird releasing. Through the GWCT's Big Farmland Bird Count (BFBC) database, we were able to undertake a rapid analysis to look at the impact of HPAI on farmland bird numbers and the implications of a cessation in game management activity through a ban on gamebird releasing. We found that of the 36% of participants who run a shoot, nearly half grow wild bird seed mixtures and 62% put out supplementary food for farmland birds. In contrast, of those who responded that they do not operate a shoot, 21% grow wild bird seed mixtures and 32% put out supplementary food.

Overall, there were significantly more farmland birds recorded on farms with shoots (291 birds per submitted count) than farms without shoots (182 per submitted count). These real-life observational data indicates that gamebird management had a positive impact on farmland bird numbers rather than a negative impact – and that if game management activity had reduced (through a restriction or ban on gamebird releasing) the likely outcome would have been a reduction in farmland bird numbers. We are increasing our practitioner monitoring initiatives in 2024 to help game managers collect information to demonstrate compliance with best practice standards and to collect data at scale to demonstrate the conservation benefits of sustainable game management.

An effective licensing regime ensures that the risks of HPAI are minimised while retaining the significant conservation benefits to designated species, such as golden plover, that sustainable game and wildlife management can deliver. © Laurie Campbell

62%

of BFBC participants who run a shoot put out supplementary food specifically for farmland songbirds

How technology has changed our research

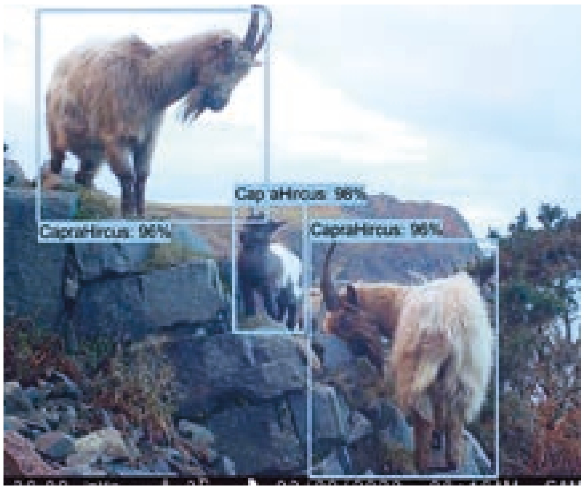
Andrew Hoodless and Chris Heward reflect on the increasing use of technology in addressing research questions

Technology is changing the face of ecological research. This can be neatly illustrated by the recent advancement of animal tracking technology, where great leaps have been made not only in the refinement of existing techniques, but the advent of entirely new technologies. Until recently, most animal tracking relied upon VHF radio-transmitters: signal-emitting tags that a field researcher would have to manually relocate with an antenna. Since the 2010s, the development of GPS tags that remotely record and transmit location data via satellites or the mobile phone network, has transformed animal tracking in a fundamental way. New technologies provide methods of remote data collection that are more efficient, more accurate, and less biased by human error than ever before. The increasing diversity and flexibility of tracking devices provides solutions for almost every problem and species.

In 2012, the GWCT started tracking woodcock with 9.5g Argos satellite tags, collecting the first accurate data on the timing and routes of spring migration of woodcock wintering in Britain and Ireland. But even this pioneering work now feels rudimentary: since 2016, we have used 4.7g GPS loggers that yield 700-800 locations per year and give detailed autumn as well as spring data. Miniature GPS tags, some now weighing as little as 3.2g, have subsequently enabled studies into a wide range of wader species, including lapwing and redshank, allowing us to answer specific questions concerning brood movements, habitat use, and post-breeding migrations (see *Review of 2021* pp.78-79).

Identifying and tracking individuals has proved harder for fish than birds but is essential for understanding survival rates at different life stages. Annual PIT-tagging of c. 10,000 salmon parr and c. 3,000 trout parr since 2005, coupled with recording of tagged fish each March and September, has enabled us to quantify mortality among fish using the River Frome. More recently, data storage tags and acoustic tags have permitted estimation of smolt movements and mortality at sea (see *Review of 2022* pp.70-71).

Technological advancements are not confined to the field of animal tracking. Advances in the field of photography, particularly the use of drones and thermal imaging, are further improving species monitoring and research. Drones give a unique perspective of the landscape, and our Welsh team has increasingly been using the powerful zoom camera and thermal imaging capabilities in systematic deer and wild goat surveys, which are far more effective than those conducted



(Clockwise from top) the use of trail cameras enable us to monitor nests constantly; PIT tags enable us to track salmon and trout journeys; drones are used to carry out systematic deer and wild goat surveys; GPS-tracking, here used to study curlew, is strictly licensed to ensure the highest possible welfare standards.

New technologies provide methods of remote data collection that are more efficient, more accurate, and less biased by human error than ever before. The increasing diversity and flexibility of tracking devices provides solutions for almost every problem and species

on the ground. Like advances in tracking technology, these changes not only increase efficiency, but also accuracy, by addressing sources of bias. Photography has transformed our studies of predation through use of trail cameras, which provide vital information on the identity of wader and grouse nest predators. Trail cameras continue to become smaller, more inconspicuous, and more sensitive, and are now capable of taking up to c. 5,000 high-definition images on a single set of batteries. Trail cameras proved invaluable in the early 2010s in enabling us to quantify visitation rates and food consumption at game hoppers by gamebirds, songbirds and unintended species, resulting in improved management recommendations.

Very similar approaches are being used to acoustically monitor species. Like trail cameras, sound recording devices can passively record data that provide information on the presence or abundance of species. GWCT research has already trialled this technique to monitor breeding woodcock in southern England, and employed acoustic detectors on several projects quantifying bat diversity in different agricultural landscapes and examining frequency of use of agri-environment habitats.

Of course, technological advances don't in themselves lead to better science and can introduce their own particular considerations. With new technology comes larger quantities of data and a requirement for novel analytical techniques. Our use of trail cameras on wader nests provides a good example, for which the development of bespoke artificial intelligence algorithms has been necessary to ensure the accuracy and feasibility of interpreting millions of images (see pp.16-17). New technology demands a continued focus on the key tenets of good scientific research: clear questions, attention to study design and appropriate statistical analysis. But in the right hands, there is no doubt technology offers us valuable new ways to address questions that were previously unanswerable with traditional field observations.

Round up

Reaching out to a new audience

Thank you for your continuing support

The Duke of Edinburgh Memorial Clay Day held at Sandringham was the highlight of our fundraising year. © Charles Sainsbury-Plaice

Jeremy Payne,
Director of Fundraising

ENGLAND

- **Major donor income at £1.6 million.**
- **£265,000 from GCUSA New York auction (subject to exchange rate).**
- **County committees at £670,000.**
- **London events at £544,000.**

The highlight of the fundraising year was undoubtedly The Duke of Edinburgh Memorial Clay Day held at Sandringham in May. Our most ambitious fundraising event ever in this country was a huge success, raising well over £300,000, and introduced the GWCT to a whole new audience. Lord Salisbury, GWCT's President, gave a remarkable speech reminding the audience of the GWCT's debt to our late Patron. On the back of this day, London events (since that team organised Sandringham) contributed more than half a million pounds.

County committees, GCUSA and the wider fundraising department once again had to navigate a tricky terrain for auction lots. We owe a particular debt of gratitude to those auction lot donors who did give despite myriad uncertainties, as well as the generous bidders at all our events, live and online.

The major donor total is broadly in line with last year despite having lost two significant funders, but once again is buoyed by the generosity of our President's Club donors.

The New York auction was another highlight, and our US trustees have again shown real generosity under the leadership of Ron Beck and Robyn Hatch. We are thinking hard about how to expand our footprint in the US from its current east coast exclusivity.

County committees raised slightly less than last year, but as ever we are 100% reliant on the amazing generosity of time and effort from all our committees up and down the country. On behalf of all at the GWCT, sincere thanks to all of you who contributed to the above numbers in 2023.

(L-R) Dylan Williams and GWCT President, Lord Salisbury. © Charles Sainsbury-Plaice

Strong fundraising events in 2023

Continuing to develop our research and communication

SCOTLAND

- Scottish Auction: This cornerstone event, achieved significant results, and raised £144,000 marking its fifth best year.
- West of Scotland: Experienced its most successful fundraising year, generating £109,000.
- Grampian Auction: Its best-ever year accumulating £43,000.
- Edinburgh & SE Scotland: Despite hosting only two events, it contributed £5,000 to the overall fundraising effort.
- West Tayside: Achieved its most successful fundraising year, generating £29,000.

Rory Kennedy,
Director Scotland

These accomplishments underscore the commitment and effectiveness of GWCT Scotland in mobilising support and resources by regional committees and strengthening key relationships.

Additionally, over the past few years there have been notable changes in major donor fundraising strategies in Scotland. This includes transitioning from a long-term external contact to a new position within the team, reflecting the importance of integrating marketing, communications, and fundraising efforts. Chloe Thornton's recent addition to the team as the head of development at the end of last year has significantly strengthened GWCT Scotland's capabilities in this regard.

Despite challenges faced throughout the year, GWCT Scotland is now in a much stronger position, and is focusing on maintaining existing relationships while cultivating new ones and enhancing both internal and external communications.

Overall, 2023 was a year of sustainable fundraising success, marked by record-breaking performances by regional events and strategic advancement that position the organisation for continued growth and impact in wildlife conservation efforts across Scotland. We would like to thank everyone for their continuing support.

The Scottish Auction is our cornerstone event and raised a fantastic £144,000. © Roy Summers/Scottish Field

Artificial intelligence for image recognition

Figure 1

Curlew detected by the YOLOv8 Model. The red box shows where the model detects the bird with a high probability

AI and nesting curlew

The curlew is an iconic wader species facing global population declines, with the demographic bottleneck primarily at the reproductive stage in their life cycle. Monitoring the behaviour of these elusive birds during nesting is challenging, involving extensive hours in the field, observing and recording. In this study, camera traps were used to monitor predator identity, and, as an experimental method, to quantify time spent on and off nests by adult curlew, with a resulting database of over one million images from 2021 to 2022 (see Figure 1). Several computer vision methods including image classification and object detection were tested, with object detection using the YOLOv8 (You Only Look Once) model providing the most accurate results (Redmon et al. 2016). The YOLOv8 model can detect a bird with 95% accuracy, even at night-time, in flight, or hazy conditions.

The AI approach we used relies on constructive collaboration between AI technology and human expertise. Curlew researchers manually drew boundaries around a nest in a camera image to define the 'on nest' and 'off nest' area (see Figure 2). The program then generated a spreadsheet recording predictions of whether a bird was on or off a nest and the time from image timestamps. The application then uses these initial predictions, timestamps, and feedback from manual checking to produce refined final predictions of when the bird left or returned to a nest. Using a combination of AI and human checking enables the system to determine, for each set of images, the time spent on/off the nest by curlew with 99% accuracy. To achieve this level of efficacy, low confidence predictions (<10% images) were manually checked by a researcher. Implementing the system allowed image interpretation to be done for the one million images taken across two years in one week, once the model was developed. This feat would have taken a single researcher at least a year.

There are several caveats of course – not every image is informative ie. the system relies on the fact that birds moving on and off nests generate a stream of images taken over a short timespan to identify off/on nest events. It is also constrained by how accurately the cameras record these events – with the camera settings affecting the timing intervals that cameras record events. This effectively means that the system records the relative time a bird is on/off a nest. It also relies on the ability and experience of the curlew researcher in placing the cameras so that they record informative images.

YOLO research reference:

Redmon, J, Divvala, S, Girshick, R, & Farhadi, A (2016). 'You Only Look Once: Unified, Real-Time Object Detection'. IEEE Conference on Computer Vision and Pattern Recognition, 779-788. (1506.02640).

You Only Look Once: Unified, Real-Time Object Detection (arxiv.org).

Figure 2

An example of the AI system interface used by researchers to draw custom boundaries, highlighting which points on an image are 'on' versus 'off' a nest

Monitoring curlew nests is challenging.

Background

The GWCT research teams have started experimenting with the use of artificial intelligence (AI) to aid image processing. Here we describe how we are applying AI to the identification and interpretation of camera trap imagery, both still and live-video streaming. The general approach is for human researchers to manually label a small number of images by drawing boxes around the object of interest in a random selection of images. The AI identification model is trained on these images and then tested on previously unseen images to check performance and generate feedback for improvement. The trained and tested model is then used to process large amounts of camera imagery.

The approach that AI uses to solve both the identification and interpretation of imagery is to break down the images into smaller sections. It examines each part of these sections for recognisable features and marks these objects with bounding boxes. The AI modelling system does this by performing mathematical operations on the images, allowing it to find edges, colours, background, etc. that match the human identified training images. It picks up patterns to recognise features such as body shape, beaks, legs, etc. (see Figure 1). There are various AI models that have been developed by researchers in this field and here we describe the use of AI by two GWCT research projects. Internally we have used AI to process still imagery from cameras trained on waders on nests, determining the relative time curlew spend on and off nests. The Welsh team is working with an external team, ConservationAI at Liverpool John Moores University, to expedite the identification of grazing species on live-feed video footage.

The in-house application is estimated to save researchers at least 90% of their time when compared with the traditional approach of human interpretation of images, including the time spent in training the model. This factors in the time taken for labelling, manual checking and feedback required by the researchers while developing the application. This system not only provides a more detailed picture of curlew nesting habits but also allows researchers to redirect their efforts more strategically, maximising the impact of our conservation actions. It can also be used to process imagery recorded for other nesting waders; we have expanded the system to consider lapwing and will explore other applications in the future.

Real-time identification of fallow deer in Wales

The Welsh Government-funded Elwy Valley Sustainable Management Scheme project was set up to explore the effects of a population of fallow deer in the Elwy Valley. As part of the project, we are working with Liverpool John Moores University to use AI recognition to identify species on trail camera footage recording video imagery. This involves the team at ConservationAI, which includes researchers from the fields of computer science, astrophysics, and conservation biology. As part of the project, we deployed over 40 trail cameras, aiming to collect data on fallow deer presence/absence and density. We tagged more than 2,000 fallow deer images, training the ConservationAI computer model so we could use it to reduce the amount of time it took to process images.

Dr Carl Chalmers and Prof. Paul Fergus, from ConservationAI, then lent us several real time CCTV cameras as a trial. They have these cameras deployed all over the world, working on projects ranging from anti-poaching programmes in Africa to human-tiger conflict in Kathmandu. These real-time cameras resulted in incredibly quick turnaround to alerting us of the presence of fallow deer. From taking an image, to processing and sending an email alert can take as little as 20 seconds. There is still

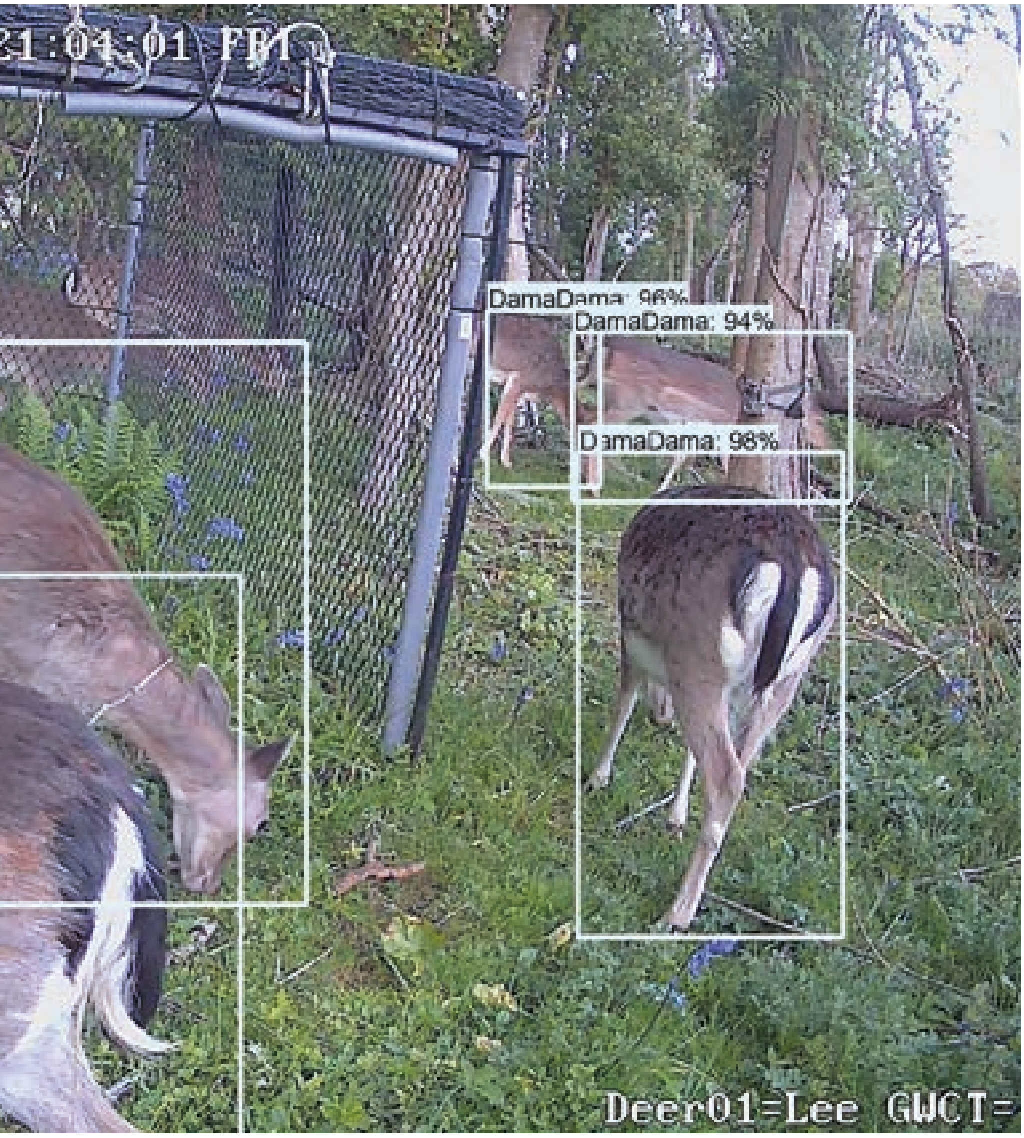


Figure 3
Correct identification of six fallow deer *(Dama Dama)*, but low certainty for a white one.

work to be done, as you can see here where the system was only 64% confident in its identification of a white fallow deer (see Figure 3). Tagging more images of white fallow deer will help to overcome this. The work that ConservationAI do overseas can literally mean life and death when it comes to tiger monitoring. In our work we would like to continue the partnership with ConservationAI to help protect red-listed species from predators (see Figure 4).

Figure 4
Identification of a red fox *(Vulpes vulpes)* from a night-time camera image

Key findings

- Curlew nest monitoring: Our in-house application uses AI object detection to provide accurate position data for curlew sitting on their nests from camera trap images. This is used to calculate nest attendance intervals and overall incubation time with an accuracy of 99%.
- Fallow deer identification: Using ConservationAI's system, our researchers receive real-time notification of fallow deer from CCTV cameras.
- The future: We will be expanding our use of both AI approaches, exploring lapwing nest attendance in our in-house approach, and using ConservationAI's real-time warning system to protect red-listed species from predators.

Sabeeth Shoeb
Elli Rivers
Julie Ewald
Lee Oliver

Breeding Woodcock Survey 2023

Roding woodcock. © Helge Sørensen

Background

The GWCT and British Trust for Ornithology (BTO) have conducted a decennial Breeding Woodcock Survey in Britain since 2003. The 2013 survey estimated that Britain's breeding population was 55,241 male woodcock (CL 95%: 41,806-69,004); a decline of 29% since 2003.

Key findings

- In 2023 the GWCT and BTO repeated the National Breeding Woodcock Survey, previously undertaken in 2003 and 2013.
- In 2023, volunteers surveyed 1,230 randomly-selected sites for roding woodcock.
- The total population estimate of breeding woodcock for Great Britain in 2023 was 50,750 males (95% CL: 42,935–59,251).
- The survey estimated a population decline of -35% over 20 years (2003-2023), or -8% over the last 10 years (2013-2023).

Chris Heward
Andrew Hoodless

In spring and summer, male woodcock perform dusk display flights ('roding'), and this conspicuous display behaviour underpins our survey method. From a randomly selected list of 2,700 1x1-km squares, first produced for the 2003 Breeding Woodcock Survey, volunteer surveyors were invited to select a wooded survey site and asked to make up to three roding counts during May-June. During a 75-minute period, beginning 15 minutes before sunset, surveyors recorded each separate woodcock sighting.

We use these data to estimate regional site occupancy (the proportion of sites where breeding woodcock are present), and an average woodcock density at occupied sites. The latter is possible using a calibration equation, derived from GWCT research conducted in the early 2000s, that estimates the number of males present from the number of sightings. Together, these two statistics allow us to calculate regional population estimates, which are combined to produce national totals. Counting woodcock at a random sample of sites is necessary to ensure that occupancy and density estimates are not biased by the over-representation of more favourable sites.

In 2023, 1,230 randomly-selected squares in Great Britain were surveyed, compared with 807 in 2003 and 829 in 2013. Among the 2023 sample, 740 of the sites had been surveyed in at least one earlier Breeding Woodcock Survey. In 2023, 38 squares were surveyed in Northern Ireland, the first time that coverage in Northern Ireland has been high enough to produce a population estimate for this region.

Site occupancy was highest in eastern England (71% of wooded 1x1-km squares were estimated to support breeding woodcock) and northern England (53% of squares supported breeding woodcock). This is broadly consistent with earlier surveys, that showed woodcock were more widespread in north-east Britain, but it is the first time that occupancy has been greater in north-east England than northern Scotland (where 40% of wooded squares supported woodcock). As in 2013, the 2023 results identified an isolated southern stronghold in England, centred on Hampshire and Berkshire.

Across the country, population densities at occupied sites averaged 2.5 ± 0.1 (1 SE) males per km^2. Regional population estimates are provided in Table 1. The total population estimate of breeding woodcock for Great Britain in 2023 was 50,750 males (95% CL: 42,935-59,251). This represents a decline of 35% over 20 years (2003-2023), or a decline of 8% over the last 10 years (2013-2023) (see Figure 1). Although most regions have seen small increases in woodcock population size since 2013, these are overshadowed by a large decline in North Scotland, which holds a significant proportion of the British population. Here, the population estimate has declined by 49.5% between 2013 and 2023, and this has dictated national trends.

The Northern Ireland population was estimated at 937 male woodcock (95% CL: 273-1,713), with comparatively low density at occupied sites (1.4 ± 0.3 males per km^2). It is not possible to say if or how woodcock populations in Northern Ireland are changing, as this is the first assessment of the region using this method.

Addressing woodcock declines remains a priority. Woodcock are thought to require woods that offer a diverse range of woodland types and ages, including some areas of young, dense woodland. Management that encourages the development of these early

TABLE 1

Breeding woodcock population estimates (estimated number of males) and change in population size for 11 custom regions in Britain, the four home nations, Britain, and the UK

	2003		2013		2023		10 yr ±		20 yr ±
	Total	**95% CL**	**Total**	**95% CL**	**Total**	**95% CL**	**2003–2013**	**2013–2023**	
N Scotland	24,088	(14,640–34,633)	23,913	(14,796–33,478)	12,168	(7,491–17,421)	-175 (-00.7%)	-11,745 (-49.1%)	-49.5
S Scotland	15,163	(6,110–28,075)	6,185	(2,023–11,095)	8,504	(4,385–13,495)	-8,978 (-59.2%)	2,319 (37.5%)	-43.9
N England	7,169	(4,192–10,469)	5,808	(2,420–11,125)	8,366	(5,426–11,833)	-1,361 (-19.0%)	2,558 (44.0%)	16.7
N Midlands	5,139	(2,998–7,612)	3,806	(1,188–7,890)	4,509	(2,965–6,228)	-1,333 (-25.9%)	703 (18.5%)	-12.3
E England	6,811	(3,011–11,712)	4,562	(1,771–8,148)	6,064	(4,059–8,450)	-2,249 (-33.0%)	1,502 (32.9%)	-11.0
E Anglia	3,485	(1,747–5,794)	1,791	(1,201–2,465)	1,976	(1,019–3,126)	-1,694 (-48.6%)	185 (10.3%)	-43.3
S Midlands	1,123	(520–1,820)	890	(277–1,719)	657	(373–981)	-233 (-20.7%)	-233 (-26.2%)	-41.5
Wales	1,767	(541–3,259)	914	(119–1,900)	1,138	(455–856)	-853 (-48.3%)	224 (24.5%)	-35.6
SW England	2,234	(774–4,147)	939	(311–1,682)	1,188	(502–1,970)	-1,295 (-58.0%)	249 (26.5%)	-46.8
Central South	6,586	(4,506–9,124)	3,928	(2,553–5,490)	4,385	(2,859–6,103)	-2,658 (-40.4%)	457 (11.6%)	-33.4
SE England	4,782	(2,480–7,785)	2,507	(1,046–4,396)	1,796	(1,135–2,518)	-2,275 (-47.6%)	-711 (-28.4%)	-62.4
Scotland	39,251	(24,173–56,632)	30,098	(19,664–41,015)	20,673	(14,709–28,058)	-9,153 (-23.3%)	-9,425 (-31.3%)	-47.3
England	37,328	(30,101–44,089)	24,229	(17,463–32,239)	28,940	(24,565–33,568)	-13,099 (-35.1%)	4,711 (19.4%)	-22.5
Wales	1,767	(541–3,259)	914	(119–1,900)	1,138	(455–1,856)	-853 (-48.3%)	224 (24.5%)	-35.6
N Ireland	-		-		937	(274–1,714)			
Britain	78,346	(61,717–96,493)	55,241	(41,806–69,004)	50,750	(42,935–59,251)	-23,105 (-29.5%)	-4,491 (-8.1%)	-35.2
UK	-		-		51,687	(43,463–60,445)			

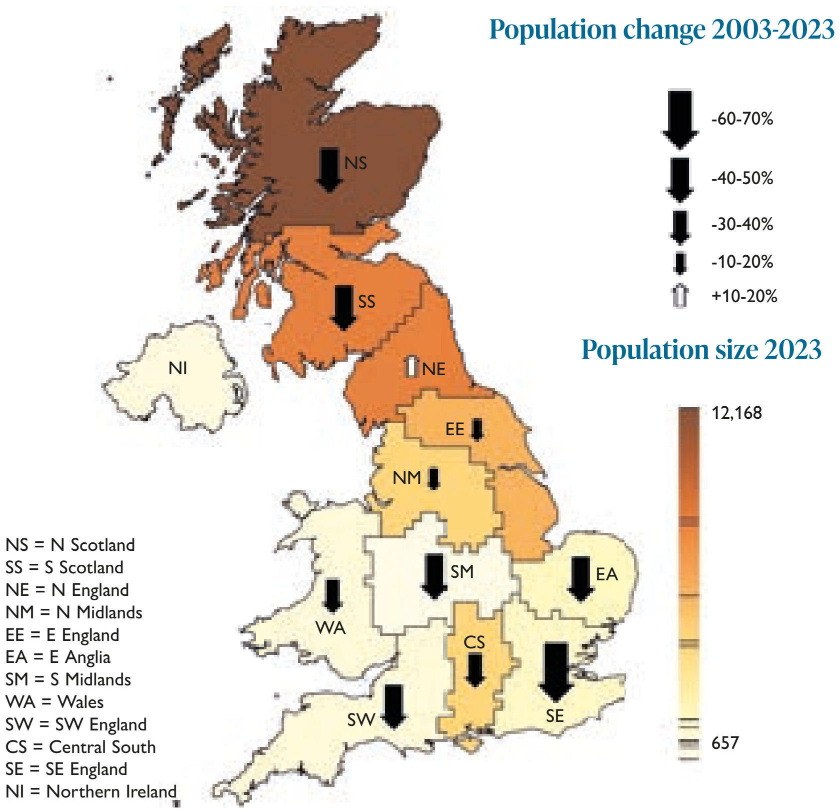


Figure 1

Woodcock population size (estimated number of males) and population change by region. No estimate of change is provided for Northern Ireland, as 2023 is the first year in which a population estimate has been produced

successional woodlands (eg. felling and replanting or allowing natural regeneration) is likely to benefit woodcock. As well as counting woodcock, surveyors in the 2023 Breeding Woodcock Survey were asked to make simple records of habitat diversity, age, and signs of recent management. The next step in this study will be to investigate the potential links between habitat and woodcock population change, using data from survey sites visited in multiple iterations of the Breeding Woodcock Survey.

Acknowledgements

We thank BTO regional organisers and all voluntary surveyors, Jacob Campbell, Gillian Dinsmore, Isaac Hoult, Kathy Fletcher, Louise De Raad, staff at Forestry and Land Scotland, Michael Stinson, BASC, Rob Fuller, Julie Ewald, Ferne Ellington, Anna Thompson, Piera Coleman, Mark Hammond, Andrew Joys and Justin Walker. We are grateful to the John Swire 1989 Charitable Trust for help with funding the 2023 survey.

Avon Valley farmers monitoring water quality

Background

The Avon Valley Farmer Cluster has been running since the LIFE Waders for Real project ended in 2020. The group is Government-funded through the Facilitation Fund and consists of 15 farmer members along the River Avon in Hampshire, Wiltshire, and Dorset, but also includes many more people, such as landowners and keepers. One of the group's priorities is the health of the river; the River Avon is what connects all members of the cluster.

The Government has set a target to reduce water pollution (nitrogen, phosphate, and sediment) from agriculture by 40% by 2038, compared to a 2018 baseline. We need to better understand our own river health and contributions to this, to be able to address this target more generally.

We can test the water temperature, electrical conductivity, nitrate, phosphate, and ammonia levels within the water to get an overview of river health along the river effectively and efficiently

In September 2023, we took our first steps as a Farmer Cluster to understanding the health of the River Avon and how we can work together to make improvements where needed. We are working with FLOW CIC and the Wessex Rivers Trust to take regular water samples to measure water quality variables. Six group members have signed up and started water quality testing along the river, some as regularly as once a week.

Using the testing kits put together by FLOW CIC, we can test the water temperature, electrical conductivity, nitrate, phosphate, and ammonia levels within the water. These key measurements allow us to get an overview of river health effectively and efficiently.

Water temperature and conductivity

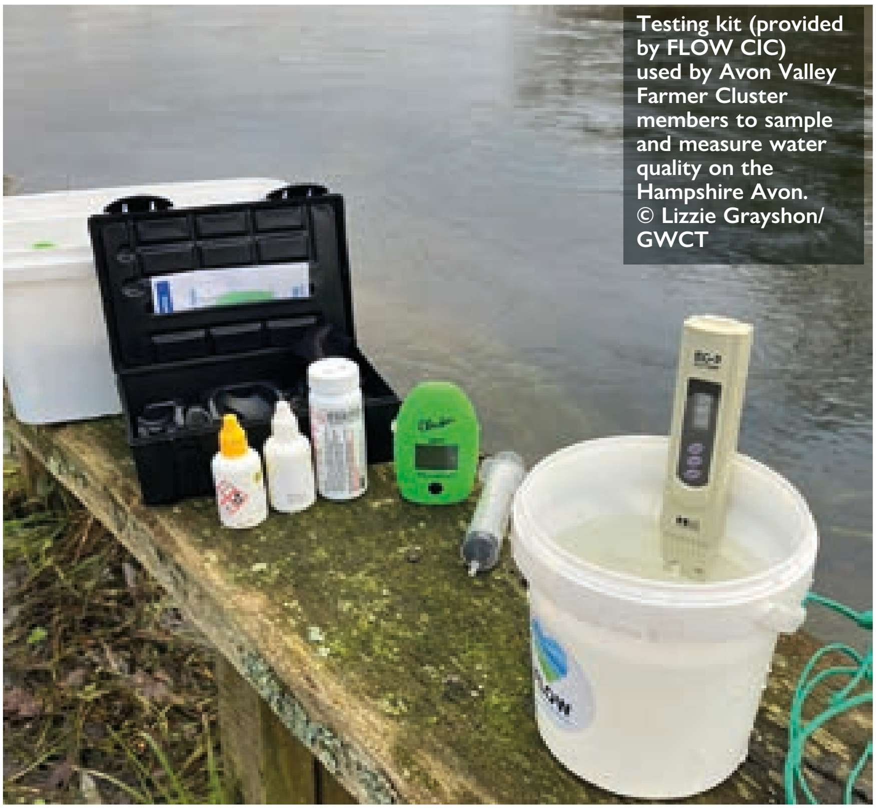
Water temperature is important to the condition of the river as temperature can affect many features of water quality. Changes in water temperature affect oxygen content within the water, nutrient uptake, growth of aquatic plants, and behaviour of wildlife within the river. Measuring the conductivity of the water shows us how much dissolved solids are in the water. A high conductivity value indicates that there are a lot of dissolved solids, possibly indicating pollution. Water temperature and conductivity are highly linked, as increased water temperature can increase the ability for water to conduct an electrical charge.

Phosphate

Phosphates are chemicals that contain phosphorous, and, although phosphorus is needed for growth in plants and animals, unusually high amounts can cause water pollution through a process called eutrophication. Phosphorus can enter the system via several pathways including run-off from fertiliser and pollution from septic systems, and sewer overflows.

Nitrate

Pollution from nitrates can also cause excessive growth of plants, removing oxygen and killing other wildlife. Nitrate pollution can occur through agricultural fertilisers, slurry, and sewage overflows.



Testing kit (provided by FLOW CIC) used by Avon Valley Farmer Cluster members to sample and measure water quality on the Hampshire Avon. © Lizzie Grayshon/ GWCT

Ammonia

Although ammonia is a form of nitrogen; unlike other forms of nitrogen, it can cause direct toxic effects on aquatic life, rather than causing over-enrichment. It can enter the river system through fertiliser run-off and industrial applications. Natural sources of ammonia come from the breakdown of organic waste and are often the result of sewage overflows and animal waste. High ammonia levels can cause a toxic build-up in aquatic organisms, potentially leading to death and this can be further influenced by water temperature and pH.

The Hampshire Avon is a Special Area of Conservation and Site of Special Scientific Interest, and is currently classed as being in unfavourable status, partly because of high nutrient levels. Significant efforts have been put in place by regulators, NGOs, and landowners to reduce nutrient levels in the river; however, levels are still too high, causing negative impacts to biodiversity.

The Avon Valley Farmer Cluster members that sample the water work alongside members of the public to provide data with a large spatial and temporal coverage. This can be compared to Environment Agency (EA) sampling that is very accurate but limited in sample locations and frequency. Using these data together we can help pinpoint trends and start to tackle poor water quality. Initial data have shown some large spikes in both phosphate and ammonia that would have otherwise gone unrecorded, and these are shared with the EA and investigated.

Our testing is currently focused on the Avon's main river channel, but we have aims to expand the testing to the various tributaries that enter the main river channel. This will also allow us to pinpoint any possible negative inputs coming into the river from further afield.

Key findings

- Volunteers from the Avon Valley Farmer Cluster have been trained to take water quality samples.
- Water quality testing has been conducted at seven points along the River Avon.
- Water testing helps to connect people with the river and aids our understanding of river health.

Lizzie Grayshon
Chris Heward

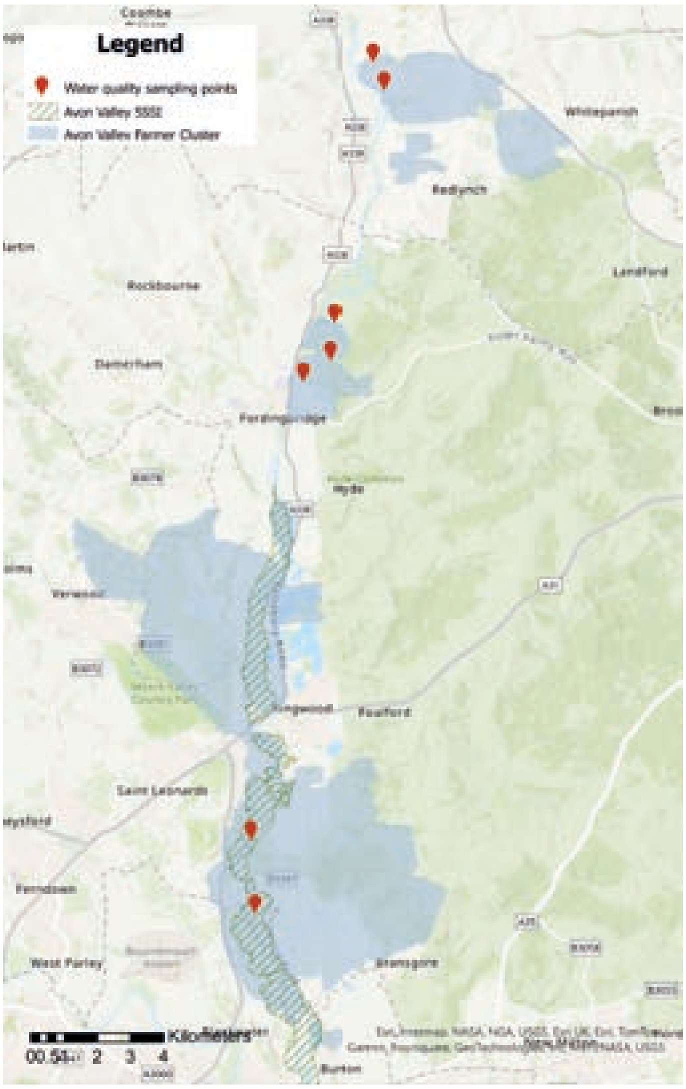


Figure 1
Locations where Avon Valley Farmer Cluster members undertake water quality sampling

Acknowledgements

Thank you to Adam Ellis for providing the water quality testing training and collating all the data we are collecting. Thank you to those who are carrying out the testing on their farms. Countryside Stewardship Facilitation Funding has funded the water quality testing kits and the training morning for all the volunteers.

Partridge & Biometrics

The PCS can be considered a long-term 'citizen science' project with gamekeepers, farmers, landowners, and other volunteers counting grey partridges on their land. © David Mason

Partridge Count Scheme – 90th anniversary

From its earliest days the GWCT and its predecessors have led efforts to monitor and conserve grey partridge numbers in the UK. One of the GWCT's key initiatives to support grey partridge conservation is the Partridge Count Scheme (PCS), which celebrated the start of its 10th decade in 2023. The PCS can be considered a long-term 'citizen science' project that started before anyone had heard the term. The citizens counting – 'doing the science' – are gamekeepers, farmers, landowners, and other volunteers who count grey partridges on their land twice a year, in spring and autumn. The use of land managers to collect data on grey partridges, the interpretation of the data, and how this is fed back to those making decisions on the ground reflects the history of how game research began in the UK, the legal status of game in this country and the changing fortunes of grey partridges over the course of the PCS' 90 years.

The predecessor of the GWCT – the ICI Game Research Station – began due to the intervention of Major Henry Gerald Eley, who was manager of Eley Cartridges. This was in response to a severe outbreak of the endoparasitic disease strongylosis in grey partridges in 1931. Major Eley convinced Imperial Chemical Industries (ICI), who owned Eley Cartridges at that time, that: "the more plentiful the game, the more cartridges will be loosed off". Clearly ICI had an obvious self-interest in devoting a small fraction of its immense resources to the study of "how best to help the gamekeeper, the 'sporting' farmer, and the big landowner to produce more game" and so the organisation that today is the GWCT was created.

25,000

grey partridges were recorded in autumn 1935 from only 43 sites, averaging nearly 600 birds each

The early business-driven origins of game research in the UK contrast sharply with the case in most other parts of the world, notably in North America and Scandinavia. In those areas, game was considered a significant annual crop, but state-aided organisations were formed and charged with conserving and researching game as part of national and regional Governments and as a public amenity, funded through game licence revenue. In the UK, game was seen as a crop, but owned by the landowner and therefore the landowner was responsible for stewarding this crop.

With the foundation of the Game Research Station, Eley funded research into wild grey partridges by the University of Oxford's new and pioneering, Bureau of Animal Population, run by Charles Elton – 'the father of animal ecology'. In 1932, Doug Middleton, a young biologist who had helped develop the early 'Bureau', turned his attention to the country's wild grey partridges. Organising a system of autumn censuses and fieldwork, visiting major estates by motorcycle to encourage gamekeepers who managed wild grey partridges, Middleton started the nascent PCS as a basis to study grey partridge ecology. That these censuses were built around the individual estates reflected the fact that game was valued by the estate. In this early period in the study of animal ecology, the simple fundamentals of observation, recording population dynamics and its fluctuations, can appear overly simplistic compared with modern methods, technology, and analysis. But it was field observations, recording brood sizes, calculating summer productivity using the straightforward measure of the ratio of Young-to-Old and autumn bird densities that laid the groundwork of our understanding of grey partridge ecology that is still relevant today.

In the first five years of the PCS, the estates involved already stretched from Hampshire to Perthshire, with an average of 40 estates counting each year. In autumn 1935, the PCS recorded more than 25,000 birds. This was from just 43 sites, averaging nearly 600 birds each. In 1937, Doug Middleton left the Bureau to become Director at the Game Research Station and brought these early count records with him. Unfortunately, 1937 was also the last autumn for the PCS before it was disrupted by the looming spectre of World War II. Game research ground to a halt and it was not until 1946 that ICI could restart its game research activities. The Game Research Station moved to Fordingbridge, its work was centralised and expanded, with modest purpose-built research laboratories on site, and began 14 years of managing an experimental shoot on 4,000 acres (1,620 hectares (ha)) of nearby farmland. This allowed the Game Research Station to expand its research into grey partridge ecology. The PCS resumed in the autumn of 1947, and in 1948, the spring pair counts were introduced. These counts assessed the number of pairs on a site prior to the birds nesting and, coupled with either a preceding or following autumn brood count, enhanced the understanding of partridge population dynamics throughout the year. Regular counting accumulated data on changes in numbers, helping identify trends and potential threats to partridges. To this day PCS members undertake spring and autumn counts, providing information on breeding densities and summer productivity and, when subsequent counts are undertaken, overwinter losses. It is perhaps the only citizen science project that can claim to measure all aspects of the life history of a species.

The PCS has evolved over the past 25 years to reflect the wider needs of farmland wildlife conservation and broadened its cohort of sites to include smaller farms, moor-fringe/in-bye farms, nature reserves and even several golf courses. It still has, at its core, many of the original estates and shoots which have retained their interest in grey partridges as a game species, but also see their wider role in restoring and improving biodiversity on their land. The PCS connects and supports the Farmer Cluster approach, encouraging collaboration and co-ordination among neighbouring landowners to deliver landscape-scale and net gain benefits for wildlife.

The data that PCS members provide through their counts give a broad understanding of the status of wild grey partridge populations regionally and nationally, as well as a baseline to compare to local surveys and grey partridge research projects. We provide reports back to PCS members, using the data supplied, to signpost the aspects of grey partridge conservation they may need to address. For example, low chick productivity and nest survival indicate a problem with the availability of chick-food insects and nesting habitat; issues with overwinter survival can be addressed with additional overwinter food using feeders or through wild bird cover. Members also receive twice yearly newsletters, covering the latest research and advice on grey partridges and farmland ecology, as well as predator management projects.

Background

Partridge counts offer valuable insight into how well your partridges breed, survive and benefit from your habitat and management provision throughout the year. Each count (spring and autumn) is easy to carry out and helps assess the previous six months without the need for continual monitoring.

How to count:

- Spring: Ensure winter coveys have broken up and breeding pairs have formed – typically in February and March. Record all pairs and any single birds.
- Autumn: Wait until most of the harvest has finished – ideally between mid-August and mid-September. Record adult males, adult females and young birds in each covey separately. Don't assume a covey is two adults and some young.
- Use a high 4WD to cover more area in less time. Drive each field perimeter and then criss-cross using tramlines to minimise crop damage. Binoculars help when examining each pair or covey.

gwct.org.uk/pcs

Regular counting accumulates data on changes in numbers, helping identify trends and potential threats to grey partridges.
© Helge Sørensen

It is important to remember that the act of counting does not, in itself, save any grey partridge. It is the on-the-ground effort to provide the correct habitats and control predators such as foxes and crows, undertaken by hundreds of PCS members, that will result in more grey partridges. The PCS is a testament to the ongoing passion of so many who recognise the grey partridge as a valuable element of UK farmland wildlife. It is also a challenge and an invitation to those who want to make a difference and join the scheme. The PCS has a long and proud history, and a bright and hopeful future. The grey partridge needs you, and so does the PCS. If you are not currently a member of the PCS, please join now.

Join the PCS

Wild grey partridges benefit from landowners and managers being able to better identify and address their needs. Join the Partridge Count Scheme to help secure the future of our native partridge. Find out more at **gwct.org.uk/pcs**

Partridge Count Scheme results

In 2023 the PCS received 434 spring counts (see Table 1), 73 fewer (-14%) than in 2022. This is partially explained by persistent rain in March, making it difficult for some PCS members to undertake a count. As a result, we recorded a total of 5,618 pairs of grey partridges across 144,200ha, down 861 pairs (-13%), compared with the previous spring. Nationally the average spring pair density remained stable, with a small (2%) increase to 4.7 pairs per 100ha. Regionally, eastern England, northern England, and Scotland recorded an increase in pair density, with eastern and northern England recording the highest average pair densities at 5.9 and 7.2 pairs per 100ha, respectively.

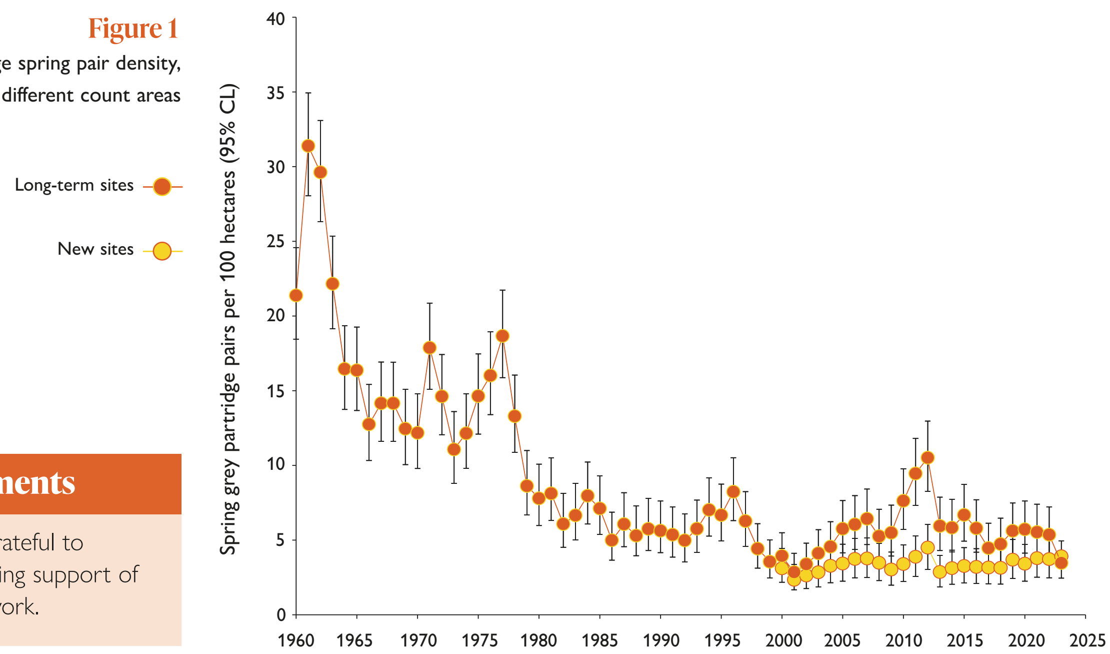
Calculating over-winter survival (OWS) requires an autumn and subsequent spring count. National OWS declined slightly from 55% to 52%, being affected by regional OWS declines in eastern England, the Midlands and Scotland. However, southern and northern regions of England saw small improvements (4-5%) in average OWS, achieving 49% and 54% respectively.

Our grey partridge pair density index (see Figure 1) illustrates the long-term trend since 1960. Differentiating between 'long-term' sites (those participating before 1999) and 'new' sites (those joining since 1999), in spring 2023 long-term sites recorded a significant 35% drop in the average pair density compared with 2022, averaging 3.5 pairs per 100ha (250 acres). New sites recorded a 5% rise, with an average spring pair density of 3.9 pairs per 100ha.

The mild spring and warm summer in 2023 should have resulted in a ready supply of chick-food insects and we were hopeful going into September for a good count, both in terms of PCS members being able to count and in there being lots of chicks to count. The favourable warm, dry conditions in early September also meant that many PCS farmers were focused on bringing in the harvest. This early favourable 'window' was then followed by repeated autumn rain – with four named storms affecting the UK from September to November. These impacted the ability of some PCS participants to undertake an autumn brood count. The PCS received 415 autumn counts, which was thankfully only 5% fewer

Figure 1

Trends in grey partridge spring pair density, controlling for variation in different count areas



Acknowledgements

We are extremely grateful to GCUSA for its ongoing support of our grey partridge work.

TABLE 1

Grey partridge counts

Densities of grey partridge pairs in spring and birds in autumn 2022 and 2023, from contributors to our Partridge Count Scheme

	Number of sites counted in spring		Spring pair density (pairs per 100ha)			Number of sites counted in autumn		Young-to-old ratio (autumn)		Autumn density (birds per 100ha)		
Region	2022	2023	2022	2023	Change (%)	2022	2023	2022	2023	2022	2023	Change (%)
South	74	64	2.2	1.5	-32	75	74	2.4	2	13.2	9.4	-29
East	154	141	5.5	5.9	7	126	120	2.4	2.5	19.3	24.4	26
Midlands	76	54	3.6	3.0	-17	63	60	2.0	3.1	15.0	27.1	81
Wales	2	1	0	0	0	2	1	-	-	0	0	-
North	118	108	6.3	7.2	14	101	104	3.1	3.2	39.5	35.4	-10
Scotland	83	66	3.0	3.1	3	72	56	3.4	3.2	18.4	17.8	-3
Overall	507	434	4.6	4.7	2	439	415	2.7	2.7	22	24.2	10

The number of sites includes all that returned information, including zero bird counts. The young-to-old ratio is calculated where at least one adult grey partridge was counted. Autumn density was calculated from sites that reported the area counted. No counts were made in Northern Ireland.

than in autumn 2022 (see Table 1). Nationally PCS members recorded nearly 21,600 grey partridges in total across 131,400ha. This was only 2% less than the area counted in autumn 2022, with the average area counted being 323ha (up from 312ha in 2022).

The national average Young-to-Old ratio (YtO – a straightforward measure of summer productivity) remained stable with 2.7 young for every adult seen. Encouragingly, all regions where young were recorded were well above the minimum 1.6 YtO necessary to ensure a stable population, with the Midlands, northern England, and Scotland achieving a YtO of 3.0 or greater. At county level, those with lower average YtO, while still above the needed 1.6 YtO, were limited to coastal counties in East Anglia and southern England. Unfortunately, four counties in England did report lower than 1.6 average YtO.

Nationally, the positive YtO led to a 10% increase in average autumn bird density to 24.2 birds per 100ha. However, regional variations were significant. In Scotland and in northern England, the decline in bird densities was due to resumed or newly counted sites in lower density areas that weren't surveyed in 2022, as well as rain preventing counts at other sites that reported good bird densities in 2022. Southern England saw a decrease attributed to a lower YtO, and again the wet autumn weather may have impacted the number of birds that were seen. In contrast, the Midlands reported an increase in bird density due to its high YtO.

Key findings

- The PCS celebrated over 90 years of counting grey partridges in 2023. Doug Middleton, one of the UK's early ecologists, began the Partridge Count Scheme in 1932. He travelled from southern England to Scotland, aiding several estates in counting their grey partridges in autumn.
- In 2023, the UK's average grey partridge summer productivity remained stable at 2.7 young birds per adult.
- Nationally the average autumn density increased by 10%.

Neville Kingdon
Julie Ewald

Brood-rearing habitats that can provide sufficient chick-food insects are necessary for grey partridge chicks to survive their first few weeks. © Peter Thompson

PARTRIDGE – grey partridge and brown hare

Background

The PARTRIDGE project, part-funded by the Interreg North Sea Region fund and led by the GWCT, ran from mid-2016 to 2023, in partnership with 12 European organisations from six participating countries (Belgium, Denmark, England, the Netherlands, Germany, and Scotland). At 10 demonstration sites (500 hectares (ha) in size, two in each country, except Denmark), the project showed how bottom-up stakeholder engagement enabled the implementation of locally adapted management plans, tailored to best practice grey partridge conservation management in mixed farming landscapes. The grey partridge was chosen as a flagship species because where measures are undertaken to help the grey partridge, other farmland wildlife will also benefit. Across the demonstration areas this resulted in an increase in the percentage of the area covered by wildlife-friendly measures – from 8.8% (±1.0%) at the start of the project, to 13.7% (±1.4%) by 2021, while at the reference sites they did not change significantly, covering 3.2% (±0.6%), (see pp30-33). This, in turn, resulted in the increase of several red-listed farmland bird species during the breeding season, together with higher overall numbers and diversity of farmland birds compared with paired reference sites (see pp.28-29 *GWCT Review of 2022*). Together with results reported on hare and grey partridge in this article, the PARTRIDGE project successfully demonstrated how farmland biodiversity on arable farmland can be restored to help achieve the UK's and the EU's 2030 Biodiversity Targets on farmland.

An important element of the PARTRIDGE project was to provide evidence that habitat management tailored to grey partridge conservation delivers more biodiversity. Several indicator species were monitored, including grey partridge, brown hare, and songbirds, to quantify the difference the habitat measures implemented at the 10 demonstration sites made.

Grey partridge

We used a standardised line-transect playback counting method across all project sites to estimate spring population density. All other available methods were either deemed impractical, not acceptable by the landowners involved, were too labour intensive, or not comparable between countries. A recorded grey partridge male call was played using a portable loudspeaker every 100 metres along a minimum of five one-kilometre transects. Call-back counts were undertaken at least three times during January-March, at dawn or dusk, coinciding with the peak male call activity during the winter covey break-up/pair formation period. The call-back calls provoked male partridges to respond either vocally or by flying towards the suspected 'male' intruder. This allowed us, together with purely visual encounters along the transects, to count male partridges (either single or already paired) in a standardised way. For a detailed description of the method used, see the PARTRIDGE monitoring factsheet *Best practice guidelines for successful grey partridge monitoring on farmland:* northsearegion.eu/partridge/output-library/.

Our analysis compared the number of grey partridge males at demonstration sites to their reference sites. Reference sites were areas of farmland close by the Demonstration sites where no extra provision of wildlife-friendly habitats were created. Effectively it looked at whether the change in partridge numbers over the project years differed between the demonstration and reference sites. While the overall trend difference across all demonstration and paired reference sites was positive, it was not statistically significant. The positive difference suggests that our measures positively influenced partridge density and hence aided their recovery. Moreover, in the final three years of the project the number of male partridges counted was significantly higher on the demonstration sites. There were an average of 2.1 male partridges per kilometre of transect (95% confidence interval: 1.3-3.6), compared with 1.0 male partridge per kilometre on the reference sites (95% confidence interval: 0.6-1.7, see Figure 1). The wide confidence intervals reflect large between-year and site variability.

Brown hare

A standardised line-transect spotlight counting method was used to determine brown hare numbers at our project sites, except for one demonstration/reference pair in the UK. Point counts with spotlights were used there, owing to the dense concentration of hedgerows along field boundaries. At most sites three separate counting sessions were undertaken annually. For a detailed description of the method used, see the

© Jasper Brenberger

GWCT students preparing for a grey partridge call-back transect count at Rotherfield demonstration site. © Francis Buner/ GWCT

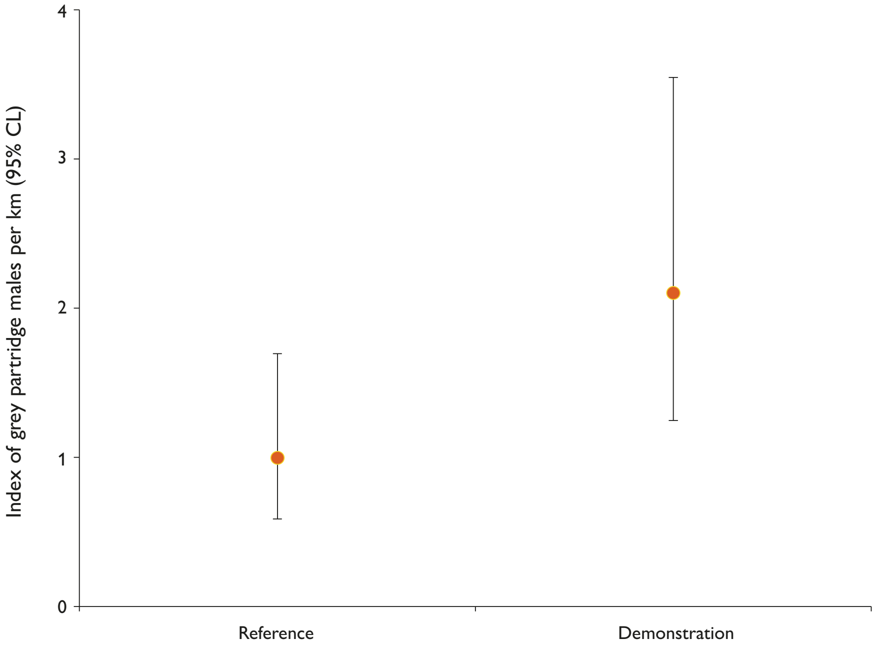


Figure 1

The average male grey partridges counted per kilometre of transect over the last three years of the project, 2021 to 2023

PARTRIDGE *Best practice guidelines for successful brown hare monitoring on farmland* factsheet at: northsearegion.eu/partridge/output-library/.

Again, we analysed the change in brown hare numbers over the project period between demonstration and reference sites. Overall, the difference in the trend in the number of brown hares counted per 100ha was not significantly different. Only at one demonstration site in Scotland brown hare numbers increased significantly more than 30% compared with its paired reference site. However, like the grey partridge results, the number of brown hares counted across all demonstration sites in the final three years of the project was significantly higher (23.9 hares per 100ha, ± 95% CL (14.0-40.9)) than on the reference sites (12.5 hares per 100ha, ± 95% CL (7.3-21.3)).

The results of our grey partridge and brown hare monitoring provide evidence that delivering quality habitat on 14% of farmland plays a crucial role in supporting local partridge and hare numbers. They also demonstrate that habitat improvements, tailored to the grey partridge, can benefit local brown hare populations, as well as breeding and wintering farmland songbirds (see pp.28-29 *GWCT Review of 2022*). Our findings highlight that: 1) farmland wildlife is likely to take several years before responding positively to changes in habitat quality and availability; 2) farmland areas with more than 10% quality habitat have significantly higher numbers of wildlife compared with farmland with less than 4%, and; 3) continued long-term, large-scale (10%+) habitat management is required to recover farmland wildlife successfully.


Overall almost twice as many hares were observed at the demonstration sites than at the reference sites. © Oly Berriman

Key findings

- Overall, the difference in the number of male grey partridge recorded in the spring on demonstration compared to reference sites showed a non-significant positive trend across all 10 demonstration sites.
- In the last three years of the project the number of male grey partridge counted in the spring was significantly higher across all the demonstration sites, compared with the reference sites.
- Overall, the difference between the number of brown hare counted on demonstration versus reference sites showed a non-significant positive trend across all 10 demonstration sites during the project period.
- In the last three years of the project the number of brown hare counted was significantly higher across all the demonstration sites compared with the reference sites.

Francis Buner, Fiona Torrance, Thomas Scheppers, Fleur Petersen

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We thank all participating GWCT staff (Julie Ewald, Cameron Hubbard, Dave Parish, Chris Stoate, Steve Moreby, John Szczur and several placement students), the PARTRIDGE co-ordinating partner organisations BirdLife NL, the Flemish Land Agency (VLM), INBO, the University of Göttingen and the Danish Hunters Association together with their local PARTRIDGE partner organisations, all participating farmers, hunters, volunteers, NGOs and Government agencies, the Steering Committee members, and the NSR Interreg Secretariat in Denmark.

PARTRIDGE - habitat and landscape change

Key findings

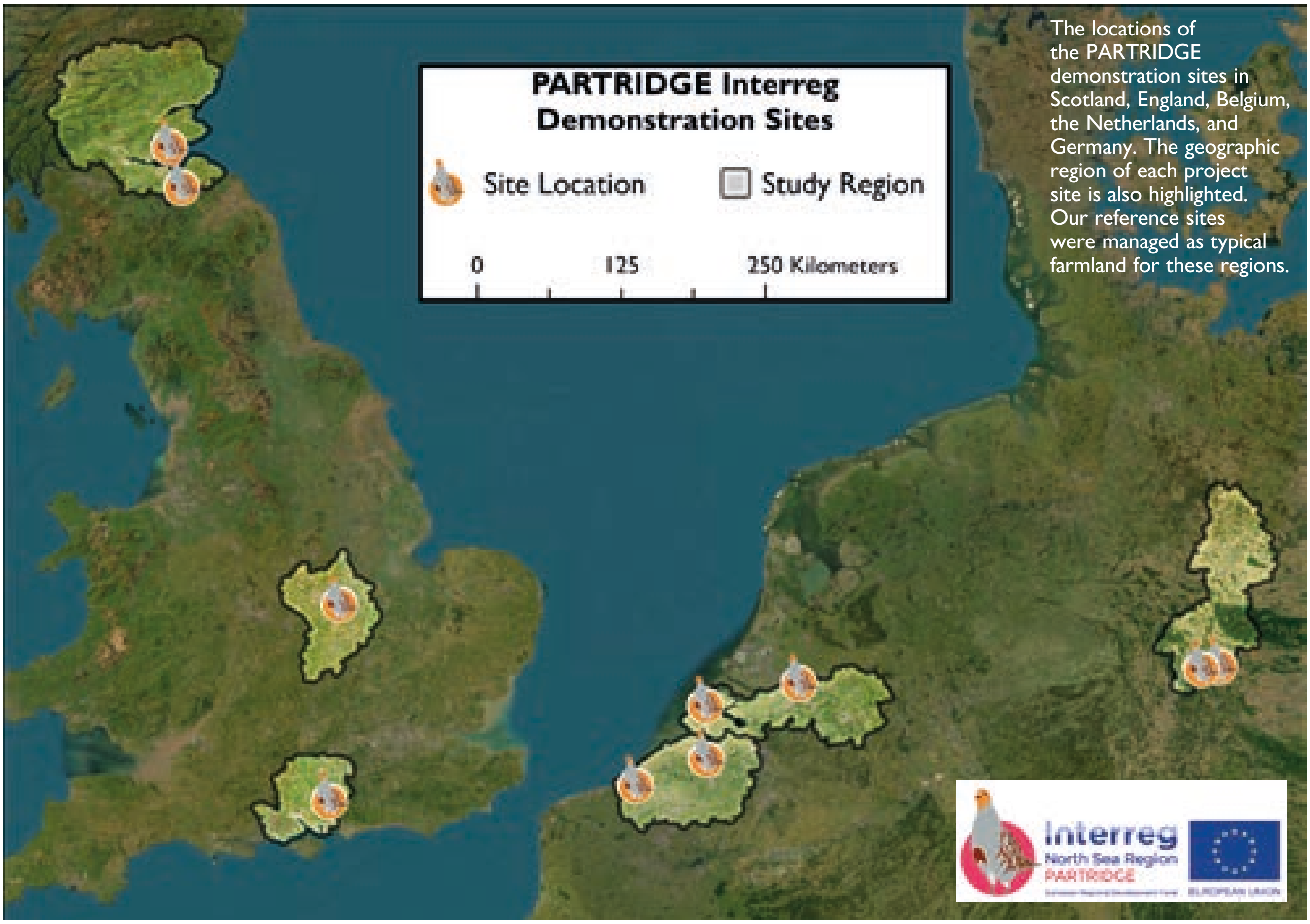
- We greatly exceeded the amount of habitat we aimed to establish at our PARTRIDGE project demonstration sites (see pp.28-29).
- Demonstration sites had more than twice the minimum amount of beneficial habitat required to recover grey partridge *(Perdix perdix)*.
- We created a significant amount of 'core habitat' with reduced predation risk for ground-nesting bird species.

Cameron Hubbard
Julie Ewald
Francis Buner

Within the PARTRIDGE project a wide range of monitoring programmes were carried out by teams of researchers and volunteers. One of these was the recording and digitization of the habitats present on the 10 demonstration and 10 reference sites, recording landcover in a Geographic Information System (GIS). This involved, for each of the 20 project sites, and for each year between 2017 and 2022, the recording of habitats present in both the summer and winter – resulting in a total of 240 maps throughout the project. We recorded habitats to a high level of detail, logging every crop, margin, hedge, beetle bank, and wild bird mix. These maps allowed us to quantify exactly what habitats were present on our demonstration sites and compare them to habitats on the reference sites.

The primary purpose of the mapping was to measure progress towards the project's aim of establishing beneficial wildlife habitat (such as wild bird mixes) on at least 7% of the arable area of the demonstration sites. Seven percent reflected the results of a published literature review into how much environmental stewardship was needed to restore farmland bird numbers. This review indicated that farmland bird populations were likely to be increased if beneficial habitat measures were adopted on at least 7% of arable farmland (Winspear et al. 2010).

We can conclusively say that the farmers on the demonstration sites far exceeded the 7% target, (see Figure 1). Across all demonstration sites the highest amount of beneficial habitat was provided in 2021, with a mean value of 13.7% (±1.4%). By the end of the project, we had achieved a statistically significant increase in the amount of beneficial habitat from our initial baseline of 8.8% (±1.0%) in 2017. The higher than expected initial baseline was likely a consequence of the fact that, to be selected as a demonstration site at the onset of the project, sites had to have recent recordings of grey partridge breeding on them. In the current state of arable farmland in northern Europe it was likely that any sites with grey partridges would already have beneficial



The locations of the PARTRIDGE demonstration sites in Scotland, England, Belgium, the Netherlands, and Germany. The geographic region of each project site is also highlighted. Our reference sites were managed as typical farmland for these regions.

An example of our primary habitat measure, a wild bird mix, established at the Diemarden demonstration site, Germany. This measure benefits grey partridge and numerous other species throughout the entire year. © Lisa Dumpe

Background

The North Sea Region Interreg PARTRIDGE project, which ran from 2017 to 2023, was a multi-national project led by the GWCT. The project included farmers, volunteers, advisors, governmental bodies, hunters, environmental groups, and researchers working together. We demonstrated how best practice and novel manage-ment solutions can be used to recover biodiversity in agricultural landscapes across northern Europe, with demonstration sites in Belgium (Flanders), England, Germany, the Netherlands, and Scotland.

These management solutions were applied by farmers on 10 demonstration sites, each covering 500 hectares, in five European countries (two sites in each country), supported through site-based advisors. The demonstra-tion sites were compared to those on 10 matched reference sites under typical farm management in the same regions.

habitat helping to maintain these populations. In comparison, the reference sites had an average of 2.9% (±0.5%) of their farmed area devoted to beneficial habitats at the beginning of the project.

The percentage of beneficial habitat at our demonstration sites increased by 4.9% (±1.4%), on average, between 2017 and 2021. By contrast, the percentage of beneficial habitat on our reference sites, representing typical farmland across Europe, did not significantly increase, with 3.2% (±0.6%), on average, of the reference areas covered by beneficial habitats at the end of the project (an average increase of 0.3% (±0.3%)). The contrast in the amount of beneficial habitat between our demonstration and reference sites at the end of the project is shown in Figure 2.

The range of additional beneficial habitat established at our demonstration sites was much more diverse than the few beneficial habitats present at our unenhanced reference sites. In 2021 the demonstration sites had more than twice as many different types of beneficial habitats compared with the reference sites, with an average of eight (±1) unique habitat types at our reference sites compared to an average of 17 (±2) at our demonstration sites. The expectation was that more diverse habitats could provide resources for a greater range of farmland species. This was reflected in our monitoring data (see page 28-29, *GWCT Review of 2022*), which showed that both the number of farmland bird species and the number of breeding territories of farmland birds, were greater at our demonstration sites than our unenhanced reference sites.

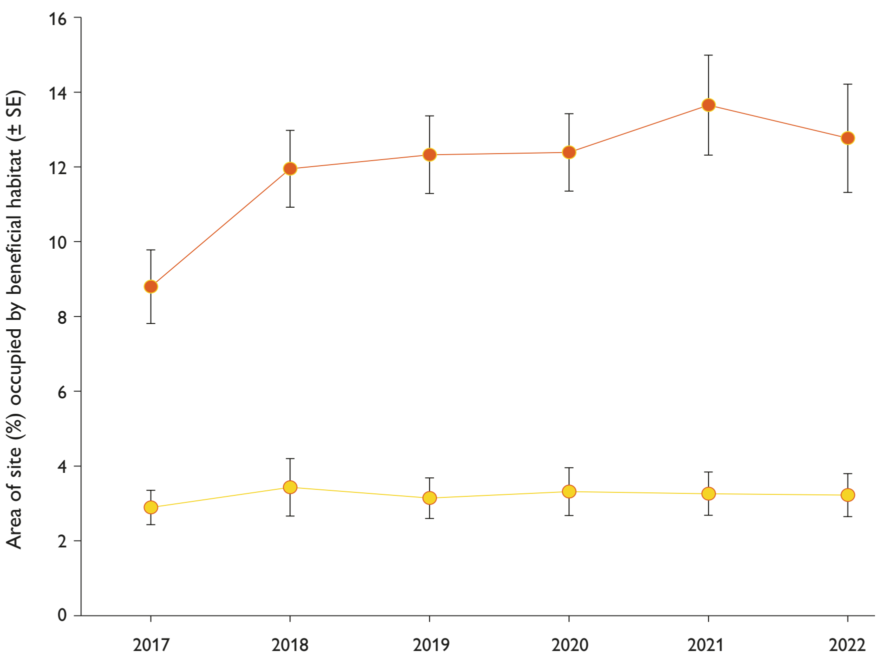


Figure 1

Change in the amount of beneficial habitat at PARTRIDGE demonstration and reference sites throughout the duration of the project. Our initial goal was to ensure that seven percent of the demonstration site was covered by benefi-cial habitat at the end of the project

Figure 2

The beneficial habitat established on demonstration sites in 2021 (left) compared with the amount at reference sites in the same year (right)

Our project was not without its challenges, and we can explore some of these with reference to the mapping. Our relatively large demonstration sites of 500 hectares (ha) can be compared to the average farm size in the UK in 2021 of 81ha, with almost half of all UK farms less than 20ha in size. In continental Europe, the average farm size ranged from 26ha in Flanders, Belgium to 61ha in Germany, with the average farm size in the Netherlands falling between these two at 41ha. Our relatively large sites meant that many of our demonstration sites consisted of a mosaic of ownerships and management, comprising dozens of individual farmers. This made it difficult to ensure an even distribution of beneficial habitat across the 500ha landscape, as each individual farmer had their own preference on the siting of beneficial habitat, with some farmers electing not to establish any habitat at all. Some of the farmers involved in our project were dairy and/or livestock farmers who found it especially difficult to relinquish areas of pasture land for wildlife, while others offered up large chunks of land, in a 'take it or leave it' manner. Consequently, the beneficial habitats on our demonstration sites were often established in large clumps, rather than evenly distributed across the landscape. This distribution of habitats made it especially difficult to provide a network of habitats across the demonstration sites.

The aggregation of this habitat did, however, have some positive landscape-level effects for those demonstration sites where there was no targeted predation management. Research in Germany, on areas of farmland without predation management, has shown that patches of nesting habitat larger than 20 metres in width (hereafter 'core habitat') provide a significantly reduced risk of predation for ground-nesting birds, such as the grey partridge (Gottschalk and Beeke, 2014). By clustering several smaller habitats together, combined with our project's focus on establishing large (>0.5ha) blocks of wild-bird mixes, we were able to significantly increase the amount of this core habitat at our demonstration sites. We were able to double the average amount of 'core habitat' present at our demonstration sites throughout the project to an average of 5% (±0.7%) – resulting in levels 10 times greater than those at our reference sites, where the average was 0.5% (±0.1%).

With our habitat analysis for PARTRIDGE concluded, we can confidently say that establishment of sufficient beneficial habitat to support the restoration of key arable species is achievable.

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This drone imagery shows the variety of shapes, sizes, and types of beneficial habitats at the Isabellapolder demonstration site. © Korneel Verslyppe

Acknowledgements

We would like to thank Frans van Alebeek, Mark Benders, Beth Brown, Amelia Corvin-Czarnodolski, Luc De Bruyn, Valentin Dienst, Lisa Dumpe, Bastiaan van Gemert, Eckard Gottschalk, Holly Kimbrey, Elouise Mayall, Fien Oost, Minna Ots, Fleur Petersen, Ellie Raynor, Lucy Robertson, Thomas Scheppers, Jochem Sloothaak, Tamara Spivey, Suzanne van de Straat, Fiona Torrance, Willem Van Colen, Catherine Vanden Bussche, Korneel Verslyppe, Yasmine Verzelen and Chris Vreugdenhil.

NGC: trends in waterbirds

Background

The NGC was established by the GWCT in 1961 to provide a central repository of records from shooting estates in England, Wales, Scotland and Northern Ireland. The records comprise information from shooting and gamekeeping activities on the numbers of each quarry species shot annually ('bag data').

Through the NGC, we monitor bag sizes of waterbirds as well as gamebirds. Several waterbird species were added onto the NGC form in 1983, following the Wildlife & Countryside Act (1981). These records provide an index of change that can be compared to change obtained through the standard Wetland Birds Survey (WeBS) of annual winter abundance conducted by the Wildfowl and Wetlands Trust (WWT), the British Trust for Ornithology (BTO) and the Royal Society for the Protection of Birds (RSPB). Trends in the bag of waterbirds as a group were last reported in the *GWCT Review of 2006.* That article explored the trends in bag records for species of water-birds with data from at least 30 sites on average each year. This allowed for reports on six species: mallard, teal and wigeon, all monitored since the NGC began in 1961, and greylag goose, Canada goose and moorhen, three species added in 1983. When we assessed the list of species with an average of 30 sites per year up through 2022 for this article, one other species fulfilled that requirement – tufted duck, and that trend in bags is included here, taking the place of moorhen due to limited space. Waterbirds are susceptible to highly pathogenic avian influenza (HPAI), spreading the virus on migration. The European Centre for Disease Prevention and Control reported high levels of virus detection in June to September 2022. The effects of this on the bag index are difficult to determine in the current trends. For each species, data analysis is based on all UK sites that have returned bag records for two or more years. The analysis summarises the average pattern of year-to-year change within sites as an index of change relative to the start year, which receives a value of 1.

Mallard (Figure 1)

The mallard is the most common of our resident duck species. It is also released for shooting on just under a quarter of NGC sites where it is shot. The bag index thus reflects changes in numbers released as well as changes in the wild population. Overall, since 1961, numbers released have risen nine-fold, while the bag itself has tripled. Increases in the overall bag are driven by releases. Over the last 25 years the bag index of shoots that reported releasing increased by 40%, while the bag index on shoots that did not report releasing declined by 40%. At the same time, we know from WWT/BTO/RSPB surveys that mallard numbers have remained steady during the breeding season in the UK, but declined by 37% over the past 25 years during the wintering period. This decline matches that of the bag index on shoots that do not release mallard. Climate change may affect migratory behaviour, with birds moving shorter distances to overwinter ('short-stopping'), resulting in lower numbers of wild mallard reaching our shores. Recent research suggests that low duckling survival may be the key driver of declines in wild mallard numbers in Europe.

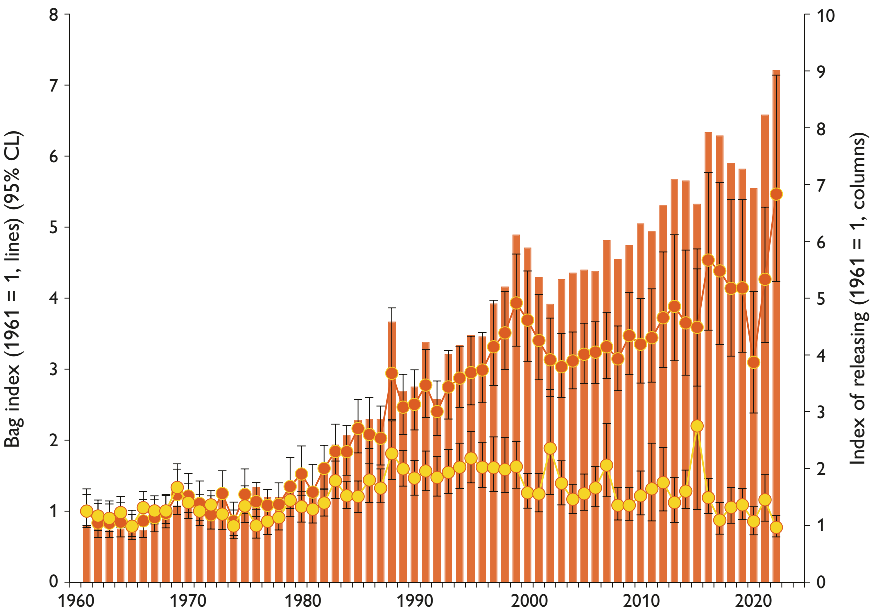
Figure 1

Index of mallard shot per km^2 on NGC sites that reported mallard releasing and ones that did not report mallard releasing across the UK (left-hand scale) and mallard releasing index (right-hand scale), 1961-2022

Mallard releasing

Shoots with releasing

Shoots without releasing



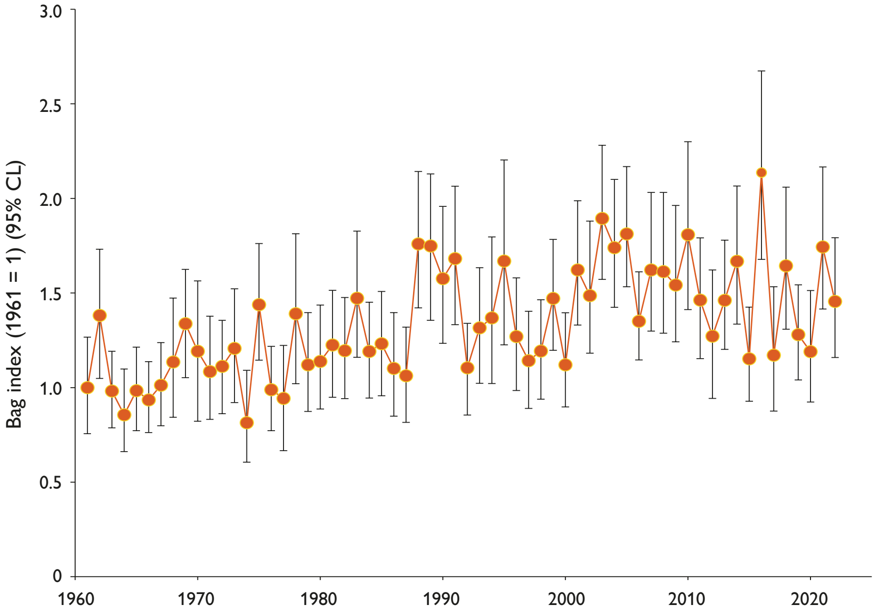


Figure 2

Index of teal shot per km^2 on NGC sites across the UK, 1961-2022

Key findings

- Increases in the mallard bag are driven by increases in the release of mallard. On shoots that release mallard, the bag increased by 40%, while the bag on shoots without releasing declined by 40%, reflecting declines in mallard numbers during the wintering period.
- Changes in the teal bag reflect numbers overwintering in the UK, while recent declines in wigeon and tufted duck bags outpace the smaller declines in numbers of these species overwintering in the UK.
- Increases in the greylag and Canada goose bags reflect increases in numbers overwintering in the UK and efforts to control numbers to limit crop damage, covered through General Licences.

Julie Ewald

Teal (Figure 2)

The teal that are shot in the UK are predominantly winter visitors, originating mainly from Iceland, Fennoscandia and western Russia. The bags show a noisy but gentle increase of just over a third over the last 62 years. Over the past 25 years there has been a slight but not significant increase in the bag index of 5%, with a slight decline (6%) in the bag over the past 10 years. These figures match those from WeBS: 5% increase over 25 years, 9% decrease over 10 years. The trend in teal numbers across Europe is uncertain, though declines in breeding numbers on eutrophic boreal lakes in Fennoscandia appear to be related to deteriorating conditions in these lakes and to predation on the nest.

Wigeon (Figure 3)

Wigeon are also mostly winter visitors to the UK, breeding in Iceland, northern Europe, and eastern Russia. The bag index remained relatively stable through the 1960s into the 1990s, with increases from then through to the early 2010s, followed by a decline. Over the last 25 years there has been a decline of 14% in the bag, similar to the 11% decline in wintering numbers identified in WeBS over the same time period. Over the last 10 years the bag index of wigeon declined by 30%, while WeBS recorded a decline of 6% over the same time span. Climate change, eutrophication and predation on

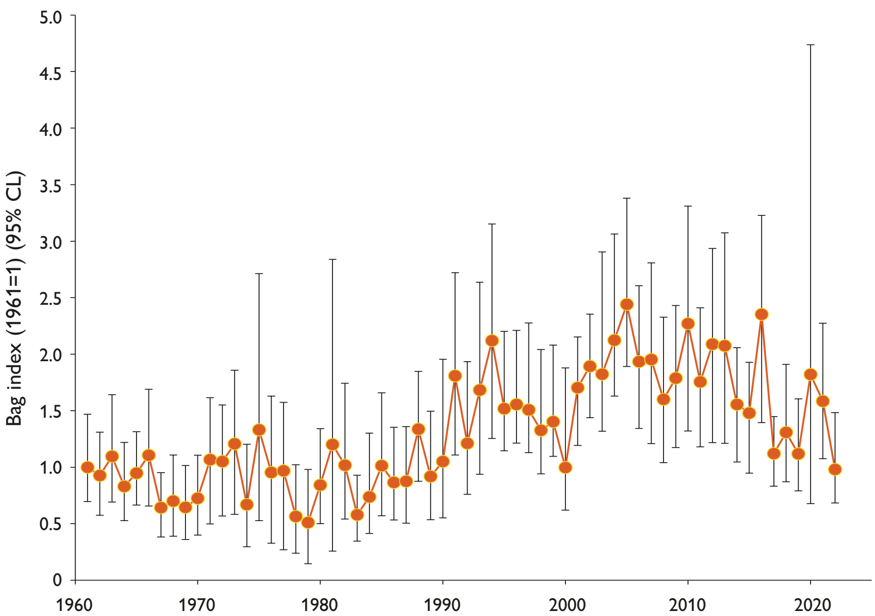
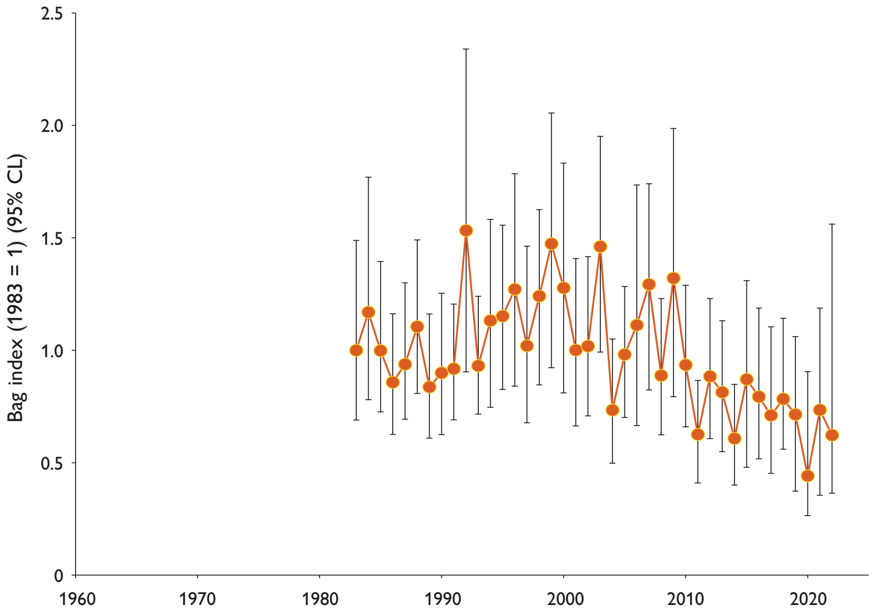


Figure 3

Index of wigeon shot per km^2 on NGC sites across the UK, 1961-2022

Figure 4

Index of tufted duck shot per km² on NGC sites across the UK, 1961-2022



NGC participants

We are always seeking new participants in our National Gamebag Census. If you manage a shoot and do not already contribute to our scheme, please contact the NGC co-ordinator on 01425 651019 or email **ngc@gwct.org.uk**.

breeding grounds can influence wigeon reproductive success, while short-stopping may be reducing the numbers overwintering in Britain.

Tufted duck (Figure 4)

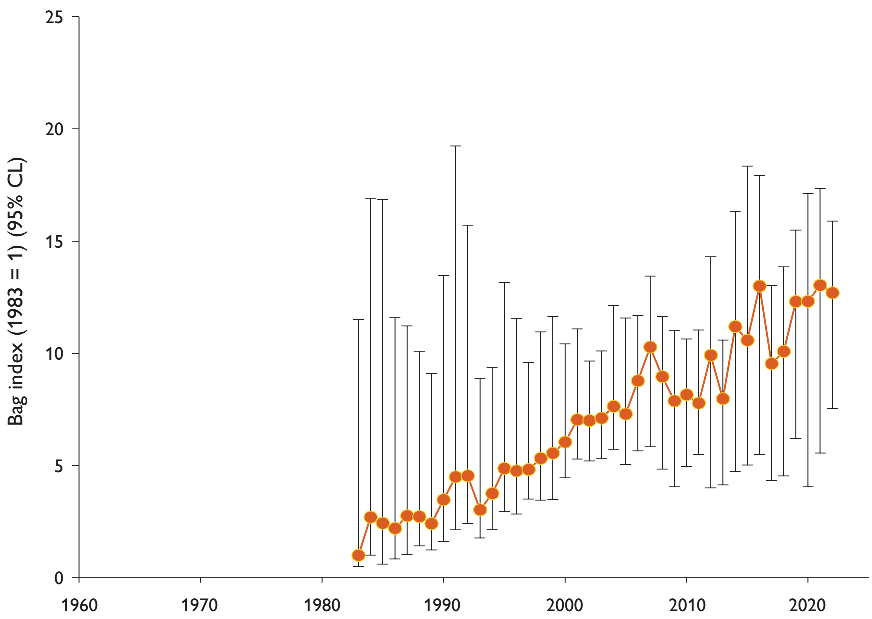
There are a relatively small number of tufted duck breeding in the UK, with most wintering birds migrating from northern Europe and as far east as central Russia. WeBS indicates a decline of 11% in wintering numbers over the past 25 years, with a decline of 8% over the last 10 years, probably as a result of short-stopping. The bag index for tufted duck was stable in the first 20 years of NGC records, with subsequent declines that outpace the declines in WeBS; the bag declined by 46% over the last 25 years and by 31% over the last 10. Declines in breeding numbers of tufted ducks in Fennoscandia may be due to increased nest predation or changes in habitat quality.

Greylag goose (Figure 5)

Apart from geese in north-west Scotland and winter visitors from Iceland, also mostly in Scotland, greylags in the UK are largely the result of reintroductions in the 1960s and 1970s. Numbers of both native and re-established birds have increased and expanded across the UK, making distinguishing between them difficult. WeBS reports a 210%

Figure 5

Index of greylag goose shot per km² on NGC sites across the UK, 1961-2022



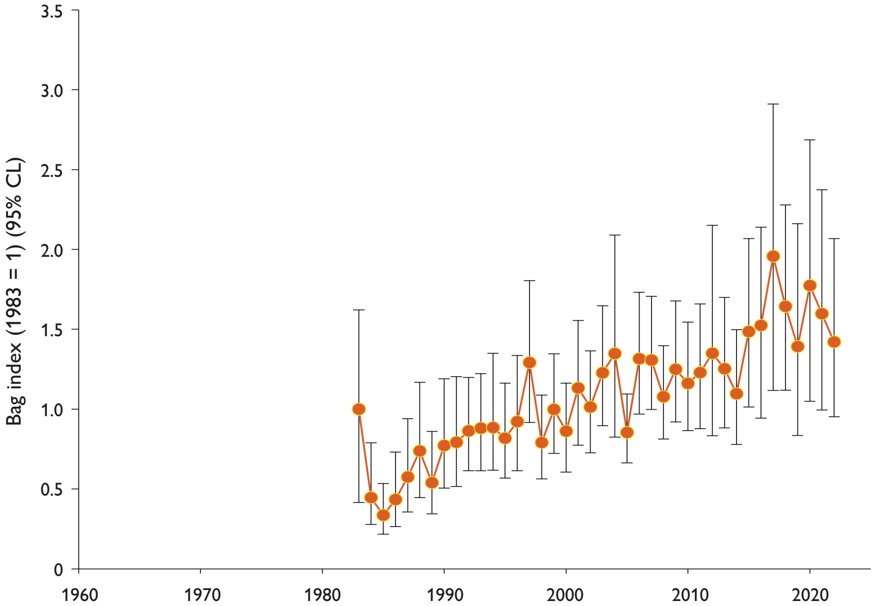
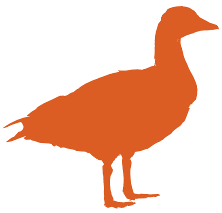


Figure 6

Index of Canada goose shot per km^2 on NGC sites across the UK, 1961-2022

increase in wintering numbers of British/Irish greylag geese over the last 25 years, with an increase of 9% over the last 10 years. NGC sites contributing bag records of this species are split roughly 50:50 between Scotland and England. Records begin in 1983, and since then there has been a significant increase in the bag index – with the current bag index over 12 times higher than the level in 1983. Over the last 25 years there has been an increase of 155% in the bag index while, over the last 10 years, the bag index increased by 36%. In Scotland, in response to the problems caused by high numbers of resident greylags, the GL02 General Licence allows their control throughout the year for the prevention of serious damage to livestock, foodstuffs for livestock, crops, vegetables, and fruit.



Over the last 25 years there has been an increase of 155% in the greylag goose bag index while, over the last 10 years, the bag index increased by 36%

Canada goose (Figure 6)

The Canada goose is a North American species that was popular in UK waterfowl collections (first recorded in 1665) and then became naturalised through escapes after the Second World War. Numbers have increased rapidly, and the species is now widespread across most of Britain. WeBS reports an increase in winter numbers of 72% over the past 25 years and an increase of 18% over the last 10 years. The increase in bags, which have nearly doubled since 1983, is comparable to the growth in the UK population over the same period, with an increase of 74% over the last 25 years and 25% over the last 10 years. Canada geese are often controlled to prevent damage to crops, appearing on three General Licences in England (GL40, GL41, GL42) and Scotland (GL01, GL02 and GL03) and the 001 General Licence in Wales.

Canada geese. © Dennis W Donohue

Merlin Magic

Merlin chicks were ringed under licence. © GWCT

Background

Merlin were returned to the Red-List of Birds of Conservation Concern in 2015 as their recovery from a historic decline had faltered. In parts of northern England declines of up to 69% since 1994 have been recorded; these are contested by grouse moor managers who feel that numbers remain stable. Increased heather management through burning or cutting on grouse moors has been suggested as a contributor to the decline in merlin through reducing the availability of tall heather for nesting, modifying habitats, and reducing the numbers of meadow pipits, an important prey species for merlin.

Merlin Magic was a 22-month project which ran from September 2021 to June 2023, funded by the English Government's Green Recovery Challenge Fund, a multi-million-pound boost for green jobs and nature recovery. The project focused on merlin, a small falcon of long-term conservation concern, which breeds on England's moorlands. Grouse moors provide important refuges, supporting an estimated 78% of breeding birds. Gamekeepers managing moors proudly host them, and raptor workers enthusiastically search for them, but these parties often disagree over their status and causes of decline. Gamekeepers consider their management for grouse helps support merlin and other ground-nesting birds, while others think that heather burning and cutting for grouse reduces merlin nesting habitat and reduces the abundance of meadow pipits and skylarks, key prey for merlin. The project aimed to reconcile opinions through promoting co-operative working, whereby gamekeepers found nests for raptor workers, who then validated nests and, under licence, ringed chicks. By additionally measuring nesting vegetation, habitat quality and avian prey, we aimed to guide dialogue between grouse practitioners and upland ecologists regarding the need for landscape-scale improvements in moorland management to benefit merlin, other ground-nesting birds, improve habitat condition and wildfire control. In doing so, we promoted public awareness of moorland conservation issues, informed conservation strategies and laid foundations for further grouse-raptor reconciliation projects.

The project operated across three upland areas covering 1,300km² in northern England; the North Pennines, Yorkshire Dales, and the North York Moors, all designated as Special Protection Areas for ground-nesting birds, including merlin. Project staff helped co-ordinate nest finding efforts between gamekeepers and raptor workers, facilitating agreement over total number of merlin breeding pairs present and their breeding success. Field data were collected to assess whether the availability of tall heather for nesting and avian prey abundance were limiting merlin distribution and breeding success. In total, 52 nest sites were visited shortly after chicks had fledged to measure vegetation composition and height, overhead cover at the nest, and to record the area of the heather patch in which the nest was located. We quantified how much tall heather was present within each breeding territory (defined as the area within a

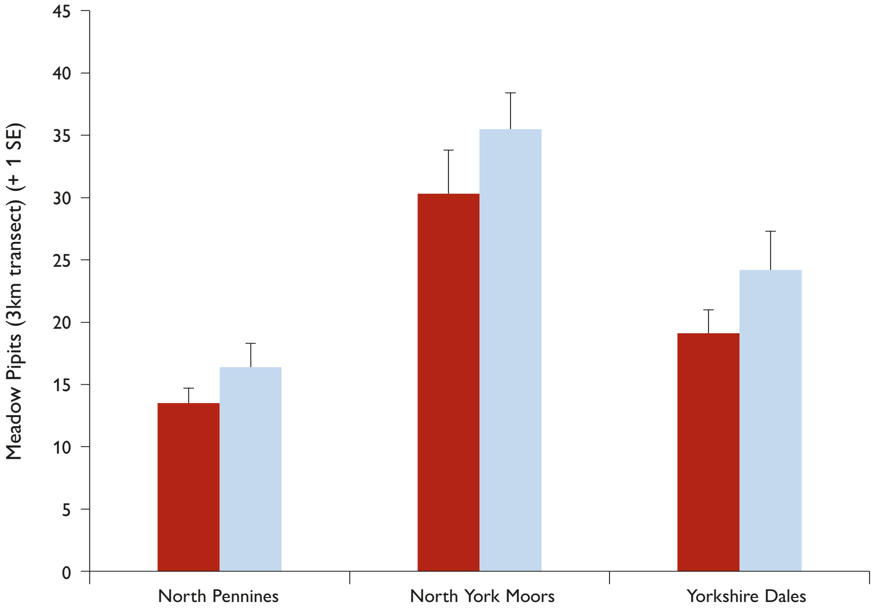


Figure 1a

Mean numbers of meadow pipits observed on territories and unoccupied control locations in the North Pennines, Yorkshire Dales, and North York Moors when merlin were settling in April/May

Occupied

Control

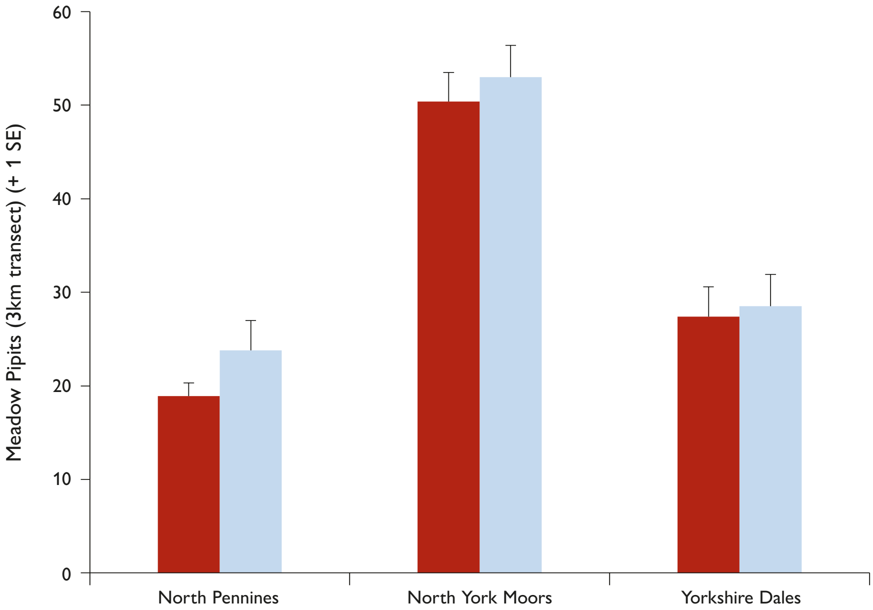


Figure 1b

Mean numbers of meadow pipits observed on territories and unoccupied control locations in the North Pennines, Yorkshire Dales, and North York Moors when merlin were feeding young in June

Occupied

Control

1-km radius of the nest) by measuring heather cover and height every 50 metres (m) along four parallel, equally spaced transects in each of 66 occupied territories and in 60 randomly selected, apparently unoccupied control locations.

We found all nests on the ground, with three-quarters of nests in heather 35 centimetres (cm) or taller. Merlin nested within the altitudinal range of 220 to 670m. At higher altitudes, generally above 600m, heather growth is suppressed by colder temperatures and exposure to winds, but, even here, they nested in the tallest heather available. We found 83% of merlin nests were in patches of tall heather that were less than 0.3 hectares (ha), equivalent to a 30 x 100m strip. The smallest patches used for successful nesting were only 2 x 2m. In our study, territories occupied by merlin had an average of 13% tall heather, ie. 35cm or more. Defra's Heather and Grass Burning Code recommends that 10% heather taller than 40cm is sufficient for ground-nesting raptors such as merlin.

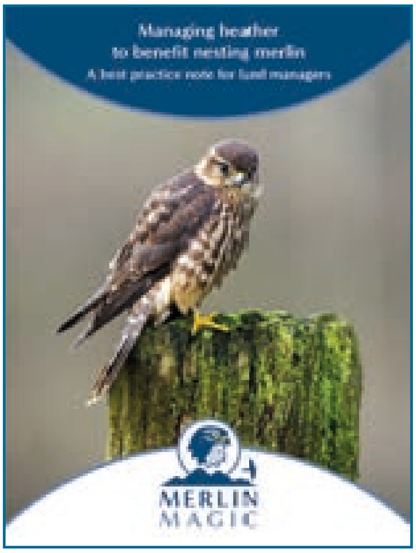
We surveyed the abundance of meadow pipits and all other birds within occupied territories and control locations using a modified Breeding Bird Survey method (consisting of two parallel 1km-transect counts and along the 0.5km transect between each end, which totalled 3km in length) to determine whether food availability for breeding

Key findings

- Merlin bred in relatively small patches of tall heather, the availability of which does not appear to limit breeding distribution on grouse moors in northern England.
- The numbers of meadow pipits, key prey for merlin, were not greater in occupied territories than control areas, suggesting food availability was not limiting.
- Grouse moors provide important refuges for breeding merlin. The low survival of juveniles during the winter months appears to be the main limiting factor for merlin.

Philip Warren

merlin could be limiting distribution. The first visit in April/May considered bird prey abundance in relation to merlin settlement patterns, while the second visit was in June, when most merlin had chicks. We found that meadow pipits were more abundant in the North York Moors, and overall, in April/May were 28% more abundant in the control areas (see Figure 1). In June, there were similar numbers in merlin territories and control locations, apart from in the North Pennines where there were 26% more on the control areas. A similar pattern was observed when including all small birds (skylarks, stonechats, wheatear, warblers), which were more abundant in the control areas in both periods, indicating that prey abundance was not limiting merlin distribution.



A leaflet was produced for land managers showing how to manage heather to benefit nesting merlin.

Merlin declines could also be triggered by increased over-winter mortality when birds leave the uplands to spend the winter in the lowlands. Originally, the plan was to explore this by fitting merlin nestlings with GPS transmitters to follow them during the winter. However, while developing this component we encountered several issues, including the small size of merlin relative to transmitter size, concerns about negative impacts of the transmitters on birds, and the short lifespan of the project. Instead, we analysed national ringing recoveries held by the British Trust for Ornithology, calculating annual survival rates of adult and first-year birds, and compared timings and possible causes of death in relation to their presence on either breeding or non-breeding (wintering) grounds. Provisional results, set alongside our collective observations of moderately high breeding success on our grouse moor study areas, strongly suggested that the demographic stage likely to limit population size is low annual survival of juveniles, especially in their first autumn/winter. At that stage, most merlin are over-wintering on lowland farmland and coastal areas. Accordingly, data collected and analysed as part of this project suggest that problems associated with merlin declines manifest themselves not on grouse moors, but while birds are away from them.

The project has enabled a better understanding of merlin nesting requirements on grouse moors, with the availability of tall heather and avian prey being sufficiently high that neither were likely to limit merlin abundance. These general findings were fed back to moorland managers and raptor workers through a programme of workshops in each of the three study regions and through follow up one-to-one estate visits. Project findings were also reported to a wider audience through an array of media, including the Merlin Magic website gwct.org.uk/merlinmagic, blogs, articles, displays at shows,

We found all nests on the ground, with three-quarters of nests in heather 35cm or taller. © GWCT

Acknowledgements

This project was funded by the English Government's Green Recovery Challenge Fund. The fund was developed by Defra and its Arm's-Length Bodies. The Green Recovery Challenge Fund is being delivered by The National Lottery Heritage Fund in partnership with Natural England, the Environment Agency, and Forestry Commission.

Green Recovery Challenge Fund

information leaflets, and presentations at conferences and to interest groups. The results have also been used to inform and prepare a *Managing heather to benefit nesting merlin – A best practice note for land managers* leaflet, with two scientific manuscripts being prepared for submission to peer-reviewed ecological journals.

We have a better understanding of merlin nesting requirements on grouse moors, with the availability of tall heather and avian prey being sufficiently high that neither were likely to limit merlin abundance. © Scott M Ward/ GWCT

Legal predator control is associated with high breeding success of curlew

Background

Most species of wader are declining across Europe owing to changes in land use and intensification of agricultural practices over the last 50-70 years. The UK breeding curlew population represents a quarter of the global population, with larger numbers found only in Finland and Russia. However, numbers in the UK have halved in the last 25 years and this decline is among the highest in European countries. The uplands of England and Scotland represent the current strongholds for the species but even here numbers have declined owing to agricultural intensification and afforestation at landscape scales. The adult survival rate of curlew remains high, but low breeding success, owing largely to predation, is driving declines.

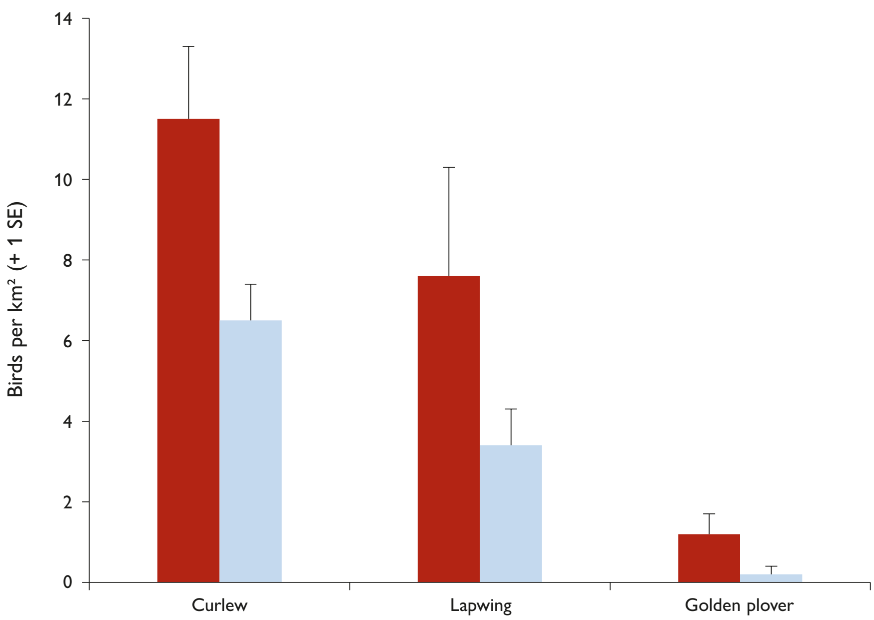
Curlews breed at high densities on moors managed for red grouse shooting. Reducing generalist predators by legal, lethal control and burning or cutting heather to provide shorter vegetation to favour grouse may also benefit curlew. Given the importance of the declining UK numbers to the global curlew population, it is important to understand the causes of low breeding success. Working on 18 study blocks across the curlew's upland breeding range, we set out to compare curlew breeding success between grouse moors and non-grouse moors and assess abundances of key predators such as fox and corvids. There was one block in North Wales, 11 in northern England, three in the Scottish Borders, and three in the Scottish Highlands. Each block consisted of a pair of sites, on average 10.1 kilometres (km) apart, one on the fringes of moorland managed for grouse shooting where fox, stoat, weasel, and some corvids were routinely killed by gamekeepers and one on similar habitat where there was no grouse shooting and predators were not routinely managed. Curlew and other waders were surveyed on five occasions at each site. Corvids, gulls, and raptors were also recorded, and fox scats were counted along 5-9km routes at each site in April.

Curlew was the commonest wader on the surveys, accounting for 46% of the 878 pairs recorded, followed by lapwing, snipe, oystercatcher, golden plover, and redshank. Wader densities were over twice as high on grouse moors as on non-grouse moors, with curlew and lapwing densities both twice as high, but no detectable difference in snipe densities. Golden plover and redshank were found on half of grouse moors but only one fifth of non-grouse moors (see Figure 1).

The percentage of curlew pairs that hatched chicks on grouse moors was twice as high as on non-grouse moors (81 ± 4% and 41 ± 4% respectively). On grouse moors 66% of curlew pairs fledged at least one chick compared to 17% of pairs on non-grouse moors (see Figure 2). To better understand this difference, we examined relationships with several potential explanatory factors across all the sites. Neither gull nor raptor abundances, nor any measures of habitat, vegetation, livestock, or peat depth were related to curlew breeding success. However, curlew hatching and fledging success were negatively related to a combined index of corvids and fox abundance, such that sites with high breeding success had low predator abundance. Grouse moors had four-fold fewer carrion crows, half as many corvids, and a three-fold lower fox scat index than non-grouse moors but similar gull and raptor indices (see Figure 3). Curlew productivity on grouse moors was estimated as 1.05 fledged chicks per pair compared to 0.27 chick per pair on non-grouse moors.

Figure 1

Mean density of curlew, lapwing and golden plover across 18 paired grouse moor and non-grouse moor sites



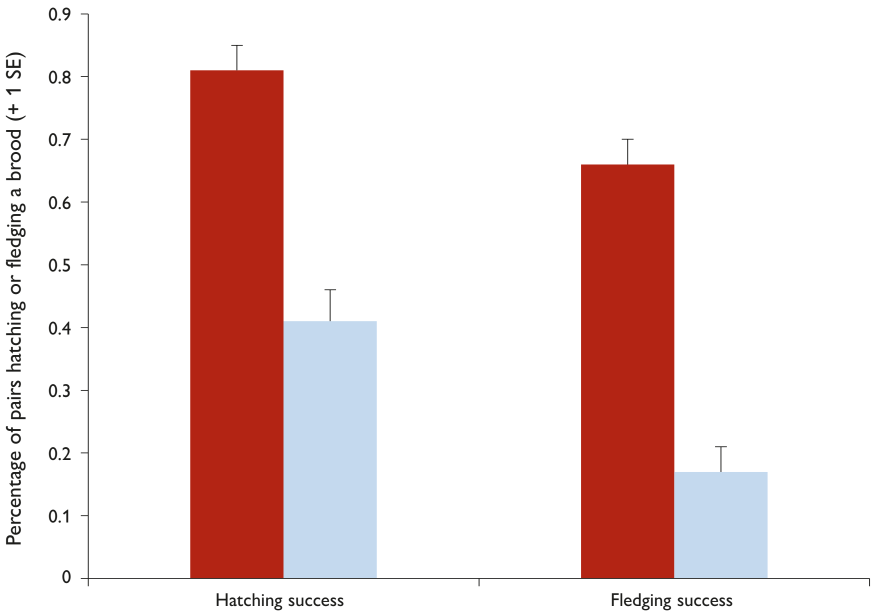
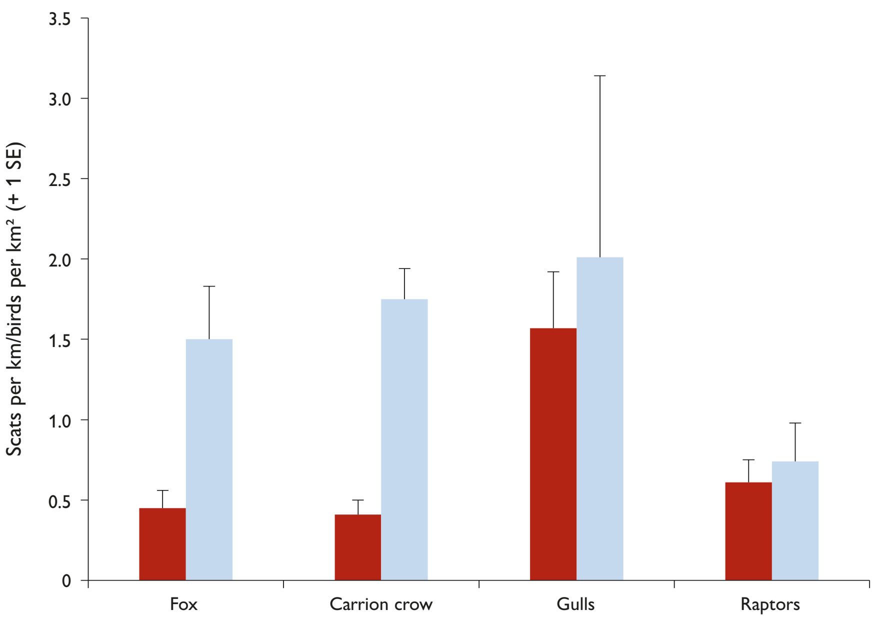


Figure 2

Mean percentages of curlew pairs hatching and fledging a brood on grouse moors and non-grouse moors

Grouse moor

Non-grouse moor



Key findings

- Grouse moors supported twice the density of waders found on non-grouse moors.
- Curlew breeding success was four-fold higher on grouse moors than non-grouse moors..
- Curlew hatching and fledging success were higher on moors where a combined index of corvids and fox was lower, and predator index values were three to four times lower on grouse moors.

David Baines
Kathy Fletcher
Nick Hesford

Figure 3

Estimates of red fox index and avian predators across 18 paired grouse moor and non-grouse moor sites

Grouse moor

Non-grouse moor

The findings were similar for other waders. For example, 68 ± 8% of lapwing pairs on grouse moors fledged at least one chick compared to 32 ± 7% on non-grouse moors, with productivity estimated as 1.0 and 0.5 fledged chick per pair on grouse moors and non-grouse moors, respectively. For golden plover, 20 of 31 pairs (55%) on seven grouse moors fledged chicks, whilst none of four pairs on two non-grouse moors fledged chicks. Similarly, 23 of 33 pairs of oystercatchers (70%) reared chicks across 11 grouse moors compared with just two of 12 pairs (17%) across four non-grouse moors. Fledging success of redshank was similar on grouse moors (76%) and non-grouse moors (83%).

Grouse moors appear to act as source areas, producing more fledged chicks than the level required for a stable population (c.0.6 chick per pair), thereby slowing the current rate of decline in curlew. To halt declines and promote curlew recovery in the UK uplands, we recommend that predator control on grouse moors is maintained, and longer-term land use policies are developed to render landscapes less amenable to current high levels of generalist predators.

Barn owl breeding success across Farmer Clusters

Barn owls are able to hunt well during dry calm periods leading to high fledging success. © Mark Medcalf

Background

The Owl Box Initiative is a GWCT project that began in 2021. This project aims to increase the availability of nest sites for breeding barn owls, engage with local communities to promote barn owl conservation and investigate the use of agri-environment scheme habitats by breeding barn owls using GPS tags deployed on adult birds for a short period of time. From these data we will determine which habitats are most important for the species during the breeding season, to enable provision of habitat recommendations to landowners, farmers and policymakers.

Sixty-two barn owl boxes were put up across Farmer Clusters in Dorset, Hampshire, and Wiltshire as part of this project to provide barn owls with safe nesting sites. We have been monitoring these boxes annually during the breeding season since 2021 to follow the breeding success of the barn owl pairs using these farmland landscapes. All of this work is carried out under BTO ringing and Schedule 1 licences by fully qualified bird ringers.

Box occupancy and breeding success rates (percentage of breeding attempts where at least one chick fledged) differ from year to year (see Table 1); this is usually in relation to weather conditions and vole numbers. In 2023, 28 pairs of barn owls nested in the boxes we monitor across the study area and 30 breeding attempts were made; this is due to two pairs renesting after their first breeding attempt failed. The average clutch size in 2023 was 4.07 (±0.2) eggs laid per breeding attempt, and at least 123 eggs were laid overall. This is 19.7% lower than 2021 and 13.8% lower than 2022 (see Figure 1), likely due to the adult females being unable to get into good breeding condition in late winter owing to long periods of wind and rain in March preventing them from hunting effectively.

From these 28 pairs and 123 eggs, we estimate 43 chicks fledged, resulting in 1.45 chicks fledging per breeding attempt, which is lower than the previous two seasons (1.57 chicks in 2021 and 1.73 chicks in 2022). The broods that fledged ranged in size from one to four chicks, but two or three chicks fledged from most of the successful broods. The average chicks per pair is brought down by some pairs that failed completely, often owing to poor weather conditions when incubating small chicks. Thirty-five percent of the eggs laid produced a fledgling owl, and 64% of pairs

TABLE 1

Nest box occupancy (number of boxes occupied/number of boxes provided) and success rate (number of breeding attempts where at least one chick fledged/total breeding attempts*, ie. clutches laid) of breeding barn owls on Farmer Clusters in Dorset, Hampshire and Wiltshire (2021-2023)

Farmer Cluster	2021		2022		2023	
	Occupancy	Success rate	Occupancy	Success rate	Occupancy	Success rate
FC 1	13/26 (50%)	10/15 (66%)	10/27 (37%)	4/11 (36%)	8/27 (30%)	5/8 (63%)
FC 2	6/34 (18%)	1/6 (17%)	8/33 (24%)	8/8 (100%)	7/31 (23%)	5/7 (71%)
FC 3	12/44 (27%)	7/12 (58%)	15/49 (31%)	11/16 (69%)	14/50 (28%)	8/15 (53%)
Overall	31/104 (31%)	18/30 (60%)	33/109 (30%)	22/34 (65%)	29/108 (27%)	18/30 (60%)

** In some cases, the number of breeding attempts is higher than the number of occupied boxes owing to repeat nesting attempts.*

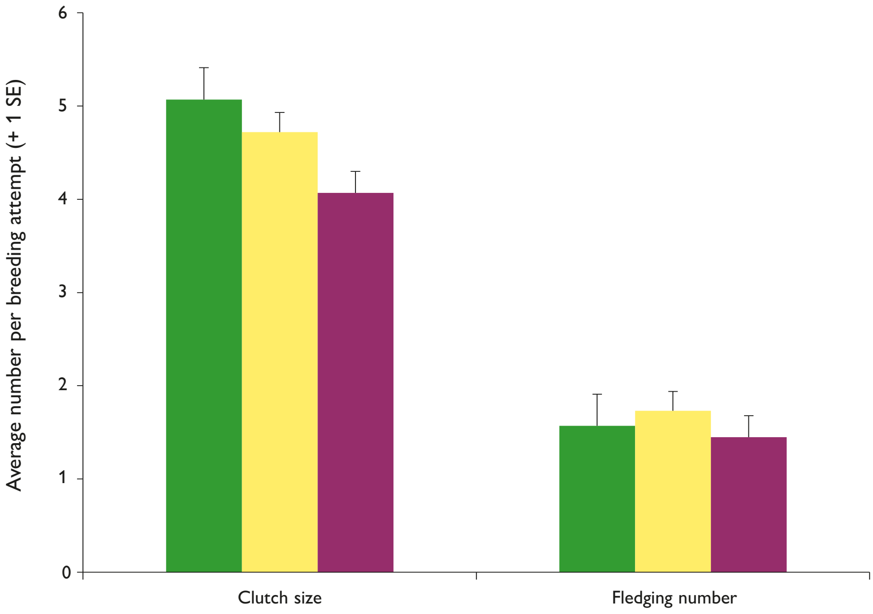


Figure 1

Average clutch size and number of chicks fledging per breeding attempt for barn owls monitored on Farmer Clusters in Dorset, Hampshire and Wiltshire in 2021-2023

- 2021
- 2022
- 2023

managed to fledge at least one chick. Overall, the breeding season was a success for most pairs, but it was a poorer season than the previous two years.

The 2021 breeding season had the highest average clutch size of 5.07 (± 0.3) eggs per breeding attempt (see Figure 1) but this did not lead to higher fledging success. Even though more eggs were laid, the chicks had poor survival due to wet weather when many pairs had tiny chicks, which prevents the adults from hunting. For around the first 25 days after hatching, the female needs to brood the chicks to keep them warm, so the male has to provide most of the food at this time, often leading to chick deaths from starvation. Of the years monitored, 2022 had the highest fledging success. We expect this was due to the weather during the breeding season being dry and calm. Owls were able to reliably hunt most nights, leading to higher survival of the nestlings. National data from the Barn Owl Trust reported similar results nationally in 2022. They report high occupancy rates and a slightly higher fledging success rate but they report that later broods did not fare as well as late-season drought may have reduced the availability of prey items (*State of the UK barn owl population* – 2022, Barn Owl Trust).

We recorded the highest fledging success in 2022. © GWCT

Key findings

- One hundred and eight owl nest boxes are monitored as part of The Owl Box Initiative across three Farmer Clusters in Dorset, Hampshire and Wiltshire.
- Since 2021, we have monitored box occupancy and breeding success of barn owl *(Tyto alba)* nesting in these boxes.
- Box occupancy fluctuates slightly between years but remains fairly stable with the lowest occupancy observed in 2023, likely due to poor over winter survival.
- We recorded the largest average number of eggs laid in 2021, but the highest average fledging success was recorded in 2022.

Ellie Ness
Niamh McHugh

Acknowledgements

This project was funded by the Green Recovery Challenge Fund, with additional funding provided by the Wixamtree Trust in 2023. Without the engagement of farmers this project would not have been possible and we thank all the farmers who have allowed us to monitor their barn owls since 2021. We are also grateful to volunteers Ryan Burrell and Simon Lane who helped with data collection.

BEESPOKE outreach

Background

Over 80% of crop species in Europe rely, to some extent, on insect pollination to produce seeds and/or fruits. The well-documented decline in wild pollinators therefore has serious implications for crop yield and quality. Wild plants, such as hawthorn and blackthorn (see *Review of 2008,* pp.56-57), also rely on pollinators to produce fruits eaten by other wildlife.

Holland, J. (2023) Boosting wild bees on farmland. Available at: *Boosting wild bees on farmlands* | Interreg North Sea.

The BEESPOKE (Benefiting Ecosystems through Evaluation of food Supplies for Pollination to Open up Knowledge for End users) project was an EU-funded project (2020-2023), led by the GWCT, which aimed to address the loss of pollination services on farmland. Eighteen partners from across the North Sea Region developed methods to measure crop pollination deficit (the difference between maximum pollination and that achieved by the pollinator community) and management interventions to address this deficit.

A key part of the project was encouraging the uptake of pollinator-friendly management by farmers and growers and to raise awareness of pollinator conservation more generally. To this end, we produced a broad suite of communication materials, including digital/paper guides, videos and podcast appearances, explaining different pollinator friendly practices. We used in-person events, such as an open day at the GWCT's Allerton Project at Loddington or a Young Farmers' meeting, to distribute these materials and to demonstrate our message, using example wildflower plots or a pinned bee collection.

To extend the reach of the BEESPOKE message, as well as break down the library of guides and information produced by the project into accessible content, the @beespoke_nsr Instagram was produced. The Instagram page content included seasonally relevant prompts, points of interest and highlighted how various identification and management guides might be useful to practitioners.

This outreach aimed to broaden grower's understanding of wild pollinators and their importance; for example wild bees, as opposed to honeybees, are responsible for the vast majority of crop polli-

Patchwork leafcutter bees nest in holes in wood. (Inset) Solitary bees such as the Ashy mining bee are able to pollinate smaller flowers such as hawthorn. © Peter Thompson

Examples of educational guides that were produced about the different pollinators.

nation in the UK. Bumblebees as a group are relatively well known but we developed a guide to enable people to identify individual species. There are 24 species of bumblebee in the UK, and they have different ecological roles. For example, long-tongued bumblebees are adapted to pollinate flowers with long flower tubes, such as red clover.

We also aimed to increase awareness of less well-known groups of pollinators by producing a guide for identifying some of the common solitary bees in the UK. Ninety percent of the 250 species of bee in the UK are solitary bees and they are important pollinators. Solitary bees transport pollen using specialised hairs on their hind legs or abdomen called 'scopae' rather than the pollen baskets (called corbiculae) that honeybees and social bumblebees have. In addition, solitary bees don't mix the collected pollen with nectar, so the pollen remains powdery. Both attributes mean the pollen they collect falls off more readily during flower visits and this can improve pollination success. Their foraging strategy and other attributes (eg. smaller body size) means they can pollinate plants with smaller open flowers (such as umbellifers and hawthorn), which may be less favoured by bumblebees.

Our ID guides provide an accessible introduction to UK pollinators. We used these guides when teaching Marks & Spencer's growers how to survey their own pollinator-friendly habitats. Better understanding of the types of pollinators present on a farm can encourage effective conservation action, such as providing foraging habitat or nesting sites. To facilitate this management, we produced how-to guides. One of the most popular was a guide on how to build a bee hotel. Bee hotels provide nest sites for aerial nesting, as opposed to ground-nesting, solitary bees. These bees usually nest in plant stems, holes in wood (eg. leafcutter bees) or in walls.

In addition to outreach activities several wildflower mixes were designed by partners in BEESPOKE, with plant lists available to download. The BEESPOKE wildflower mixes can be used to produce foraging habitat for wild bees. Some of these were crop-specific mixes (designed to support appropriate pollinators) and were tailored for a specific use on farmland, but others can be used more widely. We also produced a guide on how to manage wildflower habitat to provide the most pollinator-friendly habitat. This is of particular importance as the planting of wildflower plots in farmland, and elsewhere, is growing. Key steps, such as the annual cutting of wildflower plots and ensuring that cuttings are removed to prevent nutrient build up, can maximise the quality of these habitats for bees.

The final message from the BEESPOKE project was that: 'Agricultural landscapes have to deliver a greater abundance and diversity of flowering plants and trees to prevent further decline in pollinators'. The education and communication materials produced as part of the project are available at gwct.org.uk/beespokepubs and we hope that they can continue to be used to achieve this aim.

Key findings

- Outreach was a major part of the BEESPOKE project; across the whole project we reached approximately 400,000 people, both face-to-face and through social media.
- The BEESPOKE project produced 20 leaflets and 33 videos, covering bee identification and conservation.
- Educational materials produced in BEESPOKE can be downloaded at: gwct.org.uk/beespokepubs.

Lucy Capstick
Jayna Connelly
John Holland
Niamh McHugh

Wildflower seed mixes for wild bees

Background

Sown wildflower margins are a common agri-environment scheme option that provide insect pollinators such as bumblebees and solitary bees with floral resources on farmland. However, evidence has shown that although bumblebees visit the flowers sown in the seed mixes, solitary bees are regularly foraging from spontaneous wildflower species emerging from the seed bank, not those sown as part of the wildflower mix. It is important we sow wildflower seed mixes that cater to solitary bees as well as bumblebees.

Key findings

- We created two novel wildflower seed mixes, one based on primary research of wild bees visiting wildflowers ('Wild bee'), and one on evidence from published literature (Literature).
- We trialled our novel mixes against two standard AES seed mix options, a clover-heavy mix (AB1) and a basic wildflower mix (AB8).
- 'Wild bee' attracted the highest number of insects over the experiment, as well as the greatest abundance and richness of wild bees.
- 'Wild bee' attracted a significantly greater abundance and richness of bumblebees than the AB1 mix.
- We found that only 11 'key' wildflower species were needed to encompass all visits of wild bee species recorded during the experiment, eight of which were sown species.

Rachel Nichols
John Holland
Dave Goulson

Agricultural intensification is generally considered to be the main driver behind the decline of farmland biodiversity. Semi-natural habitats and weeds have become increasingly scarce across farmland. To counteract these declines, agri-environment schemes (AES) have been implemented throughout the UK to restore farmland biodiversity. Sowing wildflower margins and plots is a popular AES option for farmers to implement on their land. Two of the current wildflower seed mix recommendations for AES options in England are the clover-heavy seed mix (AB1) and a wildflower seed mix (AB8). However, there was little evidence available showing which seed mix, if either, attracted a diverse range of insect pollinators, including wild bees. We wanted to test the current seed mixes along with two new mixes.

We created two novel wildflower mixes: a wild bee mix based on primary research ('Wild bee') and one on literature-based evidence (Literature). To identify flowers for the wild bee mix, we surveyed visits of bumblebees and solitary bees to wildflowers growing as crops on a wildflower farm. We recorded individuals to species level to see which wildflowers attracted the greatest diversity of wild bee species. To identify flowers for the Literature mix, we used published records of wildflower species that were recorded as attracting a high abundance or richness of solitary bees. We trialled our two novel mixes against the two standard AES wildflower mixes described above, along with a fallow area that naturally regenerated from the seed bank, creating five treatments in total.

We established each treatment in 20 x 5 metre (m) plots, replicated five times, on two farms (one in Sussex and one in Oxfordshire). All four seed mixes were broadcast sown in the plots in September 2018. We then surveyed the plots four times throughout spring and summer, for three years (2019-2021 – 12 times in total). To survey the plots, we used a standard 'bee walk' to record pollinating insects and the flowers they were visiting. We identified wild bees and butterflies to species level wherever possible and recorded additional insects to family or genus. Our aim was to determine which mix attracted the highest overall insect pollinator abundance and highest species richness for wild bees.

In total, 4,002 insects were recorded making visits to flowers in our plots over the three years. Wild bees made 1,390 visits in total, and these visits were made up of at least six bumblebee species and 34 solitary bee species. Overall, the 'Wild bee' mix was highly attractive. It had the highest average number of insect visitors per plot over

'Wild bee' attracted a significantly greater abundance and richness of bumblebees. © Rachel Nichols

the experiment (6.2 ± 0.8 visits per 100m² plot, see Figure 1), and the highest average wild bee abundance per plot (2.3 ± 0.3 visits per 100m² plot) and richness per plot (1.1 ± 0.1 species per 100m² plot). Additionally, the 'Wild bee' mix attracted significantly more bumblebees than the typical low diversity AB1 mix, despite the AB1 mix being generally targeted at bumblebees.

Only 11 'key' wildflower species were required to cater to all wild bee species recorded during the study, eight of which were sown species. Dandelion, spear thistle, wild carrot, and hedgerow cranesbill had the highest 'species strengths' overall and attracted 34 of the 40 wild bee species recorded during the study. This shows we only need a few 'key' wildflower species to provide for a wide range of wild bee species, and these should be included in future seed mixes.

Our results indicate that we need to update the current wildflower seed mix recommendations to include species with scientific evidence of increasing insect abundance, and in particular wild bee richness, if we want to improve farmland biodiversity and increase the potential for pollination services to crops. Our 'Wild bee' mix should be considered for inclusion in future AES seed mixes, particularly for agricultural land with chalk/loamy soils.

Acknowledgements

We would like to thank Dominic Gardner (Lee Farm), and Sam Haynes and Chris Buxton (Church Farm), for allocating space and resources for our seed mix trial. We would also like to thank Richard Brown at Emorsgate Seeds for his advice regarding formulating mixes and their management. This work was supported by a NERC CASE studentship for Rachel N. Nichols, University of Sussex (NE/P009972/1) and by the GWCT.

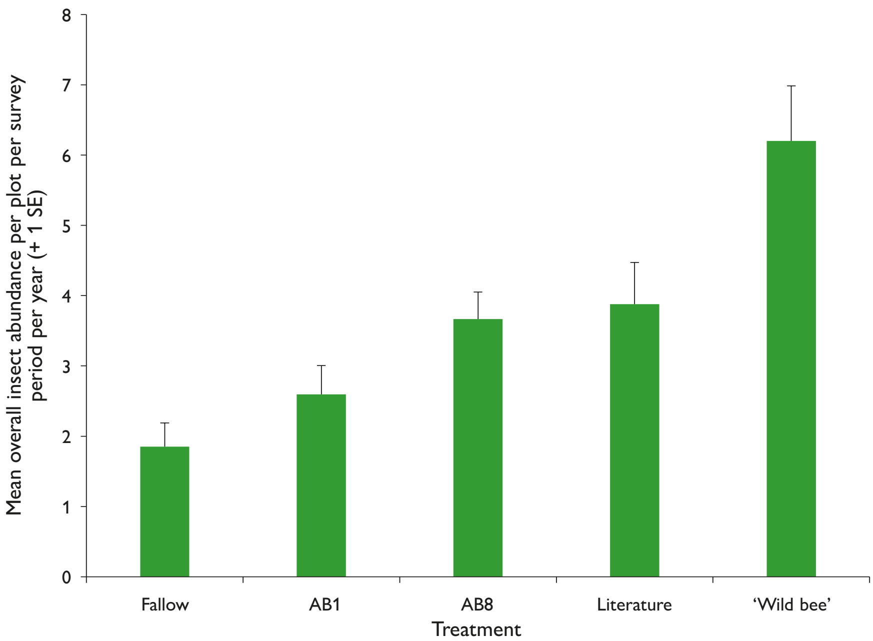


Figure 1

Insect abundance across the five treatments. The highest abundance was found on the 'Wild bee' mix

Allerton Project

Allerton Project: game and songbirds

Muntjac have been present locally since the 1970s and are now recorded quite frequently. © Simon Bratt

Background

Game and songbird numbers have been monitored annually at the Allerton Project at Loddington since it began in 1992, providing an insight into how both have been influenced by changes of management over this period. In particular, they have provided valuable information on the effects of predator control and winter feeding.

Annual spring and winter game counts at the Allerton Project farm at Loddington continue to document low numbers of wild gamebirds in spring and record very little successful breeding. The shoot relies exclusively on the release of reared pheasants. This year the shoot has changed from allowing the use of lead shot to exclusively steel for the first time.

Winter night-time counts of brown hares continue to show high numbers of this species, with nine times as many hare recorded in spotlight counts now as at the start of the project in 1992, in comparison to twice as many at our nearby control site.

A 11.5 kilometre (km) annual songbird transect conducted four times during the breeding season continues to record high overall songbird numbers, with breeding abundance in 2023 being 71% higher than in the 1992 baseline year. The transect is not intended to provide data beyond the most abundant species and the overall abundance of all species combined. It does not provide an accurate record of scarcer species, for which we rely on detailed mapping of breeding territories every five years, the last of which was undertaken in 2021.

However, because the transect has now been carried out for such a long time, even for some scarcer species it provides some indication of changes in abundance. Some species have colonised the farm during the period of the project and, while the transects may not record the actual first year of arrival, as these species become more numerous, records start to appear in the transect data.

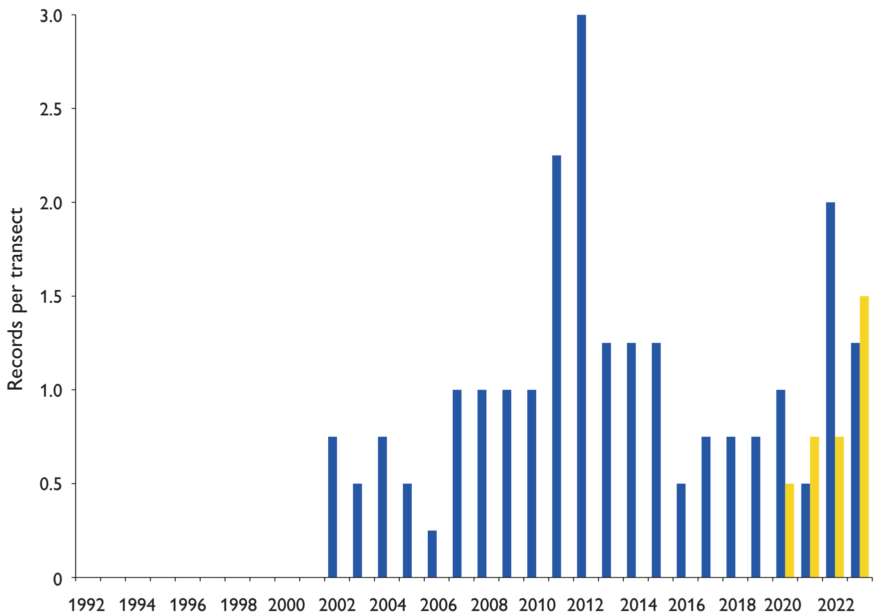
Buzzards have spread eastwards across England over the past 30 years. Few were observed in the 1990s, but this species started nesting at Loddington in 2002, and the first records started to appear in the transect data in that year (see Figure 1). More

Figure 1

Buzzard and red kite sightings from 1992 to 2023. No buzzards were recorded during the first decade of the Project, but numbers have risen steeply since, in-line with the local trend. Red kites arrived later as they expanded their range from a local release site

Buzzard

Red kite



Acknowledgements

Thank you to Kings Crops who supply the seed and provide agronomy support to the Allerton Project.

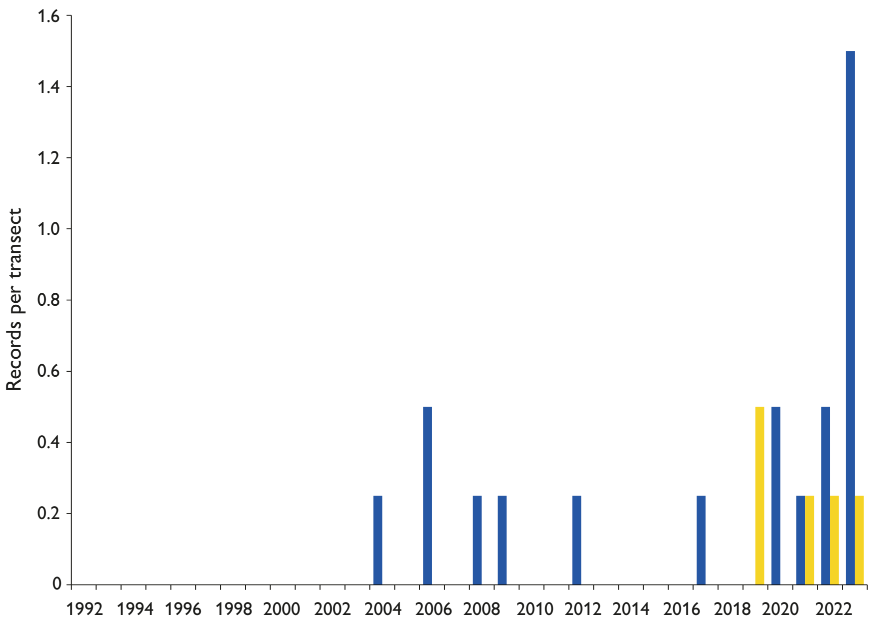


Figure 2

Muntjac and roe deer records from 1992 to 2023

Muntjac

Roe deer

Key findings

- Songbird numbers are 71% above the 1992 baseline.
- Wild gamebirds are not breeding successfully on the farm, but brown hare numbers remain high.
- Long-term (32 years) transect data reveal the appearance of formerly absent or scarce deer and raptor species.
- Foxes and magpies are recorded more frequently than in the period with full predator control, but less than when there was no predator control.

Chris Stoate
John Szczur
Matthew Coupe
Amber Lole

recently, red kites have spread out from a local reintroduction site and now nest locally and are regularly recorded on our transect.

Establishing new woodland has not been as challenging for us as it has in many parts of the country where deer numbers are higher. Muntjac have been present locally since the 1970s but were not sufficiently numerous to feature in our transects until 2004, since when they have been recorded quite frequently (see Figure 2). More recently, there have also been occasional sightings of roe deer on transects.

The transect data also provide an indication of the abundance of species that are nest predators. Following the introduction of predator control at Loddington in 1993, there were few records of foxes or magpies, but there were considerably more frequent records of these species during the period without predator control, from 2001 to 2010 (see Figure 3). Since then, with a lower level of predator control than was previously adopted, there have been some records of foxes and magpies, but at much lower levels than in the period without any predator control.

Collecting these systematic data in the same way each year highlights the value of absence records. Species that have not been recorded for nearly 30 years, but are now starting to make an appearance, include raven and mandarin duck. Maintaining these data collections will tell us when other species become sufficiently numerous to be recorded on transects.

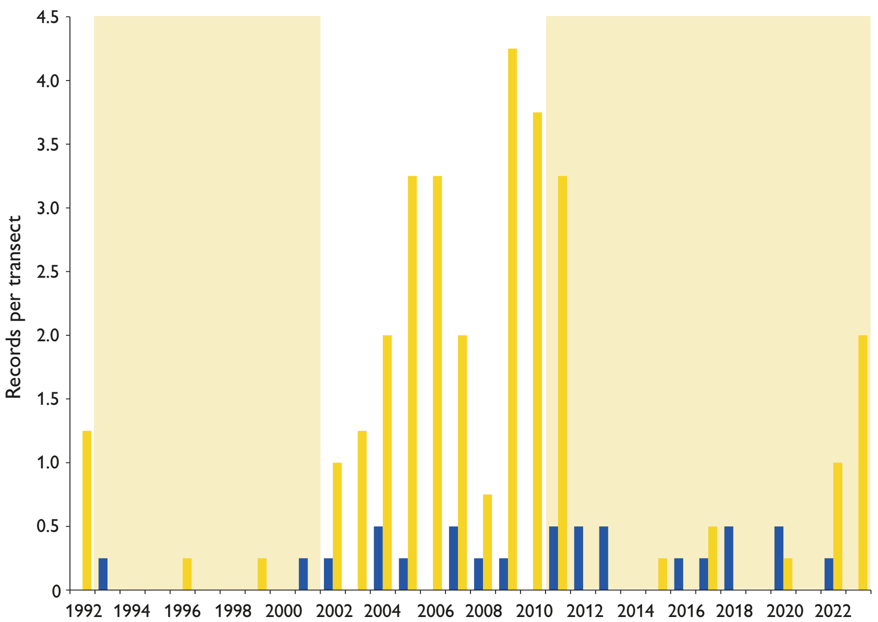


Figure 3

Fox and magpie encountered on transect counts from 1992 to 2023. Intensive predator control was undertaken during 1993-2001, no predator control was undertaken during 2002-2010, and part-time predator control has been undertaken since 2011

Fox

Magpie

Keepered periods

The Allerton farming year

Background

The Allerton Project is based around a 333-hectare (822 acres) estate in Leicestershire. The estate was left to the GWCT by the late Lord and Lady Allerton in 1992 and the Project's objectives are to research ways in which highly productive agriculture and protection of the environment can be reconciled. In 2022, it celebrated its 30th anniversary.

In what can safely be recognised as a trend, the 2022-3 season has proven challenging from a weather perspective. Climate extremes impacted operations here at the Allerton Project, as over much of the country. Conditions in the autumn of 2022 were at least reasonable enough to complete our winter drilling campaign mostly as planned, with good areas of wheat and barley going into the ground, alongside smaller acreages of beans and oilseed rape. However, conditions did transpire to require the services of neighbours once again. They provided alternative crop drills to those at Allerton, by turns helping to deal with straw residues from harvest 2022, planting beans into steep slopes at depth, and drilling into rotational grass.

The upshot of our evolving experience with our two tine drills (both acquired with gratitude and largely free of charge) has been that we identified a requirement for a robust disc drill. We need more flexibility in establishing crops in challenging conditions, which include weather and the trashy conditions often engendered by our more 'regenerative' approach. Therefore, for the autumn 2023 drilling campaign we purchased a four-metre Horsch Avatar disc drill, which has coped well across a range of conditions this season. We hope it will give us better establishment and yield alongside reduced soil movement.

In autumn 2022, we missed the drilling window to establish 12 hectares (ha) of wheat into five-year rotational grass, due to contractor scheduling issues. Unfortunately, this led to the field remaining uncropped over the winter, indeed, until April. Over the winter it was remarkable to note the disappearance of the thick mat of dead grass and clover sward which had been destroyed in preparation for autumn drilling, seemingly dragged down into the soil profile by the clearly very healthy earthworm population. By the time we did finally establish a crop of spring wheat on the field, you would never have known it had previously been in grass. This was clearly sub-optimal from a soil management perspective, with bare soil being unintentionally left exposed for some months.

This tale also hints at another of our weather-related challenges this year. Although December, January and February proved unusually dry (with only 8mm of rain falling in the latter month) the heavens opened in March and early April, derailing our spring drilling campaign which would normally have been completed in these weeks. Indeed, our final spring crops did not go into the ground until early May, with the result that they were compromised on yield from the outset. Many farms, especially those on lighter soils, took advantage of the dry winter to establish crops in February – never likely on our own heavy clay – but subsequently many also came to regret this decision with the spring rains causing many crops to fail and require redrilling. We eventually

Over the winter it was remarkable to note the disappearance of the thick mat of dead grass and clover sward, seemingly dragged down into the soil profile by the clearly very healthy earthworm population

A four-metre Horsch Avatar disc drill has coped well across a range of conditions this season. © Joe Stanley/GWCT

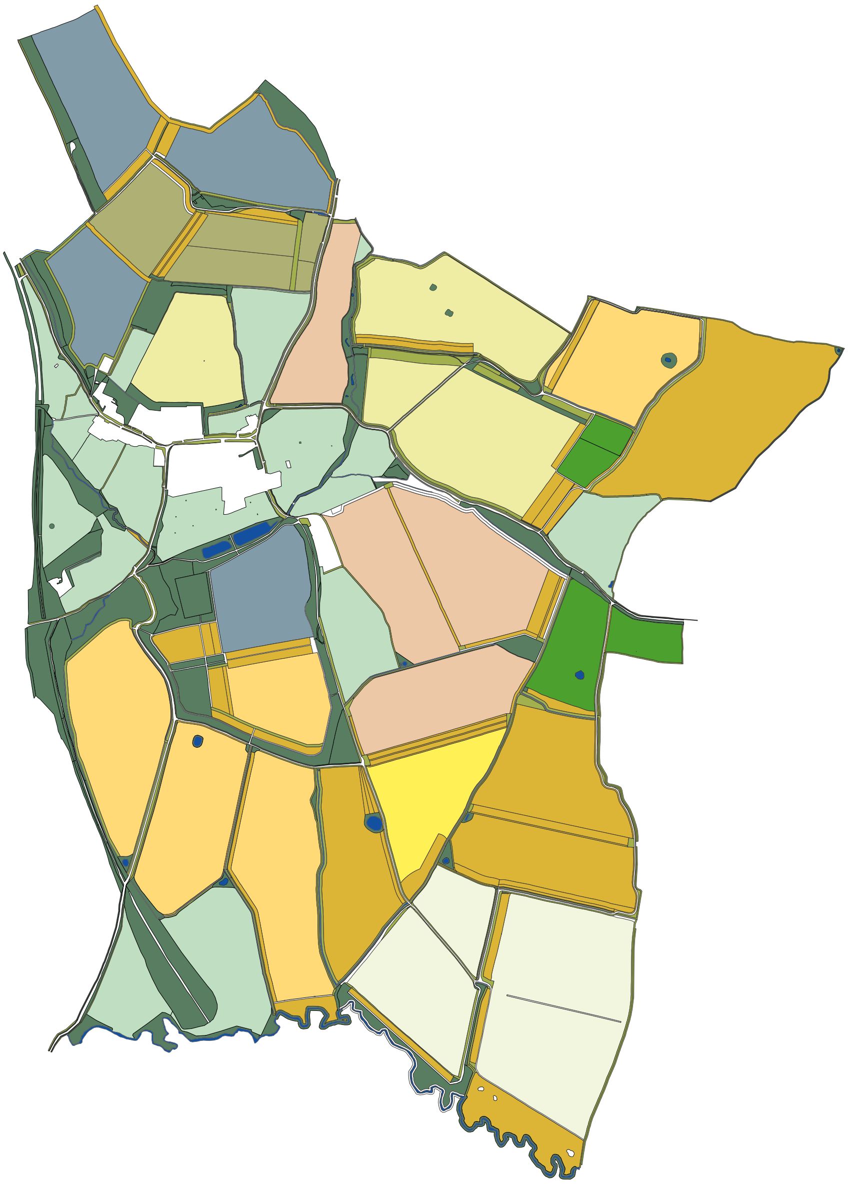


Figure 1

Allerton Project cropping 2022/23

- Woodland
- Permanent pasture
- Winter wheat
- Spring wheat
- Winter oilseed rape
- Winter barley
- Spring oats
- Red clover & lucerne
- Spring beans
- Winter beans
- Stewardship and shoot cover
- Hedgerow/verge

planted our spring oats and beans, which then struggled with a dry and hot six-week period in late April, May, and June, with temperatures peaking at over 28 degrees Celsius (see Figure 1).

TABLE 1

Arable gross margins (£/hectare) at the Allerton Project 2010-2023

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Winter wheat	673	783	255	567	590	457	442	766	780	837	568	551	1,025	953
Winter oilseed rape	799	1,082	490	162	414	533	524	713	377	528	-	485	550	-
Spring beans	512	507	817	580	646*	396*	289*	436*	176*	459*	301	460	620	495
Winter oats	808	873	676	570	354	507	156**	-	-	386	324	380	605**	587
Winter barley								367	733	423	630	558		624
Spring wheat								367	733	423	630	531		502
Spring barley								367	733	423	630	390	720	

*No single/basic farm payment included * winter beans, **spring oats*

Harvest itself was a drawn-out affair, with spoiling weather combined with reliance on contractors and late-drilled spring crops on clay leading to a final denouement on 8 October, when our spring wheat and beans were both cut at a surprisingly agreeable 16-17% moisture. Our spring oats – in common with many around the country – were remarkably uneven in maturing, both in patches across the field (with some grain ripe and others green) and in grain versus straw; as a result, pre-harvest desiccation with glyphosate was required. Although we do not do this as a matter of course, such conditions do demonstrate the importance of this product in de-risking farming operations (see Figure 2).

It was also another particularly challenging season for oilseed rape at Allerton, which is the only farm in the local area to still be growing the crop owing to our long-term research commitments. We established 12ha in the autumn. Half of this was taken to harvest with a very low-input approach, the other half was redrilled with spring oats after 'the plug was pulled' in early spring. Ultimately, there remains no reliable defence to the Cabbage Stem Flea Beetle menace, especially in the expensive, low seed-rate hybrid varieties which we need to grow at Allerton. Early flea beetle damage weakens the crop sufficiently for winter pigeon damage to deliver the coup-de-grace all too often. In autumn 2023 we experimented with autocasting rape – broadcasting seeds straight into a standing crop of winter barley shortly before harvest to see whether this lower-cost, lower-impact approach might be viable. Unfortunately – and despite ideal amounts of rain to germinate the seed – this approach was not successful on our heavy soils; as a result, we won't see oilseed rape on the estate in harvest 2024 for the first time in decades (see Figure 3).

In the autumn of 2022, we did get an excellent establishment of cover crops, having planted them in good time following a relatively early end to harvest. In some fields we measured at least 25 tonnes of above-ground biomass per hectare. This not only provided fantastic soil cover but also locked up to 150 kilogrammes of nitrogen per hectare, avoiding the risk of it being leached away by winter rains. However, December frosts took a heavy toll on the radish which made up much of the mix we had planted, and by Christmas much of that biomass had been returned to the soil as worm food. The exceptionally heavy rains of the spring therefore fell onto largely unprotected soil, again not ideal from a soil management perspective. This was purely the luck of the draw once again in a world of increasingly unpredictable climate extremes.

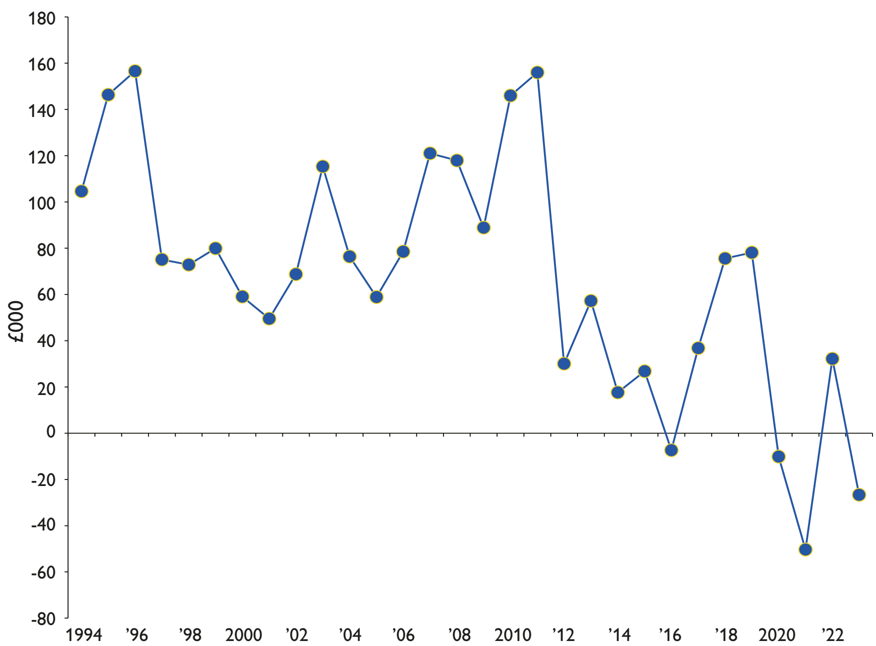
Over the winter we made good progress with our Countryside Stewardship capital works in the form of both hedge laying and coppicing, with some hundreds of metres of both completed. It's important to have a range of hedge management across the farmed landscape, and this work sets us in good stead for the future, alongside our normal rotational flailing programme. Where we coppiced hedgerows along the southern boundary of the farm, we also uncovered a long-overgrown ditch section

Key findings

- Climate extremes continue to significantly impact farm operations.
- Investment in a new crop drill is expected to yield benefits.
- Hedgerow capital works have been undertaken to improve long-term habitat and carbon quality.
- Regenerative practices are increasingly being implemented across the farm.

Joe Stanley
Oliver Carrick

Figure 2
Gross profit at the Allerton Project 1994-2023



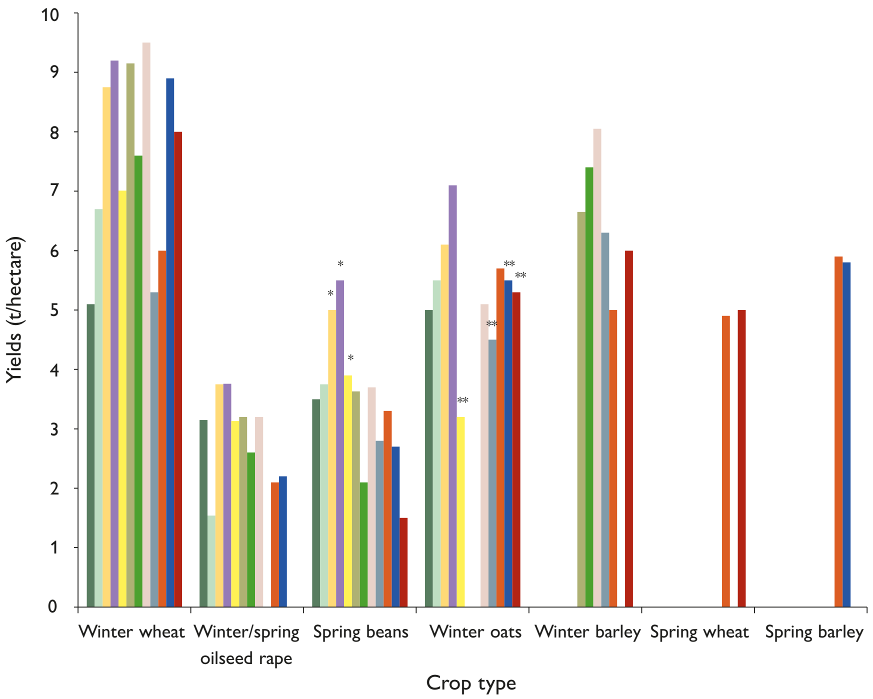


Figure 3

Crop yields at the Allerton Project 2012-2023

*Spring oilseed rape was sown in 2013, *winter beans, **spring oats*

which can now be maintained. Historically, many of our hedges were planted too close to these features. This means they are less valuable for both drainage and as habitat, as they have become overshadowed by the blackthorn and hawthorn in the hedge. Something to bear in mind when planting hedgerows in future. The cuttings from these operations will be recycled back into the biomass boilers which heat the buildings on the estate.

We also hosted a highly successful LEAF Open Farm Sunday in 2023. We collaborated with our neighbours, who contributed machinery and livestock. We were delighted to see more than 400 people come and learn about food, farming, and the environment. The entire Allerton team pitched in, and we offered tractor and trailer rides, games for the children, and informational stands. We also managed to arrange wall-to-wall blue skies and sunshine. Although we welcome some 2,000 visitors a year to Allerton, the vast majority of these are from the agricultural and wider landscape management sector, so it was great to be able to speak to our grassroots customers and show them what sustainable food production looks like.

Hedgerow capital works have been undertaken to improve long-term habitat and carbon quality. © Joe Stanley/GWCT

Spatial models and landscape-scale nature recovery

Background

Meeting the UK Government's 25-Year Environment Plan will require implementing nature recovery programmes across the country. This means there will be trade-offs between competing land use and nature recovery, affecting the provision of habitats for different species groups as well as food production. Spatial modelling of ecosystem services, on a landscape scale, can help to aid the discussions taking place across the country. A spatial model, constructed using the results of monitoring across the Eye Brook catchment by researchers from the Allerton Project, has begun to put some of these trade-offs into perspective.

The Allerton Project is in the central section of the Eye Brook catchment of the Welland river basin. The catchment forms around half the southwestern area of Leighfield Forest which includes ancient semi-natural woodland relics of the medieval royal hunting forest of Leighfield. Research staff at the Allerton Project recently surveyed bumblebees and bats at the landscape scale across the Eye Brook catchment and repeated a 2004 survey of brown trout in the Eye Brook. The latter revealed a substantial decline in brown trout numbers, most probably because of increased sediment movement from arable land to water. Sediment derived mainly from arable land has negative implications for aquatic wildlife as well as flood risk management. Bumblebees are associated with species-rich grassland, and hedges and woodland edges, which are also important for bats. The habitat requirements of these three groups of species represent the main land cover types in the area: freshwater, arable land, grassland, and hedges and woodland.

Government environmental targets include increasing the national woodland area to 16.5% by 2050, reducing sediment and phosphorous loss from agriculture to water by 40% by 2037, and increasing wildlife species populations by 10% by 2042. We adopted these targets for our study. We used a spatial model of the upper Welland river basin that was developed as part of a PhD project to explore the practical implications of these environmental targets. Through validation with our own data, we were able to demonstrate that the spatial models were particularly good at predicting water quality and bumblebee abundance. We used ground-nesting bumblebees as our proxy for wildlife to determine if it was possible to meet all of the Governmental targets above, and how meeting those targets would affect wildlife.

If we were to increase the woodland area in the Eye Brook catchment to 16.5%, we would need to convert an additional 626 hectares (ha) (23%) of arable land to no-input grassland to meet the target of a 40% reduction in sediment loss to water. This would not meet the phosphorous targets but would achieve a 43% increase in bumblebee abundance. In the absence of new woodland, we would need to convert at least 1,300ha (47%) of arable land to no-input grassland to meet the sediment and phosphorous loss targets. This would also result in a 64% increase in bumblebees but is associated with loss of food production equivalent to 10,500 tonnes of wheat.

These results for the part of Leighfield Forest within the Eye Brook catchment suggest that meeting environmental targets for water quality, flood risk management

Flower-rich margins in arable fields play an important role in the recovery of bumblebee populations. © Joe Stanley/GWCT

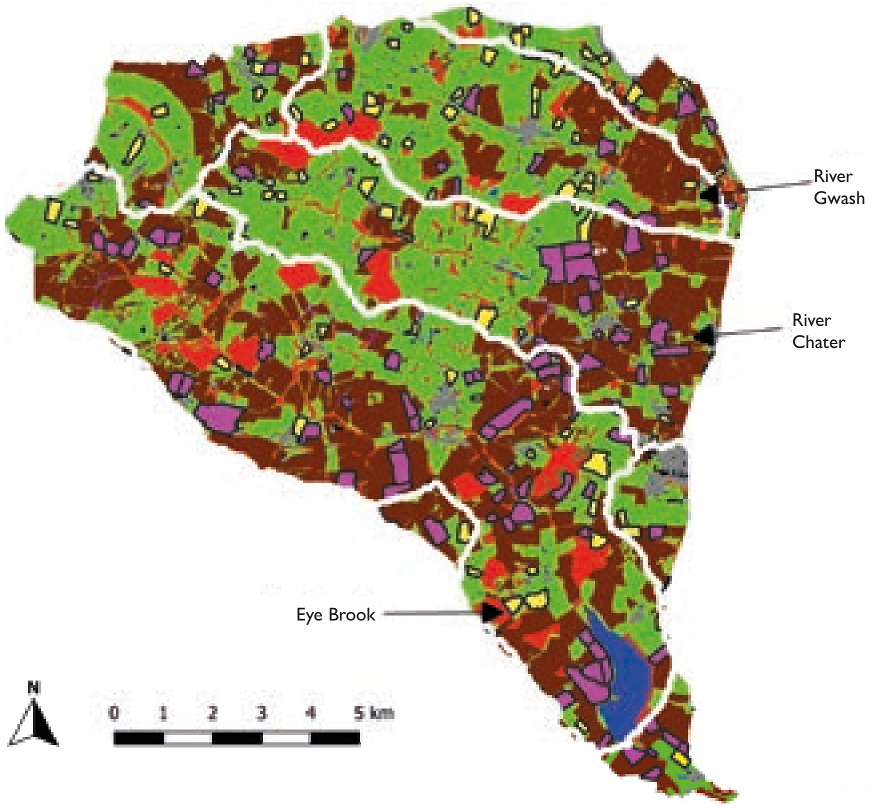


Figure 1

Map of Leighfield Forest showing areas of woodland (light red), grassland (green) and arable land (dark red). Magenta areas indicate randomly selected arable fields that would need to have 10m flower-rich margins (equivalent to 0.9% of the arable land) to achieve the 10% nature recovery target for bumblebees. Yellow areas indicate newly created no-input pasture

- Arable field with margin habitat added
- Unimproved grassland

Leighfield Forest baseline landcover

- Broadleaved woodland
- Coniferous woodland
- Arable
- Improved grassland
- Neutral grassland
- Heather
- Inland rock
- Freshwater
- Urban
- Suburban

and recovery of aquatic wildlife may be more challenging, requiring greater loss of local food production and other land uses than the nature recovery targets for bumblebees.

We extended our approach to the whole of the Leighfield Forest, concentrating on land use change needed to meet nature recovery targets specifically for bumblebees. These included converting improved grassland to unimproved low-input grazed pasture, introducing flower-rich margins to arable fields, and establishing trees along hedge lines to create woodland edge type habitat. Combining these approaches, the 10% recovery target could be achieved by converting 13.3% of improved grassland to low input pasture, creating 10-metre flower-rich margins on 0.9% of the arable area, and converting 15% of hedges to tree lines.

Our results provide a focus for discussion with local farmers and landowners, as well as other stakeholders including policymakers at local, regional, and national levels and are helping to inform the Local Nature Recovery Strategy for Leicestershire and Rutland.

Converting up to a quarter of the hedges to tree lines achieved less than a 1% increase in bumblebee abundance, but would greatly benefit bats. © GWCT

Key findings

- Spatial models can be used to explore practical implications of agri-environmental policy.
- Meeting targets for water quality, aquatic wildlife, and flood risk management may be much more challenging than meeting targets for terrestrial wildlife.
- Our spatial model of the upper Welland river basin indicates that the 10% nature recovery target for bumblebees could be achieved through conversion of 13.3% of improved grassland to low input pasture, and the creation of flower-rich margins across 0.9% of the arable area.

Chris Stoate
Max Rayner

Acknowledgements

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Regenerative agriculture to sequester carbon

Background

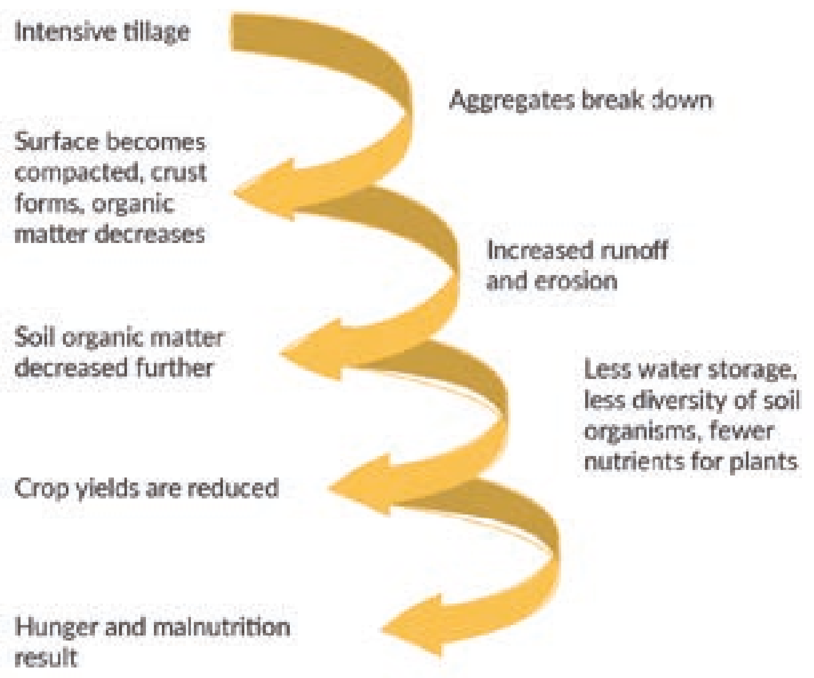
Estimates since 1750 indicate that human agency has released some 270 billion (bn) tonnes of carbon dioxide equivalent greenhouse gasses into the atmosphere from the burning of fossil fuels. Yet it's also estimated that some 78bn tonnes of carbon dioxide (from Lal, 2004) has been released by the depletion of agricultural soils, primarily via ever-more intensive cultivations. As plant organic matter in the soil (primarily composed of carbon) is exposed to the air, microbial respiration takes place, breaking it down and releasing the carbon dioxide back into the atmosphere, from whence it came via photosynthesis. By adopting more regenerative agricultural practices – such as reduced tillage and growing of cover crops – farmers are putting some of the genie back in the bottle and reversing centuries of climate emissions resulting from the growing of food.

From January 2021 to December 2023 the Allerton Project has been involved in the AgriCaptureCO_2 project, an EU Horizon 2020 initiative centred on 'regenerative' farming practices. The AgriCaptureCO_2 consortium consisted of 14 partners across seven European countries with a total budget of €3.4m. The project stemmed from the fact that climate change and extreme weather events are an increasing cause of concern for agriculture – and society more generally – and that agriculture (currently a net emitter of greenhouse gasses to the tune of some 12% of UK (2022 figures, Department for Energy Security & Net Zero) and 15% of EU totals has the potential to be a part of the solution.

AgriCaptureCO_2 focused on the role that sustainable farming practices can have for regenerating soil organic matter and by extension soil carbon and soil health more generally. In so doing, the productivity and environmental sustainability of farms can be increased, alongside a more strategic aim of drawing down (or sequestering) atmospheric carbon dioxide into the soil, and thereby contributing to net zero targets.

AgriCaptureCO_2 has had two key workstreams to achieve this; the Allerton Project has led on farmer training and the production of training materials as part of the 'European Regenerative Agricultural Community' workstream, demonstrating how to implement climate-smart farming. This has enabled the Allerton team to develop a depth of expertise in this area which will be applicable for the GWCT going forward. The second workstream was the development of technical solutions to help with the commercial uptake of 'carbon farming', specifically utilising earth observation (EO) data to help reduce the cost of measuring and quantifying soil carbon stocks. At present, accurately measuring soil carbon is a time consuming and expensive business, with many physical core soil samples required. By utilising existing datasets, satellite imagery and sophisticated machine learning, AgriCaptureCO_2 has developed a system which hopes to require significantly fewer physical samples, as well as monitoring historic and current land use to reduce carbon 'leakage' in any future carbon trading scheme.

This has been a major piece of work for us over three years, culminating in the end of project event in Brussels on 9 November 2023, where our director Alastair Leake contributed to a policy session on UK and EU 'carbon farming' and climate policy. At the event, the training & partnerships team released our landmark *Regenerative Agriculture Handbook* which can be downloaded at gwct.org.uk/agricapture.



The spiral of soil degradation. Regenerative agriculture offers a solution to the historic loss of soil organic matter and structure by mimicking more natural ecosystems. (Modified from Topp et al)

In the coming years, farmers will look increasingly to build the soil carbon stocks in their fields. This will bring agronomic benefits such as climate resilience and productivity, but also become a potentially tradable commodity. Much caution is advised in this space, but baselining current soil carbon stocks to put yourself in the driving seat in any future scenario where soil carbon uplift is monetizable is likely a wise move. Through our experience with AgriCaptureCO_2, the Allerton Project is now in a much better position to assess such schemes as they develop.

Key findings

- Farmers have the potential to sequester atmospheric carbon in biomass and soils using regenerative agriculture.
- As partners in the AgriCaptureCO_2 project the Allerton team contributed to a landmark regenerative agriculture handbook which can be downloaded here: gwct.org.uk/agricapture.
- In AgriCaptureCO_2, data from Earth Observation (EO) satellites, together with machine learning, was used to devise a method to quantify soil carbon stocks that is less reliant on expensive physical soil carbon sampling.

Joe Stanley

Farmers have the potential to sequester atmospheric carbon in biomass and soils using regenerative agriculture. © GWCT

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Decarbonising farms from the ground up

Background

Climate change is one of the biggest challenges we face as a society. It is also one of the greatest risks to the agri-food sector and farming. While agriculture can act as a source of greenhouse gas emissions, it can and must also play a vital role in acting as one of the solutions to climate change. Research has shown that up to 88% of farmers in the UK are at least somewhat worried about the impact climate change will have on the future of farming. The EU Horizon 2020 Innovation Action project, ClieNFarms – Climate Neutral Farms, aims to support the transition to climate-neutral and climate-resilient farming across Europe. It is running from 2022 to 2025. ClieNFarms approaches this problem by scaling up systemic, locally relevant solutions at a farm level, with objectives for reducing carbon footprints that are set by the farmers themselves. These objectives vary across the farms, but mainly focus on cover crops, companion crops, living mulches and lower emissions fertilisers.

The Climate Neutral Farms (ClieNFarms) project is based on farm demonstration networks. Across the European consortium of 34 partners, different networks are focusing on different elements of the agricultural supply chain. Allerton is working with Nestlé to assess how to decarbonise their cereal supply chain in the east of England. This work is based on an approach called the Innovative Systemic Solution Space (I3S below). The aim is to help farmers adopt more sustainable production methods. The Allerton Project acts as the main demonstration farm in the I3S, working closely with nine cereal farmers across the east of England as they look to adopt farming practices which will reduce their carbon footprint.

The farmers in our I3S – our 'lead commercial farmers' – were recruited in January 2023. Since then, we have been working with them to set specific objectives that they are going to work on over the lifetime of the project. Our assistance includes a range of advice, training and events designed to help them make the changes needed to meet the goals that they have set themselves. The farmers have been able to determine their carbon footprint by using metrics such as the Cool Farm Tool to develop personalised emission results and tailored reduction strategies. By working with experts from Sustainable Soil Management, Oakbank and Kings, each farmer has also received a biodiversity assessment, identifying key habitats and notable species on their farm, as well as soil analyses to measure soil organic carbon (SOC). So far, five of the farmers have completed the Certificate in Sustainable Land Management training at the Allerton Project alongside a range of other demonstration events.

At the beginning of December, all our I3S farmers met in Suffolk to visit two of the leading commercial farms in our I3S, as well as two other businesses – Fen Farm Dairy and a LEAF demonstration farm, run by Brian and Patrick Barker. Peer-to-peer learning is a big part of ClieNFarms and so this was a great opportunity to get out on farm and share ideas. The group travelled to Tom Jewers' farm, Wood Hall Farm, where they heard about Tom's role within Hutchinsons' Helix Project and his involvement in Nestlé's LENs (Landscape Enterprise Networks) initiative. LENs aims to reverse nature degradation by collaborating with businesses to derive different benefits from the same landscape. Tom explained that through LENs, he has been able to upgrade his farm infrastucture through funding to purchase new farm machinery. While taking the group on a farm tour, Tom discussed his use of cover crops, some of which were being grazed by sheep from a neighbouring farm. To finish off, Tom took the group to his Johnson-Su bioreactor – a static aerobic composter used to create microbial inoculant. The inoculant can be applied directly to the soil as compost, made into a slurry to treat seeds or applied down the spout when drilling or cultivating.

Ian Robertson talks soil health at Tom Jewers' farm. © GWCT

The Climate Neutral Farmers. Peer-to-peer learning is a big part of the project. © GWCT

The second ClieNFarms visit took place at Richard Ling's Rookery Farm in Suffolk. Richard is involved in a trial with Nestlé, testing a low-carbon fertiliser made from factory cocoa-shell waste. They are evaluating its performance in terms of crop production, soil health and greenhouse gas (GHG) emissions. We also visited Fen Farm Dairy, which is an innovative third-generation family farm, aiming to set the standard for dairy sustainability. While giving the group a tour of the farm, Jonny Crickmore told the story of how Fen Farm Dairy started selling fresh milk by the side of the road through honesty boxes, before diversifying into producing dairy products on the farm, including their very popular 'Baron Bigod' cheese. Jonny also discussed the various measures the farm has put into place to implement greener farming and become more responsible dairy farmers, from installing solar power and a 'cow poo powered' heat exchange to reducing fuel consumpion and food miles.

The final visit of the Suffolk tour was to Lodge Farm. Lodge Farm is a LEAF demonstration Farm and, until recently, an AHDB Strategic Farm. Brian and Patrick Barker discussed how the farm has undergone a huge transformation. They are continuing to concentrate on the production of high-quality and high-yielding arable crops, while simultaneously increasing their contributions to wildlife and biodiversity. Some of their activities, designed to support both their yields and wildlife, include nutrient mapping, reducing energy use, habitat creation, and pond restoration, to name just a few.

In 2024, the ClieNFarms farmers will focus on investigating and trialling their individual objectives. These vary across the farms, but most will focus on cover crops, companion crops, living mulches and lower emissions fertilisers.

Farmers heard how to adopt farming practices which will reduce their carbon footprint. © GWCT

Key findings

- ClieNFarms, funded through EU Horizon 2020, aims to scale up systemic and locally relevant solutions directed at curtailing greenhouse gas (GHG) emissions from agriculture.
- There are 34 partners in ClieNFarms, including the Allerton Project, with each partner focused on a different element of the agricultural supply chain.
- Within ClieNFarms, the Allerton Project is working alongside Nestlé to help decarbonise its cereal supply chain in the east of England, across nine farms.
- These nine farms have set individual objectives to reduce their carbon footprint, with on-farm visits in December 2023 illustrating the range of approaches that farms can take to address their contribution to climate change.

Amie Pickering
Alice Midmer

Auchnerran - demonstration farm

Auchnerran: biodiversity monitoring

Background

The main wader species we have been monitoring at the Game & Wildlife Scottish Demonstration Farm (GWSDF) Auchnerran since 2015 are lapwing, oystercatcher, and curlew. According to data from the British Trust of Ornithology, all three declined in Scotland between 1995 and 2018 by 56%, 39% and 59% respectively. We continue to monitor wader breeding success to better understand the causes of nest failure and to ensure our farm management does not negatively affect these vulnerable species.

Many breeding wader species have declined in the UK over recent decades with lapwing, oystercatcher and curlew all experiencing extensive population declines across the UK. Multiple studies suggest that unsustainably high levels of nest and chick predation are driving these declines, with increased intensification of agriculture and loss of suitable habitat further challenging these species.

Across Europe there has been an approximate 40% increase in lapwing egg predation since the 1970s, a trend that is also observed in the UK where lapwing egg predation has increased by about 30% between the 1960s and 1990s. At Auchnerran, we are fortunate to still have good numbers of wading birds, and we continue to monitor wader breeding success, identify causes of nest failure, and assess the impact of our farm management on annual wader productivity.

Predation remained the largest cause of nest failure across lapwing, oystercatcher, and curlew (20 nest failures, 23% of all nests), though it was lower than in many previous years of monitoring. This was mainly due to lower predation of oystercatcher and curlew nests, whereas the predation rate on lapwing nests was similar to previous years (see Table 1). We should highlight that, after a high percentage of wader nests were predated by badgers in 2021 (17% of all recorded nests), we have only observed a single predation event by badgers in 2022 and none in 2023. Causes of nest failure during the 2023 breeding season included abandonment (8%), agricultural and livestock disturbance (11%), and other or unknown reasons (1%).

After hatching, we undertake daily observations across the farm to follow the fate of hatched chicks to estimate fledging rate, which is the number of chicks surviving to fledging age (at approximately five weeks post hatching) per pair. We use the

TABLE 1

Nest survival probability during incubation (%) based on Mayfield daily survival probability estimates and the percentage of total observed nests predated for wader species (blue) monitored at Auchnerran from 2018-2023. Total number of nests in parentheses

	Lapwing		Oystercatcher		Curlew	
	Estimated nest survival	Predation (no. of nests)	Estimated nest survival	Predation (no. of nests)	Estimated nest survival	Predation (no. of nests)
2018	46%	18% (104)	51%	13% (16)	52%	25% (12)
2019	68%	12% (89)	75%	12% (17)	36%	44% (9)
2020	89%	18% (92)	81%	18% (22)	100%	0% (9)
2021	46%	34% (103)	39%	12% (17)	19%	50% (8)
2022	66%	24% (87)	70%	28% (18)	35%	14% (7)
2023	46%	25% (63)	64%	19% (21)	100%	0% (5)

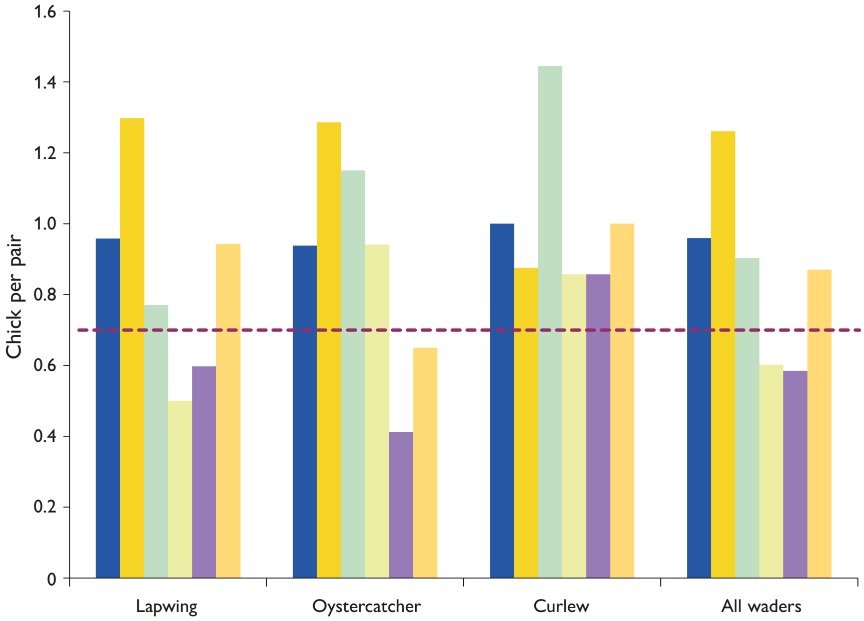


Figure 1

Fledging rate for wading birds from 2018-2023. The dotted line represents the 0.7 chick per pair average fledging rate required for population stability

- 2018
- 2019
- 2020
- 2021
- 2022
- 2023

number of first attempt nests on the farm as a proxy for the number of wader pairs. For lapwing, a minimum fledging rate of around 0.7 chick per pair is estimated to be required to maintain a stable population. For oystercatcher and curlew, this is more challenging to estimate due to birds not breeding until two or three years of age, but since these are longer-lived species than lapwing, the required annual productivity is thought to be slightly lower (c. 0.6 chick per pair for curlew). Nevertheless, at Auchnerran we use a fledging rate of 0.7 for all wader species as our benchmark for a successful breeding year.

We recorded high numbers of fledged chicks relative to the number of nests with a total of 49 lapwing, 13 oystercatcher and five curlew chicks fledging. For all species this reflects an increased fledging rate, compared with 2022, and is at a level that should sustain current wader population levels (see Figure 1). For lapwing we recorded an average fledging rate of 0.8 chicks per pair across all years, despite extremely low productivity in 2021 due to predation (see Figure 1).

Although this suggests that we are looking after our breeding waders well and population levels should remain stable (or even increase), we are concerned that the number of waders returning to the farm (as estimated by the number of first attempt nests) may be declining due to factors out of our control. Although the number of oystercatcher nests has remained stable since 2018 at 16-22 nests, we recorded fewer lapwing (63 vs 87) and curlew nests (5 vs 7) than last year. We know that at least two of our historic Auchnerran curlew pairs have moved their nests off the farm and have nested further up the hill in 2023, suggesting that the lower number of nests does not necessarily indicate a decline in pairs. It is also possible that Avian Influenza may have contributed to fewer returning birds. If this were the case, then a fledging rate of 0.7 may not be sufficient to sustain population levels. We plan to gain a better understanding of adult return rates in future through increasing our programme of colour-ringing large wader chicks.

Oystercatchers don't breed until two or three years of age. © GWCT

Acknowledgements

We are grateful to Working for Waders and Perdix Wildlife Supplies Ltd for supporting our research on wading birds at GWSDF Auchnerran farm.

Key findings

- We recorded a total of 63 lapwing nests (down from 87 in 2022), five curlew nests (down from seven in 2022) and 21 oystercatcher nests (up from 18 in 2022), with the number of first nesting attempts suggesting a decrease in breeding pairs.
- Predation on nests across all wader species was lower than in many previous years (22%) since monitoring began in 2018, but it remained the main cause of nest failure.
- Fledging rate (chicks fledged per pair) across wader species was 0.9, which is above the 0.7 estimated to be required to maintain stable lapwing populations. However, a lower return rate of adults, possibly due to Avian Influenza, may still result in a declining wader population at Auchnerran.

Max Wright
Louise de Raad

The Auchnerran farming year

Background

The Game & Wildlife Scottish Demonstration Farm (GWSDF), trading as Auchnerran Farm, is a 482 hectare farm in east Aberdeenshire, bordering the Cairngorms National Park. GWCT took on the farm lease in 2015, with the aim to demonstrate how modern agricultural practices and livestock management can co-exist with wildlife conservation and game management to form an economically viable system in a hill-edge setting. More information, including our *Auchnerran Annual Reports*, can be found at gwct.org.uk/auchnerran.

Dyfan Jenkins has settled in well as our livestock manager and he put 1,388 ewes to the tup in December 2022, resulting in a mean lamb scanning percentage of 156% and 1.25 lambs weaned per ewe (see Table 1). Last year we kept more of our ewe hoggs, and we have now increased the flock to 1,500 breeding ewes. We believe this is the optimum flock size that can be supported on the farm, be managed by one person and provide sufficient tick control on the adjacent grouse moor where the sheep graze during the summer months. In 2023, we produced 841 bales of silage, with an average of 19.8 bales per hectare (see Table 1). In addition, we left one field uncut that was strip-grazed over winter.

To further supplement winter feed for the sheep, we grow brassicas on the farm. Last year, we ran a small-scale demonstration trial, growing different varieties of swedes and fodder beets. Alongside the Lomond swede variety, which has previously been grown on the farm, we have also grown the Invitation swede variety. We are comparing these to several fodder beet varieties, including Robboss, Blaze, and Felherr. We are undertaking yield, dry matter and nutrient analysis and will monitor frost resistance over winter to provide a full cost-benefit analysis of the different varieties.

In previous years we reported that Ovine Pulmonary Adenocarcinoma (OPA) has been a concern since the GWCT took on the farm in 2015. It was estimated that this invariably fatal disease was responsible for up to 70 deaths (5% of our flock) annually. Dr Phil Scott, a highly respected OPA expert who scans more than 75,000 sheep per year, scanned the rams and older ewe age groups at Auchnerran. He found an exceptionally low OPA prevalence of 0.6%, which did not justify scanning the gimmers, where the OPA prevalence is expected to be much lower still. Although it is difficult to predict the full impact of OPA on annual flock mortality at Auchnerran, Dr Scott estimated it is likely that OPA affects only around 10 sheep per annum. To decrease this further, we will continue to pro-actively cull those sheep showing respiratory signs and/or unexplained weight loss – both symptoms of OPA, scan incoming tups and continue other policies such as minimising the use of feed blocks. We are also considering the purchase of a Hustler bale unroller, which will further minimise nose-to-nose contact when feeding sheep silage over winter.

As in many other areas in Scotland, the woodlands at Auchnerran have been damaged by various storms since November 2021, when Storm Arwen particularly affected us. With support from Treeline Forestry Ltd., we plan to address the windblow damage and carry out much needed management of other woodland blocks that require initial or follow-on thinning. In October 2023, we obtained a felling licence from Scottish Forestry that will allow us to carry out this management. We

We have now increased the flock to 1,500 breeding ewes. We believe this is the optimum flock size that can be supported on the farm, be managed by one person and provide sufficient tick control

TABLE 1

Flock size at the start of the year and productivity (percentage of lambs per ewe that reach weaning age) at Auchnerran, along with annual silage production

	Breeding ewes	Productivity (lambs/ewe)	Silage bales per year	Bales per hectare
2015	1,440	60%	730	17
2016	1,205	97%	717	20
2017	1,126	120%	1,100	25
2018	1,000	126%	460	12
2019	986	124%	986	23
2020	1,400	129%	830	24
2021	1,380	126%	600	20
2022	1,400	127%	551	24
2023	1,388	125%	841	20

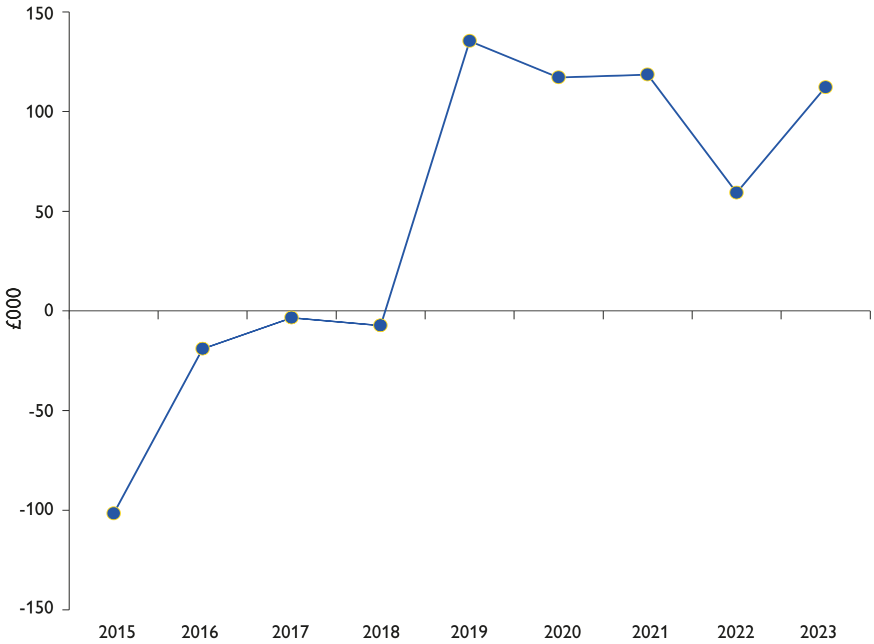


Figure 1
Auchnerran farm profit, 2015-2023

Farm profit

have appointed KSM Land Services (Inverurie) as our contractor as they have low pressure equipment to limit potential ground damage. They will undertake the work over a two-year period which started in January 2024, avoiding working from March to mid-September to avoid disturbance during the various breeding seasons. Under the felling licence we must complete woodland restocking by the end of June 2028, which we aim to do through a combination of natural regeneration and manual replanting. We will focus on replanting native conifers and broadleaved tree species. We will take this opportunity to explore the impact of two types of ground disturbance (mechanical and by using livestock) on woodland regeneration. As part of our woodland management, we have developed comprehensive rabbit and deer management plans to give natural tree regeneration the best chance of success.

We continue to put measures in place to farm for a better climate and nature restoration while remaining profitable (see Figure 1). We are responding to changing landscape policy and preparing for changes in the Scottish rural payments, expected from 2026. With support from our farm advisors at Laurence Gould we submitted a new application to the Scottish Agri-Environment Climate Scheme (AECS) (2024-2028). We are committed to delivering sustainable and regenerative in-field options, rather than just using AECS to reach climate and biodiversity goals, and are working closely with Roots for Nature in our journey towards a fully regenerative farming system.

The sheep graze the adjacent grouse moor during the summer months to help with tick control. © Dyfan Jenkins/GWCT

Key findings

- The farm performed well under new management. After a scanning percentage of 156%, we weaned 1.25 lambs per ewe and produced 841 bales of silage, with an average of 19.8 bales per hectare.
- We have grown the flock, putting 1,500 breeding ewes to the tup in December 2023, finally reaching our 'target flock size'.
- In contrast to earlier concerns regarding high Ovine Pulmonary Adenocarcinoma (OPA) occurrence at Auchnerran, scanning demonstrated we have <1% OPA in our flock.
- We will carry out thinning and clear felling in the woodland on the farm in the winters of 2023/24 and 2024/25, clearing up existing windblow and managing the woodlands for optimal productivity.

Louise de Raad
Dyfan Jenkins

Predation

Nest protection cages and wader hatching success

In 2022 and 2023, monitoring of oystercatcher nests with cameras showed fox predation to be the principal cause of nest failure, leading to the development and trialling of a novel nest-protection cage. © GWCT

Background

Predation management for breeding wader recovery is controversial, costly, and time-consuming. A fundamental decision for land managers seeking to support breeding waders, is whether to use lethal control or non-lethal control measures, or a combination of approaches. For coastal site managers, decision-making is often complicated by poor site access, firearm safety constraints for fox control, the difficulty of hiding traps, and the logistical challenge of using electrified fencing in the tidal zone. Further, although fencing can deter foxes and badgers, it does not protect nests from avian predators, and the linearity of beaches and territorial nature of ringed plover and oystercatcher, can add to its impracticality.

In the UK, the ringed plover is a red-listed bird of conservation concern experiencing a steep decline in both wintering and breeding birds. The UK breeding population was estimated to be approximately 5,450 pairs in 2007, with an estimate of 1,688 pairs in England in 2019. The Solent region in Hampshire is a stronghold for ringed plover breeding in southern England but, according to the Hampshire Bird Atlas, numbers declined from an estimated 140-165 pairs in 1991, to just 25 pairs reported in 2012. A more thorough survey in 2022, conducted by Hampshire Ornithological Society, estimated 55 pairs of ringed plover in Hampshire, of which 25 pairs (45%) were found on the North Solent National Nature Reserve (North Solent NNR).

Similarly, the UK breeding population of Eurasian oystercatcher – currently estimated at 96,000 pairs – has undergone considerable decline in recent decades, with a 22% fall between 1995 and 2020. This decline is mirrored across Europe, and they are now red-listed as 'Near Threatened' globally. The number of breeding pairs of oystercatcher in England remains unclear, but was estimated at <10,000 pairs in 2005, with continued range contraction occurring from coastal zones.

A combination of habitat degradation, human development, disturbance, and sea-level rise – collectively termed 'coastal squeeze' – is widely regarded as the main threat to beach-nesting wading birds, but how important is predation? Since 2022, we have used trail cameras to monitor nesting success of ringed plover and oystercatcher on the North Solent NNR, and have documented catastrophic nest losses to foxes, carrion crows, and lesser black-backed gulls, all opportunistic predators that thrive in human-dominated landscapes. Importantly, our nest monitoring work has been largely confined to a site with restricted access, including a two-kilometre section of shingle beach protected by a seasonally enforced Bird Sanctuary Order. This means we can effectively rule out recreational disturbance as a factor influencing nesting success.

Ringed plover: Since 2022, alongside our nest monitoring with cameras, we have worked with the North Solent Reserve Management team and Beaulieu Estate to develop and field-test nest-protection cages. For ringed plover, cameras showed that unprotected nests were quickly predated by lesser black-backed gulls and carrion crows. In 2022, only five out of 13 monitored nests were known to have hatched. Those that hatched were all replacement clutches that were protected 'emergency fashion' with a variety of nest-cage designs. The cage design we used has also been used in Poland and has since been adopted by the RSPB's Life on the Edge project.

The circular cage is constructed of 50mm wide wire mesh which allows adult ringed plover to easily enter, while providing a barrier to larger nest predators. Cameras showed that cages were quickly accepted by incubating adults and greatly improved hatching success. Given the local importance of the NNR as a breeding site for ringed plover, it was unanimously agreed by all researchers on the project that all nests found in the subsequent year would be caged using this design.

In 2023, we recorded 26 ringed plover pairs that made a total of 38 nesting attempts (including re-lays), with 36 nests caged. Of the caged nests, 30 hatched, producing a minimum of 95 chicks. Of the six caged-nest failures, cameras showed that two were lost to tidal inundation, two failed after foxes took adults fleeing from

In 2022, monitoring of ringed plover nests (circled) with cameras showed predation by lesser black-backed gulls to be the most significant cause of nest failure. © GWCT

the cage, one nest was abandoned, and one clutch was infertile. The two unprotected nests were predated, one by a fox and one by a lesser black-backed gull.

We do not know how many of these 95 chicks survived and fledged in 2023, but nest camera evidence shows that crows and gulls patrol around cages, clearly eager to take chicks that emerge from them. Further chick survival studies are needed to determine the overall contribution that nest cages can make to ringed plover breeding success, but it was encouraging that >20 juvenile ringed plover were recorded (with many flying) on the core beach-nesting area in mid-July. Nevertheless, the weekly effort required to locate ringed plover nests to protect them is considerable.

Oystercatcher: In 2022, camera evidence revealed high losses of oystercatcher nests to foxes and carrion crows on the North Solent NNR, despite seasonal culling of both species across the reserve. Again we recorded nest predation by lesser black-backed gulls. Hence, we set about developing a suitable nest-protection cage to augment efforts to reduce nest losses. Because of the overlap in body-size between oystercatcher and their nest predators, it is difficult to design a structure that allows incubating adults to enter, while providing a physical barrier to their nest predators. Nevertheless, by exploiting known behavioural traits of foxes and corvids, and the aggressive nature of breeding oystercatchers, we designed a suitable nest cage for a pilot-trial.

In 2023, we recorded 30 breeding pairs of oystercatcher on the NNR, twice as many pairs as was expected, which highlights the regional importance of this site. In our pilot-trial, cameras showed that our nest cages performed well, both in terms of their rapid acceptance by 11 breeding pairs, and by demonstrably deterring nest predators to improve oystercatcher hatching success.

This novel oystercatcher nest cage design will be rigorously field-tested through a randomised block design experiment in 2024 and 2025, as part of a trial of non-lethal nest protection measures for beach-nesting birds. This research forms part of an innovative new project called Gravelly Shores, which is funded by Natural England's Species Recovery Programme. The project aims to boost populations of coastal breeding birds through provision of new nesting habitat on shingle above the intertidal zone and deployment of novel nest protection measures. It will assess the advantages and disadvantages of non-lethal nest protection measures and facilitate further opportunities to gather camera evidence of nest predation by lesser black-backed gulls, which were afforded greater protection following recent changes to the General Licences.

Key findings

- In the UK, ringed plover and oystercatcher are of high conservation concern, affected by poor breeding success.
- Pilot-trials of nest protection cages for ringed plover and oystercatcher improved hatching success on the North Solent National Nature Reserve.
- Gravelly Shores is an innovative new project, funded through Natural England's Species Recovery Programme, which aims to boost the conservation status of beach-nesting birds in the Solent.

Mike Short

In 2023, we deployed wire cages around ringed plover nests, which greatly improved hatching success. Look carefully and you will see two chicks being brooded, and two chicks outside the nest cup. © GWCT

Fox movements in wet grassland habitats

Background

Lowland wet grasslands, such as the meadows within the Avon Valley in Hampshire, are important for breeding waders like lapwing and redshank. However, until 2015, long-term monitoring by the GWCT showed that for the lapwing breeding there, on average, 61% of nesting attempts failed, with 82% of those nest failures caused by predation. Wildlife managers working on wader conservation aim to minimise the risk of fox predation for waders during the nesting season, using both lethal control as well as non-lethal control methods, such as electric fencing around nesting areas. Fox-tagging research, as part of the EU LIFE+ 'Waders for Real' project (2015-2019), sought to understand how many foxes resided within typical wet grassland areas in the Avon Valley and where they spent their time. The goal of this research was to improve the design of predation management strategies to help reverse the decline of breeding waders.

Key findings

- Home range estimates for 35 GPS-tagged foxes in two wet grassland sites ranged from 0.13 to 1.24km². These estimates implied minimum densities of >10 foxes/km² at one site, similar to densities reported in UK urban areas.
- Fox activity levels were highest during evening twilight and during the night.
- Fox density may be subsidised by anthropogenic food sources.

Tom Porteus
Mike Short

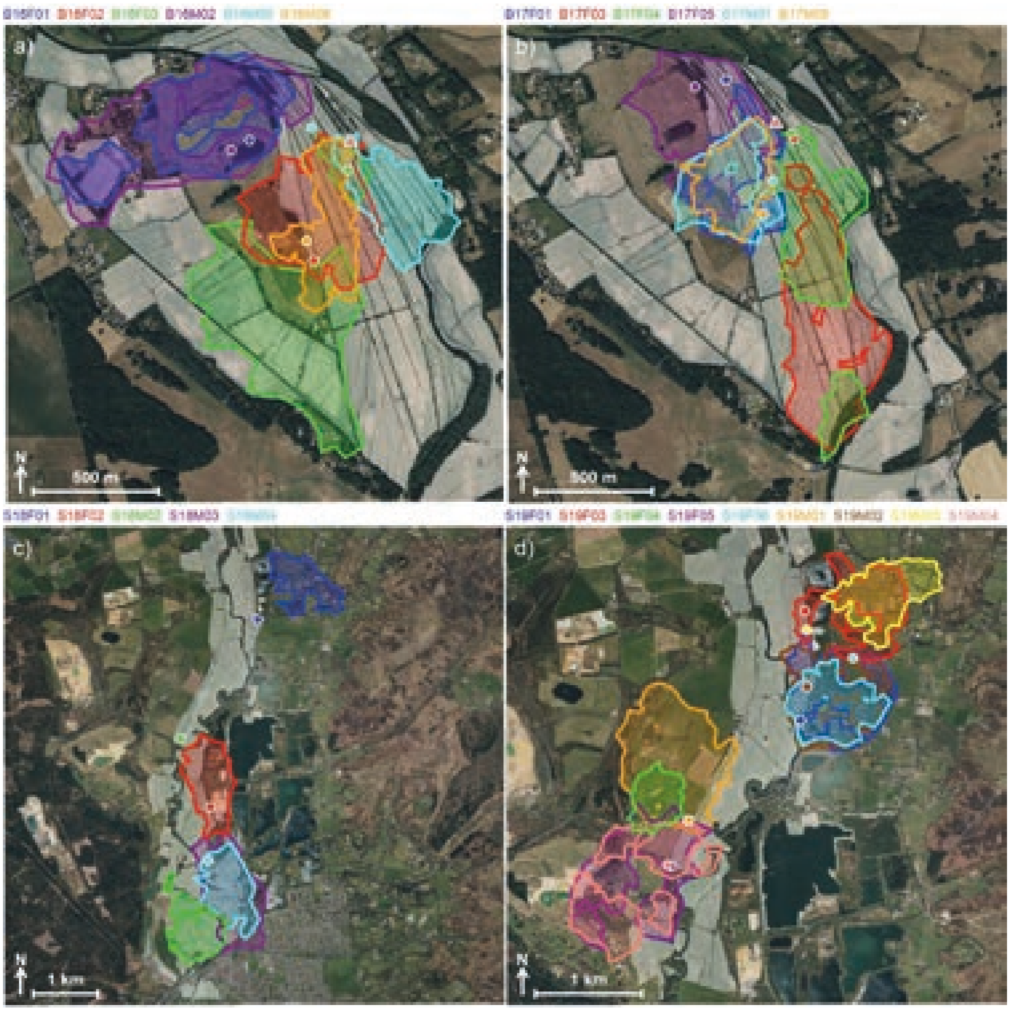
The red fox is a significant predator of ground-nesting birds and is implicated in declines of wading bird populations throughout Europe. In the UK there is limited knowledge of fox ecology in wet grassland habitats, so wildlife managers must use educated guesswork and prior experience to decide where and when to apply control efforts. Improved understanding of fox home range size and density in wet grassland, when and where they are active, and how they move across the landscape during the critical nesting period for waders could help to design more effective management strategies.

We used humane cable restraints (HCRs) to catch and GPS-tag 35 foxes in the March-June wader nesting season. We also deployed trail cameras throughout the area where foxes were tagged. We worked on two contrasting wet grassland sites in the Avon Valley: Britford in the upper valley in 2016/17 and Somerley in the lower valley in 2018/19. The extent and structure of the wet grasslands differed between sites, as did predator management effort, with no fox control at Britford, but control at Somerley. Both sites had good quality nesting and chick-rearing habitat, but at Britford there were no records of waders breeding since 2010. Could the numbers and activity of foxes provide an insight as to why?

Over four years we recorded >150,000 location fixes from the tagged foxes. We used these to estimate fox home range areas using local convex hulls, a method suitable for identifying territory boundaries (see Figure 1). Mean home ranges at Britford (0.21km², ±0.025km²) were significantly smaller than at Somerley (0.68km², ±0.067km²), though both were smaller than in similar wet grassland habitats elsewhere in Europe. We estimated minimum fox density at each site and year by combining home ranges of resident foxes and using these areas with the number of tagged foxes (including dispersers and itinerants), recognising that actual density would be higher due to unknown numbers of untagged foxes.

At Somerley, the minimum density averaged across years was 2.4 foxes/km², at the upper end of the expected range given estimates in other farmland habitats. Minimum density at Britford was over four times greater at 10.6 foxes/km². Such exceptionally high densities have only previously been recorded in urban areas. One reason they were so high at Britford could be the lack of lethal control over the past couple of

Adult fox at Britford carrying a scavenged trout. © GWCT



decades, while foxes are routinely culled at Somerley to protect livestock and released gamebirds. Another reason may be food availability. The relict water meadows at Britford rarely flood and so provide excellent year-round vole habitat; field voles and water voles were the most frequent prey items found in fox scats collected there. Perhaps more important was the availability of dead fish from the trout farm located at Britford. Several tagged foxes, including those that dispersed away from the meadows while tagged, were repeat visitors to this site, which supplied a bountiful anthropogenic food resource. We also recorded many photos of adult foxes carrying dead fish on trail cameras in this area, presumably taking the fish back to earths to feed cubs.

Data on daily activity patterns and movement behaviour of each fox, from GPS-tags and trail cameras, showed foxes were more active and moved faster during evening twilight and night hours. This confirmed these time periods as best for shooting to control foxes where this is practical. However, some foxes spent all their time within the water meadows where areas for safe-shooting and the use of electric fences were constrained by landscape and topographical features, as well as poor access. An alternative method of controlling fox predation here would be through careful use of HCRs, the same technique that was used to capture foxes for GPS-tagging. Foxes were active for more of the night at Somerley and their home ranges there were larger, compared with Britford. Fox activity also increased during the wader nesting season, reflecting the need for foxes to provision cubs. Surprisingly, foxes were also found to be active for one-third of daylight hours – waders in the Avon Valley and elsewhere do not get much rest from risk of fox predation, especially when there are cubs to feed.

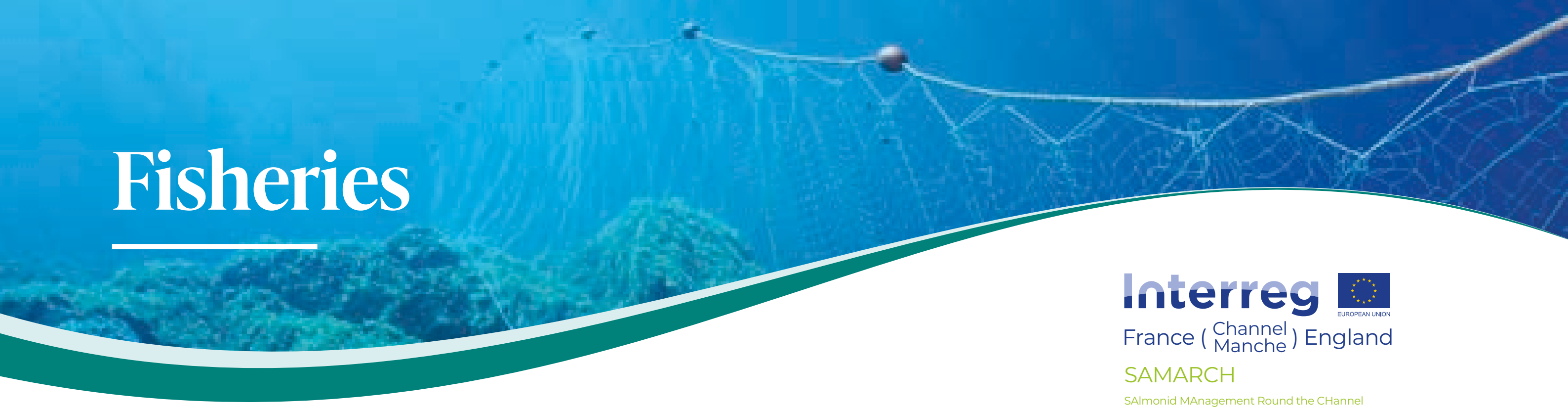
The movements of itinerant and dispersing foxes during the nesting period suggests that lethal control would need to be very intensive to be effective. This, combined with high fox densities at Britford, suggest managers face a large challenge in their efforts to re-establish breeding waders; reducing fox access to anthropogenic food resources could help reduce predation pressure on waders.

Figure 1

Estimated fox home ranges at Britford a) 2016 and b) 2017, and Somerley c) 2018 and d) 2019. Home ranges determined as the 95% isopleth of the utilisation distribution given by Local Convex Hulls. 'F' and 'M' in legends indicate female and male foxes, respectively. Wet grassland habitats are shown by transparent white shading. Capture locations for each fox are shown by matching coloured circles with a white outline. Britford fish farm is shown by a salmon-coloured triangle with a white outline. Contains Bing imagery (© Microsoft Corporation 2022)

Acknowledgements

We would like to thank the landowners in the Avon Valley where this study took place, and our students who helped collect and analyse fox scats. Our fox-tagging research was part-funded by the EU LIFE+ 'Waders for Real' project.



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Fisheries

Interreg
France (Channel Manche) England
SAMARCH
SAlmonid MAnagement Round the CHannel
European Regional Development Fund

The risk to Atlantic salmon from bycatch at sea

Background

Atlantic salmon have suffered recent declines in abundance. Reduced salmon survival at sea in recent decades, due to anthropogenic activities, has been implicated as a key driver of these declines. Salmon are vulnerable to bycatch by marine quota fisheries. Their risk to bycatch in space and time has not been quantified, despite legal responsibilities to avoid or reduce bycatch of protected species. Sophie Elliott from the GWCT was invited by the International Council for the Exploration of the Sea (ICES) to provide expertise on Atlantic salmon bycatch and report on the effectiveness and adequacy of the current bycatch monitoring programmes at the 2023 Working Group on North Atlantic Salmon (WGNAS). Here is a review of the regulatory background involved and what data are needed to better define and address the problems that Atlantic salmon face during their time at sea.

A substantial research effort to understand bycatch risks to Protected Endangered and Threatened Species (PETS) has been made in recent years. This can be especially seen in marine mammals and birds. There are numerous legislative instruments in place across the world to monitor and reduce the bycatch of PETS (eg. Regional Fisheries Management Organisations (RFMOs)). Nonetheless, the protected and threatened Atlantic salmon seems to have ‘slipped through the net’ and is currently not listed on the ICES Working Group for Bycatch of Protected Species (WGBYC) roadmap. WGBYC is tasked with the monitoring and assessment of bycatch information for PETS and has 232 listed species to assess.

The objective of the North Atlantic Salmon Conservation Organisation (NASCO), as an RFMO, is to conserve, restore, enhance, and rationally manage Atlantic salmon through international co-operation, taking account of the best available scientific information. In 2022, NASCO commissioned the International Council for the Exploration of the Sea (ICES) to advise on the risk of salmon bycatch (catch that represents non-targeted fish from a fishing operation) from pelagic (open sea) and coastal fisheries in the northeast Atlantic. For such a risk assessment to be undertaken, detailed knowledge of the migration routes of salmon at sea is needed. Salmon bycatch risk can then be calculated by comparing existing fishing effort and bycatch data with knowledge of salmon distribution at sea.

Experts on bycatch came together at the ICES Working Group on North Atlantic Salmon (WGNAS) to review existing literature on bycatch risk and provide guidance to ICES in developing its advice to NASCO (ICES, 2023). A similar working group – Study Group on the Bycatch of Salmon in Pelagic Trawl Fisheries (SGBYSAL) – last convened nearly 20 years ago in 2004. Key recommendations from SGBYSAL included the need to improve the following: information on salmon migration at sea; understanding of the fisheries at risk of bycatching the species across its range; the screening of bycatch by commercial vessels; and estimations of bycatch rate.

The latest review compiled new research on salmon migratory paths at sea. Clear evidence has also been brought to light on the bycatch of salmon within estuarine and coastal waters by gillnets. Nonetheless, insufficient information currently exists to undertake quantitative analysis to evaluate the risk of coastal bycatch (ICES, 2023) as fine scale spatial and temporal, gear-specific fishing effort data is currently unavailable to analyse.

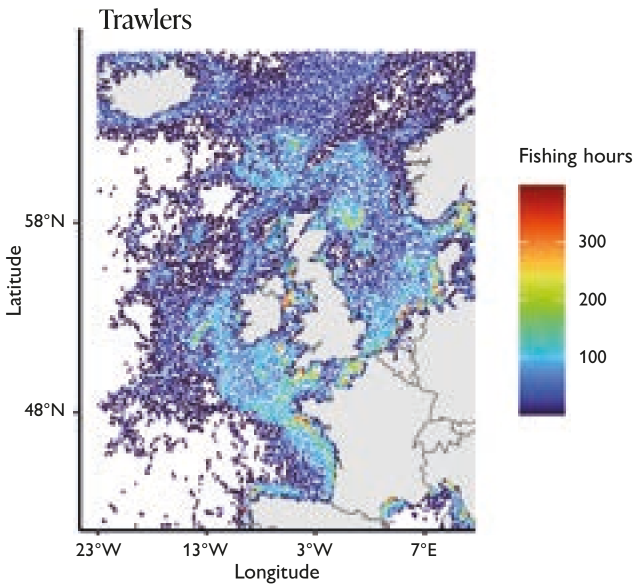
For bycatch risk from pelagic fishing activities, the WGNAS pulled together a risk matrix by metier (fishing gear targeting a specific species) across the migratory range of salmon from commercial pelagic fishing reports submitted to ICES (ICES, 2023). Furthermore, through the ICES Workshop for North Atlantic Salmon At-Sea Mortality (WKSALMON), pelagic fishing effort data across the species’ range have been requested to help quantify pelagic bycatch risk.

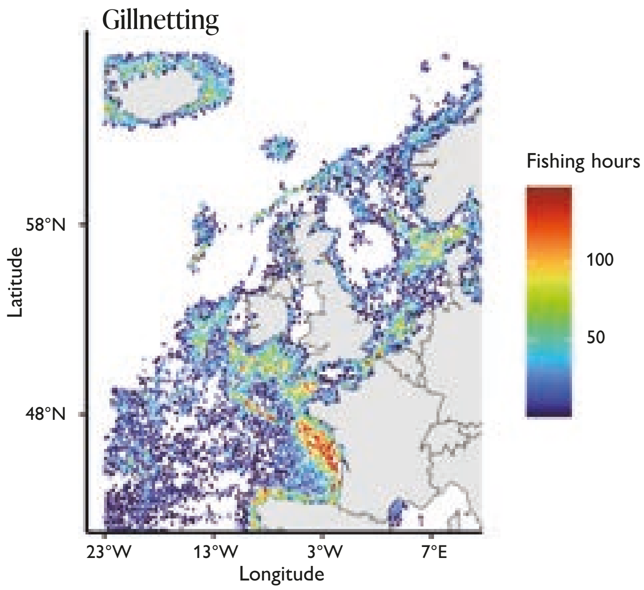
The WGNAS review on bycatch found differences between and within national bycatch monitoring programmes. Accessing information on the country and fishery-specific observer effort (eg. number of observed vessel-day/total days fished, per fishery/year) proved challenging. Observer-effort information varies between countries but seldom exceeds 5% of a nation’s total annual fishing effort (https://datacollection.jrc.ec.europa.eu/wp/2020-2021). There is evidence of under-reporting of bycatch, perhaps due to the time and effort needed to note down all bycatch when aboard vessels. A dedicated bycatch study on the critically endangered European sturgeon managed to collate ~300 fish between 2012 and 2021, whereas bycatch monitoring programmes only reported ~11 individuals over 18 years.

Although pelagic fishing vessels, in open waters, can catch up to 250 tonnes of fish in a single haul (depending on their size, capacity, and target species), few pelagic

Acknowledgments

We are extremely grateful to WGNAS for inviting Sophie Elliott to take part in this work alongside other Atlantic salmon bycatch experts.





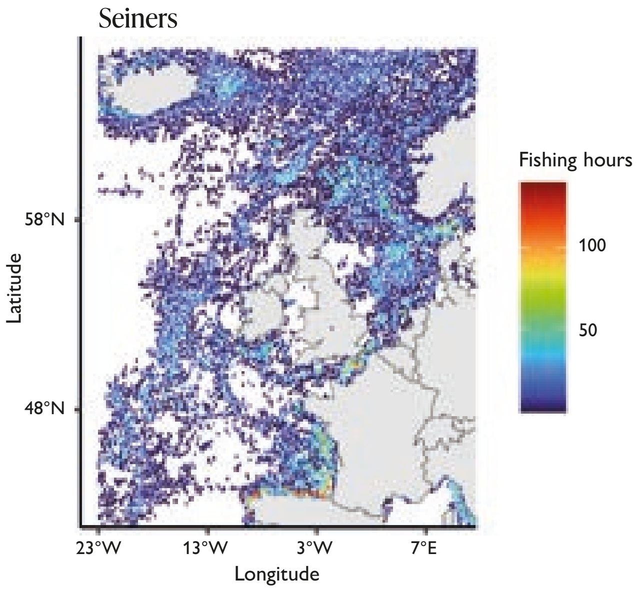


Figure 1

Global Fishing Watch (GFW) aggregated fishing effort data for three types of fishing gear relevant to salmon bycatch, measured in fishing hours per day, and provided at 100th of a degree of latitude and longitude, 2012 to 2022. Figures were calculated by using the monthly total fishing effort for each GFW gear category on an area of 0.2 x 0.2 decimal degrees, averaged over 11 years. Note GFW does not capture information on vessels <10m in size, which make up >80% of the UK fleet, nor does it distinguish between gear categories to the level of the Vessel Monitoring System (VMS)

fishery catches are monitored for bycatch and this monitoring only screens a very small proportion of the catch. This is in part because there is far less bycatch from pelagic gear types than from that used by demersal vessels/sea floor fishing, and in part due to the difficulties in detecting salmon from the tonnes of other target species caught on pelagic vessels. In England and Wales, it is not clear what percentage of pelagic vessels are monitored by onboard observers, but for those that are monitored, just one 'bucket' of fish from each pelagic haul is checked for bycatch.

Assessing bycatch

To reliably assess the effect of bycatch on the status of Atlantic salmon we need:

- Access to fishing effort data from pelagic fisheries and gillnets, provided at fine temporal and spatial scales and modelled alongside existing data on salmon distribution at sea.
- Observer screening time needs to be standardised between gear types, at sea and onshore, within and across nations with specific requirements for minimum data collection (spatial and temporal data, numbers of fish, their lengths, and weights).
- Species can be difficult to identify, especially when a specimen may be a small immature salmon crushed in among 100s of tonnes of a target species. To address this environmental DNA data collection should be mandatory to improve the detection of salmon in bycatch and expand our understanding of their migratory pathways.

References

ICES. 2023. Working Group on North Atlantic Salmon (WGNAS). *ICES Scientific Reports.* 5:41. 478 pp. https://doi.org/10.17895/ices.pub.22743713. (GWCT author S. Elliott).

Key findings

- Atlantic salmon bycatch risk assessment has 'slipped through the net' at a national and international scale.
- There is insufficient data available to carry out a risk assessment of coastal fishing Atlantic salmon bycatch.
- A pelagic fisheries bycatch risk matrix has been reviewed using commercial pelagic fishing information submitted to ICES.
- Some of the key recommendations from the 2004 workshop group on Atlantic salmon bycatch have not been addressed, despite ongoing declines in Atlantic salmon.
- Fine-scale temporal and spatial, gear-specific pelagic and inshore fishing effort data are essential to be able to quantify the risk of bycatch to salmon.

Sophie Elliott

Migratory fish in coastal and transitional waters

Background

The genetic component of the SAMARCH project had several aims: 1) to determine the river of origin of sea trout sampled at sea around the English Channel; and 2) to understand how far sea trout have travelled from their natal river. To do this, teams of scientists at Exeter, Rennes in France, and the GWCT collaborated to construct a genetic database cataloguing the genetic profiles of trout from each major river around the Channel. The genotypes of trout caught at sea were compared to this database to identify their river of origin and, by extension, the extent of their movement at sea, based on the best match of the genetic profiles of the sea trout with those in the database. This knowledge of fish movement allowed us to identify marine areas potentially used by sea trout. Our findings will inform work on the designation of marine protected areas for sea trout.

Accurate information on wild trout life history and migration patterns is needed to effectively manage their populations. We need reliable data on population size, location of spawning areas, and potential threats (ie. habitat and water quality, pollution, location of barriers to fish movement) to manage in-river populations of trout. The marine phase of the trout life cycle is less easy to manage as sea trout spend a considerable proportion of their life at sea. For such an iconic fish, little is known about the marine phase of the sea trout life cycle. The use of physical tags and tracking (researched elsewhere in the SAMARCH project) provides an excellent tool for following small numbers of fish, and previous studies have shown that while many sea trout stay close to their natal river, a minority can move considerable distances. Unfortunately, due to low recovery rates, these methods do not yield sufficient information for population-level studies.

However, every fish carries its own natural unique genetic 'tag' or profile, which can be analysed and which provides another means to study the movements of sea trout in marine and coastal waters. Considering this, researchers from the University of Exeter, INRAE Rennes, France and the GWCT have collaborated to build a genetic database incorporating DNA profiles of trout populations (sampled as resident juveniles) from potential source rivers of sea trout from around the English Channel. This database has enabled us: (1) to determine the river of origin of adult sea trout sampled at sea from various experimental netting sites around the Channel; and (2) to understand how far sea trout have travelled from their natal river. Additionally, the INRAE and Exeter teams are currently completing mapping of the marine areas that are preferentially used by adult sea trout. Together, these data will provide a valuable resource for managers and stakeholders involved in the designation of marine protected areas and exploring the impact of new coastal and offshore developments.

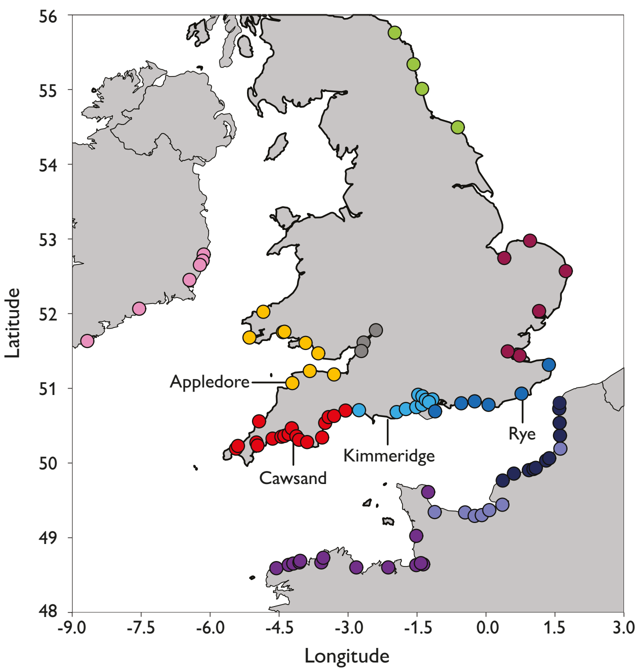
The genetic database

We collected samples from trout parr in English and French rivers flowing into the English Channel, as well as from rivers in north-east England, the Bristol Channel (north Devon and Cornwall, and south Wales), East Anglia and Ireland (see Figure 1). The current genetic baseline comprises genotypes for more than 3,000 individual trout sampled from 103 UK, Irish and French rivers, each genotyped at a suite of 95 genetic markers (loci). Initial findings indicate significant genetic structuring across the region, with the identification of 11 genetic groups (see Figure 1). For the purposes of assigning sea trout sampled at sea to their natal river, these groups are referred to as 'reporting regions'.

Figure 1

The location of the 103 English, Welsh, Irish, and French rivers from which juvenile trout were sampled for the SAMARCH genetic baseline. The colour of the dot indicates which of the 11 distinct genetic groups the trout population in each river belongs to

North-east England
South-east Ireland
Inner Bristol Channel
Outer Bristol Channel
Devon & Cornwall
Dorset & Hampshire
South-east England
Thames & Norfolk
Brittany
Lower Normandy
Upper Normandy



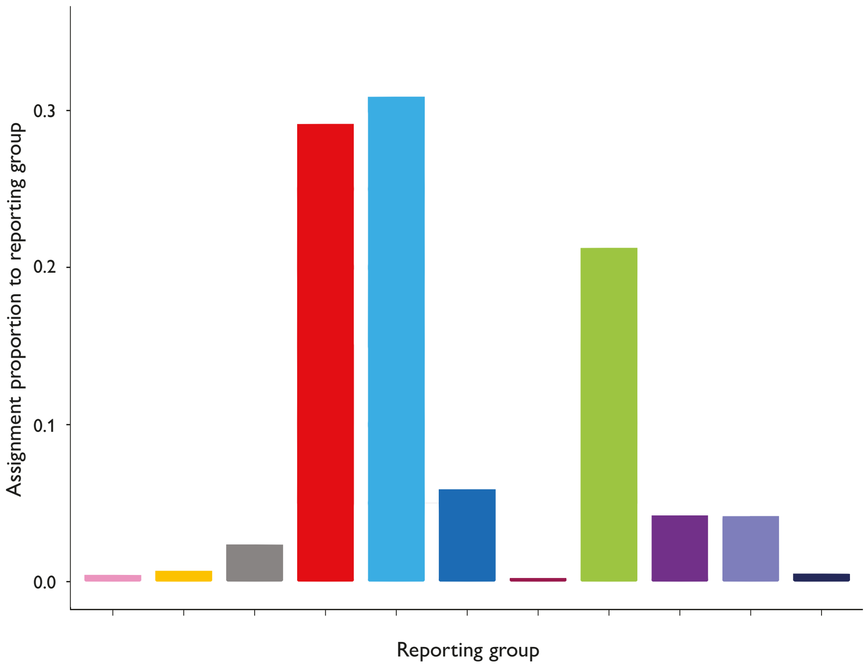


Figure 2

Stock composition of sea trout sampled from Kimmeridge Bay, Dorset showing the proportion of 27 fish assigned to each of 11 distinct genetic groups (a.k.a. reporting regions)

- South-east Ireland
- Outer Bristol Channel
- Inner Bristol Channel
- Devon & Cornwall
- Hampshire Basin
- South-east England
- Thames & Norfolk
- North-east England
- Brittany
- Lower Normandy
- Upper Normandy

Assignment of sea-caught sea trout to their river of origin

We undertook at-sea sampling of sea trout by netting at four locations around southern England (Appledore, Cawsand Bay, Kimmeridge Bay and Rye Harbour). We also obtained sea trout from commercial fisheries along the East Anglian coast and around the northern Dutch barrier islands near the outflow of the Rhine/Meuse estuary, as well as from fixed nets and anglers in the estuaries of the Taw/Torridge, Tamar, and Sussex Ouse rivers. This resulted in samples from 371 fish.

Results from each marine sampling location revealed sea trout from mixed stocks. For example, around half of the 27 sea trout sampled from Kimmeridge Bay were identified as coming from Hampshire Basin rivers (see Figure 2). However, we also recorded fish from Devon, Cornwall, and south-east England in the waters of Kimmeridge Bay. Results suggest that French sea trout originating from rivers in lower Normandy are also moving along the Dorset coast. Interestingly, several fish from north-east English rivers were caught at Kimmeridge, indicating a migration greater than 800 kilometres from their natal rivers.

Overall, our findings confirm that on entering the sea, most sea trout appear to be staying local to their natal river; however, some are undertaking extensive long-distance migrations which may make them vulnerable to exploitation outside their 'home' waters. These findings accord with the results of tagging/tracking research undertaken within the SAMARCH project, which also provided insight into the propensity for long distance offshore migrations by some sea trout.

Key findings

- Most sea trout in the English Channel appear to stay close to their natal rivers, but this pattern varies between regions.
- Some sea trout move very long distances at sea more than 1,000km.
- Trout movement from their natal rivers is predominantly west to east, but movements in the western Channel and eastern Channel show different patterns.

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Andrew King
Sophie Launey
Mathieu Vanhove
Dylan Roberts

A SAMARCH tagged sea trout in the process of being recaptured. Tagging provides valuable insight into their long distance migrations and behaviour at sea. © GWCT

Interreg
France (Channel Manche) England
SAMARCH
SAlmonid MAnagement Round the CHannel
European Regional Development Fund

Unique trout in metal-polluted environments

Background

The British Isles have been worked for millennia to extract metal ores to feed industrial development, leaving a legacy of mine-water pollution that continues to impact freshwater ecology in many regions. Brown trout persist in these metal-impacted systems as apex predators, with previous studies showing some metal-impacted populations to be highly genetically divergent. We sought to understand the scale of genetic diversity across regions in the British Isles, the repeatability of genetic divergence in trout populations affected by metal pollution, and whether these patterns are best explained by industrial history.

Interreg
France (Channel Manche) England
SAMARCH
SAlmonid MAnagement Round the CHannel
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Key findings

- We found multiple instances where trout populations in metal-polluted catchments were genetically distinct from those living in clean rivers.
- The time of genetic divergence of metal-impacted populations coincides with historical periods of peak mining activity.
- Brown trout from physically and chemically isolated populations had reduced genetic diversity.

Dan Osmond
Jamie Stevens

We collected trout samples from four regions of the British Isles with a shared history of mining: Cornwall, south-east Ireland, north-east England, and western Wales. We collected trout directly downstream of point sources of metal pollution and collected control samples from relatively unimpacted tributaries in the same catchment, or nearby catchments with otherwise similar chemical and physical properties. These were screened using a panel of 95 genetic markers (SNPs), developed as part of the SAMARCH project to give the genetic structure of 1,139 individual fish from 68 sampled sites. We used two different statistical methods, with different underlying assumptions, to investigate genetic structure and calculated basic indices of diversity within each population. We conducted demographic modelling, simulating possible historical population events and parameters, to find the most credible scenarios to explain how the observed modern genetic patterns in our populations were produced.

Across all our sampled populations in the British Isles, brown trout from the metal-impacted rivers of western Cornwall are the most genetically distinct (see Figure 1A). Considering all our sampled populations, we see repeated patterns of nested genetic divergence in the most metal-impacted populations within geographical regions, with reduced levels of genetic diversity in these metal-impacted populations. We also see repeated genetic isolation of populations of trout living upstream of artificial barriers, particularly in western Wales (see Figure 1E, purple genetic cluster). Demographic modelling suggests that the splits of the metal-impacted populations from the surrounding unimpacted populations occurred within recent history (the last few hundred years), coinciding with periods of peak mining industry activity. These splits were accompanied by reductions in population size. Our results show little genetic structure between sampled sites that were not metal-impacted from adjacent catchments within regions, such as within the low-moderate metal impact sites in north-east England (see Figure 1 F&G.) This highlights the role of low-level straying of sea trout in maintaining wider genetic connectivity and adaptive potential across these catchments, within regions.

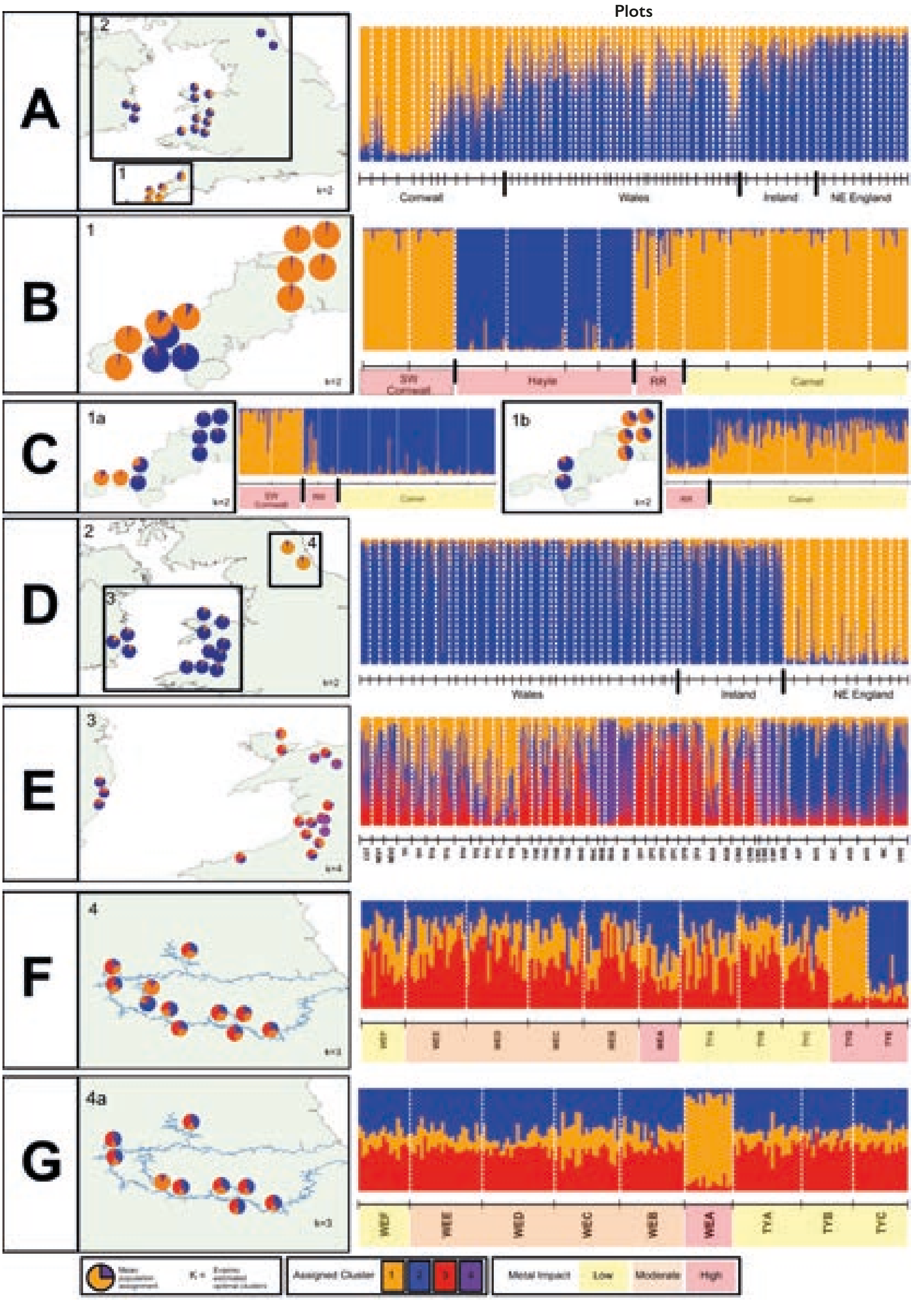
The distinction of Cornwall from the rest of the British Isles (plot A), is driven by the metal-impacted river Hayle (plot B), Red River (RR) and Trevaylor and Crowlas in south-west Cornwall (plot C). There is a broad geographical split between Celtic Sea-draining rivers and those in north-east England (plot D). In plot E, we see strong genetic structure relating to the influence of artificial barriers (purple group) and a metal-impacted group on the Teifi (TFB-TFD, orange group) and the highly copper polluted Afon Gogh on Anglesey (AGA). Plots F and G show the genetic distinction of highly metal-impacted trout populations in north-east England, one section in the Wear (WEA) and two in the Tyne (TYD and TYE), with relatively little genetic structure detected between other sampled individuals across the Tyne and Wear.

Our results demonstrate that the impact of legacy pollution continues to affect brown trout populations. Reduced genetic diversity in metal-impacted populations and those isolated by artificial barriers is likely to be an issue for brown trout conservation in the British Isles. In England and Wales, 9% of rivers do not meet chemical or ecological targets due to mine-water pollution. Across the UK, current estimates indicate a barrier on average every 1.3 kilometres of river distance. Amelioration of pollution and removal of obsolete barriers will enable the restoration of gene-flow to reduce possible negative fitness consequences of genetic drift. Ongoing work is examining divergent regions in the genome of metal-impacted trout populations to identify parallel pathways of adaptation.


Wild resident brown trout. © Dan Osmond

Figure 1

Hierarchical assignment analysis of trout genotype data using the program STRUCTURE and the Evanno Δk method. Average assignment of individuals from each sampled river are given by the portion of the pie chart on each map (left). Sub-sampled populations are denoted by boxes on the maps. The value of k (most statistically credible number of distinct genetic groups) is plotted for each level of the analysis to the right of each corresponding map. Individual assignment plots (right) represent each sampled trout by a vertical bar, with the proportion of colour grouping corresponding to the assignment to each of the n most credible groups. Individual sampling sites are separated by white dashed lines, with relative metal impact shaded as per the legend at the bottom of the figure, where genetic structure is most credibly driven by relative metal impact. Relative metal impact was estimated by obtaining water chemistry data from the last 10 years from the Environment Protection Agency Ireland, the Environment Agency, and Natural Resources Wales. The chemistry data used were calculated bioavailability of dissolved metals and multidimensional scaling of these multiple variables per population. Low values indicate no background metal enrichment, moderate values indicate somewhat elevated but below levels predicted to have acutely toxic impact, and high values indicate populations where bioavailable metal concentrations exceed those predicted to have acutely toxic effects



Salmonid growth and migration across latitudes

Background

Atlantic salmon and brown trout, referred to collectively as salmonids, are species of great ecological and commercial value. Their numbers have been in decline across Europe since the 1970s, with Atlantic salmon of particular concern. To protect these important species, we must understand what factors drive changes in their life history and how anthropogenic factors, such as climate change, may contribute to declining populations.

Salmon and trout are anadromous, meaning they migrate from rivers to the sea as smolts. All salmon and about 20% of trout undertake this migration, living and feeding at sea before returning to their river of origin. Returning trout, referred to as sea trout, are bigger and produce more eggs than most resident freshwater trout, so are key to maintaining healthy populations.

Previous research, in collaboration with the GWCT, has shown that larger smolts are more likely to survive better at sea compared with smaller specimens. Metabolism is a measure of energy expenditure, at a given moment, required for survival. Excess energy can be used for enhanced growth and reproduction. Both growth and feeding behaviour are underpinned by metabolism, making it a potentially key driver of successful salmonid migration. Metabolism increases with temperature up to the thermal optimum of the species, so understanding how temperature alters metabolism, and therefore growth, is key to predicting how salmonids may react to a warming world. By studying salmonid juveniles across a range of locations, at differing latitudes, we aim to determine how rising temperatures will affect juvenile growth.

We are in the process of sampling salmonids across their thermal range in Europe from Northern Spain to Iceland (see Figure 1). At each site, salmon and trout juveniles are captured by electrofishing and the following measurements are taken: metabolic rates (via oxygen consumption in a sealed chamber), growth (by reading growth rings in fish scales akin to tree rings), and diet (from stomach contents obtained through stomach flushing). Each fish is implanted with a PIT tag before release, allowing us to know if and when the fish migrate to and return from the sea. Doing this across the thermal range of salmonids will allow us to address three questions concerning the effects of temperature, size, and metabolism on salmonid survival at sea.

Is metabolism a determinant of migration strategy and success in Atlantic salmon and brown trout? We expect that higher metabolic rates (for fish of comparable size and from rivers with similar temperatures) will improve early life growth rate and correlate with an earlier migration period for salmon and an increased probability of marine migration in trout.

Do higher temperatures change the relationship between metabolism and growth? We expect that the relationship between metabolism and growth will be stronger in fish acclimated to lower temperatures and less in fish acclimated to higher temperatures.

Do higher temperatures in rivers result in smaller fish migrating? We expect that rising temperatures will reduce the scope for salmonid growth in freshwater, leading to migration to the marine environment at a smaller size.

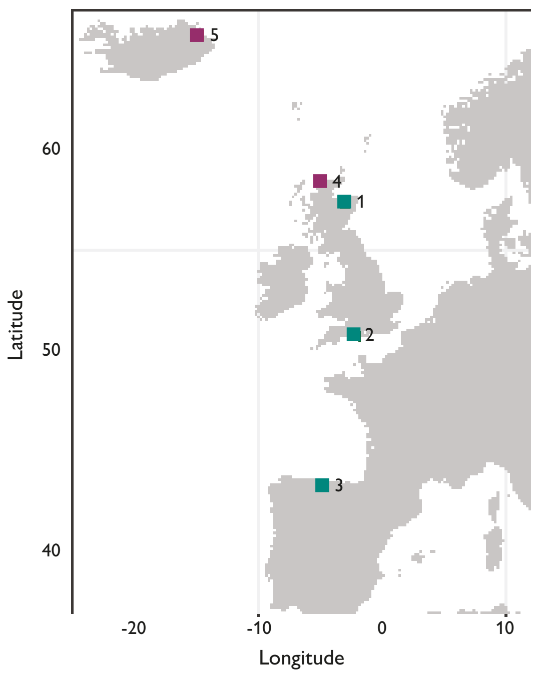


Figure 1

Locations where salmonids have been or will be sampled. Locations that have been sampled in 2023: 1) Deveron in Aberdeenshire, Scotland, 2) Frome in Dorset, England, 3) Deva in Spain. In 2024 we will sample in 4) the Laxford, Highlands, Scotland, and 5) the Vesturdalsá, Iceland. The colour of locations sampled in 2023 is reflected in Figure 2

Experimental setup measuring metabolism in the Deva catchment, Spain. © Peter Betts

Key findings

- Larger salmonid smolts are more likely to return from sea migration.
- Juvenile salmonid growth reflects an interaction between water temperature and fish metabolism.
- Initial results suggest that the metabolism of salmon may be more sensitive to temperature than trout.

Peter Betts
Eoin O'Gorman

This year we have sampled and tagged 197 salmon and 62 brown trout juveniles from the River Frome (Dorset, England), 218 salmon and seven trout from the River Deveron (Aberdeenshire, Scotland), and 235 brown trout from a range of tributaries in the Deva catchment (Spain). The surviving salmonid smolts should head to the sea in the coming year, providing data on the timing of their migration. Next year we will extend the sampling to cover the full thermal range of each species, sampling the Laxford (Highlands, Scotland) and Vesturdalsá (Iceland), alongside re-sampling some sites. Preliminary results suggest that the metabolism of salmon is more sensitive to rising temperatures than that of trout (see Figure 2), implying global warming will affect them more acutely. However, there are still more data to collect, process, and analyse over the coming months and years to get a more complete picture.

Overall, predicting how rising temperatures will impact salmonids should allow us to understand which populations are most at risk from climate change and better plan mitigation strategies. One proposed nature-based solution would involve restoring riparian vegetation in deforested areas. The resulting canopy cover may help reduce in-river temperatures and associated physiological stress on salmonid metabolism.

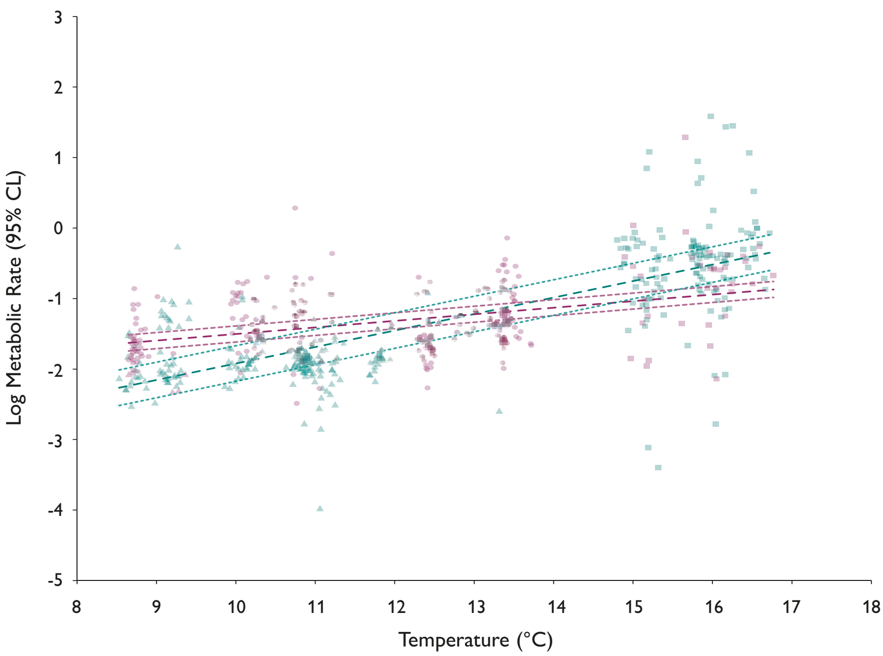


Figure 2

Preliminary analysis suggests that the relationship between the metabolic rate of juvenile salmon and temperature (measured as oxygen consumption in a sealed chamber) may differ to that of juvenile trout. The regression line is the line of best fit for salmon (green) and trout (purple), with the 95% confidence intervals shaded in grey and sites denoted by shape. Further analysis and data collection are needed to understand this relationship more thoroughly

- Trout
- Salmon
- River Frome
- The Deva Catchment
- River Deveron

Understanding gamebird releasing and foxes

Background

Current debate asks if land that hosts released game is leading to an increase in fox numbers. If this is the case, ground-nesting species may be negatively impacted by an increase in fox predation during the breeding season. So far, however, there has been little evidence to support or refute the idea that releasing results in more foxes. This research project was set up in January 2022 to look at this issue. The data collection phase has finished, and we are undertaking analysis. This article presents a preliminary look at the results.

For the last 19 months, we have been exploring how gamebird releasing is related to fox activity with a large fieldwork programme involving 18 field sites across central southern England. Our main aim was to visit estates that release gamebirds and estates that do not release, and to measure differences in the number of scats found as an indication of fox activity. Release sites were all large (>10,000 pheasants released). We walked a fixed 3km survey route every three weeks on each of the 18 sites (10 release and eight non-release sites) from March 2022 to September 2023, and counted and collected the fox scats we found. In addition to foxes, we were also interested in how release and non-release sites differ in terms of key wildlife groups such as red kites, buzzards, deer, hares, and various corvid species. We recorded numbers of these species while walking our survey routes, which involved two people, one looking for fox scats and the other scanning for key species.

A key aspect of our study is the amount of fox culling that gamekeepers carry out. Foxes are typically killed on release estates to protect gamebirds, and on some sites that do not release, as a conservation measure to protect vulnerable ground-nesting birds. The amount of control carried out by gamekeepers is likely to impact the number of foxes present on a site and therefore the number of scats we find. Our study was not designed to look at how the amount of fox control is related to scats directly, as this would have required an unachievable experimental study design including randomly applying treatment (fox control) to both release and non-release sites.

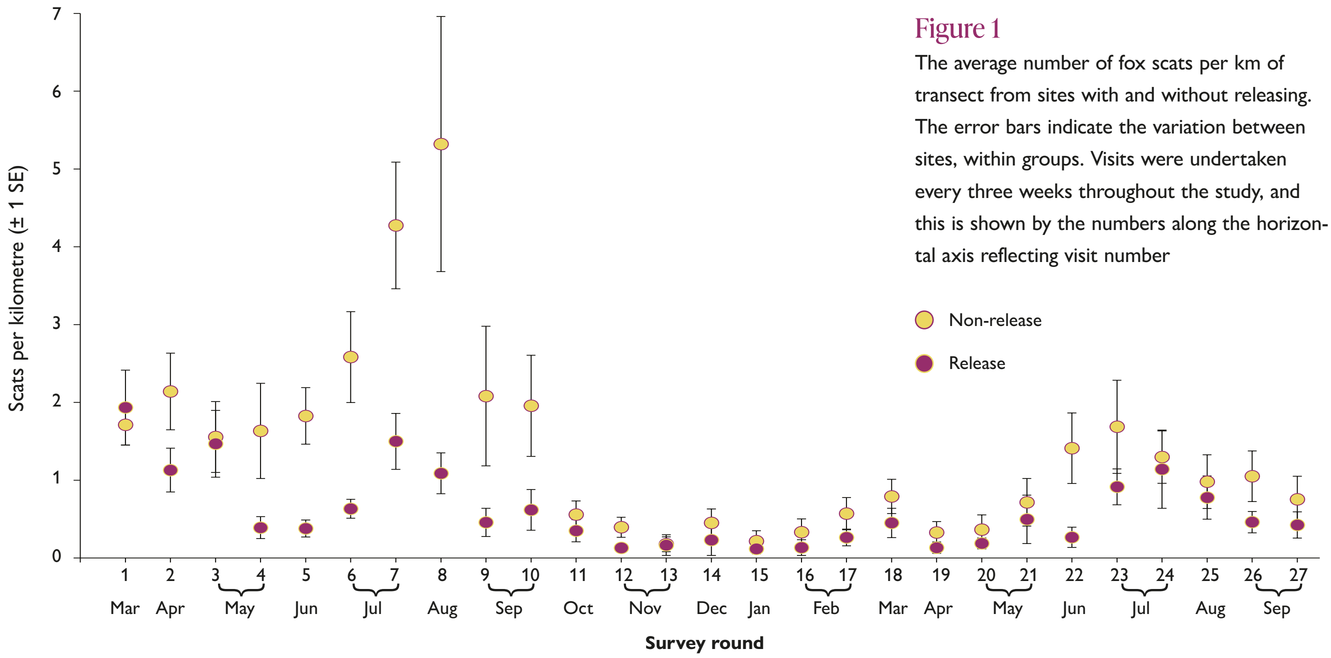


Figure 1

The average number of fox scats per km of transect from sites with and without releasing. The error bars indicate the variation between sites, within groups. Visits were undertaken every three weeks throughout the study, and this is shown by the numbers along the horizontal axis reflecting visit number

So, although we cannot examine how fox control is related to the number of scats we found, we did still obtain a measure of the culling effort put in at all sites that carry out fox control. We collected fox control records from all 10 release estates and from two non-release sites that undertook some fox control for conservation purposes. The field data collection has now finished, and we can present the results of that here.

Our data show that our fox 'activity' index ie. scats found per km, changes throughout the year, with peaks in June to August (see Figure 1). The higher peak in 2022 compared with 2023 may be related to the relative success of the fox breeding season in that first year, but we don't know that. In the summer of the first year of the study, we found significantly more scats on non-release sites compared with sites that release game (see Figure 1). In both years there were never more fox scats at the release sites.

When examining fox control records, we found that the amount of effort was very variable. The number of hours spent shooting foxes across the whole 19 months of the study ranged from 58.5 hours to 1,500 hours per site. It was interesting to note

Figure 2a, b

See Figure 1 legend for explanation of horizontal axis

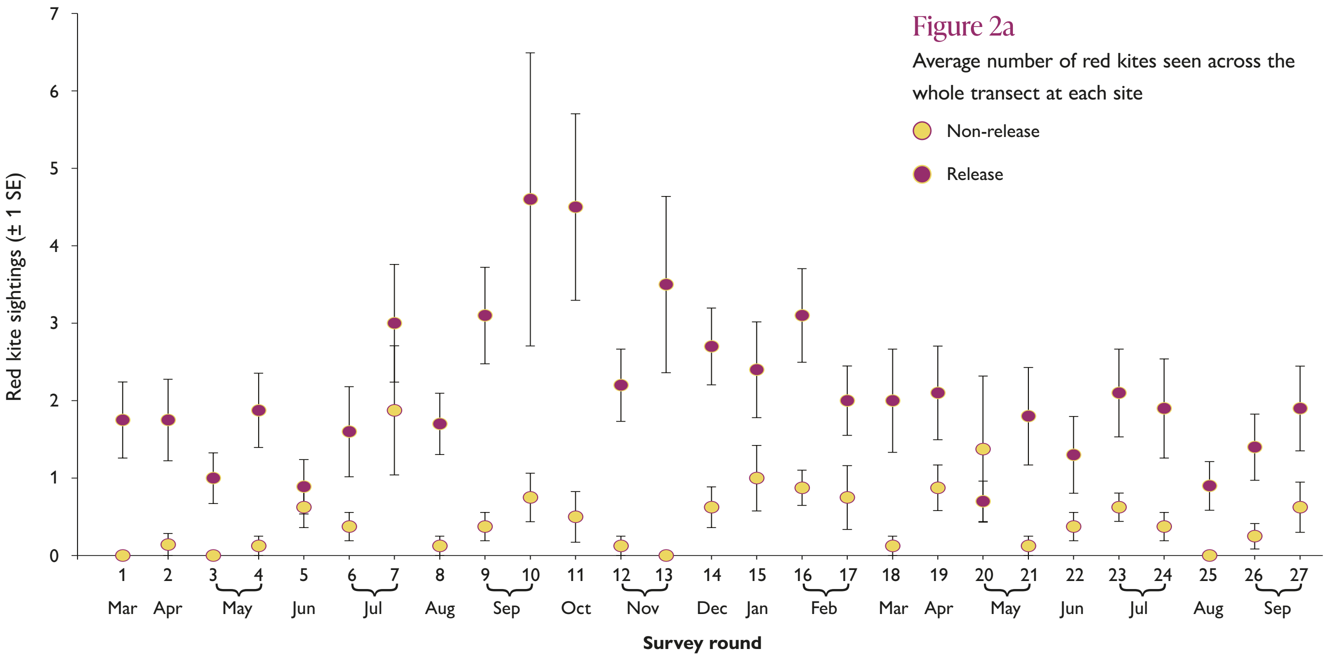


Figure 2a

Average number of red kites seen across the whole transect at each site

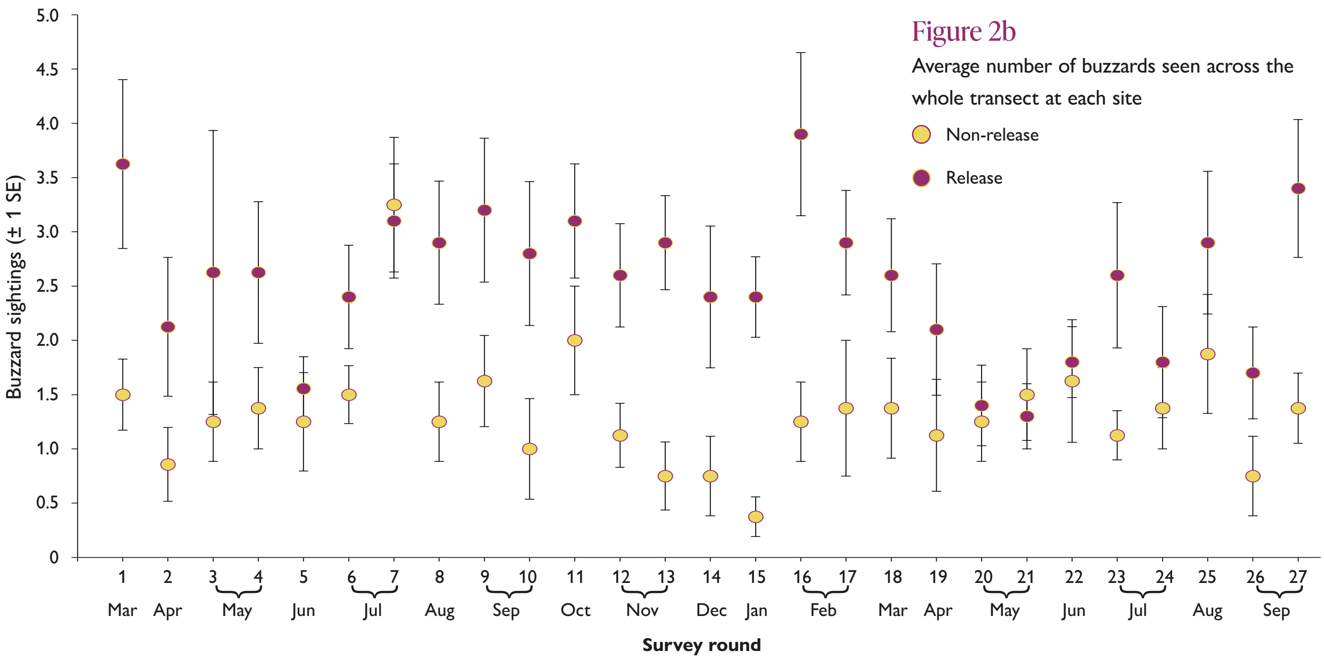


Figure 2b

Average number of buzzards seen across the whole transect at each site

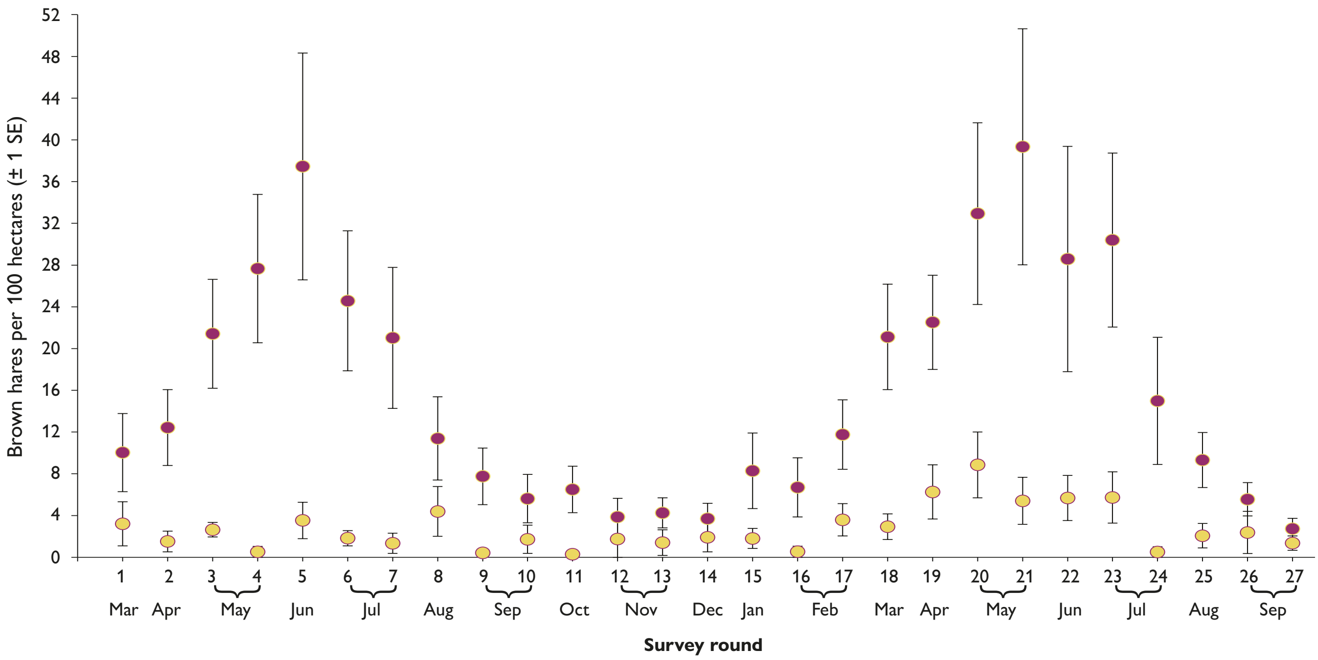


Figure 2c

Average number of brown hare seen across the whole transect at each site. See Figure 1 legend for explanation of horizontal axis

Non-release

Release

Key findings

- Fox activity changes throughout the year, with peaks in June to August.
- More fox scats were found on non-release sites than on sites that release game, during the summer in the first year only.
- At other times of the year in our 19-month study there was no difference in fox activity between gamebird release and non-release sites.
- Gamebird release sites have more red kites, buzzards, and brown hares than non-release sites and non-release sites have more magpies than release sites.

Jenny Coomes
Maureen Woodburn
Joe Werling
Katie Holmes
Owen Hickman
Rufus Sage

that, of the two non-release sites that undertook some fox control, one did a large amount: nearly 500 hours over the 19 months, despite not releasing any game, and was motivated by conserving vulnerable species. Overall, release sites did put more effort into fox control than non-release sites and this is a possible explanation for why we see fewer scats on release sites, though as mentioned, we are not able to test this hypothesis experimentally.

These findings are important because they suggest that releasing estates are not harbouring large numbers of foxes, as has been speculated. If foxes are being attracted to release sites because of the large numbers of gamebirds, it is likely that the fox control being carried out on these sites is reducing the numbers of those foxes, but we do not know this.

The data from our wildlife sightings show more red kites and buzzards on release sites than non-release sites (see Figures 2a and b). This result may be explained by the raptors being attracted to the large numbers of game on these sites. However, we cannot rule out the fact that release sites are likely to maintain certain habitats that non-release sites don't, such as cover crop/wild bird mix plots. These crops hold more small mammals and songbirds, which the raptors may be attracted to.

Hares were also more abundant on release sites compared with non-release sites (see Figure 2c), with a pronounced peak in abundance in May and June for both years. Previous studies have shown that young hares (leverets) are vulnerable to fox predation and fox control can enable hares to breed more successfully. Habitat quality may also be a factor affecting hare numbers.

We found more magpies on non-release than release sites, with the number of jays similar across the two types of sites (see Figures 2d and 2e). Magpies are often controlled by gamekeepers in accordance with Defra's General Licence arrangements as they are nest predators. However, we did not gather records of magpie control directly from gamekeepers in this study. Jays, although also nest predators, are not usually controlled by keepers. They are less common and largely confined to woodland.

This piece of work contributes to but does not close the knowledge gap relating to gamebird releases and foxes. Our study shows similar or sometimes more fox activity on sites that do not release game, compared to otherwise similar releasing estates. Fox control carried out on estates that release game probably plays a significant role in suppressing fox numbers although we could not look at that directly in this study. It is also plausible that gamebird releasing does not necessarily attract foxes in the way that is sometimes assumed. Our study indicates at least that the relationships between gamebird releasing and fox activity in a landscape is more complex and variable than is reflected in current debate.

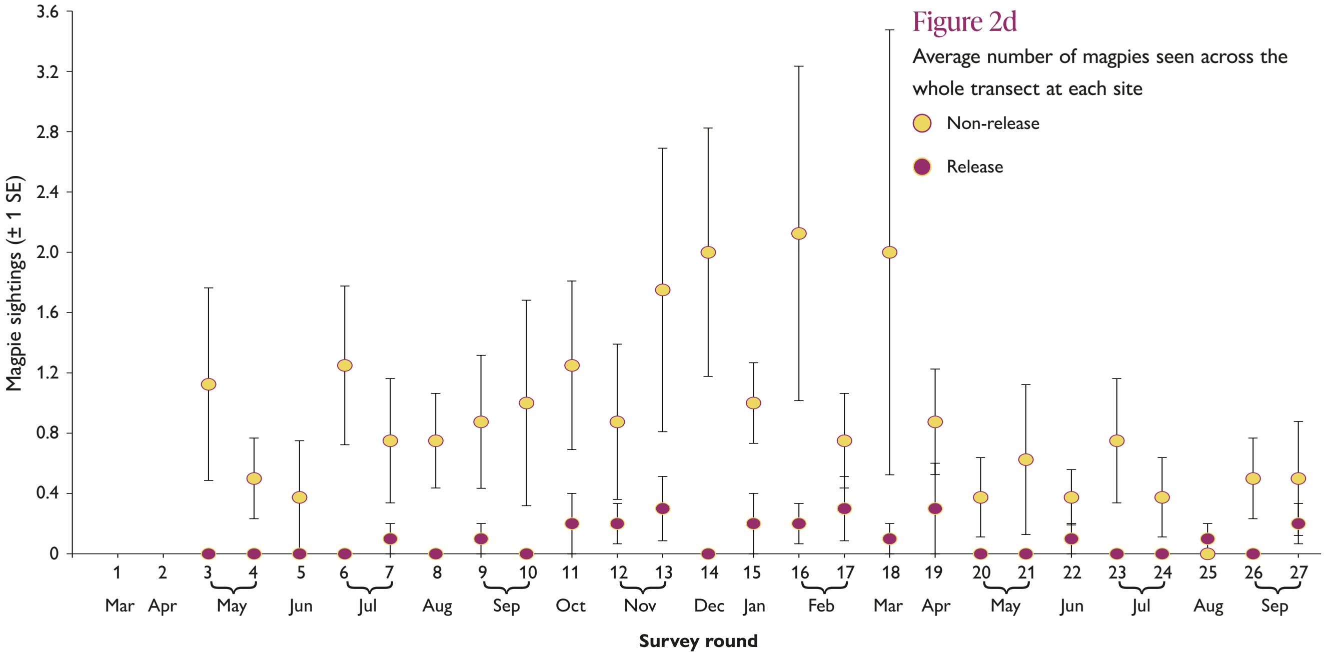


Figure 2d

Average number of magpies seen across the whole transect at each site

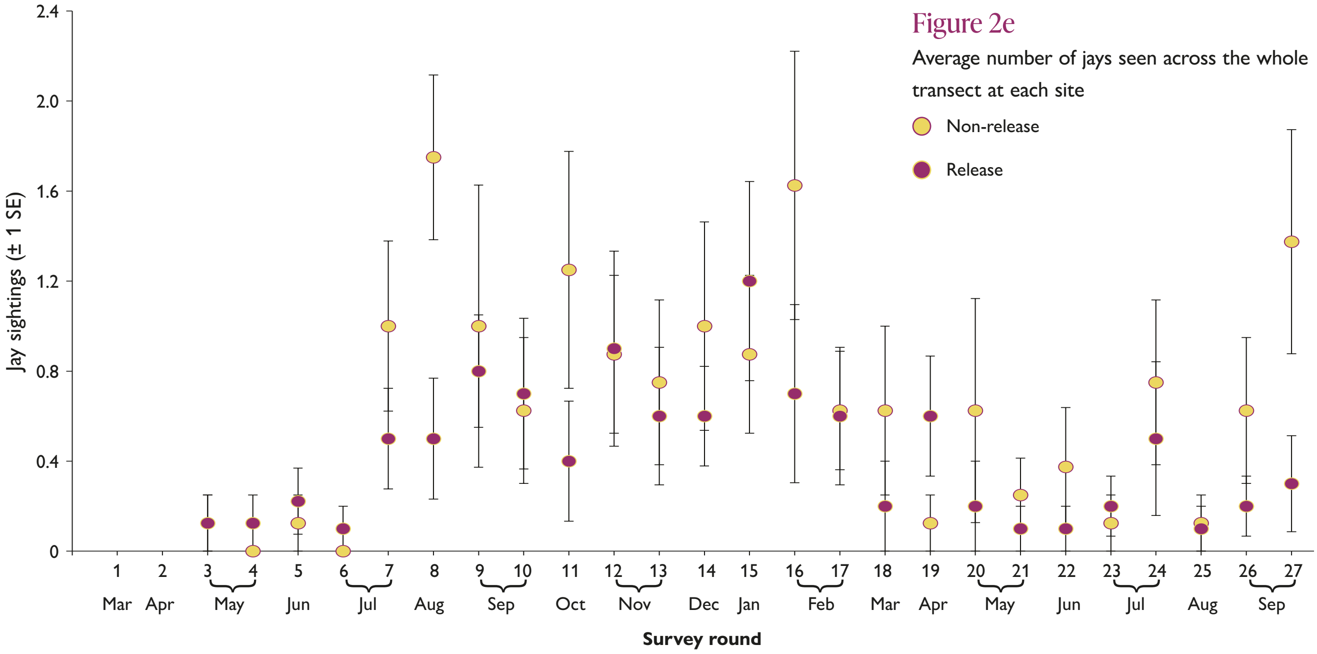


Figure 2e

Average number of jays seen across the whole transect at each site

Fox scats were collected and analysed.

Figure 2d, e

See Figure 1 legend for explanation of horizontal axis

Acknowledgements

We are very grateful to the 18 estates involved in our current study. Also to BASC who made a substantial donation which made the study possible.

GWCT research projects 2023

WETLAND RESEARCH IN 2023

Project title	Description	Staff	Funding source	Date
Woodcock monitoring	*Examination of annual variation in breeding woodcock abundance*	*Chris Heward, Andrew Hoodless, collaboration with BTO*	Shooting Times Woodcock Club	*2003- ongoing*
Woodcock survival and site fidelity	*Intensive ringing and recapture of woodcock at three winter sites*	*Andrew Hoodless, Chris Heward, collaboration with the Woodcock Network*	*Core funds*	*2012- ongoing*
Woodcock migration and breeding site habitat use	*Use of GPS tags to understand autumn migration and breeding site habitat use*	*Andrew Hoodless, Chris Heward, collaboration with ONCFS*	Shooting Times *Woodcock Club, private donors, Woodcock Appeal*	*2017-2024*
Winter movements of lapwings	*Comparison of lapwings breeding in Scotland and southern England using GPS tracking*	*Andrew Hoodless, Dave Parish, Marlies Nicolai, Lizzie Grayshon, Ryan Burrell*	*EU LIFE, Associated British Ports, Core funds, Elmley NNR*	*2019-2024*
Avon Valley Farmer Cluster (see p22)	*Farmer-led habitat restoration and wader recovery in the Avon Valley*	*Lizzie Grayshon*	*NE Facilitation Fund, core funds*	*2020-2026*
Breeding redshank in the Avon Valley	*Examining habitat use and breeding success of redshank in the Avon Valley using GPS tracking and colour-ringing*	*Lizzie Grayshon, Clive Bealey*	*Hampshire Ornithological Society, core funds*	*2021-2024*
GWCT/BTO Breeding Woodcock Survey 2023 (see p20)	*Large-scale assessment of UK's resident woodcock population's status, and study of factors driving population trends*	*Chris Heward, Andrew Hoodless, collaboration with BTO*	*Shooting Times Woodcock Club, BASC, private donors, Core funds, John Swire 1989 Charitable Trust*	*2022-2024*
Year-round habitat use of British breeding curlew	*Assessing breeding success, broadscale winter habitat use and migration strategy of curlew using GPS-GSM tags*	*Chris Heward, Andrew Hoodless, collaboration with David Scott*	*Abbeystead Estate, private donors*	*2022-2024*
Headstarting curlew in southern England	*Assessing the viability of headstarting as a method of establishing breeding curlew populations*	*Andrew Hoodless, Chris Heward*	*Norfolk Estate, Cranborne Estate, Elmley Estate*	*2022-2027*
Lapwings on fallow plots	*Monitoring and improving lapwing breeding success on arable fallow plots*	*Lizzie Grayshon, Bleddyn Thomas, Chris Heward, Andrew Hoodless*	*Natural England's Species Recovery Programme (SRP)*	*2023-2024*
New Forest Farming in Protected Landscapes collaboration	*Working with local farmers to put in Farming in Protected Landscape grant applications to achieve local conservation goals*	*Lizzie Grayshon*	*New Forest National Park Authority*	*2023-2025*
PhD: Role of camouflage in the survival and conservation of ground-nesting birds	*Influence of nest and chick crypsis on lapwing breeding success and possible modifications to field and sward management*	*George Hancock. Supervisors: Andrew Hoodless, Dr Jolyon Troscianto, Dr Martin Stevens (University of Exeter), Dr Innes Cuthill (University of Bristol)*	*NERC*	*2019-2023*
PhD: Woodcock in Ireland	*Breeding woodcock distribution and habitat relationships. Effect of shooting on winter woodcock behaviour and mortality rate*	*James O'Neill. Supervisors: Andrew Hoodless, Prof John Quinn (UCC)*	*Irish Research Council, NARGC, NPWS, Core funds*	*2019-2024*
PhD: Landscapes for curlews	*Monitoring breeding success and use of GPS tracking to determine foraging areas of adult curlews and brood ranges*	*Elli Rivers. Supervisors: Andrew Hoodless, Mike Short, Prof Richard Stillman & Dr Kathy Hodder (BU), Andy Page (FE)*	*Hampshire Ornithological Society, Forestry England, private donors*	*2020-2024*
PhD: Lapwings and avian predators	*Quantifying lapwing chick survival in arable habitats and the effects of disturbance by corvids and raptors*	*Ryan Burrell. Supervisors: Andrew Hoodless, Prof Richard Stillman & Dr Kathy Hodder (BU)*	*Core funds*	*2020-2024*

PARTRIDGE AND BIOMETRICS RESEARCH IN 2023

Project title	Description	Staff	Funding source	Date
Partridge Count Scheme (see p24)	*Nationwide monitoring of grey and red-legged partridge abundance and breeding success*	*Neville Kingdon, Julie Ewald, Nicholas Aebischer, Sabeeth Shoeb, Piera Coleman, Rosa Hicks, Robert Turner, Amin Alhawary, Matt Cooper, Ferne Ellington*	*Core funds, GCUSA*	*1933- ongoing*
National Gamebag Census (see p34)	*Monitoring game and predator numbers with annual bag records*	*Julie Ewald, Corinne Duggins, Nicholas Aebischer, Cameron Hubbard, Piera Coleman, Rosa Hicks, Robert Turner, Amin Alhawary, Matt Cooper, Ferne Ellington*	*Core funds*	*1961- ongoing*
Sussex Study	*Long-term monitoring of partridges, weeds, invertebrates, pesticides and land use on the South Downs in Sussex*	*Julie Ewald, Nicholas Aebischer, Steve Moreby, Cameron Hubbard, Piera Coleman, Rosa Hicks, Amin Alhawary, Matt Cooper, Ferne Ellington*	*Core funds*	*1968- ongoing*
Wildlife monitoring at Rotherfield Park	*Monitoring of land use, game and songbirds for the Rotherfield Demonstration & NSR PARTRIDGE*	*Francis Buner, Cameron Hubbard, Beth Brown*	*Core funds, Interreg (EU North Sea Region)*	*2010-2023*
Grey partridge management	*Researching and demonstrating grey partridge management at Whitburgh Farms*	*Hugo Straker, Fiona Torrance, Rebecca Mills, Rhiannon Wooldridge*	*Whitburgh Farms, Core funds*	*2011- ongoing*
Cluster Farm mapping	*Generating cluster-scale landscape maps for use by the Advisory Service and the Farmer Clusters*	*Julie Ewald, Neville Kingdon, Cameron Hubbard, Piera Coleman, Rosa Hicks, Matt Cooper, Ferne Ellington*	*Core funds*	*2014- ongoing*
Developing novel game crops	*Developing perennial game cover mixes*	*Fiona Torrance, Hugo Straker, Rebecca Mills, Rhiannon Wooldridge, Isabella Allan, Rachael Hustler*	*Balgonie Estates Ltd, Core funds, Kingdom Farming, Kings Crops Scottish Agronomy*	*2014-2023*
Grey partridge recovery	*Monitoring grey partridge recovery at Balgonie Estate and impacts on associated wildlife*	*Hugo Straker, Fiona Torrance, Rebecca Mills, Rhiannon Wooldridge Isabella Allan, Rachael Hustler*	*Balgonie Estates Ltd, Core funds, Kingdom Farming, Kings Crops Scottish Agronomy*	*2014-2023*
PARTRIDGE (see p28, 30)	*Co-ordinated demonstration of management for partridge recovery and farmland biodiversity in the UK, the Netherlands, Belgium, Germany and Denmark*	*Francis Buner, Fiona Torrance, Julie Ewald, Paul Stephens, Ben Stephens, Corinne Duggins, Ellie Raynor, Beth Brown,*	*Interreg (EU North Sea Region) Core funds*	*2016-2023*

		Rebecca Mills, Rhiannon Wooldridge Cameron Hubbard, John Szczur, Chris Stoate, Roger Draycott, Francesca Pella, Nicholas Aebischer		
Recovery of grey partridge populations in Scotland	*Encouraging grey partridge management and monitoring across Scotland*	*Fiona Torrance*	*Core funds*	*2017- ongoing*
PepsiCo Arable Biodiversity Project	*Demonstrates how arable farming can support the environment by implementing measures to improve the quality of available semi-natural habitats to benefit biodiversity and by adjusting agricultural practices to increase cost-effective, nature-friendly productivity*	*Louise de Raad, Fiona Torrance, Ross Macleod, Rhiannon Wooldridge, Rebecca Mills, Isabella Allan, Rachael Hustler*	*PepsiCo PAO fund, core funds, Scottish Agronomy, Balgonie Estates Ltd, Kingdom Farming*	*2022-2024*
Automate reporting for Advisory Scotland	*Automate practitioner data downloading, collation and display for Advisory Scotland*	*Cameron Hubbard, Sabeeth Shoeb, Nick Hesford, Marlies Nicolai, Amin Alhawary, Julie Ewald*	*Core funds*	*2023-ongoing*
Automate camera image recognition (see p16)	*Develop research team capacity to utilise automatic. image recognition of field camera data*	*Sabeeth Shoeb, Robert Turner, Amin Alhawary, Elli Rivers, Mike Short, Julie Ewald*	*Core funds*	*2023-ongoing*
PhD: Biodiversity footprint of foods	*Creating an index of crop-farming traits to assess the biodiversity footprint of foods*	*Helen Waters. Supervisors: Julie Ewald, Dr Alfred Gathorne-Hardy (University of Edinburgh), Dr Barbara Smith (Coventry University)*	*NERC/GWCT*	*2019- ongoing*

UPLANDS RESEARCH IN 2023

Project title	Description	Staff	Funding source	Date
Grouse count scheme	*Annual grouse and parasitic worm counts in relation to moorland management indices and biodiversity*	*David Baines, Philip Warren, Kathy Fletcher*	*Core funds, Gunnerside Estate*	*1980- ongoing*
Black grouse monitoring	*Annual lek counts and brood counts*	*Philip Warren, David Baines, Kathy Fletcher*	*Core funds, Natural England*	*1989- ongoing*
Heather burning on peatland	*Vegetation and hydrological responses to burning on peatland*	*Sian Whitehead*	*Core funds*	*2018-2027*
Long-term heather management experiments on blanket peat	*Are burning and cutting useful management tools for blanket bog restoration? Does the structure and composition of pre-burn vegetation influence post-burn vegetation recovery?*	*Sian Whitehead, Leah Cloonan, Holly Appleby*	*Core funds*	*2019-2028*
Rush management for breeding waders	*Experimental rush cutting to improve habitat for breeding lapwing*	*David Baines, Sian Whitehead*	*Philip Wayre Uplands Trust*	*2020-2023*
Cranefly monitoring	*Pilot study to test methods of quantifying cranefly emergence periods on peatland habitats*	*David Baines, Leah Cloonan*	*Core funds*	*2021-2023*
Meadow pipits	*Standardised permanent transects to consider annual variations in pipit abundance and defining optimal diurnal survey periods*	*David Baines*	*Core funds*	*2021-2023*
Merlin (Magic) Recovery Project (see p38)	*Testing proposed hypotheses of merlin decline on grouse moors in northern England*	*David Baines, Philip Warren, Matthew Henderson*	*Defra Green Recovery Challenge Fund through HLF*	*2021-2023*
Long-term heather cutting experiments	*Vegetation recovery and brash decomposition rates following heather cutting at different heights and over different peat depths*	*Sian Whitehead*	*Core funds*	*2021-2030*
Recovery of heather post-beetle outbreak	*Experimental cutting and burning to aid heather recovery after heather beetle attacks*	*Sian Whitehead, David Baines*	*Gunnerside Estate*	*2021-2030*
Predators of wader clutches	*Camera traps to detect specific predators of wader clutches in the North Pennines*	*David Baines, Angus Smith, Holly Appleby*	*Core funds*	*2022-2023*
Maternal condition in red grouse	*Roles of food quality, parasites and weather in influencing pre-breeding hen condition*	*David Baines, Leah Cloonan*	*Core funds*	*2022-2023*
Upland Review	*A review of the biodiversity impacts of upland management in the UK*	*Felix Meister, Scott Newey, Louise de Raad, Andrew Hoodless*	*Core funds, private donors*	*2022-2024*
Mountain hare and tick	*The relationship between mountain hare abundance and the number of ticks on red grouse and wader chicks*	*Scott Newey, Kathy Fletcher*	*Private donors, Core funds*	*2022-2025*
Fires in the uplands	*Future impact of prescribed fires and woodland restoration on biodiversity and carbon stocks in the Cairngorms National Park*	*Michel Valette (Imperial College London), Scott Newey, Kate Schrenberg and Terry Dawson (Kings College London)*	*Leverhulme Trust (Grant No. RC-2018-023), Core funds*	*2023-2024*
Black Grouse Range Expansion	*Translocation of black grouse from North Pennines to North York Moors. Exploration of factors influencing chick survival*	*David Baines, Philip Warren, Holly Appleby*	*Natural England Species Recovery Programme*	*2023-2025*

FARMLAND RESEARCH IN 2023

Project title	Description	Staff	Funding source	Date
Chick-food and farming systems	*A comparison of grey partridge chick-food in conventional and organically farmed crops and habitats*	*Steve Moreby, Niamh McHugh, Jayna Connelly, Madeleine Baker, Imogen Vowles, Emily Aitken*	*Private funds*	*2015- ongoing*
Long-term monitoring	*Monitoring of wildlife on BASF demonstration farms*	*Lucy Capstick, Niamh McHugh, Jayna Connelly, Madeleine Baker, Madeline Kettlewell, Imogen Vowles, Emily Aitken*	*BASF*	*2017- ongoing*
Chick-food invertebrate levels	*Chick-food invertebrate levels in crops and non-crop habitats on three estates*	*Niamh McHugh, Steve Moreby, Jayna Connelly, Madeleine Baker, Madeline Kettlewell, Imogen Vowles, Emily Aitken*	*Private funds, The Millichope Foundation*	*2017- ongoing*

BEESPOKE (see p46)	Increasing the area of pollinator habitat	Lucy Capstick, Niamh McHugh, Jayna Connelly, John Holland	EU Interreg North Sea Region	2019-2023
The Owl Box Initiative (see p44)	Barn owl conservation, research and engagement project	Ellie Ness, Niamh McHugh, Chris Heward	Wixamtree Trust	2020-2023
FRAMEwork	Evaluation and development of Farmer Cluster approach across Europe	Niamh McHugh, Rachel Nichols, Ellie Ness, Jayna Connelly, Madeleine Baker, Madeline Kettlewell	EU Horizon 2020	2020-2025
Farmland birds and farming systems	Comparison of farmland bird abundance relative to conventional and organically farmed crops and agri-environment habitats	Niamh McHugh, Ellie Ness,	Private funds	2020- ongoing
H3 Healthy soils, healthy food, healthy people	Ecological evaluation of Regenerative Agriculture	Niamh McHugh, Lucy Capstick, Ellie Ness, Jayna Connelly, Imogen Vowles, Emily Aitken	UKRI (Subcontract) Cambridge University	2021-2025
Use of green finance by Farmer groups	Explores the potential of Regional Farm and Rural Support Groups to stimulate Green Finance Markets	Niamh McHugh, Lucy Capstick	Natural England	2023-2024
PhD: Solitary bees (see p48)	Seed mixes for solitary bees	Rachel Nichols. Supervisors: John Holland, Prof Dave Goulson (University of Sussex)	NERC/GWCT	2018-2023
PhD: Effects of farm management practices	Exploring the synergies and trade-offs of farm management practices on environmental health and human wellbeing	Samantha Bishop. Supervisors: Niamh McHugh, Dr Mark Lee (Royal Holloway University Of London)	Royal Holloway	2023-2027

ALLERTON PROJECT RESEARCH IN 2023

Project title	Description	Staff	Funding source	Date
Monitoring wildlife at Loddington (see p50)	Annual monitoring of game species, songbirds, invertebrates, plants and habitat	Chris Stoate, John Szczur, Alastair Leake, Steve Moreby, John Holland	Allerton Project funds	1992- ongoing
Effect of game management at Loddington	Effect of ceasing predator control and winter feeding on nesting success and breeding numbers of songbirds	Chris Stoate, Alastair Leake, John Szczur	Allerton Project funds	2001- ongoing
Water Friendly Farming	A landscape-scale experiment testing integration of resource protection and flood risk management with farming in the upper Welland	Chris Stoate, John Szczur, Jeremy Biggs, Penny Williams, (Freshwater Habitats Trust), Prof Colin Brown (University of York)	EA, Regional Flood and Coastal Committee	2011-2027
Soil monitoring	Survey of soil biological, physical and chemical properties	Chris Stoate, Jenny Bussell, Alastair Leake, Gemma Fox	Allerton Project	2014- ongoing
Conservation & Regenerative Agriculture	Economic and environmental impacts of three contrasting crop production approaches	Alastair Leake, Joe Stanley, Jenny Bussell, Gemma Fox, John Szczur, Oliver Carrick	Syngenta	2017- ongoing
Kellogg's Origins	Helping Kellogg's cereal growers reduce their environmental and climate impact	Alastair Leake, Alice Midmer	Kellogg's	2017-ongoing
Agroforestry	Optimising tree densities to meet multiple objectives in grazed pasture	Chris Stoate, Jenny Bussell, Gemma Fox, Alastair Leake, John Szczur, Joe Stanley	Woodland Trust	2018- ongoing
Farming with Nature	Promoting sustainable farming practice & Integrated Pest Management	Saya Harvey, Jemma Clifford, Alice Midmer	Marks & Spencer	2019- ongoing
Tree leaves as ruminant fodder	Assessing the multiple benefits of tree leaves as fodder for ruminants	Chris Stoate, Jenny Bussell, Gemma Fox, Dr Nigel Kendall (Nottingham University)	Woodland Trust	2019-2023
AgriCapture CO_2 (see p58)	Promoting regenerative agricultural practice & use of farm carbon credits across Europe	Alastair Leake, Joe Stanley, Jemma Clifford	EU Horizon 2020	2021-2023
Biochar Demonstrator	Working with the University of Nottingham to assess impact of biochar application to arable land	Jenny Bussell, Gemma Fox, Olly Carrick, Joe Stanley, Chris Stoate	UKRI	2022-ongoing
Soil Biology and Soil Health	Investigating the impacts of long-term direct-drill on the microbial community and carbon storage	Jenny Bussell, Gemma Fox	Kildare	2022-2023
Eye Brook Farmer Cluster	Identifying synergies between environmental and farm business objectives at the landscape scale	Chris Stoate, Joe Stanley, Olly Carrick	RPA	2022-2025
Climate Neutral Farms (ClieNFarms) (see p60)	Working with Nestlé UK to help wheat farmers move toward carbon neutrality in the east of England	Alastair Leake, Joe Stanley, Alice Midmer, Amie Pickering	EU Horizon 2020	2022-2025
Biostimulant trials	Working with Nestlé UK and FERA to trial a variety of novel biostimulants on arable crops	Jenny Bussell, Gemma Fox, Olly Carrick, Joe Stanley	Nestlé UK	2023-ongoing
Landscape use by bats	Landscape use by bats in Leighfield Forest	Chris Stoate, Niamh McHugh, Nathalie Cossa, Andy Neilson, Leicestershire & Rutland Wildlife Trust	NE	2023-2024
Landscape scale bumblebee conservation (see p56)	Spatial modelling of landuse change to deliver 10% nature recovery of bumblebees	Chris Stoate, Max Rayner	NE	2023-2024
Brown trout in the Eye Brook	Survey of brown trout in the Eye Brook, and farmer engagement to reduce agricultural impacts	Chris Stoate, Will Beaumont, Luke Scott, John Szczur	NE	2023-2024
Nitrogen Climate Smart (NCS) Farming	Working with PGRO to increase the area of the UK pulse crop and reduce climate impact of UK arable rotation	Jenny Bussell, Olly Carrick, Gemma Fox, Chris Stoate, Joe Stanley	Defra	2023-2026

AUCHNERRAN PROJECT RESEARCH IN 2023

Project title	Description	Staff	Funding source	Date
Rabbit population monitoring	Assessing rabbit numbers in relation to control methods	Max Wright, Panagiotis Nikolaou, Adam Watts, Kate Goodman, Seth Howell	Core funds	2016- ongoing

Wader population monitoring	*Surveying of wader numbers, distribution and productivity in relation to farm management practices*	*Max Wright, Panagiotis Nikolaou, Adam Watts*	*Core funds, Working for Waders*	*2017- ongoing*
Core farm monitoring	*Assessing population trends of farmland birds, raptor nesting and breeding success, surveying corvid numbers and distribution, assessing gamebird and hare numbers*	*Max Wright, Panagiotis Nikolaou, Adam Watts, Kate Goodman, Seth Howell*	*Core funds*	*2017- ongoing*
Woodcock surveys	*Assessing woodcock resident and migratory population trends*	*Max Wright, Panagiotis Nikolaou, Adam Watts*	*Core funds*	*2017- ongoing*
Carbon and natural capital assessments	*Undertaking and assessing the applicability of assessments*	*Ross Macleod, Louise de Raad*	*Core funds, CNPA Horizon 2020 funding*	*2021- ongoing*
The impact of egg predators on waders (see p62)	*Quantifying the impact of different predator species on wader productivity*	*Louise de Raad, Max Wright, Panagiotis Nikolaou, Adam Watts*	*Core funds, Working for Waders*	*2021- ongoing*
Winter food for snipe and woodcock	*By digging in hay bales and covering them with rabbit/deer gralloch we encourage winter food even in freezing conditions*	*Louise de Raad, Max Wright, Panagiotis Nikolaou, Adam Watts Kate Goodman, Seth Howell*	*Core funds*	*2022- ongoing*
Songbird feeders	*Providing two different songbird mixes across the farm to enhance winter survival and breeding condition*	*Louise de Raad, Max Wright, Panagiotis Nikolaou, Adam Watts*	*Core funds*	*2022- ongoing*
Soil sampling	*Investigating soil condition in advance of new grassland management techniques*	*Louise de Raad, Dyfan Jenkins, Max Wright*	*Core funds, CNPA Horizon 2020*	*2022- ongoing*
Badger Monitoring	*Monitoring activity and population of badgers at GWSDF*	*Max Wright, Panagiotis Nikolaou, Adam Watts, Kate Goodman, Seth Howell*	*Core funds*	*2023- ongoing*
Frost resistance & productivity fodder beet trial	*Trialling new farm initiatives such as testing fodder beet and swede crop frost resistance*	*Louise de Raad, Dyfan Jenkins, Max Wright, Kate Goodman, Seth Howell*	*Core funds*	*2023- ongoing*

PREDATION RESEARCH IN 2023

Project title	Description	Staff	Funding source	Date
Use of ink-tracking tunnels by small mustelids in a river meadow habitat	*Revision of scientific write-up following peer review*	*Mike Short, Tom Porteus*	*Core funds*	*2015-2023*
Fox GPS-tracking in the Avon Valley (see p68)	*Analysis of GPS tracking data and DNA evidence to determine resident density, activity patterns and habitat use of foxes in the Avon Valley, in the context of declining wading bird populations*	*Mike Short, Tom Porteus, Jodie Case, Andrew Hoodless*	*Core funds, private funds*	*2015-2024*
Diet of foxes in the Avon Valley and New Forest	*Macro and molecular analysis of stomach and faecal material to determine main dietary components supporting foxes in areas where wading birds breed*	*Mike Short, Jodie Case, Rosa Hicks, Nathan Williams*	*Core funds, The Kilroot Foundation, Exeter University*	*2021- ongoing*
Wader nest monitoring across the New Forest National Park	*Use of trail cameras to monitor clutch survival of waders of conservation concern including coastal species*	*Mike Short, Jodie Case, Elli Rivers*	*Core funds, private funds*	*2021- ongoing*
How effective is predator control for wading bird conservation?	*Collection and analysis of predator culling records from multiple sites managed for breeding waders*	*Mike Short, Jodie Case, Elli Rivers, Nathan Williams, Tom Porteus*	*Core funds, private funds*	*2021- ongoing*
Non-lethal nest protection for wading birds (see p66)	*Design and evaluation of novel nest protection measures for wading birds of conservation concern*	*Mike Short*	*Core funds, Natural England, private funds*	*2022- ongoing*
Population dynamics of foxes in the New Forest	*Analysis of uteri from culled foxes, to determine cub productivity*	*Mike Short, Rosa Hicks, Nathan Williams*	*Core funds, private funds*	*2023*
Curlew chick survival in the New Forest	*Radio-tracking curlew chicks to determine survival outcomes and causes of mortality*	*Elli Rivers, Jodie Case, Rosa Hicks, Mike Short*	*Core funds, private funds*	*2023- ongoing*
The Gravelly Shores Project	*Creation of shingle habitat for coastal shorebirds breeding in the Solent, and evaluation of novel non-lethal predation management measures*	*Mike Short, Elli Rivers, Matthew Cooper, Ben Stephens*	*Natural England Species Recovery Programme*	*2023-2025*
PhD: Why are there so many foxes?	*How the large-scale spatial population dynamics of the red fox, may determine the local fate of wading birds breeding in the Avon Valley and New Forest*	*Nathan Williams Supervisors: Mike Short, Tom Porteus, Andrew Hoodless, Dr Emilie Hardouin, Dr Demetra Andreou & Prof Richard Stillman (BU)*	*Core funds, private funds NERC*	*2021-2024*

FISHERIES RESEARCH IN 2023

Project title	Description	Staff	Funding source	Date
Salmonid life-history strategies in freshwater	*Understanding the population declines in salmon and sea trout*	*Rasmus Lauridsen, Dylan Roberts, William Beaumont, Luke Scott, Sophie Elliot, Thomas Lecointre, Jonathan Gilson (Cefas)*	*Core funds, EA, Cefas, The Missing Salmon Alliance EU Interreg Channel*	*2009- ongoing*
Grayling ecology	*Long-term study of the ecology of River Wylye grayling*	*Luke Scott, William Beaumont, Thomas Lecointre, Richard Cove (GRT), Robert Wellard (PS), Jessica Marsh (Cefas)*	*Core funds, Grayling Research Trust, Piscatorial Society*	*2009- ongoing*
Headwaters and salmonids	*Contribution of headwaters to migratory salmonid populations and the impacts of extreme events*	*Rasmus Lauridsen, William Beaumont, Luke Scott, Dylan Roberts, Sophie Elliott Thomas Lecointre, Jonathan Gilson (Cefas)*	*Core funds, Cefas, Defra, The Missing Salmon Alliance*	*2015-2023*
Salmon and trout smolt tracking in four estuaries in the Channel	*Movements and survival of salmon and sea trout smolts through four estuaries in the English Channel as part of the SAMARCH project*	*Céline Artero, Rasmus Lauridsen, Luke Scott, Dylan Roberts, William Beaumont, Thomas Lecointre, Stephen Gregory (Cefas), Elodie Reveillac (Agrocampus Ouest)*	*EU Interreg Channel The Missing Salmon Alliance*	*2017-2023*
Sea trout kelt tracking in the Channel	*Movements and survival of sea trout kelts at sea from three rivers in the English Channel as part of the SAMARCH project*	*Céline Artero, Rasmus Lauridsen, William Beaumont, Luke Scott, Dylan Roberts, Will Beaumont, Thomas Lecointre, Elodie Reveillac (Agrocampus Ouest)*	*EU Interreg Channel, The Missing Salmon Alliance*	*2017-2023*

Genetic tools for trout management (see p72)	*Creation of a genetic database for trout in the Channel rivers (ca. 100 rivers) and a tool for identifying areas at sea important for sea trout*	*Jamie Stevens, Andy King (Exeter University), Sophie Launey (INRAE), Dylan Roberts, Rasmus Lauridsen, Thomas Lecointre,*	*EU Interreg Channel, The Missing Salmon Alliance*	*2017-2023*
New and improved salmon stock assessment tools	*Providing new information for stock assessment models and new stock assessment tools in England and France as part of the SAMARCH project*	*Stephen Gregory (Cefas), Marie Nevoux (INRAE), Etienne Rivot (Agrocampus Ouest), Rasmus Lauridsen*	*EU Interreg Channel, The Missing Salmon Alliance*	*2017-2023*
New policies for salmon and sea trout in coastal and transitional waters	*Developing new policies for the better management of salmon and sea trout in coastal and transitional waters based on the outputs of SAMARCH*	*Sarah Bayley Slater, Dylan Roberts, Cameron Hubbard, Lawrence Talks, Simon Toms, Phil Rippon (EA), John Hickey, Janina Gray (Widlfish Conservation)*	*EU Interreg Channel, The Missing Salmon Alliance*	*2017-2023*
PhD: Trout metal tolerance (see p74)	*Disentangling the three main factors affecting trout ability to tolerate metals: evolution, local adaption and pollution*	*Daniel Osmond. Supervisors: Rasmus Lauridsen, Dr Jamie Stephens (Exeter University), Prof Mike Bruford (Cardiff University), Bruce Stockley (WRT)*	*GW4 FRESH CDT, Core funds*	*2019-2023*

LOWLAND GAME RESEARCH IN 2023

Project title	Description	Staff	Funding source	Date
Game crops and breeding birds	*Gamecrops on grassland in Exmoor area and hedgerow breeding birds*	*Rufus Sage, Maureen Woodburn, Sam McCready, Jenny Coomes*	*Greater Exmoor Shoot Association*	*2021-2023*
Releasing gamebirds and foxes (see p78)	*Field-based study of fox abundance and diet in relation to releasing gamebirds and predator control*	*Jenny Coomes, Maureen Woodburn, Rufus Sage, Joseph Werling, Katie Holmes*	*BASC*	*2021-2024*
Released gamebird dispersal	*Documenting movement and dispersal of released gamebirds*	*Rufus Sage, Maureen Woodburn, Jenny Coomes, Joseph Werling, Katie Holmes*	*BASC*	*2021-2024*
Enhanced pheasants	*Documenting release success for pheasants enhanced in rearing system*	*Maureen Woodburn*	*Core funds*	*2022- ongoing*
Invertebrates and releasing gamebirds	*Review paper of effect of releasing on invertebrates*	*Rufus Sage*	*NE*	*2023-2024*
Pheasant releasing and designated woodlands	*National field study of effects of pheasant releases on SAC and SSSI woodlands*	*Rufus Sage, Maureen Woodburn, Clive Bealey*	*NE*	*2023-2025*

Key to abbreviations: BASC = British Association for Shooting and Conservation; BASF = Badische Anilin und Soda Fabrik; BBSRC = Biotechnology and Biological Sciences Research Council; BEESPOKE = Benefiting Ecosystems through Evaluation of food Supplies for Pollination to Open up Knowledge for End users; BTO = British Trust for Ornithology; BU = Bournemouth University; CEFAS = Centre for Environment, Fisheries & Aquaculture Science; CNPA = Cairngorms National Park Authority; EA = Environment Agency; EU = European Union; FE = Forestry England; FRAMEwork = Farmer clusters for Realising Agrobiodiversity Management across Ecosystems; GCUSA = Game Conservancy USA; GRT = Grayling Research Trust; GWSDF = Game & Wildlife Scottish Demonstration Farm; H2020 = Horizon 20:20; HLF = Heritage Lottery Fund; INRAE = Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement; Interreg = European Regional Development Board; LIFE = L'Instrument Financier pour l'Environnement; NARGC = National Association of Regional Game Councils; NPWS = National Parks and Wildlife Service; NE = Natural England; NERC = Natural Environment Research Council; NNR = National Nature Reserves; NSR PARTRIDGE = North Sea Region Protecting the Area's Resources Through Researched Innovative Demonstration of Good Examples; PAO = Positive Agriculture Outcomes Fund; PGRO = Processors and Growers Research Organisation; PS = Piscatorial Society; QMUL = Queen Mary University of London; RPA = Rural Payments Agency; SAMARCH = SAlmonid MAnagement Round the CHannel; SARIC = Sustainable Agriculture Research and Innovation Club; SSSI = Sites of Special Scientific Interest; UCC = University College Cork; UKRI = UK Research Innovations; WRT = Westcountry Rivers Trust.

Eurasian oystercatchers. © Rudmer Zwerver

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GWCT research projects in 2023

GWCT scientific publications 2023

Capercaillie. © Wild Media

Artero, C, Gregory, RS, Beaumont, WA, Josset, Q, Jeannot, N, Cole, A, Lamireau, L, Réveillac, E & **Lauridsen, RB** (2023) Survival of Atlantic salmon and sea trout smolts in transitional waters. *Marine Ecology Progress Series*, 709: 91–108.

Baines, D & Aebischer, NJ (2023) Estimating capercaillie *Tetrao urogallus* population size in Scotland from annual leks and counts of broods over the period 2010-2020. *Wildlife Biology*, 2023(e01104): 1–10.

Baines, D & Fletcher, K (2023) A comparison of genetic and field methods for assessing capercaillie abundance. *European Journal of Wildlife Research*, 69(109): 1–4.

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Bristow, TG, McHugh, NM, Heward, CJ, Jenkins, DL, Newson, SE & Snaddon, JL (2023) Vocal individuality measures reveal spatial and temporal variation in roding behaviour in woodcock *(Scolopax rusticola)*. *Ibis*, 165: 959–973.

Capstick, L, Connelly, J, McHugh, NM & Holland, J (2023) Crop and landscape factors affecting variation in composition and behaviour of the pollinator community in field bean crops. *Journal of Pollination Ecology*, 34: 341–357.

Dambrine, C, Lambert, P, **Elliott, SAM**, Boavida-Portugal, J, Mateus, CS, Leary, C, Pauwels, I, Poole, R, Roche, W, Bergh, E, Vanoverbeke, J, Chust, G & Lassalle, G (2023) Connecting population functionality with distribution model predictions to support freshwater and marine management of diadromous species. *Biological Conservation*. 287: 110324. DOI: 10.1016/j.biocon.2023.110324.

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Elliott, SAM, Deleys, N, Beaulaton, L, Rivot, E, Réveillac, E & Acou, A (2023) Fisheries-dependent and -independent data used to model the distribution of diadromous fish at-sea. *Data in Brief*, 48(109107): 1–6.

Hancock, GRA, **Grayshon, L, Burrell, RA**, Cuthill, I, **Hoodless, A** & Troscianko, J (2023) Habitat geometry rather than visual acuity limits the visibility of a ground-nesting bird's clutch to terrestrial predators. *Ecology and Evolution*, 13(e10471): 1-13.

ICES, 2023a. ICES. 2023. Working Group on North Atlantic Salmon (WGNAS). *ICES Scientific Reports*. 5:41. 478 pp. https://doi.org/10.17895/ices.pub.22743713.

ICES, 2023b. The Second ICES/NASCO Workshop on Salmon Mortality at Sea (WKSalmon2; outputs from 2022 meeting). *ICES Scientific Reports*. 5:36. 69 pp. https://doi.org/10.17895/ices.pub.22560790.

Jenkins, DL, Sparks, TH & **Parish, DMB** (2023) Wader population trends and productivity 1987-2022 in mid-Deeside, north-east Scotland, and the factors driving them. *Scottish Birds*, 43: 195–205.

Lilly, J...... **Elliott, SAM**, et al. (2023) Migration patterns and navigation cues of Atlantic salmon post-smolts migrating from 12 rivers through the coastal zones around the Irish Sea. *Journal of Fish Biology*, 104(1), 265-283.

McHugh, NM, Nichols, R, McVeigh, A, Bown, B, Powell, R, Wilson, P, Swan, E & **Holland, J** (2023) Foraging preferences of bumblebee castes are weakly related to plant species cover on two arable agri-environment habitat types: Plant preferences of bumblebees by caste. *Journal of Pollination Ecology*, 34: 252–266.

Nichols, RN, Holland, JM & Goulson, D (2023) A novel farmland wildflower seed mix attracts a greater abundance and richness of pollinating insects than standard mixes. *Insect Conservation and Diversity*, 16: 190–204.

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Smith, BM, Eggleton, P, **Holland, JM**, Andruszko, F, Gathorne-Hardy, A & Carpenter, D (2023) Resolving a heated debate: The utility of prescribed burning as a management tool for biodiversity on lowland heath. *Journal of Applied Ecology*, 60: 2040–2051.

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GWCT current staff in bold

Financial report
for 2023

The summary report and financial statement for the year ended 31 December 2023, set out below and on pages 90 to 91, consist of information extracted from the full statutory Trustees' report and consolidated accounts of the Game & Wildlife Conservation Trust and its wholly-owned subsidiaries Game & Wildlife Conservation Trading Limited, Game & Wildlife Scottish Demonstration Farm, GWCT Natural Capital Advisory Limited and GWCT Events Limited. They do not comprise the full statutory Trustees' report and accounts, which were approved by the Trustees on 24 April 2024 and which may be obtained from the Trust's Headquarters. The auditors have issued unqualified reports on the full annual accounts and on the consistency of the Trustees' report with those accounts, and their report on the full accounts contained no statement under sections 498(2) or 498(3) of the Companies Act 2006.

KEY POINTS

- Income was £11 million, very similar to 2022.
- Expenditure on charitable activities was £7.4 million compared with £6.6 million in 2022.
- There was a surplus of £440,000 on unrestricted funds.
- The Trust's net assets were £12.7 million at the end of the year.

Thanks to the continuing generosity of our supporters and some very welcome legacies, we were able to increase our research programme while maintaining the stable financial position which the Trust has established over the last few years. The Trust ran a full programme of fundraising events while engaging with an increasing constituency of supporters through our use of modern communications methods.

The Trustees reviewed the Trust's reserves policy in 2021 in the light of the pandemic and determined that the target should be increased to £2.2 million, with a minimum of £1.5 million, to reflect the uncertainties which it created. In current circumstances where the UK and the world economy remain under strain we feel that the revised level remains appropriate. Having established this new level the Trustees continue to be satisfied that the Trust's financial position is sound.

Plans for future periods

A new five year business plan was approved in July 2021. The key aims are:

1. To establish and build significant public support for a more positive approach to conservation.
2. To tackle research knowledge and evidence gaps in: Released gamebird dispersal, predator distribution and the recovery of salmonid species.
3. To persuade game managers to: Practise GWCT's Sustainable Game Management Principles; To embed the ethos of net biodiversity gain into their game management and quantify its biodiversity and environmental delivery; Quantify and communicate their net biodiversity gain through structured reporting using Apps such as EpiCollect, backed with timely interpretation; Accredit their net biodiversity gain through GWCT Shoot Biodiversity Assessments either online or through assessment visits.
4. To secure policy change such that: The role of predation control in species recovery is understood and embedded in Environment Land Management Schemes and equivalent agri-environment schemes in Wales; There are practical, workable licences for the control of protected predators to enhance nature conservation; Post-Brexit Agri-Environment Schemes are fit for purpose, informed by GWCT's researched options; Environmental principles such as the Precautionary, Polluter Pays and Offsetting principles are pragmatically implemented into future policy; Game management remains economically and culturally active enough to continue to make a net contribution to biodiversity gain.
5. To be a leader in the demonstration and uptake of greener farming.
6. To support our staff by: Drawing up our first people strategy and people plan; Creating a flexible, agile, adaptable team of scientists delivering accessible high-quality science.
7. To maintain the financial viability of GWCT by: Increasing the number of membership subscriptions; Reviewing the cash reserves policy and increase cash reserves as appropriate.

Sir Jim Paice
Chairman of the Trustees

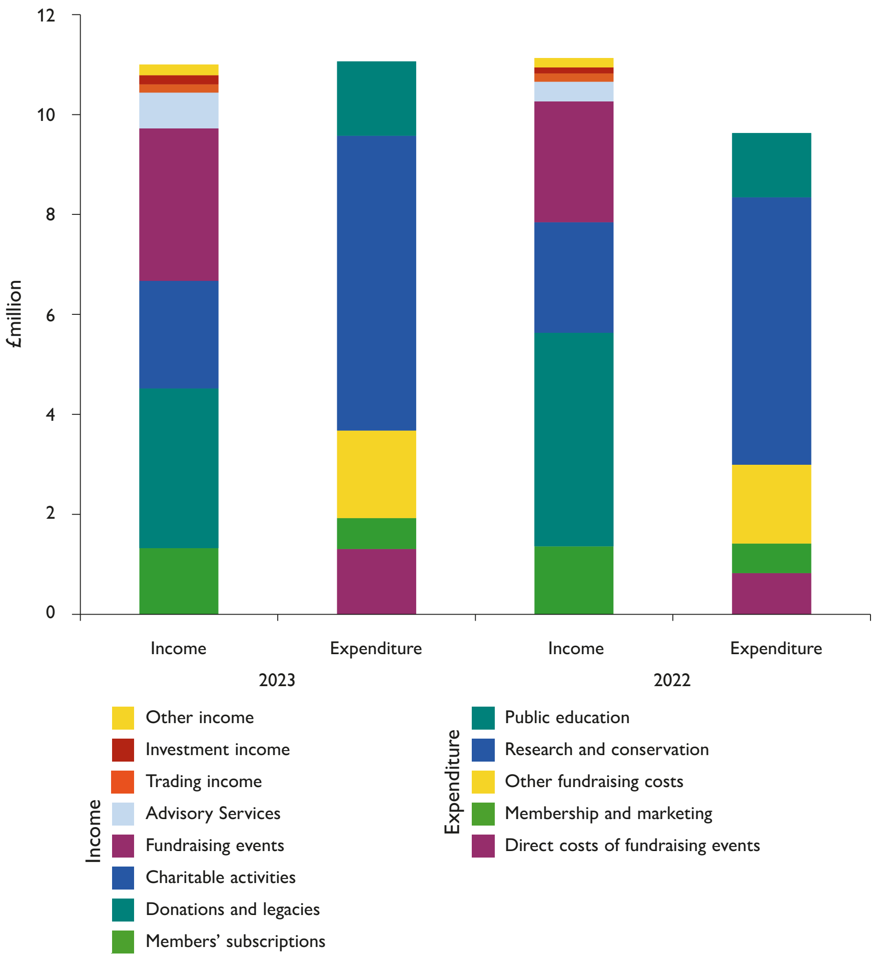

Figure 1

Total incoming and outgoing resources in 2023 (and 2022) showing the relative income and costs for different activities

Independent auditors' statement

to the Trustees and Members of the Game & Wildlife Conservation Trust (limited by guarantee)

We have examined the summary financial statement for the year ended 31 December 2023 which is set out on pages 90 and 91.

Opinion

In our opinion the summary financial statement is consistent with the full annual financial statements of the Game & Wildlife Conservation Trust for the year ended 31 December 2023 and complies with the applicable requirements of Section 427 of the Companies Act 2006 and the regulations made thereunder.

Respective responsibilities of Trustees and Auditors

The Trustees are responsible for preparing the summarised Financial Report in accordance with applicable United Kingdom law. Our responsibility is to report to you our opinion of the consistency of the summary financial statement with the full annual financial statements and the Trustees' Report, and its compliance with the relevant requirements of section 427 of the Companies Act 2006 and the regulations made thereunder.

We also read the other information contained in the summarised Financial Report and consider the implications for our report if we become aware of any apparent misstatement or inconsistencies with the summary financial statement. The other information comprises only the Review of Financial Performance.

FLETCHER & PARTNERS
Chartered Accountants and Statutory Auditors
Salisbury, 29 April 2024

Consolidated

Statement of financial activities

	General Fund £	Restricted Funds £	Endowed Funds £	**Total 2023 £**	Total 2022 £
INCOME AND ENDOWMENTS FROM:					
Donations and legacies					
Members' subscriptions	1,327,363	-	-	**1,327,363**	1,359,424
Donations and legacies	2,208,162	983,046	-	**3,191,208**	4,273,574
	3,535,525	983,046	-	**4,518,571**	5,632,998
Charitable activities	-	2,151,769	-	**2,151,769**	2,211,746
Other trading activities					
Fundraising events	2,984,153	68,794	-	**3,052,947**	2,417,225
Advisory Service	714,769	-	-	**714,769**	394,783
Trading income	169,337	-	-	**169,337**	166,162
Investment income	37,418	144,655	-	**182,073**	121,429
Other	114,183	99,416	-	**213,599**	184,498
TOTAL	7,555,385	3,447,680	-	**11,003,065**	11,128,841
EXPENDITURE ON:					
Raising funds					
Direct costs of fundraising events	1,307,798	-	-	**1,307,798**	827,478
Membership and marketing	620,345	-	-	**620,345**	590,460
Other fundraising costs	1,741,529	-	10,501	**1,752,030**	1,573,339
	3,669,672	-	10,501	**3,680,173**	2,991,277
Charitable activities					
Research and conservation					
Lowlands	1,287,108	1,401,928	-	**2,689,036**	2,268,946
Uplands	505,933	142,336	-	**648,269**	672,005
Demonstration	303,295	1,654,001	4,150	**1,961,446**	1,748,599
Fisheries	-	596,443	-	**596,443**	666,146
	2,096,336	3,794,708	4,150	**5,895,194**	5,355,696
Public education	1,349,015	139,820	-	**1,488,835**	1,282,677
	3,445,351	3,934,528	4,150	**7,384,029**	6,638,373
TOTAL	7,115,023	3,934,528	14,651	**11,064,202**	9,629,650
Income/(expenditure) before investment gains	440,362	(486,848)	(14,651)	**(61,137)**	1,499,188
Net gains/(losses) on investments:					
Realised	(7,806)	-	10,619	**2,813**	(29,166)
Unrealised	74,390	-	112,077	**186,467**	(356,032)
NET INCOME/(EXPENDITURE)	506,946	(486,848)	108,045	**128,143**	1,113,990
Transfers between funds	-	-	-	-	
NET MOVEMENT IN FUNDS	506,946	(486,848)	108,045	**128,143**	1,113,990
RECONCILIATION OF FUNDS					
Total funds brought forward	4,908,242	2,802,972	4,861,846	**12,573,060**	11,459,070
TOTAL FUNDS CARRIED FORWARD	£5,415,188	£2,316,124	£4,969,891	**£12,701,203**	£12,573,060

Consolidated
Balance sheet
as at 31 December 2023

		2023		2022
	£	£	£	£
FIXED ASSETS				
Tangible assets		4,059,137		3,604,872
Investments		4,888,590		5,014,580
		8,947,727		8,619,452
CURRENT ASSETS				
Stock	475,759		496,279	
Debtors	2,110,726		2,136,478	
Cash at bank and in hand	2,983,156		3,069,675	
	5,569,641		5,702,432	
CREDITORS:				
Amounts falling due within one year	1,562,293		1,469,955	
NET CURRENT ASSETS		4,007,348		4,232,477
TOTAL ASSETS LESS CURRENT LIABILITIES		12,955,075		12,851,929
CREDITORS:				
Amounts falling due after more than one year		253,872		278,869
NET ASSETS		£12,701,203		£12,573,060
Representing:				
CAPITAL FUNDS				
Endowment funds		4,969,891		4,861,846
INCOME FUNDS				
Restricted funds		2,316,124		2,802,972
Unrestricted funds:				
Fair value reserve	276,043		193,847	
General fund	5,106,438		4,683,558	
Non-charitable trading fund	32,707		30,837	
		5,415,188		4,908,242
TOTAL FUNDS		£12,701,203		£12,573,060

Approved by the Trustees on 24 April 2024 and signed on their behalf

J PAICE
Chairman of the Trustees

GWCT staff 2023

CHIEF EXECUTIVE	Teresa Dent BSc, FRAgS, CBE
Personal Assistant	Laura Gell
Business Assistant	Liz Scott *(until May)*
Minute Taker (p/t)	Venetia Tucker *(from January)*
Chief Operating Officer	Edward Macfarlane *(from May)*
Facilities Assistant	Kitty Benson *(from October)*
Head of Administration & Personnel	Alastair King Chartered MCIPD, MAHRM *(until September)*
HR Administrator	Thomas Davis
Headquarters Site Maintenance	Steve Fish
Site Maintenance	Kevin Hill
Cleaner	Theresa Fish
Chief Finance Officer	Nick Sheeran BSc, ACMA, CGMA
Accountant	Leigh Goodger *(until July)*
Head of Finance	Hilary Clewer BA
Finance Assistant	Lindsey Chappé De Leonval
Finance Assistant	Alan Gray
Finance Assistant	Julie Jones
Finance Assistant	Fiona Tierney *(from July)*
Head of Information Technology	James Long BSc
IT Assistant	Dean Jervis HNC, BA
DIRECTOR OF RESEARCH	Andrew Hoodless BSc, PhD
Personal Assistant (p/t)	Lynn Field
PhD Student *(Bournemouth University)* - lapwings and avian predators	Ryan Burrell BSc
PhD Student *(UCC Cork)* - woodcock in Ireland	James O'Neill BSc
PhD Student *(University of Exeter)* - lapwing nest crypsis	George Hancock BSc, MSc
Public Sector Fundraiser	Paul Stephens BApp.Sc
Public Sector Fundraiser Administrator	Ben Stephens MAAT
Curlew Country	Amanda Perkins
Curlew Country Project Officer	James Warrington BSc *(from February)*
Senior Biometrician *p/t*	Nicholas Aebischer Lic ès Sc Math, PhD, DSc
Principal Scientist – Farmland Ecology & GIS	Julie Ewald BS, MS, PhD
Librarian, National Gamebag Census Co-ordinator & Head of CRM	Corinne Duggins Lic ès Lettres
Partridge Count Scheme Co-ordinator	Neville Kingdon BSc, PgCert
GIS/Biometrics Analyst	Cameron Hubbard BSc, MSc
Placement Student shared with Predation *(University of Bristol)*	Matt Cooper *(from September)*
Placement Student shared with Uplands & Wetlands *(University of Kent)*	Ferne Ellington *(from August)*
Data Engineer/Scientist	Sabeeth Shoeb B.Tech, MSc
Placement Student – Computer Science *(UWE Bristol)*	Amin Alhawary *(from September)*
Head of Wildlife Recovery & Head of PARTRIDGE	Francis Buner Dipl Biol, PhD
PARTRIDGE Placement Student *(Bangor University)*	Jasmine Canham *(from September)*
Research Assistant	Ellie Raynor BSc *(until February)*
Head of Fisheries	Dylan Roberts BSc
Fisheries Policy and Communications officer	Sarah Baley Slater *(until June)*
Senior Fisheries Scientist	Sophie Elliott BSc, MSc, PhD
Data Scientist	Tommy Tham BSc *(from September)*
Head of Fisheries – Research	Rasmus Lauridsen BSc, MSc, PhD *(until May)*
Senior Fisheries Scientist (p/t)	William Beaumont MIFM
Fisheries Ecologist	Luke Scott
Project Scientist	Céline Artero BSc, MSc, PhD *(until March)*
Fisheries Project Officer	Will Beaumont BSc, MSc
Research Assistant	Thomas Lecointre BSc *(until January)*
PhD Student *(University of Exeter)* - adaption of trout to metal polluted rivers	Daniel Osmond BSc, MSc
Principal Scientist - Lowland Gamebird & Wildlife Research	Rufus Sage BSc, MSc, PhD
Senior Scientist	Maureen Woodburn BSc, MSc, PhD
Senior Scientist	Jenny Coomes BSc, MSc, PhD
Placement Student *(University of Sussex)*	Owen Hickman *(from July)*
Head of Wetland Research	Chris Heward BSc, PhD
Ecologist	Lizzie Grayshon BSc, MRes
Placement Student *(Harper Adams University)*	Lydia Farnell *(from September)*
Head of Predation Management Research	Mike Short HND
Research Assistant	Jodie Case BSc
PhD Student *(Bournemouth University)* - fox genetics	Nathan Williams BSc, MSc
PhD Student *(Bournemouth University)* - New Forest curlew	Elli Rivers BSc, MSc
Head of Farmland Ecology	Niamh McHugh BSc, MSc, PhD
Senior Entomologist	Steve Moreby BSc, MPhil
Senior Scientist	Lucy Capstick BSc, MSc, PhD
Research Scientist (p/t)	Rachel Nichols BSc, MSc, PhD
Research Assistant	Eleanor Ness BSc
Research Assistant	Jayna Connelly BSc, MSc
PhD Student *(Royal Holloway)* - effects of farm management practices	Samantha Bishop BSc, MSc *(from September)*
Placement Student *(University of Liverpool)*	Emily Aitken *(from September)*
Placement Student *(University of Brighton)*	Imogen Vowles *(from September)*
Director of Upland Research	David Baines BSc, PhD
Team Support Officer	Marie Jewitt *(until July)*
Senior Scientist	Phil Warren BSc, PhD
Species Recovery Project Assistant	Holly Appleby BSc, MRes *(from March)*
Research Assistant	Matthew Henderson *(until March)*
Senior Scientist	Siân Whitehead BSc, DPhil
Research Assistant Uplands	Leah Cloonan
Placement Student *(Harper Adams University)*	Jay Thomson *(from August)*
Director of GWSDF & Head of Research - Scotland	Louise de Raad BSc, MSc, PhD
Research Assistant - GWSDF Auchnerran	Max Wright BSc, MRes
Head Shepherd	Dyfan Jenkins
Placement Student *(Harper Adams University)*	Kate Goodman *(from August)*
Placement Student *(University Of Nottingham)*	Seth Howell *(from August)*
Senior Scientist - Scottish Upland Research	Scott Newey BSc, MSc, PhD

Senior Research Assistant - Scottish Upland Research	Kathy Fletcher BSc, MSc, PhD
Research Assistant	Felix Meister BA, MSt, DPhil *(until October)*
Senior Scientist Scottish Lowland Research	Bryony Tolhurst BSc, MSc, PhD *(April-December)*
Research Assistant - Scottish Grey Partridge Recovery Project	Fiona Torrance BSc
Placement Student *(University of Plymouth)*	Isabella Allan *(from August)*
Placement Student *(University of Reading)*	Rachael Hustler *(from August)*

DIRECTOR OF ADVISORY & EDUCATION	Roger Draycott HND, MSc, PhD[2]
Co-ordinator Advisory Services (p/t)	Lizzie Herring
Biodiversity Advisor – Farmland Ecology (p/t)	Jessica Brooks BSc, MSc, ACIEEM *(until July)*
Regional Advisor	Amber Lole BSc, MSc, BASIS
Senior Advisor	Mike Swan BSc, PhD
Head of Education & Advisor for Wales and NW England	Matthew Goodall BSc, MSc
Regional Advisor	Alex Keeble BSc, BASIS
Game Manager (p/t) – Allerton Project	Matthew Coupe
Biodiversity Advisor – northern England (p/t)	Jennie Stafford BSc, BASIS
Farmland Biodiversity Advisor	Megan Lock BSc, MCIEEM, BASIS
Ecologist	Ellie Raynor BSc *(from February)*
Graduate Ecologist	Sebastian Seely BSc *(from May)*
Operations Officer – Natural Capital Advisory	Digby Sowerby
Business Assistant – Natural Capital Advisory	Rachel Ridd

DIRECTOR OF POLICY, PARLIAMENTARY AFFAIRS & THE ALLERTON PROJECT	Alastair Leake BSc, MBPR (Agric), PhD, FRAgS, FIAgrM, CEnv
Secretary (p/t)	Sarah Large
Policy Officer (England) (p/t)	Henrietta Appleton BA, MSc
Assistant Project Manager – Allerton	Alice Midmer BSc, MSc, MBA, CEnv
Projects Administrator	Joanne Horrigan *(from December)*
Project Officer	Amie Pickering *(from December)*
Head of Research for the Allerton Project	Prof. Chris Stoate BA, PhD
Ecologist	John Szczur BSc
Soil Scientist (p/t)	Jennifer Bussell BSc, PhD
Research Assistant (p/t)	Gemma Fox BSc, MSc
Welland Project Officer	Patricia Antunes *(until March)*
Welland Community Engagement Officer	Katherine Field *(until March)*
Head of Farming, Training & Partnerships	Joe Stanley BA, GDip, ARAgS
Project Co-ordinator	Nieves Lovatt *(until October)*
Farm Manager	Oliver Carrick BSc
Farm Assistant	Michael Berg *(until August)*

DIRECTOR OF FUNDRAISING	Jeremy Payne MA, MCIOF
Prospect Researcher	Tara Ghai
Head of Events and Engagement	Vanessa Steel BA, MA
Events Manager	Iona Campbell BSc
Northern Regional Fundraiser (p/t)	Sophie Dingwall
Senior Regional Fundraiser	Max Kendry
Regional Organiser (p/t)	Anthony Holdsworth
Regional Organiser (p/t)	Sam Middleton
Regional Organiser (p/t)	Stephen Roberson
Regional Organiser (p/t)	Gay Wilmot-Smith BSc
Regional Organiser (p/t)	Charlotte Meeson BSc
Regional Organiser (p/t)	Pippa Hackett
Regional Organiser (p/t)	Fleur Fillingham BA
Administration Assistant	Daniel O'Mahony

DIRECTOR OF COMMUNICATIONS, MARKETING & MEMBERSHIP	James Swyer
Team Assistant	Vivienne Tomlin *(until June)*
Membership & Shop Manager	Beverley Mansbridge
Membership Administrator	Heather Acors
Shop & Database Administrator	Helen Pape
Shop & Database Administrator	Caroline Marlow
Publications Officer (p/t)	Louise Shervington
Graphic Designer	Chloe Stevens
Membership Recruitment Manager – North	Rebecca Houseman
Online Marketing Manager	Rob Beeson
Website Editor	Oliver Dean
Online Marketing Executive	Danny Sheppard
Head of Communications	Joe Dimbleby
Writer and Research Specialist	Amber Hopgood BSc, MSc
Communications Officer	Katherine Williams *(until April);* Eleanor Williams *(from June)*
Communications & Engagement Officer	Emma Mellen BA, PgCert

DIRECTOR SCOTLAND	Rory Kennedy
Scottish HQ Administrator (p/t)	Beth Davies
Head of Policy (Scotland)	Ross Macleod MA, MBA
Head of Events & Membership	Rory Donaldson
Head of Development	Chloe Thornton *(from August)*
Scottish Research & Development Administrator	Janine Strikeleather *(from August)*
Head of Advisory - Scotland	Nick Hesford BSc, PhD
Senior Scottish Advisor	Hugo Straker NDA[1]
Advisor Scotland	Marlies Nicolai
Trainee Advisor Scotland	Felix Meister BA, MSt, DPhil *(from September)*

DIRECTOR WALES	Sue Evans *(until August)*, Lee Oliver BSc CF *(interim from September)*
Project Officer	Bleddyn Thomas MBiolSci *(until December)*
Placement student *(Bangor University)*	Jasper Elms *(from November)*
Fundraising & Engagement Officer	Alaw Ceris BSc
Wales Curlew Connections Project Manager	Julieanne Quinlan BSc *(from September)*
Curlew & People Officer	Katie Appleby *(from October)*

[1] Hugo Straker is also Regional Advisor for Scotland and Ireland; [2] Roger Draycott is also Regional Advisor for eastern and northern England.
Placement students spend one year with the GWCT. This list includes students who began their placement with us in 2023.

External committees with GWCT representation

The Allerton Project farm. © Joe Stanley/GWCT

1.	*Agriculture and Rural Development Stakeholder Group*	*Ross Macleod*
2.	*Aim to Sustain Avian Influenza working group*	*Roger Draycott*
3.	*Aim to Sustain group (Wales)*	*Sue Evans*
4.	*Aim to Sustain Standards Committee*	*Roger Draycott*
5.	*Allenford Farmer Cluster*	*Megan Lock (Facilitator)*
6.	*Animal Network Welfare Wales Group*	*Matt Goodall*
7.	*Arun to Adur Farmer Cluster Steering Group*	*Julie Ewald*
8.	*Avon Valley Farmer Cluster*	*Lizzie Grayshon (Facilitator)*
9.	*BASC Gamekeeping and Gameshooting*	*Mike Swan*
10.	*BBC Rural Affairs Committee*	*Mike Short*
11.	*BBC Scottish Rural and Agricultural Advisory Committee*	*Rory Kennedy*
12.	*Birds of Conservation Concern Steering Group*	*Nicholas Aebischer*
13.	*Bracken Management Group*	*Alastair Leake*
14.	*British Game Assurance Advisory Group*	*Roger Draycott*
15.	*Camlad Valley Project*	*Matt Goodall*
16.	*Capercaillie Science Advisory Group*	*David Baines*
17.	*CFE National Co-ordination group*	*Jess Brooks*
18.	*CIC Head of Small Game Specialist Group*	*Francis Buner*
19.	*CNPA Cairngorm Upland Advisory Group*	*Rory Kennedy/ Louise de Raad*
20.	*CNPA Nature Index Group*	*Ross Macleod*
21.	*Code of Good Shooting Practice*	*Mike Swan*
22.	*Cold Weather Wildfowling Suspensions*	*Mike Swan/Marlies Nicolai/Matt Goodall*
23.	*Co-ordinated Uplands Partnership*	*Henrietta Appleton*
24.	*Cors Caron Project*	*Matt Goodall*
25.	*Curlew Recovery Partnership (England) Steering Group*	*Andrew Hoodless/ Teresa Dent*
26.	*Gylfinir Cymru*	*Amanda Perkins/Sian Whitehead/Matt Goodall*
27.	*Cynnal Coetir Sustainable Management Scheme Elwy Project*	*Lee Oliver/ Sue Evans*
28.	*Deer Management Qualifications*	*Alex Keeble*
29.	*Defra 30by30 on land stakeholder working group*	*Henrietta Appleton*
30.	*Defra Gamebird stakeholder Avian Influenza working group*	*Roger Draycott*
31.	*Defra Upland Stakeholder Forum*	*Henrietta Appleton*
32.	*Dorset Beaver Trial*	*Dylan Roberts*
33.	*East Cairngorms Moorland Partnership*	*Rory Kennedy/ Louise de Raad*
34.	*Echoes Project Advisory Board*	*Matt Goodall*
35.	*Ecosystems and Land Use Stakeholder Engagement Group (Scotland)*	*Ross Macleod*
36.	*Environmental Farmers Group*	*Teresa Dent*
37.	*European Sustainable Use Group*	*Nicholas Aebischer/ Julie Ewald (Chair)*
38.	*Executive Board of Agricology*	*Alastair Leake*
39.	*Diadromous Fish at Sea Research Committee*	*Sophie Elliott*
40.	*Fellow of the National Centre for Statistical Ecology*	*Nicholas Aebischer*
41.	*Fish Welfare Group*	*Dylan Roberts*
42.	*Freshwater Fisheries Defra Meetings*	*Rasmus Lauridsen*
43.	*Frome, Piddle & West Dorset Fisheries Association*	*Rasmus Lauridsen*
44.	*FWAG (Administration) Ltd*	*Alastair Leake*
45.	*Gamekeepers Welfare Trust*	*Mike Swan*
46.	*Gelli Aur Slurry Project Steering Group*	*Sue Evans*
47.	*German Grey Partridge Recovery Project Steering Committee*	*Francis Buner*
48.	*Glamorgan Rivers Trust*	*Dylan Roberts*
49.	*Good Food Leicestershire Expert Advisory Group (Chair)*	*Chris Stoate*
50.	*Greenhouse Gas Recovery Biochar Demonstrator Expert Advisory Group (Chair)*	*Chris Stoate*
51.	*Hampshire Avon Catchment Partnership*	*Andrew Hoodless*
52.	*Hen Harrier Brood Management Project Board*	*Henrietta Appleton*
53.	*Honorary Scientific Advisory Panel of the Atlantic Salmon Trust*	*Rasmus Lauridsen*
54.	*HORIZON PRO-Coast co-ordination team*	*Julie Ewald*
55.	*ICES Trout Working Group*	*Rasmus Lauridsen/ Sophie Elliott*
56.	*ICES Working Group on North Atlantic Salmon*	*Sophie Elliott*
57.	*International Association of Falconry Biodiversity Working Group*	*Julie Ewald/ Francis Buner*
58.	*International Organisation for Biological and Integrated Control - WPRS Council*	*John Holland*
59.	*Interreg PARTRIDGE Steering Group*	*Roger Draycott*

60.	*IUCN Commission on Ecosystem Management*	*Julie Ewald/ Nicholas Aebischer*
61.	*IUCN Species Survival Commission Galliformes Specialist Group*	*Francis Buner/ Nicholas Aebischer*
62.	*IUCN Species Survival Commission Grouse Specialist Group*	*David Baines*
63.	*IUCN Species Survival Commission Re-introduction Specialist Group*	*Francis Buner*
64.	*IUCN Species Survival Commission Woodcock & Snipe Specialist Group*	*Andrew Hoodless/ Chris Heward*
65.	*IUCN Sustainable Use and Livelihoods Specialist Group (SULI)*	*Nicholas Aebischer/ Julie Ewald*
66.	*Martin Down Farmer Cluster*	*Megan Lock (Facilitator)*
67.	*Missing Salmon Alliance Steering Group*	*Teresa Dent/ Dylan Roberts*
68.	*Missing Salmon Alliance Technical Group*	*Rasmus Lauridsen/Dylan Roberts/Sophie Elliott*
69.	*Moorland Management Best Practice Steering Group*	*Ross Macleod*
70.	*Mountain Hare Monitoring Group*	*Nick Hesford/Ross Macleod*
71.	*Natural England Scientific Advisory Committee*	*Nicholas Aebischer*
72.	*Natural Resources Wales Fish Eating Birds Review Group*	*Dylan Roberts*
73.	*Natural Resources Wales Fisheries Forum*	*Dylan Roberts*
74.	*Natural Resources Wales Wild Bird Review - Stakeholder Meeting - Land Management and Shooting Sector Group*	*Matt Goodall/Sue Evans*
75.	*NatureScot - Farming with Nature External Advisory Group*	*Ross Macleod*
76.	*NatureScot Species Reintroduction Forum*	*Ross Macleod*
77.	*NE Compliance and Enforcement Stakeholder Group*	*Henrietta Appleton*
78.	*NFU County Chairman (Leicestershire, Northants & Rutland)*	*Joe Stanley*
79.	*NFU ELM Task & Finish Group*	*Joe Stanley*
80.	*NFU Midlands Regional Board*	*Joe Stanley*
81.	*NFU National Environment Forum*	*Joe Stanley*
82.	*NGO National Committee*	*Roger Draycott*
83.	*Nurturing Nature Project Advisory Group*	*Jodie Case*
84.	*Oriental Bird Club Conservation manager for Pakistan and Northern India*	*Francis Buner*
85.	*Peakland Environmental Farmers Board*	*Teresa Dent*
86.	*Perthshire Black Grouse Study Group*	*Kathy Fletcher*
87.	*Pesticides Forum Indicators Group of the Chemicals Regulation Directorate*	*Julie Ewald*
88.	*PHCI Fisheries Sub group*	*Dylan Roberts*
89.	*Poole Harbour Agriculture Sub Group*	*Dylan Roberts*
90.	*Poole Harbour Catchment Initiative*	*Dylan Roberts/ Will Beaumont*
91.	*Purdey Awards*	*Mike Swan*
92.	*River Deveron Fisheries Science*	*Dylan Roberts*
93.	*River Otter Beaver Trial*	*Dylan Roberts/Mike Swan*
94.	*Rural Environment & Land Management Group (Advisors)*	*Ross Macleod/ Rory Kennedy (chair)*
95.	*Rutland Agricultural Society*	*Alastair Leake*
96.	*Salisbury and District Natural History Society committee*	*Jayna Connelly*
97.	*Scotland's Moorland Forum and sub-groups*	*Rory Kennedy/Ross Macleod/Nick Hesford*
98.	*Scottish Capercaillie Group*	*David Baines/Kathy Fletcher*
99.	*Scottish Farmed Environment Forum*	*Ross Macleod*
100.	*Scottish Government Technical Assessment Group (Snares and traps)*	*Hugo Straker*
101.	*Scottish Grouse Shoot Code Review Group*	*Ross Macleod*
102.	*Scottish Moorland Groups*	*Hugo Straker/ Nick Hesford*
103.	*Scottish Muirburn Code Review Group*	*Nick Hesford*
104.	*Scottish PAW Executive, Raptor and Science sub-groups*	*Ross Macleod/ Nick Hesford*
105.	*SGR Monitoring Group*	*Alastair Leake*
106.	*Shoot Liaison Committee Wales*	*Matt Goodall/Sue Evans*
107.	*Snakes in the Heather Advisory Group*	*Jodie Case*
108.	*South Coast White-tailed Eagle Reintroduction project steering group*	*Mike Short*
109.	*South Downs Farmland Bird Initiative*	*Julie Ewald*
110.	*South East England Pine Marten Working Group*	*Mike Short*
111.	*Southern Curlew Forum*	*Andrew Hoodless/ Amanda Perkins*
112.	*Sparsholt College Industry Liaison Group – Land & Wildlife*	*Jodie Case/ Mike Short*
113.	*Speyside Black Grouse Study Group*	*Kathy Fletcher*
114.	*Swedish Environmental Protection Agency Scientific committee for wildlife research*	*Scott Newey*
115.	*Tayside Biodiversity Partnership*	*Fiona Torrance*
116.	*The Bracken Management Group*	*Alastair Leake*
117.	*The CAAV Agriculture and Environment Group*	*Alastair Leake*
118.	*The Curlew Country Board*	*Amanda Perkins/Sue Evans*
119.	*Voluntary Initiative National Steering Group*	*Alastair Leake*
120.	*Welland Resource Protection Group (Chair)*	*Chris Stoate*
121.	*Welland Valley Partnership (Chair)*	*Chris Stoate*
122.	*Welsh Government Fox Snaring Advisory Group*	*Matt Goodall*
123.	*Welsh Government Land use Stakeholder Group*	*Sue Evans*
124.	*Wild Purbeck Group*	*Dylan Roberts*
125.	*Wildlife Estates England Scientific Committee*	*Andrew Hoodless*
126.	*Wildlife Estates England Steering Group*	*Roger Draycott*
127.	*Wildlife Estates, European Scientific Committee*	*Alastair Leake*
128.	*Wildlife Estates Scotland Board & Sub Groups*	*Rory Kennedy/ Ross Macleod*
129.	*Working for Waders*	*Ross Macleod/Max Wright*
130.	*World Pheasant Association Scientific Advisory Committee*	*David Baines*

Key to abbreviations: BASC = British Association for Shooting and Conservation; CAAV = Central Association of Agricultural Valuers; CFE = Campaign for the Farmed Environment; CIC = International Council for Game and Wildlife Conservation; CNPA = Cairngorms National Park Authority; FWAG = Farming & Wildlife Advisory Groups; ICES = International Council for the Exploration of the Sea; IOBC-WPRS = International Organisation for Biological and Integrated Control of Noxious Animals and Plants-West Palearctic Regional Section; IUCN = International Union for Conservation of Nature; NE = Natural England; NFU =National Farmers' Union; NGO = National Gamekeepers' Organisation; PAW = Partnership for Action Against Wildlife Crime; PHCI = Poole Harbour Catchment Initiative; SGR = Second Generation Rodenticide.

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