Review
of 2019

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

Game & Wildlife
CONSERVATION TRUST

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Game & Wildlife Conservation Trust
Image © Jon Farmer

REVIEW OF 2019

Game & Wildlife Conservation Trust

Issue 51

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.

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as of 1 January 2020

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Bristol & North Somerset	Tom Hyde
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Cambridgeshire	Claire Smith
Cheshire	no chair
Cornwall	Gary Champion
Cumbria	William Johnson
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North Yorkshire	Toby Milbank
West Yorkshire	no chair

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Fife & Kinross	no chair *(Douglas Williams)*
Grampian	Ruairidh Cooper
Highland	James Macpherson-Fletcher
East Tayside	Michael Clarke
West Tayside	Hugh Arbuthnott
West of Scotland	David MacRobert
Scottish Auction	Bryan Johnston

Wales

Ceredigion	Owen Williams
North Wales	Rupert Bevan
Powys	Julian Salmon
South-East Wales	Roger Thomas

Names in brackets were chairmen that stepped down during 2019.

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Measuring vegetation in the Avon Valley. © Lizzie Grayshon/GWCT

Game & Wildlife CONSERVATION TRUST

Working towards a sustainable balance

Teresa Dent CBE,
Chief Executive

© Hugh Nutt

The Langholm Moor Demonstration Project concluded that grouse moor management could improve and sustain protected moorland habitat and waders. © Laurie Campbell

- Greater emphasis on sustainable use and wise use.
- The importance of soil is recognised in the new Agriculture Bill.
- GWCT research would not be possible without the continuing support of our loyal members, donors and supporters.

It was a great pleasure to be working with our new Chairman, Sir Jim Paice, last year. He is a passionate and knowledgeable countryman and as an ex-Government Conservative party minister, is very focused on establishing what the problems are, then finding ways to put them right.

As a charity whose strapline for at least the last 70 years is conservation through wise use, that is a very good fit. Wise use could be considered to be the terminology of the previous generation; in modern parlance it is sustainable use. A huge amount of our work in recent years and in the pages of this *Review* goes to the issue of sustainable use.

The 10-year Langholm Moor Demonstration Project, for which the final report was published in October 2019, studied where the sustainable balance lay between red grouse and raptors. It concluded that grouse moor management could improve and sustain protected moorland habitat and waders. However, we established that new forms of licensed management were probably needed to maintain the balance between raptors and red grouse which could allow an economically sustainable bag for driven shooting.

In the political section (see page 6) we look at the outcome of the Review of Grouse Moor Management in Scotland chaired by Professor Werritty, again looking at the sustainability of management practices associated with grouse moors.

One of GWCT's guiding principles for sustainable use is that land used for shooting should produce a net biodiversity gain over and above that delivered on the same land in the absence of game management. These principles of wise use, sustainable use and net gain are not new and are embodied in national and international approaches to nature conservation and the environment.

The declarations of climate and biodiversity emergencies in 2019 has prompted huge attention on the sustainable use of biological resources. Support for the more sustainable use of soils is embodied in the new Agriculture Bill that is going through

Parliament. The equally new Environment Bill calls for developers to deliver net biodiversity gain of 10% from development.

All this should remind us as game managers to refocus on wise use and sustainable use to ensure these same principles are still embodied in our game management. Sustainable use needs to be firmly aligned with best practice. We know that good game management delivers good net biodiversity gain; now let's show how that is aligned with international standards.

As always the excellent work of our staff, some of which is highlighted in this *Review,* would be impossible without the continuing support of our members, donors and other supporters. We are lucky to have not just a committed Chairman, but also an expert and dedicated set of trustees who support and steer our work in these uncertain and rapidly changing times.

Thank you for your continued support

Sir Jim Paice
GWCT Chairman

I have been Chairman of Trustees for 18 months and would like to thank members, staff and fellow trustees who have made me feel so welcome. I have met many of you and hope to meet many more in my travels and work for the Trust.

Looking back, what a year 2019 proved to be for all involved in the countryside and never has the work of the GWCT been so vital and influential for wildlife conservation. The challenge by Wild Justice leading to the General Licence debacle should have made even the most reluctant realise that the threats to sensible wildlife management are very real (see page 9). It is not over yet as the interim licences are being reviewed and GWCT research results are critical evidence of why legal and balanced predator control is essential. Wild Justice then challenged releasing pheasants near protected sites; Defra is still working on its response but again our work is the only credible research. Later in the year the RSPB launched a review of its policy on game shooting which worried a lot of people. However, we are working hard to build a good relationship with them and we have offered to submit all our research for their consideration.

"never more has the work of the GWCT been so vital and influential for wildlife conservation"

Through all of this time we saw the gradual evolution of a new agricultural policy for post-Brexit. Again the GWCT is heavily involved. We are sitting on two working groups and successive Secretaries of State have visited our Allerton Project farm at Loddington (see page 18). We have pushed hard for soil quality to be seen as a public good and it now seems that Defra has accepted our arguments. Following the December General Election, the new Government has brought in the Agriculture Bill and the Environment Bill. Both have considerable impact on our activities and as they progress through Parliament we will be working to influence the detail.

In the meantime, we have been working with the shooting community to address other challenges such as the developing evidence against lead shot and to encourage all shoots to achieve best practice. Central to that and all else we do, is to promote the need for all shoots large and small to assess whether they are delivering a net biodiversity gain. Our evidence shows that game management done well delivers a net biodiversity gain compared with land where no shoot takes place, and we are offering a range of ways shoots can make this assessment (see page 9). We need to ensure that it is widely understood that without good game management, the countryside and its wildlife would be worse off.

Informing legislation with sound science

Alastair Leake
Director of Policy and Parliamentary Affairs

© Hugh Nutt

(L-R) Geoff Coates (facilitator for the Strathmore Wildlife Cluster), Andrew Ogilvie-Wedderburn, Will Henderson, George Fleming, Pete Wishart MP, Ross Macleod (GWCT) and Brian Kaye admiring a fantastic mix of white mustard, phacelia, vetch, crimson clover and white clover sown in early May as part of an Agri-Environment Climate Scheme. © GWCT

England

- Sustainable soil management and food security added to the Agriculture Bill.
- Withdrawal of General Licences causes confusion and difficulties for gamekeepers and conservationists alike.
- We worked closely with Defra helping to design the Environmental Land Management Scheme.

Throughout the year we saw legislation being developed to cover our departure from the European Union. Little of it made it through Parliament, delayed principally by the difficulties of the Withdrawal Bill, but this gave us time to develop our own policies on important matters such as the Environment Bill and the Agriculture Bill.

Despite the ambition set out in the 25 Year Environment Plan, the subject and importance of sustainable soil management was not mentioned in the first iteration of the Agriculture Bill. Even more surprisingly, neither was food security. We highlighted these omissions by submitting written evidence to Government consultations and enquiries and raised them in Westminster during debates run by our All Party Parliamentary Group (APPG) on Game & Wildlife Conservation. It is rewarding, therefore, to see Bills redrafted and brought back to the Commons with such omissions addressed, even if unsatisfactorily, as occurred with the Agriculture Bill, allowing us to revisit the detail as it passes through the Committee Stage.

This year also brought the withdrawal of General Licences, causing confusion and difficulties for gamekeepers and conservationists alike (see page 9). The interpretation of wildlife law in the UK has been a ticking time bomb that we have been aware of for some time. In fact, our first formal APPG meeting held back in 2010 was entitled 'Common-sense conservation' and dealt with this very issue and led indirectly to the Law Commission Review of Wildlife Law which was published back in 2015. In this review the Commission proposed that the level of protection afforded to a species was determined by its conservation status, allowing adjustments to be made to the level of control or protection required. This seems very sensible to us, but it involves discarding a number of protective Acts of Parliament at a politically sensitive time for environmental governance. As such, it is unlikely to be brought forward at this time.

We have been working constructively with Defra in helping to design the Environmental Land Management Scheme (ELMS) which will replace Countryside Stewardship, funded by money modulated from the Basic Farm Payment which is due to be phased out over the coming years. Our continual involvement with such schemes means we have a good idea about what works. There is little point having a scheme full of options which is so overly complex that it deters participation. As the Chairman of Natural England commented to me on a visit to our Allerton Project: "It seems to me that those that have the most to say about conservation are the ones that have the least to do with it". Conversely, those that have the least to say are the ones which do the most. Keeping farmers in the countryside will be essential if we are to keep nature conserved. Rewards must be provided for delivering a wider spectrum of so called 'public goods' from privately-owned land.

Scotland

- The year was dominated by upland policy with publication of both the Langholm and Grouse Moor Management Review (Werritty) reports.
- Muirburn, mountain hares and wading birds were the focus of work on adaptive management and best practice moorland management in many multi-partner fora.
- Farmer Clusters in Scotland took a step forward at a time when the Scottish Government is deciding how to balance farming productivity and environmental outcomes.

Adam Smith,
Director of Policy Scotland

The *Review of 2018* predicted that two major upland reports would be published in 2019. Both were published and common themes were evident in both. Unless game conservation is relevant and endorsed by society, the sector's skills in muirburn, predator control, or other management researched and developed over decades and which could help deliver net zero carbon or deliver more wading birds, will be deemed irrelevant or worse damaging.

Such a rejection of game management principles would be a huge loss for the UK. The impact of such a loss was suggested by the final report of the Langholm Moor Demonstration Project (www.gwct.org.uk/langholmreport). In it the partners (Scottish Natural Heritage, Buccleuch, GWCT, RSPB and Natural England) considered the implications of the project's management and research for moorland across the UK. Concluding that driven shooting has much to offer, it recognised that securing a wide buy-in for driven grouse will need grouse shooters, the public and politicians to all accept changes in how they wish the uplands to be used.

The Langholm Project itself informed the other major upland report, the Grouse Moor Management Review or *Werritty Report*. Initiated by the Scottish Government, GWCT research and policy positions were evidenced throughout the report, which was published in November 2019. The Review made 35 main and sub-recommendations about the future of moorland management. As with the Langholm Project, many of the recommendations endorsed aspects of grouse moor management as in the public interest. The immediate licensing of grouse moors was not supported. However, many of the recommendations were critical of ways in which moors were managed and suggested changes that made challenging reading. At the end of the year GWCT was assessing what a formal response from the Scottish Government might contain.

The uplands were also often the backdrop to demonstrating adaptive management and best practice. Informing the ever-expanding body of consultative groups is very important as the big ideas of what role our uplands should play are being tested. Often these big strategic ideas need a hook, and muirburn (discussed at an All Parliamentary Party Group in Westminster Hall), mountain hares (the estate monitoring of which is being endorsed by the GWCT as an example of public goods delivered by private investment) and wading bird conservation (which provides common ground on which to discuss predator control) were common topics.

Adaptive management and the delivery of best practice approaches are not unique concepts to the uplands. Yet while public policy on Scottish agriculture remains broadly aimed at developing support for both production and environmental goods, the urgency for change appears less acute than in the uplands, or England. Although a vast amount of attention was paid on steps to net zero by stakeholders, debates over devolved rights and responsibilities created drag.

It seems likely that Scottish farmers will be encouraged to produce public goods for public support. Proof that such change can be led from within Scotland's land management rather than forced by public policy positions on climate and biodiversity emergencies, will reduce the risk of the change being an economic or social drag. So we were delighted that in 2019 we helped more Farmer-led Clusters form in Scotland. As it has in other parts of the country, working with neighbours should bring efficiency and good results for both farming and the environment. Proof that change is afoot across all of Scotland's land management.

Success of collaborative working in Wales

Sue Evans, Director of Wales

(L-R) Dave Ashford and James Owen two Welsh officials who visited a dairy farm in north Wales discussing future farming schemes with the farmers on the ground. © GWCT

Wales

- Shaping the future of agri-environment schemes in Wales.
- Engaging with policymakers and politicians in Cardiff.
- Providing evidence and advice on the review of General Licences.

2019 was a year of building relationships and spreading the word. We attended regular stakeholder meetings organised by the Welsh Government throughout the year to feed into the development of a new agri-environment scheme. We also presented at other organisation's events and to groups around the country. Our soils and biodiversity event in May on 'How soils and biodiversity should fit into future schemes' raised awareness of how the GWCT can contribute and inform policymakers.

We had a series of very useful one-to-one meetings with high level Welsh Government officials highlighting the GWCT's 80 years of scientifically-developed practices. This was also an opportunity to ask for immediate funding to tackle ministerial announced climate emergency issues and biodiversity declines.

James Owen, the newly appointed Deputy Director for Land Management Reform, spent two days with our team in November. He visited Ty Newydd organic dairy farm in north Wales where Alastair Leake spoke about the future of agri-environment schemes and the importance of soil. The following day he visited Cruglas, a showcase mixed farm, part of the Cors Caron farmer group who have successfully got through the Expression of Interest phase of the Sustainable Management Scheme (SMS) application process. A presentation was also delivered by David Thomas from the Powys Moorland Partnership Project (SMS) highlighting the successes of the collaborative landscape-scale working approach to agri-environment management.

We are working with a number of farmers to develop trials and demonstration farms in Wales to further showcase solutions to the question we are being asked by many farmers in Wales: 'How can we increase biodiversity on our farms above what we've delivered through years of agri-environment schemes?'

Wild Justice also launched challenges in Wales which caused Natural Resources Wales (NRW) to review General Licences with a new licence put in place in October. During NRW's consultation process with stakeholders, we have repeatedly raised concerns over several proposed changes to the licences. Our scientific evidence, technical expertise and experience in practical management have not been taken into account nor referenced, and NRW's scientific evidence review process and conclusions drawn from it are deeply flawed. There are several changes to the licences including rooks being removed from licences 001 and 004. NRW have also produced a list of Site of Special Scientific Interest (SSSI) designated areas where the General Licences are not authorised and therefore no action can be taken within these areas or within 300 metres of their boundaries. For further information go to **www.gwct.org.uk/wales**.

Solving the General Licence conundrum

- Three English General Licences were revoked covering 16 bird species.
- GWCT members helped provide evidence showing the implications of licence withdrawal.
- We are engaging with Defra and Natural England on the General Licence consultation with results expected in summer 2020.

Roger Draycott, Head of Advisory

General Licences were withdrawn at a critical time of year leaving birds and their young, such as lapwing, at more risk of predation. © Marlies Nicolai/GWCT

On the 25 April 2019, Natural England revoked three General Licences covering 16 largely commonly occurring bird species as a result of a legal challenge from Wild Justice, a wildlife campaigning organisation. Natural England conceded that the licences were unlawful, hence the revocation. The decision caused huge concern among licence users (mainly farmers, conservationists and gamekeepers) who were no longer able to undertake lethal control measures for birds damaging crops, injuring and killing newborn lambs or protecting the nests and chicks of birds of conservation concern such as lapwing and curlew, as well as gamebirds at a critical time of year.

On 4 May 2019 the Secretary of State for Defra and Natural England agreed that the legal powers relating to these General Licences would be exercised by the Secretary of State from that date. Defra undertook a short evidence gathering process to gain a clear understanding of the licence revocation on the implications for the protection of wild birds, and the impacts on crops, livestock, wildlife, disease, human health and safety and wider nature conservation efforts. The evidence gathered from this process included a submission from the GWCT. Our evidence was based on a combination of: 1) scientific research; 2) our understanding of the legal framework; 3) our practical experience of operating under General Licences; and 4) the experience of over 450 members who responded to the call for evidence. On the 13 June Defra issued new, albeit temporary, workable licences. Much work was undertaken by GWCT and other rural organisations behind the scenes to help Defra, Natural England and the many licence users through this difficult period.

In autumn 2019 Defra launched a consultation on General Licences to help it develop a future licensing system and the results of this consultation are not expected until summer 2020. Again, GWCT have been actively engaged with Defra and Natural England throughout this process and have attended countless meetings and teleconferences. An important part of the process for Defra was gathering information from actual users of the licences and we were delighted that more than 3,000 GWCT supporters responded to our survey which we presented to Defra in December. We were able to provide Defra with practitioner evidence on the species controlled, the reasons control was necessary, the non-lethal measures that had been tried and their effectiveness. This evidence, alongside GWCT scientific evidence on the impacts of predation and predation control on nesting birds on farmland and moorland, have been hugely valuable in informing the policymakers responsible for licensing the control of problem birds.

GWCT BIODIVERSITY ASSESSEMENTS

The GWCT's experienced and respected team of advisors offer bespoke Shoot Biodiversity Assessments aimed at providing an independent expert report on best practice and biodiversity gain on individual shoots. For more information please see **www.gwct.org.uk/shootbiodiversity** or contact the advisory team on 01425 651013.

The Farmer Cluster story

Jess Brooks looks at the success of Farmer Clusters which have grown from one farmer-led NIA in 2012 to 120 Farmer Clusters at the end of 2019

Almost a decade ago, Sir John Lawton's *Making space for nature* report was published, highlighting the need for 'bigger, better and more joined up' conservation. In response, GWCT helped a group of farmers in the Marlborough Downs win funding to establish a Nature Improvement Area (NIA) and pursue a landscape-scale approach to conservation. This was the only farmer-led NIA created, and since 2012 they have delivered tremendous results on the ground.

GWCT was inspired to find out whether this 'bottom-up' process of working alongside a group of farmers would work with normal everyday funding streams such as Countryside Stewardship. So, we set up five pilot 'Farmer Clusters' with funding from Natural England.

Land managers quickly understood the benefits of joining forces to manage the countryside, showing huge enthusiasm. Soon the pilot clusters were devising their own conservation plans, and choosing target species, issues and habitats. The work is generally underpinned by independent but co-ordinated agri-environment schemes, and groups are led by a farmer chairman and 'facilitated' by an advisor chosen by them.

Natural England commissioned a report on the success of the pilots, and as a result, introduced the Countryside Stewardship Facilitation Fund (CSFF) to help farmers work together and fund advisors. A small but increasing number are self-funding or pursuing private funding from corporate sponsors, water companies or charitable trusts. At the end of 2019, there were 120+ groups across England covering over 500,000ha and involving more than 3,000 land managers. The results of the fourth round of CSFF will be announced in 2020 and could significantly boost those numbers.

"...at the end of 2019, there were 120+ groups across England covering over 500,000ha and involving more than 3,000 land managers"

Martin Down 'Supercluster'

The Martin Down 'Supercluster' was established at the junction of Dorset, Wiltshire and Hampshire in 2016 and comprises three Farmer Clusters surrounding the Martin Down National Nature Reserve (NNR). Together, this huge trio of clusters cradles the nature reserve, covering an area of 23,600 hectares ($236km^2$), and the combined force of 45 farmers are united in their aim to protect and enhance the iconic and threatened wildlife of Martin Down NNR on surrounding farmland.

Martin Down Farmer Cluster (MDFC)

Like other farmer-led landscape-scale projects, the MDFC holds several training workshops, social events, talks and walks every year for members. Conservation action is co-ordinated as much as possible across the landscape and the cluster has a significant focus on species monitoring to track progress over the years.

Jess Brooks, Farmland Biodiversity Officer

(Top) Farmers in the clusters devise their own conservation plans, choosing target species, issues and habitats.

The Martin Down Supercluster

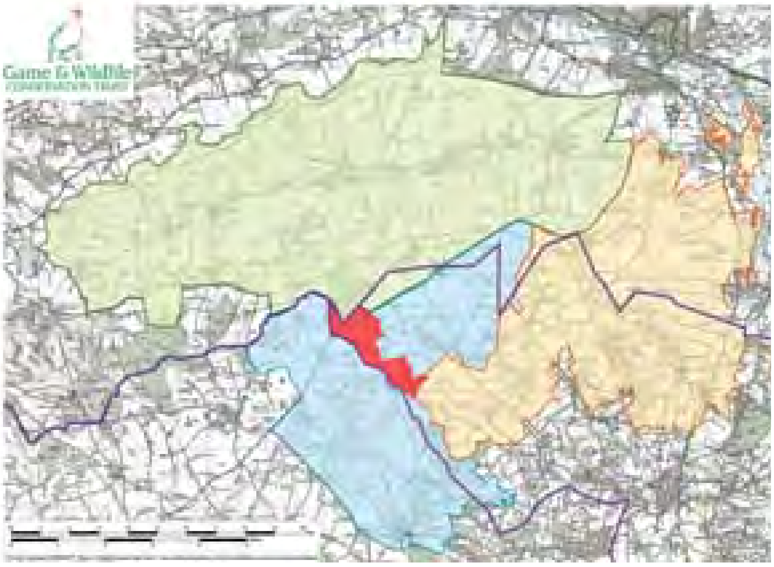
Allenford Farmer Cluster – est. 2014, 6,100 hectares (ha), 10 members

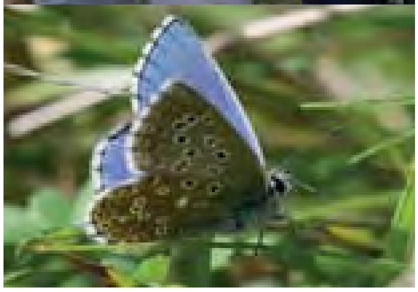
Chalke Valley Farmer Cluster – est. 2015, 12,000ha, 25 members

Martin Down Farmer Cluster – est. 2016, 5,500ha, 12 members

PRIORITIES: Turtle dove, woodcock, orchids, hedgehogs, harvest mice, lapwing, arable flora, bumblebees,

earthworms, barn owl, grey partridge, corn bunting, dung beetles, Duke of burgundy/dark green fritillary/ small blue butterflies, soil organic matter and chalk downland links.





(L-R) Map of the Martin Down Supercluster; occupation of barn owl broods in nest boxes increased by 23% between 2018 and 2019, and average brood size increased from 2.5 to 2.75; 60% of all British resident butterflies can be found across the cluster area such as meadow brown, comma, brimstone, peacock, and special butterflies include adonis blue (above), white admiral, purple emperor and dark green fritillary.

© Will George

Monitoring

We have been running a long-term wildlife-monitoring effort to track the cluster's progress. All farmer members have participated in the monitoring, aided by local volunteers, farm staff and family. Over 10,000 species records have been submitted to biodiversity recording centres to date. Collecting these data has really accelerated the farmers' learning and enthusiasm, as well as informing conservation plans. It's still early days, and long-term data are required to assess the outcome of conservation work across the cluster which will take a minimum of five years.

Community outreach

Residents in the Martin Down area have taken an interest in the project, such as joining the farmers in a landscape-scale hedgehog footprint tunnel survey and adopting butterfly transects. The Martin Down Farmer Cluster has a 'Friends' group, made up of local people and naturalists who attend farmland wildlife events, get updates on the conservation activities and participate in surveys.

The cluster has produced a fundraising calendar, created using photos taken by the farmers, keepers and locals. The 2019 calendar raised £320 net proceeds which went towards the restoration of a turtle dove pond on Martin Down NNR. The 2020 calendar proceeds will be donated towards grazing equipment to restore butterfly habitat on Kitts Grave.

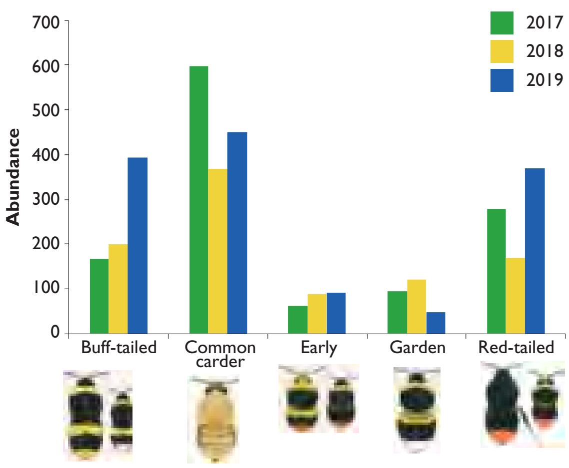
The farmers are keen to engage with the wider public and visitors, so we have created a unique poster for each farm to show what they are doing for their local environment and what can be seen on the farm.

Wider engagement and public relations

The Martin Down Supercluster has hosted several visits for Government officials and large landowners, to share with them our experience of landscape-scale conservation. We are also part of the Southern England Regional Facilitators Group, which enables Farmer Clusters in southern England to share experiences, ideas and advice.

Last autumn lead farmer Tim Palmer and facilitator Jess Brooks, hosted a visit from NFU President Minette Batters, and also took the message of landscape-scale farmer collaboration to big audiences including the CLA Rural Business Conference.

In 2019 – our third year of monitoring – we recorded the highest abundance of three of our five most common bumblebees.



Martin Down Farmer Cluster highlights since 2017

- Created 185 acres of brand new grass and flower margins, wild bird seed plots, cultivated margins for arable flora, arable reversions and pollen and nectar mixes.
- Increased the amount of wild pollinator habitat on arable land by 50%.
- Doubled the number of ponds helpful for turtle doves.
- Improved education about hedgehogs in local villages.
- Created grey partridge habitat on 600ha.
- Nine out of 11 farmers are now running Larsen traps to reduce magpie predation pressure on turtle doves.
- Supplementary feeding is provided for birds on all the farms.

www.farmerclusters.com

MARTIN DOWN FARMER CLUSTER

To our dedicated supporters - thank you all

Jeremy Payne, Director of Fundraising and Bruce Russell, Director Scotland

(L-R) Archery was just one activity on offer at the unique Dorset inter-shoot challenge; the popular Edinburgh and South-East shoot walk; staff from the Alchemilla Restaurant prepare for the delicious game cookery evening at Welbeck Abbey in Nottinghamshire.

- County committees have had another strong year, projected at £800,000.
- London events raised £230,000.
- Major donor income at just under £1,085,000.
- Scotland had a strong year and exceeded its fundraising target.

In England, the fundraising team had another very good year, with estimated income of just over £2.5 million. We had our best year ever with major donors who kindly gave more than £1 million for the first time. If anything, the uncertainty of the times has increased, so we take this as a sign of the importance this very generous group attach to an active and thriving GWCT. We are sincerely grateful to all of those who supported us in this way.

The total amount raised, represents thousands of hours of volunteered time by hundreds of people who are part of our county committees. This income is equivalent to our annual budget for all of our uplands work and our grey partridge work. Shoot sweepstake income has once again increased to approximately £170,000, an increase of about £30,000 on last year. This is a very impressive outcome, particularly in this competitive area, so a heartfelt thank you to all those who chose us as your beneficiary, and of course to your guns.

GCUSA contributed £280,000, an impressive first 'score on the door' for its new President Ron Beck, with a hugely successful annual auction. London events benefited from a very popular Ball, and the exclusive Le Gavroche dinner hosted by Michel Roux Jr. The latter has established such a reputation (including for the amazing wines sourced by Sebastian Riley-Smith) that places sell out within days.

On behalf of all my GWCT colleagues, sincere thanks to all of you who helped fundraise in 2019. It's clear to most of us that the need for our work has never been greater, which means your support has never been needed more.

In Scotland

April 2019 saw a change in directorship in Scotland as I took over from Adam Smith allowing him to concentrate on policy work. Adam passed on the fundraising responsibilities, having made a large dent in 2019 donor fundraising and having seen David MacRobert and his team produce another marvellous result at the Glasgow auction.

Success in Glasgow was matched by another great performance by Bryan Johnston and his team at the Scottish auction at Prestonfield. Scotland's regional groups led by Malcolm Leslie (Edinburgh and SE), James MacPherson-Fletcher (Highland), Rory Cooper (Grampian), Mike Clarke (East Tayside) and Hugh Arbuthnott (West Tayside), all surpassed their targets. The Grand Grouse Draw was a huge success and it was also another good year for the Scottish Game Fair under the experienced eye of Hugo Straker. For all of you reading this who more than played your part and gave your time freely to organise events, donate auction lots, bid for auction lots or so generously donate funds, a huge thank you from GWCT Scotland. We are also extremely grateful to more than 50 organisations who sponsor our events. These partnerships are an enormous part of what we do and once forged, they are long and successful. The good news is that overall Scotland exceeded its fundraising target.

There remain some very challenging issues in Scotland, particularly around grouse shooting, in a charged political environment. The requirement to play a strong part in the post-Brexit climate change, rural, wildlife and conservation debates, means that Scotland's research-based work and pragmatic approach will remain essential to influence tomorrow's challenges. And that starts with fundraising. I thank you all in advance.

© Jamie Williamson

Guests enjoying the record breaking West of Scotland dinner and auction.

Solving problems using research

- The GWCT's research seeks to address and solve problems.
- GWCT research continues to inform Government policy as well as those managing the land.

Nick Sotherton,
Director of Research

© Hugh Nutt

The *Review* reports on and showcases some of the research work undertaken by the GWCT's research department and with others over the last 12 months.

The GWCT's research is very applied, meaning it seeks to address problems such as the recovery of declining species or problems arising from intensive management. For many researchers, an end point is the publication of their work in peer-reviewed scientific journals. GWCT scientists also strive to do this but, for us, this is not an end point but the start of a second phase during which we strive to get our research discussed in policy forums and among those managing land. In this *Review,* arable farmers will benefit from our work on Barley Yellow Dwarf Virus (see page 14), no-till cultivation and attempts to hold phosphate fertiliser on the land where it can be taken up by crop plants and not released to watercourses where it causes problems (see page 24).

We continue to take research into policy. Dr Jonathan Reynolds' article on page 36 is taken from our submission to Defra on invasive non-native species and hopefully, reflects our understanding of how wildlife conservation can co-exist with current land management priorities. We also continue carrying out fundamental research on the conservation of our game species. Our work on mountain hare, capercaillie, woodcock and red grouse demonstrate this (see pages 50 and 62-73).

Our commitment to training the next generation of wildlife conservation scientists continues. In 2019 two PhD studies were successfully defended and two more PhD theses were submitted for examination in early 2020. Congratulations to Chris Heward (woodcock) and Jessica Marsh (freshwater ecology of salmonids) and fingers crossed for the others. The first GWCT-supervised PhD study was successfully defended in 1980. In 2020 we will see the 97th thesis produced, creeping ever closer to the 100 milestone.

Researchers monitoring bats and their use of agri-environment schemes. © GWCT

GWCT researchers D-vacing for insects at Assenede in Belgium, one of the PARTRIDGE sites. © GWCT

Farmland ecology

Sticky traps, aphids and barley yellow dwarf virus

The yellow sticky traps were used to catch aphids and changed every week. © John Holland/GWCT

BACKGROUND

Barley yellow dwarf virus (BYDV) is the most economically important virus disease of cereal crops with the potential to cause yield reductions of 30% in wheat and 75% in barley. The virus is transmitted by cereal aphids that fly into the crop with yields being most reduced by autumn infestations. The threat of the disease is now much higher following the ban on three neonicotinoid insecticides in 2019, which previously were applied as seed dressings to protect the young plants. To control the aphids, farmers now have to spray pyrethroid insecticides that are also toxic to the beneficial insects in the crop and have the potential to contaminate waterways where they are highly toxic to aquatic insects.

ACKNOWLEDGEMENTS

The project was funded by AHDB Cereals & Oilseeds. Our thanks to all of the farmers and agronomists for participating in the study, our collaborators from Agrii and Amy Corrin, Ellen Knight and Clementine Bourgeois for helping conduct the field studies and identifying the very many aphids. Also to Oecos Ltd who kindly supplied the sticky traps.

A pilot study was funded by the Agriculture and Horticulture Development Board (AHDB) in 2018 to examine the potential for developing a field-based monitoring approach to predict the risk of barley yellow dwarf virus (BYDV) transmitted by cereal aphids in the autumn. Such an approach has the potential to reduce insecticide usage as not all fields are infested with aphids and typically only about 5% carry the virus. Monitoring can also help improve the timing of insecticide applications so that they target the aphids before they have a chance to spread within the crop. However, aphids are difficult to observe in the crop, therefore our farmland ecology unit, in conjunction with Agrii, has been evaluating the use of yellow sticky traps as a monitoring method. The yellow sticky traps that we tested were 20 x 20cm of card coated with wet-stick and we attached them to two plastic pegs and mounted them horizontally just above the crop. Yellow is known to be attractive to aphids. A plastic sleeve was placed over the traps when they were collected and the aphids identified using some form of magnification, with binocular microscopes the best. Two of the project aims were:

1) To evaluate the practicalities of using sticky traps with farmers;
2) To determine whether landscape composition, boundary type and type of tillage affect aphid immigration.

The final project report is now available online so only the key findings are given here. www.ahdb.org.uk/field-monitoring-of-bydv-risk-in-winter-cereals-pilot-study.

To test the practicalities of the sticky trap system we asked seven farmers/agronomists to trial them for at least a month, changing the traps every week. Traps were deployed in the headland area (five metres (m) from the crop edge) and mid-field (70m) in 41 fields. We gave the farmers and agronomists only a very basic aphid identification guide as we wanted to assess the level of current expertise and whether further training materials would be needed if the sticky traps were to be used in future. Five of the farmers/agronomists underestimated the number of aphids by 50-89%, while two overestimated their numbers by 80-82%. Despite this, their assessments were still sufficient to detect the same changes over time as the expert's assessments of the aphid numbers. Overall, they liked the simplicity of the approach and would be willing to use it, but wanted better training in aphid identification.

Sticky traps were also deployed in the headland area and mid-field of 15 fields located in landscapes with different proportions of grassland. In both of these studies, different cultivation systems were used to establish the crop (direct drilling, minimum tillage and ploughing) allowing us to investigate their impact. Over both studies at least three times as many flying aphids were caught in the headland area compared with the field centre (see Figure 1), and especially next to tall boundaries, indicating that wind currents determined aphid immigration patterns within fields. Further research is needed to confirm the impact on whole field populations and BYDV infection, accommodate pesticide application restrictions and investigate the threat to invertebrates overwintering in the field boundary. Considerable variation (24% of fields

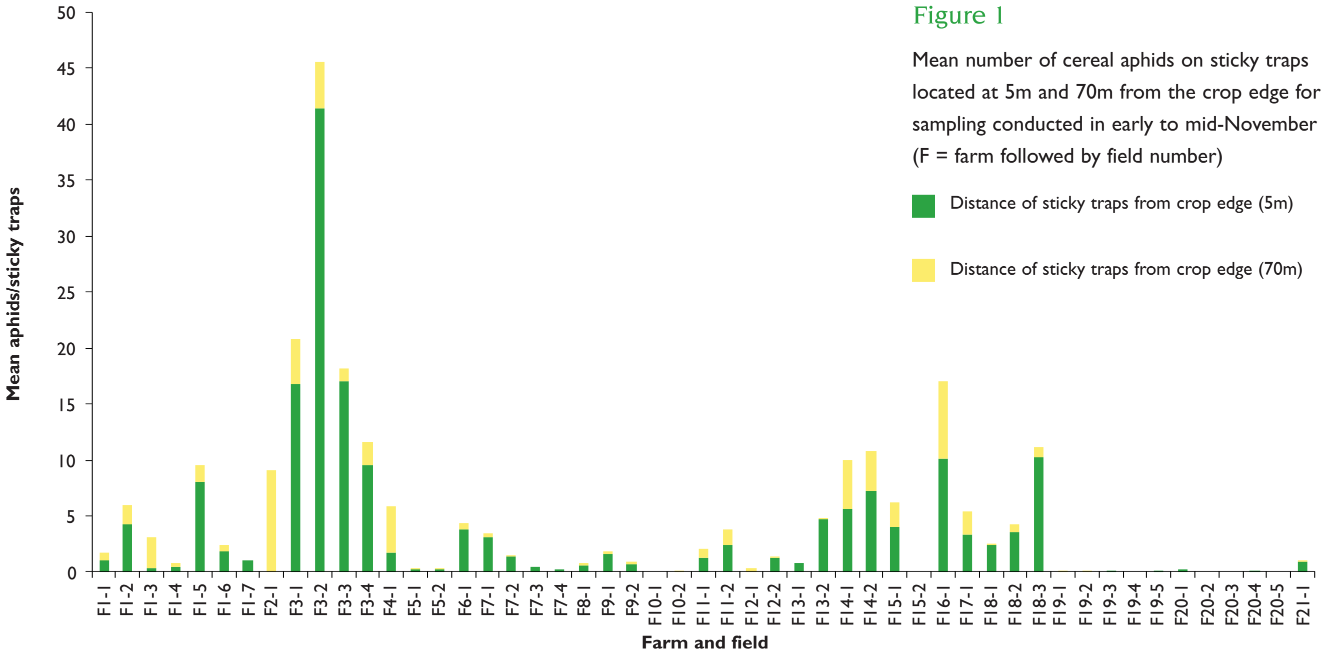


Figure 1

Mean number of cereal aphids on sticky traps located at 5m and 70m from the crop edge for sampling conducted in early to mid-November (F = farm followed by field number)

Distance of sticky traps from crop edge (5m)

Distance of sticky traps from crop edge (70m)

had no aphid immigration) was found in levels of immigrating aphids between fields, even on the same farm, confirming the merit of a field-based monitoring system to reduce insecticide usage. The type of tillage had no impact on levels of immigrating winged aphids, showing that deposition was passive, determined by wind vortices, on the leeward side of a boundary rather than by active selection during flight. In the landscape study, more aphids occurred where there was a higher proportion of grassland within a one kilometre radius of the sampled field. A more detailed study of aphid infestation patterns within two fields confirmed that aphids immigrated primarily into the field headlands (see Figures 2a & b).

KEY FINDINGS

- The sticky trap system was easy to use and captured aphids effectively.
- Farmers and agronomists will need training to ensure accurate identification of aphids.
- The majority of immigrating aphids landed within the headland area of the field.
- Aphid immigration levels varied hugely between fields with 24% having none.
- The type of tillage system had no effect on aphid immigration.

John Holland
Belinda Bown
Adam McVeigh
Niamh McHugh

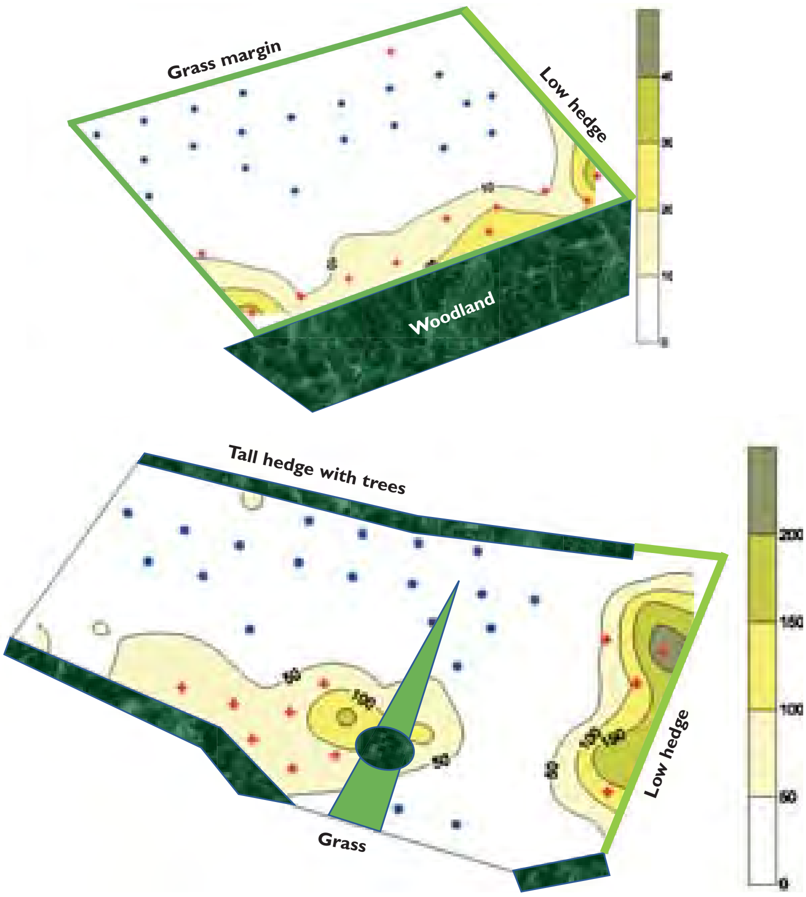


Figure 2a & b

Contour maps depicting total number of cereal aphids within two fields. Blue dots indicate where sticky traps had significantly fewer aphids (gaps) and red dots where there were significantly more (patches)

Bats and agri-environment schemes

Setting up a detector in the field to monitor bats. © Niamh McHugh/GWCT

Across Europe agri-environment schemes (AES) have been introduced which attempt to counteract biodiversity losses relating to agricultural intensification. However, the potential benefits of AES to non-target groups such as bats are unclear. The AgriBats project aimed to determine how AES habitats are used and can be best managed to benefit a range of bat species. In our study, we assessed how the vegetative characteristics of four commonly employed AES habitat types (grass margins, wildflower margins, wild bird seed mixture plots and pollen and nectar plots) influenced the occurrence and activity of bats.

Surveys were conducted on 48 AES habitat plots across 15 farms. Each plot was surveyed for nine nights between 12 April and 1 September 2017 using passive real-time bat detectors, resulting in 432 nights of recordings being collected over the project. After data checking 9,154 recordings of bats were available for analysis representing six species and a further two bat genera (see Table 1). Common pipistrelle were recorded most frequently accounting for 71% of recordings, soprano pipistrelle and barbastelle were also recorded relatively frequently, representing 10% and 6% of recordings respectively. Therefore, in this summary, we focus on relationships between these three bat species and AES.

The vegetative characteristics of AES habitats were assessed in five 0.5-m² quadrats, spaced 10 metres (m) apart, centred around the bat detector. Grass, broad-leaved plant and bare ground coverage was estimated in each quadrat, and counts of the number of ground flora species and the number of individual flowering plants present within quadrats were made. The adjacent field boundary height was estimated to the nearest 0.5m and averaged across five points. The number of trees present was also counted and distance measured to the nearest woodland, as the crow flies.

The importance of AES vegetation characteristics varied between bat species. Cover of flowering plants was positively correlated with the occurrence of common pipistrelle. Soprano pipistrelle and barbastelle activity increased with plant diversity within plots, and barbastelle activity showed a further positive correlation with flowering plant abundance. Common pipistrelle was most influenced by field boundary features and its activity was positively correlated with boundary height and the number of trees present. Barbastelle activity was also positively related to boundary

BACKGROUND

Several European bat species declined during the 20th century owing to many factors including the loss of roost and feeding sites through agricultural intensification. Bat roosts in England are protected by law, but feeding sites are not, making them susceptible to land use change. English agri-environment schemes (AES) represent approximately 14% of agricultural land in the UK and, although they do not specifically target mammals, many are designed to increase invertebrate food resources. They may therefore represent important local foraging patches for bats.

TABLE 1

Recorded bat species and the number of validated recordings. Passive real-time bat detectors recorded bat activity over nine nights in 48 fields in south-west England in 2017

Common name	Number of validated recordings	Percentage
Common pipistrelle	6,540	71.4
Soprano pipistrelle	901	9.8
Nathusius' pipistrelle	75	0.8
Barbastelle	559	6.1
Serotine	358	3.9
Common noctule	106	1.2
Myotis species	268	2.9
Plecotus species	62	0.7
Unidentified	285	3.1
Total	**9,154**	

height. Negative relationships were also identified between barbastelle occurrence and distance to the nearest woodland.

The importance of specific AES vegetation characteristics varied between bat species, but common pipistrelle, soprano pipistrelle and barbastelle demonstrated significant positive relationships with the cover of flowering plants, plant diversity or flowering plant abundance. These habitat characteristics best describe pollen and nectar plots and wildflower margins, both of which are designed to benefit invertebrates. Furthermore, soprano pipistrelle and barbastelle bats were associated with woodland proximity and may therefore benefit from floristically diverse foraging sites, which are attractive to bat invertebrate prey, if they are in close proximity to potential roost sites. Common pipistrelle were also attracted to AES habitat patches with a high coverage of flowering plants and were also more abundant if such habitats were located along tall field boundaries with trees, which probably provided shelter for their prey. Therefore, if AES habitats are to be used to help conserve bats, consideration should be given to the spatial arrangement of floristically rich and diverse AES habitats in relation to fixed landscape features.

For more details, see the published paper: McHugh, NM, Bown, BL, Hemsley, JA & Holland, JM 2019. Relationships between agri-environment scheme habitat characteristics and insectivorous bats on arable farmland. *Basic and Applied Ecology* 40, 55-66.

AgriBats
Learning about bats on arable farmland in Hampshire & Dorset

KEY FINDINGS

- Soprano pipistrelle and barbastelle bats were more abundant near woodland, possibly because it was being used for roosting. They also favoured habitat characteristics which best describe pollen and nectar plots and wildflower margins.
- Common pipistrelles were attracted to agri-environment scheme (AES) habitats with high flower coverage and also preferred it when these habitats were adjacent to field boundaries with trees.
- The spatial arrangement of flower-rich AES habitats in relation to landscape features, should be considered if AES habitats are to be used to benefit bat conservation.

Niamh McHugh
Belinda Bown
Jade Hemsley
John Holland

ACKNOWLEDGEMENTS

We are grateful to the landowners who allowed us to conduct fieldwork and to Anna Forbes and Sophie Potter for their assistance in data collection. This work was supported by the Heritage Lottery Fund, Natural England, the Hamamelis Trust, Chapman Charitable Trust, Wixamtree Trust and the Mercer's Company.

Quadrats were used to assess ground flora species. © Niamh McHugh/GWCT

Research and demonstration farms - Allerton Project

Allerton Project: game and songbirds

Wild bird seed mixtures are part of our stewardship scheme and provide food for our songbirds. © Kings

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.

Since 2011 the Allerton Project farm has been managed as a released pheasant shoot, following nine years of no game management, in turn preceded by nine years of wild game management. The current regime includes habitat management and winter feeding, as in the period of wild game management. The level of predator control is intermediate between that in the wild game management phase of the project and that of a conventional released bird shoot, as our previous research has demonstrated the benefits of predator control to some songbird species.

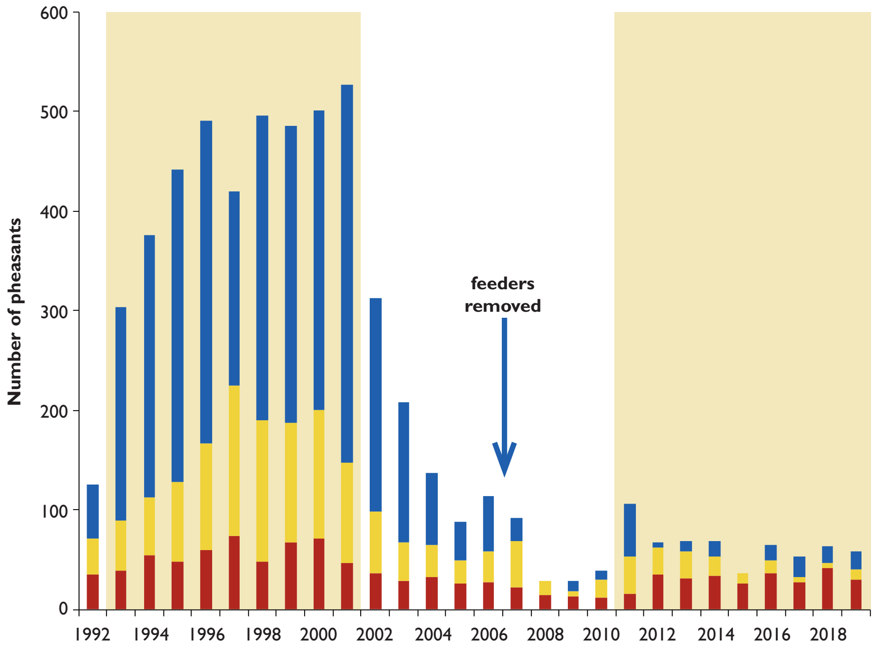
Some exceptional shoot days are held, but we continue to struggle to increase the numbers of wild gamebirds. Our cull records and wildlife monitoring indicate that the number of both generalist predators which we can control legally, and protected species, have increased in number locally.

Autumn gamebird counts reveal that wild pheasant numbers remain well below those present in the wild game management phase of the project (see Figure 1). Only 18 poults were present at the end of the breeding season, compared with up to 379 during the wild game management period.

Our game count data suggest that grey partridges have not bred on the farm since 2014, and 2019 continued this trend. Winter hare numbers on the other hand were 5.8 times higher than on the comparison site, and 3.8% higher than the 1992 baseline. Overall songbird numbers were 62% above the 1992 baseline but 27% lower than the peak recorded during the period of wild game management (see Figure 2). The

Figure 1

Autumn wild pheasant numbers from 1992 to 2019



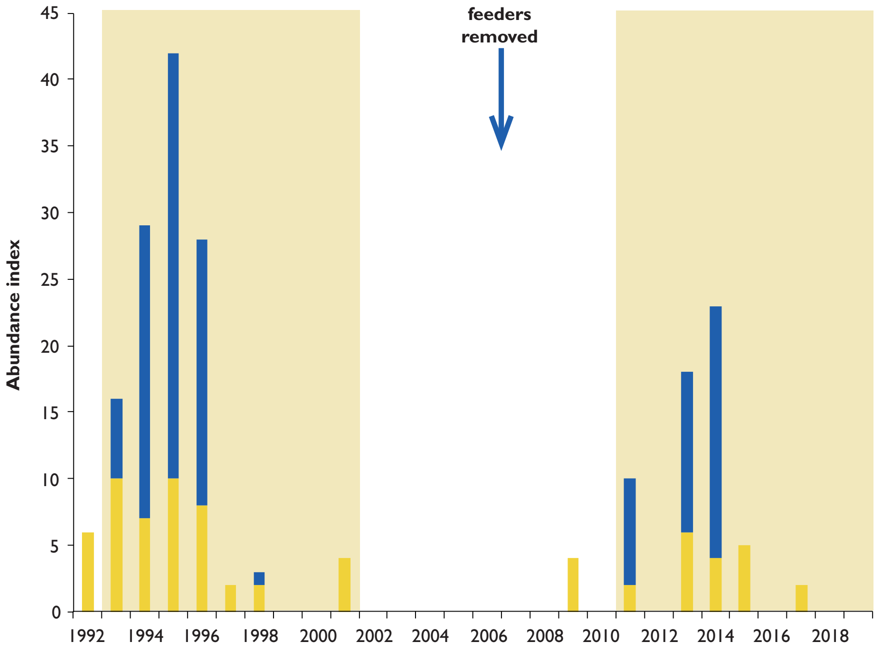


Figure 2

Autumn grey partridges

Adults

Young

Keepered period

equivalent figures for Biodiversity Action Plan (BAP) species were 32% and 31%. This is likely to be due to the lower level of predator control than during the early phase of the project, especially resulting from General Licence restrictions in 2019, and to drought conditions during the 2018 breeding season.

As described in the article on page 46, we radio-tagged 44 hen pheasants in early March. Half of the tagged birds died before the start of the nesting season but we put trail cameras on four nests and closely monitored another two. All the nests failed and three were confirmed to have been predated by badgers. Our experience in 2019 is consistent with our findings in 2018 when all radio-tagged pheasants died as a result of disease, predation or an interaction between the two.

Our previous songbird research revealed that late winter feeding of grain to gamebirds also benefited songbirds, resulting in 30% higher songbird breeding numbers in subsequent springs. Alongside other sources of food such as road kills and farm livestock feed sites, predated and scavenged pheasants may be contributing to enhanced survival and breeding numbers of some generalist predators. We are developing plans to investigate and address this issue.

KEY FINDINGS

- Overall songbird numbers are currently 62% above the 1992 baseline.
- Biodiversity Action Plan songbirds are 32% above the 1992 baseline.
- Wild gamebirds are not responding to our management.

Chris Stoate
John Szczur
Austin Weldon
Matthew Coupe

ACKNOWLEDGEMENTS

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

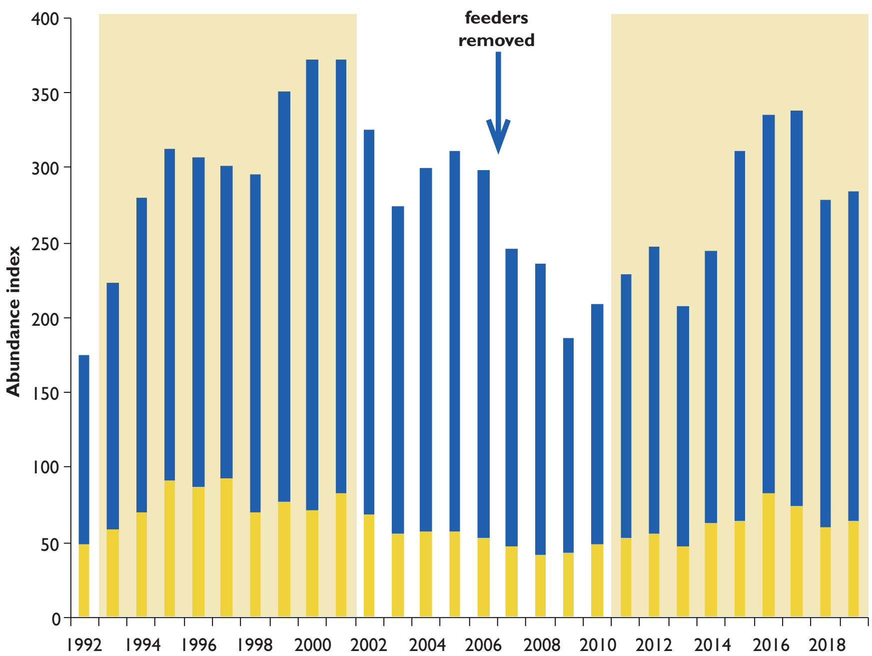


Figure 3

Songbird abundance

Biodiversity Action Plan species

Others

Keepered period

The farming year at the Allerton Project

One component of our regenerative approach is reduced cultivations. © Phil Jarvis/GWCT

As the 2019 farming year unfolded, two very different issues have shared centre stage. Firstly, the continuing saga of the UK leaving the European Union and secondly the increasingly serious concerns over our climate and weather patterns.

Brexit discussions rumbled on with indecision bringing agricultural planning and investment to a standstill. It is only as the year rolled over into a new decade that a majority Government looked like it could pass the required legislation to break the impasse that had prevailed. Farming businesses can now turn their attention to the sort of trade deal that will influence the markets for the produce our farms provide.

While negotiations on the political agenda advance, a more complex and serious situation develops around global climate change and the implications for farming. It is interesting that reports on farming and the environment, written as little as 15 years ago, concentrated on wildlife and biodiversity rather than climate. Closer to home we have seen both ends of the weather spectrum with predominantly drier conditions dominating the first six months (54mm/month) and some of the wettest late September to December (97mm/month) conditions that the farm has experienced since the start of the project.

TABLE 1

Arable gross margins (£/hectare) at the Allerton Project 2010-2019

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Winter wheat	673	783	255	567	590	457	442	766	780	837
Winter oilseed rape	799	1,082	490	162	414	533	524	713	377	528
Spring beans	512	507	817	580	646*	396*	289*	436*	176*	459*
Winter oats	808	873	676	570	354	507	156**	-	-	386
Winter barley								367	733	423

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

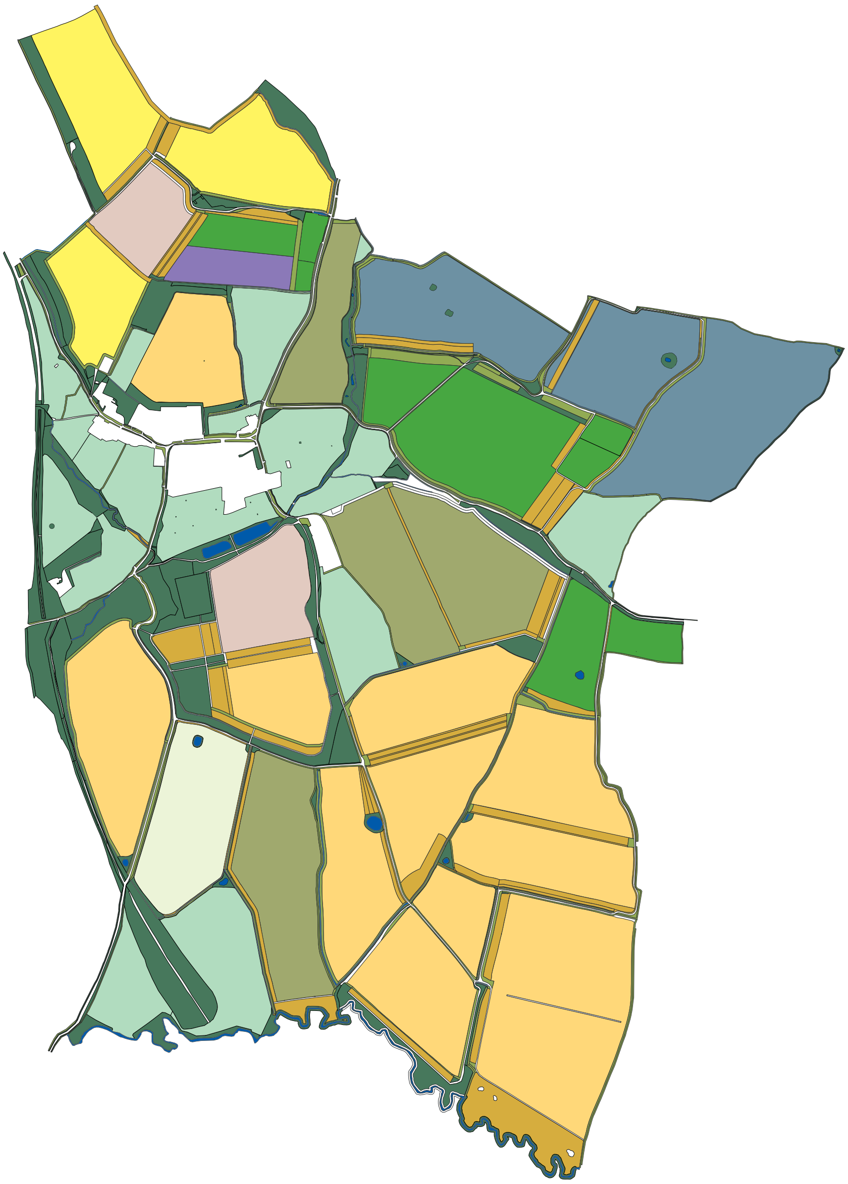


Figure 1

Allerton Project cropping 2018/19

- Woodland
- Permanent pasture
- Winter wheat
- Winter oilseed rape
- Herbal ley
- Winter beans
- White clover & ryegrass
- Spring beans
- Winter oats
- Winter barley
- Stewardship and shoot cover
- Hedgerow/verge

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. The Project also has an educational and demonstration remit. The Project celebrated its 25th anniversary in 2017.

Our Biodiversity and Environmental Training for Advisors (BETA) course aims to set an industry-recognised standard. © GWCT

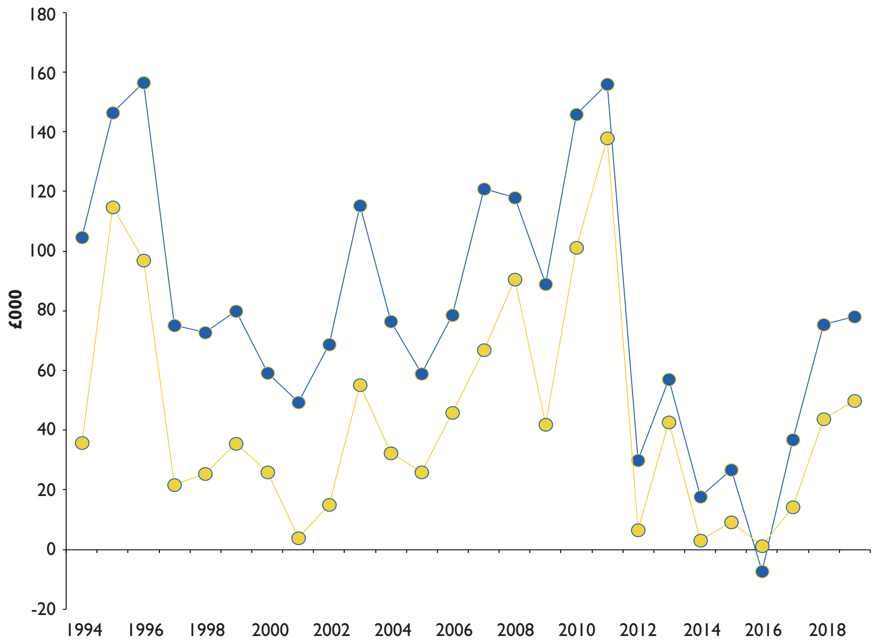
Figure 2

Gross profit* and farm profit at the Allerton Project 1994-2019

**Gross profit = farm profit plus profit foregone to research, education and conservation*

Gross profit

Farm profit



KEY FINDINGS

- The farm continues to address food production challenges caused by extreme weather.
- No winter cereals sown in autumn 2019, the first time in 27 years, leads to spring crops and fallow.
- Environmental land management opportunities will complement our climate friendly farming approach.
- Conservation habitats, management and training remain a sharp focus for the project into 2020.

Phil Jarvis
Alastair Leake

The 2019 harvest produced above-average yield for winter wheat (9.5 tonnes/hectare) and barley (7.7t/ha). Beans (3.7t/ha) and oil seed rape (3.2t/ha) broke even. Our winter oat crop (5t/ha) suffered with some inclement wind and rain in August, which left many grains on the floor before we were able to gather them in.

The establishment of crops for harvest in 2020 was a somewhat different story. Had we been composing this article 20 years ago, most of the crops would have been sown, emerged and be ready to face the winter. However, the planned delay to combat black-grass and unprecedented rainfall from October through to December has meant no winter cereals were sown. This is a first in 27 years for the farm and it shows that climate and weather will have an increasing effect on our farm business. Plans are in place to sow spring crops or possibly leave some land fallow. Longer-term

Pollinator attractive habitat to help improve biodiversity on the farm. © Phil Jarvis/GWCT

© Phil Jarvis/GWCT

Herbal leys will be an integral part of our rotation.

plans could see us increase our environmental area as our Higher Level Stewardship scheme finishes in 2020.

The current use of Mid-Tier Countryside Stewardship will allow us to complement our regenerative farming systems approach. The expansion of herbal leys, low-input cereals and other in-field options should help spread risk and strive towards better financial margins as opposed to chasing yield. Converting narrow grass margins to a more flower-rich habitat, improving field corners into more diverse floral and 'pollinator attractive' habitats will help us improve biodiversity in the UK's farmed landscape. Many of the farming and environmental challenges will be dealt with practically by our new assistant farm manager, Oliver Carrick, who joined the team in May.

With many of the fields on the farm involved in research, it is worth highlighting the work that we are doing on greenhouse gas emissions, soil biological activity and carbon storage. With 'Carbon Net Zero' firmly entrenched in global, national and regional agenda, our work has never been more relevant. Our cultivation work is looking at the differences in carbon dioxide, methane and nitrous oxide gas emissions from the soil; which in turn is building a better understanding of the complexities and impacts of the farming systems needed in the future. Soil research at the project continues to expand showing an active soil ecosystem can provide many of the nutrients required by our crops, while storing more carbon to help alleviate emissions from other sources.

Collating the farm, environmental and research data is a continual challenge and much of it now forms the foundation of our BASIS Conservation Management course which grows from strength to strength. With Jim Egan moving to pastures new, Phil Jarvis has taken the lead in training and partnerships. Two new team members have joined the project; Saya Harvey (training manager) and Jemma Clifford (partnerships manager).

The focus for next season will be on producing high quality research and training based around our experiences on clay soils. With Brexit moving apace and a society realising more needs to be done to address climate concerns, let's hope the 2020 spring weather is kind to us and allows our cropping to proceed as planned.

TABLE 2

Farm conservation costs at the Allerton Project 2019 (£ total)

Higher Level Stewardship costs (including crop income forgone)	-23,939
Higher Level Stewardship income	26,516
Woodland costs	-2,161
Woodland income	3,915
Farm Shoot expenses	-3,845
Farm Shoot income	3,845
Grass strips (not in Stewardship)	-500
Total profit forgone	
- conservation	**3,831**
- research and education	**-32,000**
	-28,169

Further information on how these costs are calculated is available from the Game & Wildlife Conservation Trust.

Can cover crops recover legacy phosphorus?

Cover crops such as buckwheat have been shown to reduce nitrogen loss to water and to reduce soil erosion. © Chris Stoate/GWCT

BACKGROUND

As one of five research and demonstration farms in Defra's national Sustainable Intensification research Platform (SIP), we set up an experiment to explore the potential benefits of cover crops to soil and commercial crops. This article describes a PhD project, in partnership with Nottingham University and Rothamsted Research, which investigated one biological aspect of phosphorus cycling in more detail.

Phosphate fertiliser is essential for crop growth but is a finite resource. It is available only from a limited number of sources worldwide, many of them at risk of political instability. The price to farmers has increased substantially in recent years. Like other farms across the country, we try to maintain soil phosphate at an index of 2 for optimum use of this resource, although even with regular soil nutrient testing, this is not always easy to manage. Once in the soil, phosphate becomes bound to soil particles and most of the phosphate applied as fertiliser over the years is estimated to have become unavailable to crops in this way. This soil-bound fraction is known as legacy phosphate.

Loss of soil to water is associated with transport of phosphate into watercourses where it is a major cause of eutrophication and deterioration of aquatic ecosystems. From both an environmental and an economic perspective, there is an increasingly recognised need to improve the efficiency of phosphate use on farmland.

One area of interest is the store of phosphate currently locked up in soil. This can be remobilised by phosphatase enzymes produced by soil microorganisms and some plant roots. We were interested in exploring the potential of cover crops grown over the autumn and winter between the harvest of one crop and the drilling of a following spring-sown crop. Cover crops have been shown to reduce nitrogen loss to water and to reduce soil erosion, with implied benefits in terms of phosphate conservation, but we were interested in potential additional benefits associated with the biological activity in the soil.

In 2017, we set up a replicated experiment involving plots of oats, radish, phacelia, vetch and buckwheat, with bare stubble plots lacking cover crops as controls, with three replicates of each. We collected soil samples for laboratory analysis for phosphatase in March, and in the following June when the spring-sown oats crop was actively growing. Through laboratory analysis at Rothamsted Research, this enabled us to assess the presence of phosphatase enzymes at the end of the cover crop growing period, and during the period of peak growth for the following cash crop.

In March, cover crop plots of oats showed significantly greater phosphatase activity than any of the other plots, with phacelia showing intermediate activity. The same relationship was found in the following oats crop, with the plots that had been oats cover crop showing the highest activity, and phacelia intermediate levels (see Figure 1), so cover crop effects were following through potentially to benefit the spring-sown cash crop.

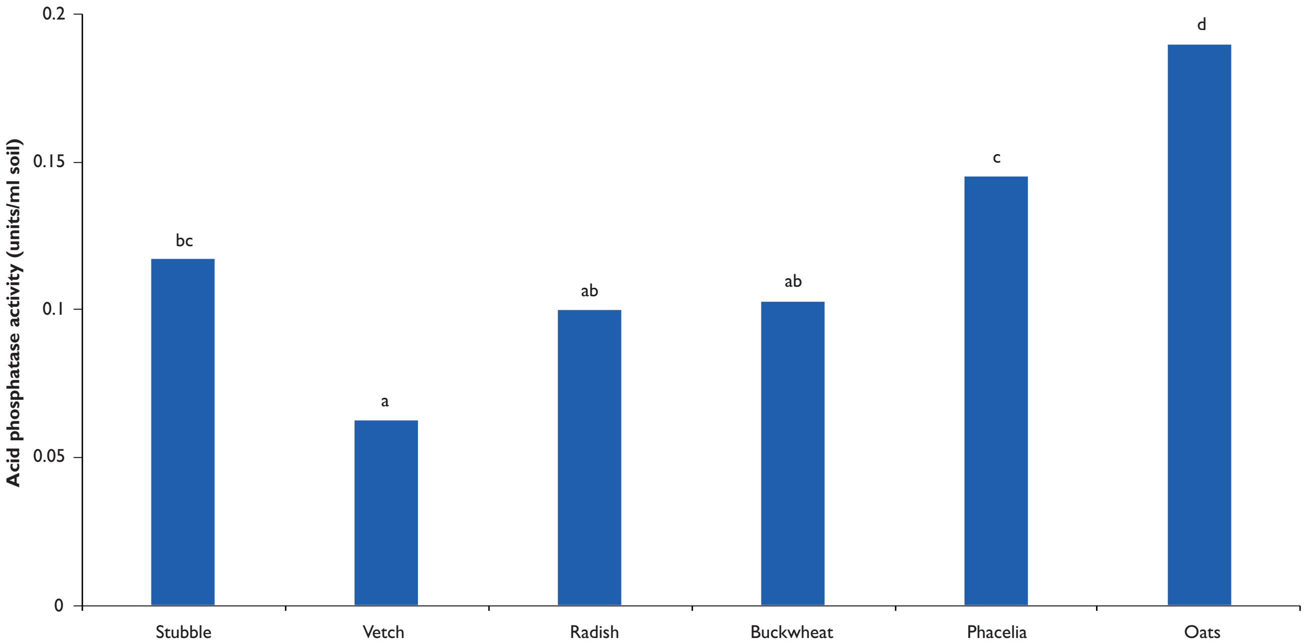


Figure 1

Soil acid phosphatase activity under different cover crop species sampled in June. 1 unit is the amount of enzyme to hydrolyse 1 μm para-nitrophenyl phosphate min-1. Species similarly superscripted (a, b, c, d) are not significantly different

Unfortunately, results of laboratory analysis in 2019 reveal that similar findings were not obtained when the experiment was repeated in 2018, and nor were these findings repeated under controlled conditions in pot-based laboratory experiments at Rothamsted. Some cover crops may have a role to play in making legacy phosphate available to crops, reducing the need for imported and purchased fertiliser, but there remains uncertainty over the potential of this approach.

We are currently contributing to the RePhoKUs project, led by Lancaster University, to better understand broad issues associated with the phosphorus cycle at a range of scales. This includes laboratory tests at Sheffield University to assess the rate of depletion of available phosphate from two local soil types, with a view to exploring other options for mobilising legacy phosphate. It is important to note that, like mined rock phosphate, legacy phosphate in soils is also a finite resource and our work with the RePhoKUs project is exploring options for more efficient management of phosphate through the food chain.

KEY FINDINGS

- Oats and phacelia cover crops were associated with higher phosphatase activity and phosphate mobilisation than other crops. Phosphatase is an enzyme secreted by roots and microorganisms which increases availability of soil-bound phosphorus.
- These results were not repeated in year 2 or in the lab.
- Some cover crops may have the potential to improve phosphate use efficiency, but we don't yet have the evidence to make a recommendation.

Chris Stoate
Sam Reynolds

Once in the soil, phosphate becomes bound to soil particles, known as legacy phosphate, and becomes unavailable to crops. © Paul Maguire/Shutterstock

Reducing compaction in no-till systems

Carbon dioxide emissions from soils were 132% higher in ploughed soil than in less disturbed soils. © Felicity Crotty/GWCT

SoilCare is an EU-funded project which is exceptional in that the exact experimental research to be carried out was not specified in the contract. Instead, much of the first year involved applying a structured approach, in collaboration with social scientists, to enable local farmers to set the research agenda by prioritising topics that would be of most value to them. Our local farmers considered compaction in reduced and no-till systems to be a widespread problem that has negative impacts on crop profitability and soil function. It also has a negative impact on flood risk and water quality by accelerating runoff and erosion.

We set up a replicated experiment with three replicates per treatment at the Allerton Project in the barley (2018) and field beans (2019) stages of the rotation. The means of compaction alleviation that we tested were traditional ploughing and the use of a low disturbance subsoiler (LDS). A third treatment involved the use of a mycorrhizal inoculant which was not expected to influence physical soil properties, but could improve crop nutrient uptake through the fungal strands. The experimental area was deliberately compacted by driving a tractor up and down at right angles to the tramlines before the alleviation methods were applied, and we evaluated the three methods against control plots in which the crops were direct drilled without any form of compaction alleviation.

The SoilCare project is concerned with wider environmental considerations, as well as the crop performance and economic considerations of the farmers and so a wide range of data were collected. Most notably, the SoilCare project enabled us to buy innovative equipment to monitor greenhouse gas flux associated with the various treatments so that we could assess their implications for climate change.

Carbon dioxide flux (exchange and movement of the gas) varied seasonally, being around 130% higher in the summer than in the winter. Due to the high variation in carbon dioxide flux no significant treatment differences were found, but there was a strong trend with CO_2 emissions; 132% higher in the plough plots. Nitrous oxide flux was significantly ($P=0.042$) higher in the non-cultivated plots. However, even considering the much higher (298 times more than CO_2) global warming potential of nitrous oxide, the global warming potential of these emissions were very low across all plots when compared with the carbon dioxide results. These findings are important as we were concerned that anaerobic (low oxygen) conditions associated with direct drilling and compacted ground may have resulted in higher nitrous oxide flux than in plots where the soil had been disturbed. As well as higher carbon dioxide emissions from the soil, the act of ploughing and subsequent cultivations is also associated with additional emissions of greenhouse gases through the increased burning of diesel fuel.

Water infiltration rates showed no significant differences but were highest in the plough and subsoiled plots in 2018, but lowest in the plough plots in 2019. Earthworm

BACKGROUND

The Allerton Project at Loddington is one of 16 study sites across Europe for the EU-funded SoilCare project. The project will test soil management practices intended to increase farm business profitability, while also delivering environmental benefits. Our local farmer network helps to set the research agenda to ensure that the research is relevant to their interests and needs.
They considered compaction in reduced and no-till systems to be a widespread problem that has negative impacts on crop profitability and soil function. It also has a negative impact on flood risk and water quality by accelerating runoff and erosion.

The Gasmet GHG analyser monitors greenhouse gas flux in the crop. © Jenny Bussell/GWCT

densities were significantly (P=0.046) affected by the plot treatments and were highest in the inoculated plots in 2018 and in the control plots in 2019, being lower in the treatments with more soil disturbance in both years (see Figure 1). Infiltration rates can be higher in ploughed than undisturbed direct drilled soil because of the initial more open structure, but can also be higher in direct drilled soil where high earthworm densities create channels through which infiltration can take place. However, in our experiment, earthworm densities were 69% lower in 2019 than in 2018, not higher, so this relationship between soil management and infiltration rates requires further investigation.

Crop yields did not differ significantly between treatments in the beans or barley, but showed a trend towards being higher in plough (8.15t/ha) and LDS (7.99t/ha) than inoculated (6.64t/ha) and control (6.58t/ha) plots in the barley. There was little difference in net income from barley because of the costs associated with cultivations, but in the beans, the control and inoculated plots were associated with about 25% higher net margins.

This research has improved our understanding of the environmental and economic implications of alleviating compaction in our arable rotation; information that we are already sharing with the farmers who suggested this work, and much more widely.

KEY FINDINGS

- Carbon dioxide emissions from soils were 132% higher in ploughed soil than in less disturbed soils.
- There was no difference in bean yield, but barley yield was 20% higher in plough and LDS (subsoiled) plots.
- Owing to differences in cultivation costs the beans had approximately 25% higher net margins in the direct drill plots. There was little difference in net income from barley.

Chris Stoate
Felicity Crotty
Jenny Bussell
Phil Jarvis
Gemma Fox

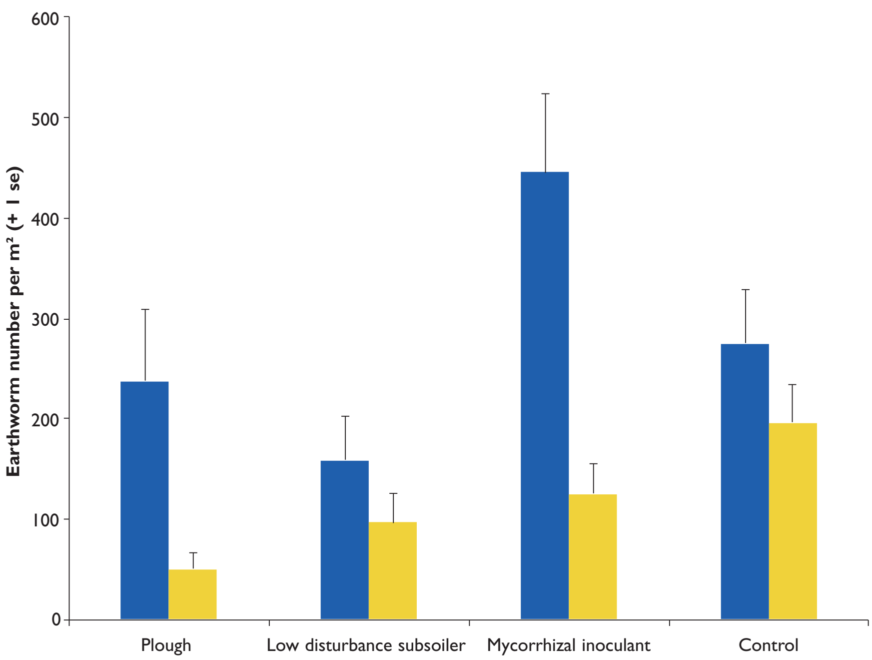


Figure 1

Earthworm abundance in relation to compaction alleviation methods in 2018 and 2019

2018

2019

Scottish demonstration farm - Auchnerran

Auchnerran: game and songbird counts

The number of first clutches for lapwing remained the same as last year, despite a fall in pair density. © Marlies Nicolai/GWCT

BACKGROUND

We have been managing our Game & Wildlife Scottish Demonstration Farm, Auchnerran (GWSDF) since taking on the tenancy in November 2014. At that time, the farm had been run down for some years previously, although a team of gamekeepers from the adjacent grouse moor included Auchnerran in their predator control activities during this time and since then. The farm is around 70% grass (total farm size 417ha) with a flock of just under 1,000 ewes plus followers. In 2015 and 2016 the research team at Auchnerran carried out extensive baseline surveys to determine the wildlife 'natural capital' on the farm, before any major changes to the management regime took place. This showed that the farm supported lots of wildlife, with the 'jewel in the crown' being significant numbers of breeding waders.

2019 was a pivotal year for Auchnerran. The Trust has been running the farm for five years and made significant improvements to its management, which have benefited farm outputs (see page 30). A very important task for the research and monitoring team is to survey key wildlife groups every year to identify any impacts that farm management may have on them; after all our vision is to have 'an economically-viable farm, rich in game and wildlife'.

We follow the fortunes of a diverse mix of species like soil invertebrates and bumblebees, rabbits and pine martens, and of course game species, to name a few. We put additional effort into our bird monitoring, including several wader species, to get a more in-depth understanding of the processes behind the patterns. Our baseline survey work in 2015 and 2016 revealed high abundances especially for lapwing, oystercatcher, curlew and woodcock. Every year we count the breeding pairs and map nests for the first three of these species, so that we can follow their breeding attempts.

A downturn in the abundance of some of the wader species was recorded last year (*Review of 2018,* see page 22) but now appears to be the case for some of the other monitored species too (see Figure 1). Although wader pair abundance fell in 2018 and 2019, the number of first clutches we have found has remained approximately stable over the years, suggesting it may be the non-breeding birds that are not returning to Auchnerran. We will be monitoring the situation closely next year but have also begun investigating potential causes and associations. For example, one pattern that seems to emerge from the wader nest locations is a change in nest distribution: some fields that have been improved, for example by reseeding, were used less by breeding lapwing and oystercatcher, whereas some other habitats like our game crop plots and the moorland just above the farm, were used more.

There was also a decline in abundance of the Scottish farmland bird index species too, with the average density down 63% between 2018 and 2019, and 15 of the 27 species showing a decline. This sounds like a major fall in numbers, but the bulk of the change was due to declines in some flocking species (eg. jackdaw, wood pigeon and starling) which had a disproportionately large impact on the average figure. Similarly, the thrushes that we monitor in our woodlands via a different approach showed a 14% decline over the same period.

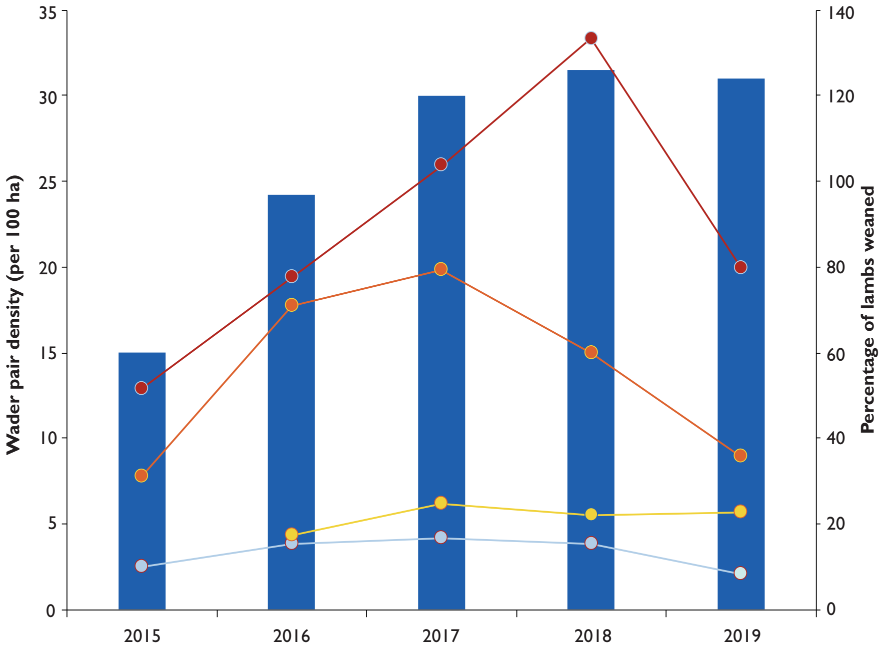


Figure 1

Density of wader pairs (per 100ha) at Auchnerran in relation to the percentage of lambs reaching weaning age (a measure of farm performance), 2015 to 2019

**Woodcock data are density of roding males*

Lambing percentage

Lapwing

Oystercatcher

Curlew

Woodcock*

It is entirely possible that these declines are temporary and perhaps unrelated to any changes on the farm, so we will watch closely over the next year to confirm this. We are also continuing to explore our datasets to look for further evidence of any significant associations that might help explain the changes, but most importantly we are already taking practical steps to support wildlife on the farm.

The farm and research teams work closely together and, as far as possible, farm operations in areas sensitive to disturbance are kept to a minimum. Similarly, the management of our game cover plots is organised to avoid operations during spring/summer, so that they offer wader nesting habitat. A final potential boon for waders and others will hopefully come from the Agri-Environment and Climate Scheme plan that we have implemented this year (see page 30). This includes elements aimed at waders such as 'wader grazed grassland' and 'wader scrapes', and songbirds ('wild bird seed for farmland birds'), which will hopefully benefit game too.

KEY FINDINGS

- Auchnerran supports lots of wildlife, but 2019 saw some declines in the abundance of some bird species.
- It is not clear if these were temporary or what might have caused them.
- Although the density of some waders fell, the number of first-clutches found remained unchanged, suggesting the decline was among non-breeding birds.
- Practical steps have been taken to help support these groups including altering farm operations wherever possible, managing game cover to provide potential nest sites for waders and measures introduced as part of the Agri-Environment and Climate Scheme management plan available in Scotland.

Dave Parish
Marlies Nicolai

ACKNOWLEDGEMENTS

Thank you to SongBird Survival for supporting our research on thrushes at GWSDF Auchnerran.

New habitat options such as wader scrapes and wader grazed grassland will benefit birds such as oystercatchers. © Laurie Campbell

The farming year at Auchnerran

We have improved habitat across the farm including putting in some new wader scrapes. © *Dave Parish/GWCT*

2019 has been an important year for Auchnerran. The Trust has now been managing the farm for five years and we are starting to see progress from the hard work and investments put into it. Many readers will remember the condition of the farm when we took over: dilapidated fencing; poor grazing quality due to a lack of liming; an ageing sheep flock in poor health and, not surprisingly, producing relatively few lambs. Now all the sheep at Auchnerran are no older than four years of age after weeding out the old ewes, and the flock is far more productive as a result of better husbandry and the removal of the sick or barren animals. The improvement is clear to see in the lambing percentage in Table 1, with 2019 again exceeding 120%, despite a prolonged cool wet spring. The process of flock improvement has led to an overall reduction in flock size up to 2019, but we are forecasting a return to our target of approximately 1,500 ewes within no more than two years.

A challenge that we have faced since the outset, related to the state of the farm when we took on the tenancy, is in ensuring that the flock has sufficient grazing during the winter. Between the months of June and November the flock grazes the neighbouring moorland and relatively few sheep stay on the farm. This allows the fields to regenerate and for some to produce a crop of silage which is then fed to the sheep in winter. However, this has at times been insufficient, resulting in the need to buy in additional forage. A number of steps have been taken to alleviate the pressure on the farm over winter. Our improvements to field management have increased silage production (see Table 1), but this is also dependent on the weather during the summer which can limit grass growth when particularly dry, as in 2018 for example.

BACKGROUND

Auchnerran is a grass-dominated hill-edge farm in east Aberdeenshire. The farm extends to 417ha, around 70% of which is grass with the remainder comprising woods, fodder crops and game cover. The soils are dominated by post-glacial sandy deposits, so are free draining – useful in wet weather but problematic during prolonged periods without rain when grass stops growing. The principal commodity on the farm is the sheep flock. When the GWCT took over the farm tenancy in November 2014 it was in a poor state after many years with a general lack of investment in infrastructure and an ageing sheep flock with low productivity.

TABLE 1

Flock size and productivity (percentage of lambs reaching weaning age) at Auchnerran, along with annual silage production

	Ewes	% weaned	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	1,260*			
2021	1,500*			

**Projected ewe numbers for 2020/21.*

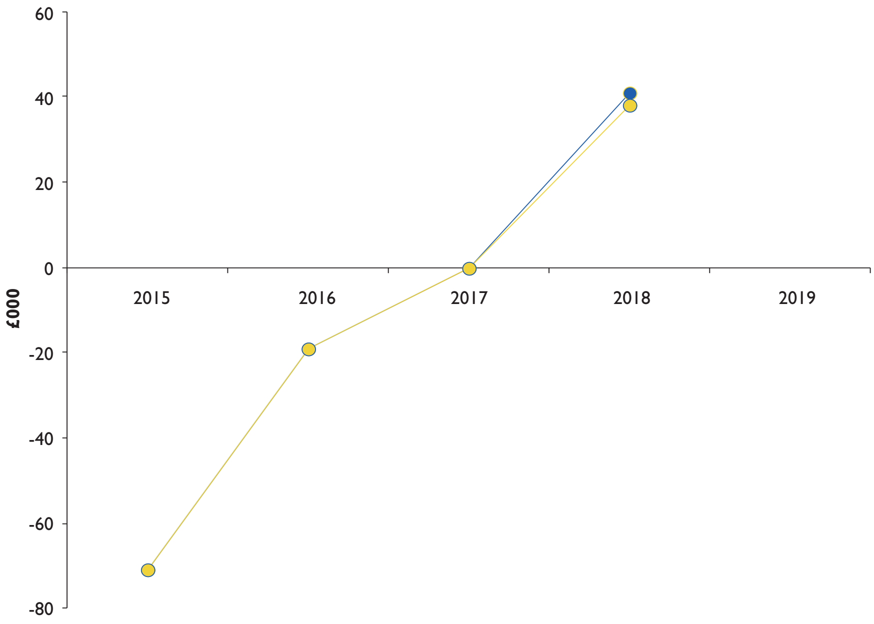


Figure 1

Gross profit* and farm profit at GWSDF Aucherran 2015-2019

Gross profit = farm profit plus profit foregone to research, education and conservation

Gross profit

Farm profit

We now regularly grow a mix of brassicas to supplement grazing which also helps, though again is dependent on the growing conditions during the summer and so is not guaranteed. Last winter we also began away-wintering some of the sheep: this is where they are taken to another farm for this crucial period before returning in spring. In addition, for the first time this year, we have struck an agreement with one of our neighbours and now effectively share a few fields that we can graze during the winter as needed. Although the measures have helped enormously we still need to be vigilant as the flock size is going to increase markedly over the next two years.

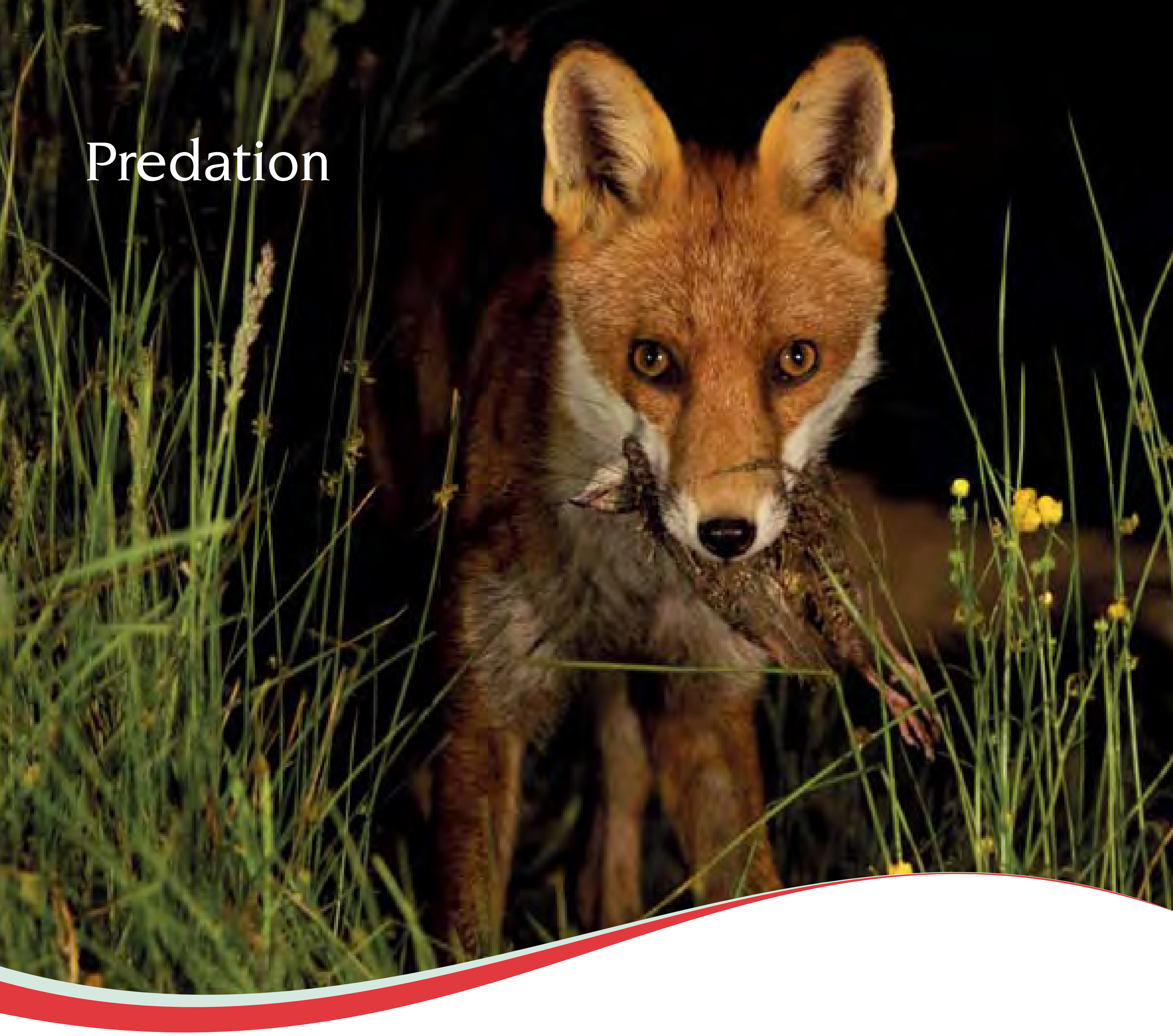
Another aid to increasing the availability of grazing for the sheep, and a big development for Auchnerran in its own right, was the start of our Agri-Environment and Climate Scheme (AECS) management plan. This has enabled us to complete the fencing upgrade, which means that a couple of large areas of the farm are now able to be grazed for the first time. These are relatively rough areas of wet ground with a mix of grass and scrub, but which will provide 'a bite' for the sheep at times through the winter, again taking the pressure off some of our main pastures. This will also have benefits for the farm's wildlife as it should help to prevent further scrub expansion and maintain the open habitats of value to our breeding waders. Other significant components to the AECS plan include 'wader grazed grassland' areas and 'wader scrapes', plus additional 'wild bird seed for farmland birds', all of which we hope will help our breeding wader populations and support our wintering pheasants and songbirds (see page 28).

KEY FINDINGS

- The GWCT has managed Auchnerran for five years and has seen great improvements to farm productivity.
- 2019 again achieved good lambing rates, despite challenging conditions.
- We have introduced a number of measures to meet the challenge of finding sufficient winter grazing for the flock, though time will tell if this is resolved as flock size increases in 2020 and 2021.
- Our first year in the Scottish Agri-Environment and Climate Scheme has progressed well, allowing us to upgrade the remaining old fencing and implement a number of beneficial options for wildlife.

Dave Parish
Allan Wright
Adam Smith

Being part of the Agri-Environment and Climate Scheme has enabled us to upgrade all our old fencing. © Dave Parish/GWCT



Predation

Killing foxes and controlling fox density: when are they the same thing?

It is not always certain that culling foxes amounts to effective control. © Danny Moore

BACKGROUND

Foxes are culled to protect vulnerable prey species from predation on shooting estates and wildlife reserves. It's a defensible practice if it works. But how many fox control efforts do make a worthwhile impact on fox density? Does replacement of culled foxes through immigration defeat the aim in some situations?

Predator-removal experiments like Salisbury Plain and Otterburn have shown that control of predators including foxes can make a substantial difference to prey numbers. In those studies, the predator control clearly was effective. But elsewhere, regional fox population, operator skills and resources, and habitat may all be very different, and it is not certain that culling foxes always amounts to effective control. In particular, if culling takes place on a relatively small area like a shooting estate and fox density in the surrounding region is high, culled foxes may be replaced rapidly through immigration. Does that make it futile? This puzzle applies to virtually all lethal control of predators and pests, so it's an important question to answer.

What we did

It is almost impossible to measure fox density in the field where culling is ongoing, because the situation changes so rapidly. Instead, we devised a method of analysis that teases this information from daily records of fox culling activity by gamekeepers. The data we used were recorded in the 1990s by 74 gamekeepers on estates reflecting a wide range of circumstances across Britain. All contributors used night shooting with spotlamp and rifle ('lamping') as their preferred culling method and recorded both foxes seen and foxes killed, as well as the effort expended. The number of foxes seen on each lamping excursion can reasonably be assumed to reflect the number of foxes present. Each fox culled – by whatever method – should result in fewer foxes being seen on the next excursion. If it doesn't, there must have been replacement, so every removal is informative about both the number of foxes present and how quickly those killed are replaced.

We developed a computer model (technically, a 'Bayesian state-space' population model) with one part representing the population processes – births and deaths, immigration and emigration – by which fox numbers within the estate change through time. A second part of the model described the lamping process in mechanical terms, like the time spent lamping, vehicle speed and visibility of foxes. The two are linked in the model because the number of foxes seen while lamping depends on the number present at that time and the searching efficiency of the gamekeeper. To tease apart the population processes, the model needed data from at least three consecutive years. Data from 22 estates with an average area of $8km^2$ met this requirement.

We set the computer to adjust the values of the population processes and searching efficiency in the model until the output best matched the data observed on each estate. Using the model with those values, we then derived the number of foxes alive within the estate fortnight by fortnight. We assessed the impact of the cull by comparing these estimates with the density expected without culling (the 'carrying capacity'), which was also inferred from the data and ranged between 1.9 and 8.2 foxes/km^2 among the 22 estates.

Results and implications

To focus on the conservation angle, we considered the effectiveness of fox culling from the perspective of wild ground-nesting birds, although this was not necessarily the focus on every estate. For these bird species, nesting in spring and early summer is the critical stage when they are most vulnerable to predation by foxes. All 22 gamekeepers achieved a reduction in fox density by the start of spring, with fox density in late winter on average 47% (range 20-90%) of what it would have been without culling (see Figure 1). On a few estates fox density was close to zero, although on every estate there was always at least one fox present in any given fortnight.

ACKNOWLEDGEMENTS

We are indebted to the gamekeepers who for several years patiently recorded the data drawn on for this study. The study would not have been possible without Murdoch McAllister, our collaborator at the University of British Columbia.

Ground-nesting birds are more vulnerable to predation by foxes in the spring and early summer. © Marlies Nicolai/GWCT

The number of foxes killed annually is not a reliable indicator of effectiveness, as it can simply reflect rapid replacement of culled foxes. © Dave Kjaer

KEY FINDINGS

- A novel analysis of data recorded by gamekeepers revealed the success of fox control on 22 shooting estates.
- Fox density on all estates was suppressed compared to that expected without fox culling.
- Replacement of culled foxes by immigration was rapid in some cases. To keep numbers low, this had to be counteracted by intensive and sustained control effort.
- Maintaining low fox density through spring and early summer to protect vulnerable ground-nesting birds was clearly challenging.

Tom Porteus
Jonathan Reynolds

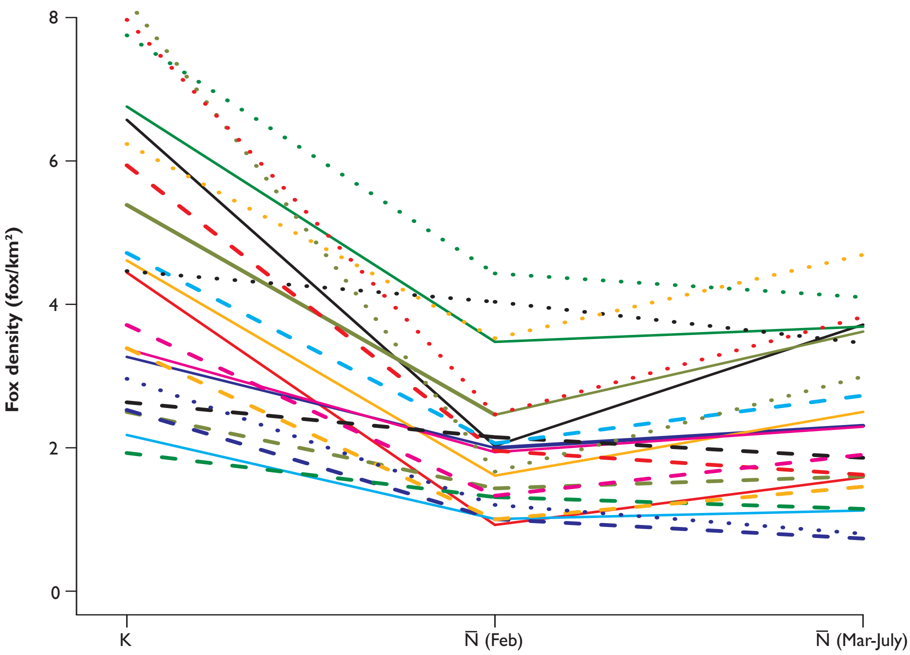
Through spring and early summer, when shooting becomes less efficient because of vegetation cover, it was clearly challenging for gamekeepers to maintain low fox density. On 15 of the 22 estates, fox density increased through this period, although it always remained below carrying capacity (range 27-78%). Nonetheless, even modest suppression of numbers can have substantial implications for fox food requirements. One set of data came from the Allerton Project (see Figure 2), where a strong positive impact of predator control through the spring/summer period on wild gamebird and hare numbers had already been demonstrated.

On some estates, high immigration rates clearly limited the gamekeeper's ability to control fox numbers, despite prodigious effort. The extreme case – an estate in southern England – experienced an influx of more than two foxes per week throughout the year, and as a result intensive effort and a large cull achieved only minor suppression of fox density within the estate. This is why bag size (the number of foxes killed annually) is not a reliable indicator of effectiveness, as it can simply reflect rapid replacement of culled foxes.

This study expands our understanding of the impact of fox culling in a range of circumstances, and of what determines success or failure. The conclusions are

Figure 1

For each of 22 estates (represented by different colours) these lines link estimated values of fox carrying capacity (K, likely fox density in the absence of culling), average fox density estimated at the end of winter (February) and average fox density through the bird nesting period (March to July). In all cases, end-of-winter fox density was suppressed relative to carrying capacity, but in many cases crept up again during spring and summer



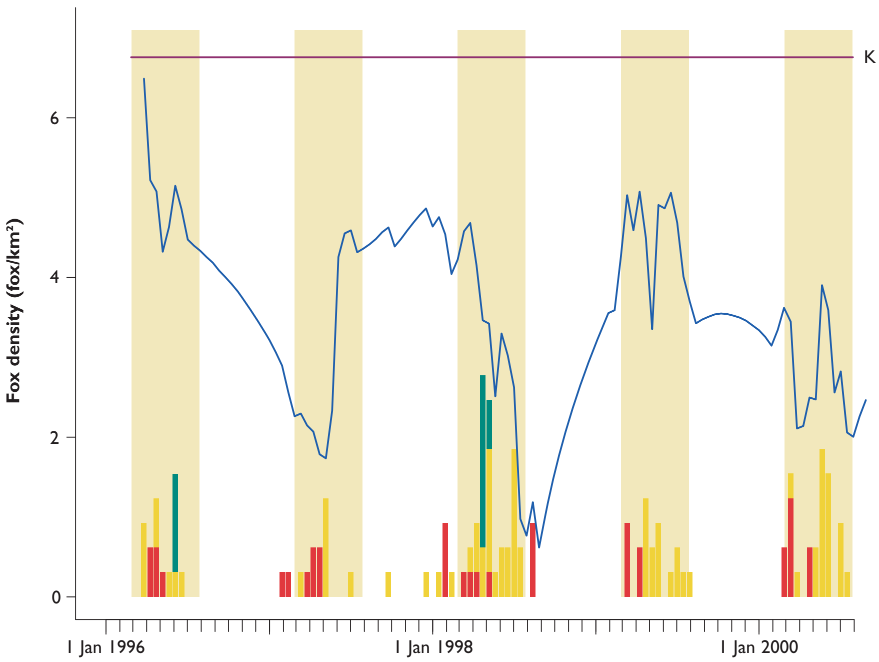


Figure 2

Estimated density of foxes (blue line) at the Allerton Project during 1996-2000, in relation to the fox cull removed by different methods (lamping, snaring and other methods, cubs killed at earths – see legend) and estimated carrying capacity (K, purple line). Fox control was deliberately seasonal, focused on reducing fox predation during the bird nesting period

Lamping

Snare/other

Earths

Bird nesting period

important to inform the public debate about lethal control of foxes and of other problem wildlife. Replacement through immigration does not render lethal control pointless, but it makes it more difficult and costly. So if we are to protect wild breeding prey species – be they grey partridges or godwits, black grouse or curlews – how should we best combine available methods to achieve the best trade-off of conservation benefits against economic, non-target and welfare costs? That too is something that we can explore through this approach. We can now also use the model to predict what might have happened if different culling strategies had been used on each of these estates.

For more details and to read the full manuscript published online in PLOS ONE please go to https://doi.org/10.1371/journal.pone.0225201.

On some estates, high immigration rates clearly limited the gamekeeper's ability to control fox numbers, despite prodigious effort. © Richard Faulks

Invasive wildlife species

Across Europe wild boar are considered by far the most problematic and costly wildlife species, but they are native. © Randy van Domselaar/Shutterstock

BACKGROUND

Despite a co-ordinated approach across Europe, the UK does not have convincing strategies to respond to invasion by alien wildlife species that are known to be damaging, nor to manage those that are already established here. 'How?' is only part of the issue. We take a step back to consider which of us has a vested interest in any wildlife problem, who should pay, and what workforce is available.

KEY FINDINGS

- Forty nine non-European wildlife species are recognised to be highly invasive and damaging.
- Defra has consulted on management plans for 14 of these which are already present in the UK.
- Contingency plans do not yet exist for most of the other 35 species.
- The Government must make serious plans to ensure that the UK can cope with all problem wildlife, both present and expected.

Jonathan Reynolds

The zeal of 19th-century aristocrats to establish exotic species in the UK has long ago passed out of fashion. Current UK legislation makes it illegal to release any species that is not ordinarily resident here. There is also a list of 49 invasive alien species (26 animals, 23 plants) that are recognised throughout Europe to be particularly threatening, and in 2014 EU Regulation 1143 required member states to have a cascade of measures, beginning with prevention by strict legislative enforcement; then eradication where it is still possible; failing that, containment; and finally control to limit adverse impact. Brexit notwithstanding, it is in the UK's interests to implement these measures, both to avoid acquiring any more problematic species, and because as a good neighbour and trading partner the UK should be careful not to become a portal through which invasive species enter continental Europe.

Enforcement was addressed in the UK by the Invasive Alien Species (Enforcement and Permitting) Order 2019, which defines new offences and penalties. The EU Regulation – somewhat idealistically – invoked the 'polluter pays' principle. The UK legislation allows the imposition of 'Restoration Notices' and variable penalties up to £250,000. That may be a deterrent, but it certainly won't recover clean-up costs, or the indefinite cost of a damaging species that becomes irrevocably established.

A Defra consultation in 2019 proposed strategic management plans for the 14 (of the 49) EU-listed species that are already widespread in the UK. This was a disappointingly narrow scope. Some of these species (eg. grey squirrel, muntjac) have been established here for more than a century. Although eradication of highly invasive species is never easy, the EU Regulation recognises that it is a smaller task when the invaders are still in low numbers. That is the point of compiling a list of alien species known to be invasive and damaging: fore-warned is fore-armed. If the presence of a recognised invasive species (eg. raccoon dog) is detected, well-prepared detailed contingency plans (with funds) should swing into action to ensure a swift outcome.

The question of scope pervades this discussion, and one suspects that narrow definitions are being used to excuse inaction. Not all alien species that are both invasive and damaging appear on the EU list: American mink is conspicuously absent, apparently because of its importance to the fur industry in certain EU member states. Not all species that are invasive and damaging in the UK are technically alien: for instance, across Europe the wild boar is considered by far the most problematic and costly wildlife species, but is native. Many problematic alien species are now considered *de facto* natives in Britain because they were introduced and did their invading a long time ago: rabbit and fallow deer are vertebrate examples.

My point is not to absurdly broaden an already difficult task. However, we need effective policies both for when alien species have arrived and for the problem wildlife we already have, and these must answer the same questions. Whose problem is it? Whose responsibility is it? Who will lead? What is the goal? Is it achievable? Who will pay? Who will do the work? What will make it effective? What could prevent success?

The history of practical wildlife management shows that top-down encouragement or coercion do not produce the motivation to get the job done. We suggest that correctly identifying vested interests is key to success, but that this does not absolve the

Government from duties. For the vertebrate invasive species at least, Defra expects the necessary resources to be found by private interests ('stakeholders'). Defra has repeatedly stated that responsibility rests with the landowner, although there is no obligation for the landowner to take any action. The presence of an invasive species may be more of a problem to his neighbour or to the public. The public's vested interest in invasive species was scarcely recognised in Defra's consultation document.

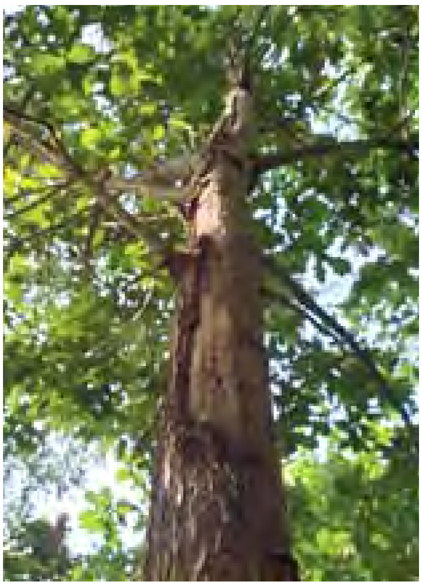
The control of grey squirrels to protect growing trees illustrates that vested interests do not lie where you might expect. Public interests include encouragement of domestic (vs imported) timber production; carbon sequestration; amenity and recreation; biodiversity; cultural landscape. For these reasons, the taxpayer already supports woodland grant schemes of various kinds, and all political parties have pledged to spend a lot more. That money is wasted unless the trees fulfil the public interests. Without effective grey squirrel control, foresters cannot grow trees that live a full life and achieve their potential to store carbon as timber; the business interest is then seriously damaged, shifting more of the cost to the public purse. The private vested interests of landowners in woodland are fewer: timber production; outdoor recreation businesses including pheasant shooting; landscape; and personal enjoyment. Clearly there is synergy between public and private interests, but they are not identical. Currently, short-term profit may be more important to landowners than the slow and risky production of timber. In many cases woodland occupies land that could otherwise be used for food production or building houses.

Managing problem wildlife requires a workforce. Defra has put a lot of faith in volunteers, organised into Local Action Groups. The Environmental Audit Committee (EAC) were impressed by New Zealand's aim to train 150,000 people in biosecurity by 2025 and envisaged a 'trained biosecurity citizens' army' in the UK of perhaps two million. Although this might genuinely help the detection of fresh invasions, it seems unlikely to answer the need for practical management. A lot of wildlife management work is unrewarding or distasteful, and the last stages of an eradication are especially unrewarding. For instance, few volunteers have the drive to continue checking and maintaining mink rafts, once mink detections become a rare event; yet that is what it takes to finish the job. Lethal control also involves specialist equipment and skills. In the UK there is already an 'army' of about 180,000 people licensed to use firearms and many or most have some level of deer-stalking training; yet this workforce has not prevented the spread of muntjac. It is unlikely that the police would welcome the further proliferation of firearms; and there are issues over access to land and generating the motivation to eradicate or control rather than harvest.

Westminster is wrapped up in human affairs and commits far too little thought to wildlife. Unfortunately, some wildlife has a profound impact on human interests. The UK needs joined-up thinking on how to manage both invasion threats and established problems.

Species such as muntjac have been established in the UK for more than a century. © Laurie Campbell

Without effective grey squirrel control, foresters can not grow trees that live a full life and achieve their potential to store carbon as timber. © Laurie Campbell/National Forest



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

River Frome Atlantic salmon population

The gauging weir is dammed off while the new fibreglass fish counter base is installed. © GWCT

BACKGROUND

At the Salmon & Trout Research Centre at East Stoke we carry out research on all aspects of Atlantic salmon and trout life history and have monitored the run of adult salmon on the River Frome since 1973. The installation of our first full-river-coverage PIT-tag systems in 2002 made it possible for us to study the life-history traits of salmon and trout at the level of the individual fish. The PIT-tag installation also enabled us to quantify the smolt output. The River Frome is one of only 14 index rivers around the North Atlantic reporting to the International Council for the Exploration of the Sea on the marine survival of Atlantic salmon and the only one in the private sector.

Smolts: In 2019 an estimated 9,185 (±1578) smolts left the River Frome (see Figure 1). This is slightly below the 10-year average (9,341), which is disappointing given that the number of parr in the catchment in 2018 was the third highest recorded since estimates started in 2005. In the Frome catchment there is a negative relationship between number of parr in the catchment and their mean size, whereby mean size reduces by approximately 0.8mm per 10,000 parr in the catchment (see Figure 2). So as expected with high numbers of parr in the catchment in 2018, average size was small. In fact it was the smallest on record and more than 5mm smaller than the 10-year average. The small size of the parr will have impacted their fitness, however, it is likely that other factors contributed to the poor over-winter survival and resulting disappointing smolt run in 2019.

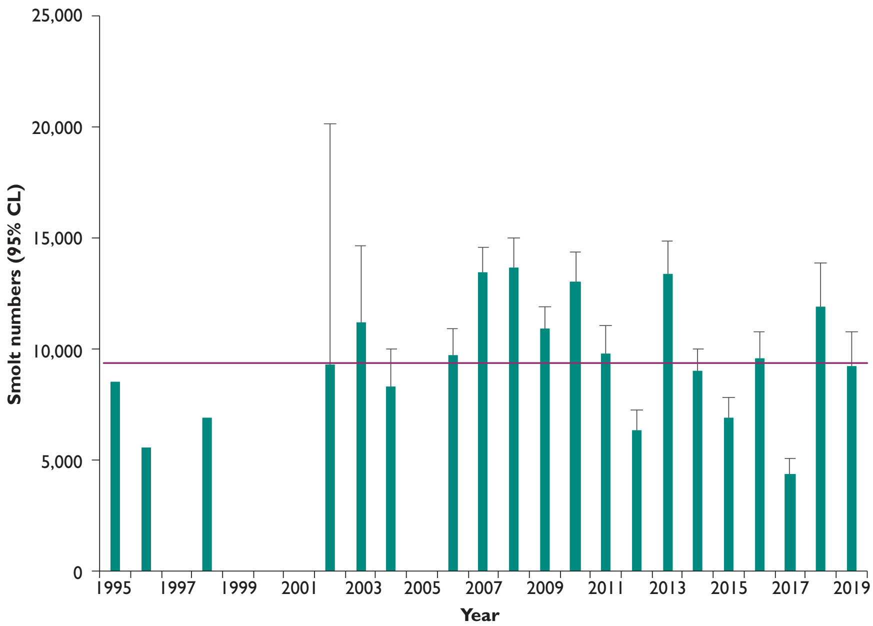
Parr tagging: Despite a relatively low number of spawners in 2018 we encountered reasonable numbers of parr during our 2019 parr-tagging campaign. In most parts of the catchment there was good weed cover (*Ranunculus sp.*), which we have shown benefits parr densities as well as their growth rate. Similar to 2018, dry settled weather prevailed during the parr-tagging campaign but it still took two teams of seven people 21 days to catch and tag the target 10,000 salmon parr and 3,000 trout parr.

Adults: We count up- and downstream movement of adults at East Stoke using our resistivity counter. This counter has been in the river for more than 30 years and it

Figure 1

Estimated spring smolt population 1995-2019

10 year average = 9,341



SALMONID GROWTH

River Frome salmonids grow fast and all the PIT tagged parr are young of the year. As a result of the fast growth >97% of salmon smoltify after one year in the river, whereas trout smolts are a mixture of one and two year olds.

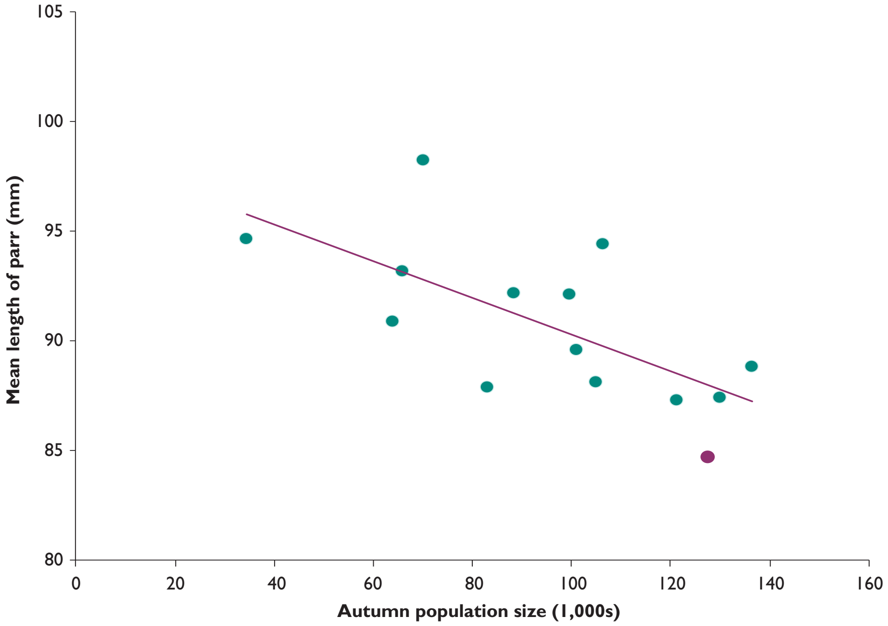


Figure 2

The relationship between the population size of juvenile Atlantic salmon in the catchment and their average size. Each dot represents a year and the purple dot is 2018 ($y = -0.084x + 98.67, R^2 = 0.454$)

has been clear for some time that it needed to be refurbished. With the help of our SAMARCH project, 2019 saw the fish counter refurbished with a new fibreglass base installed at the bottom of the river (see picture). The new base has improved the quality of both the electrical signal and the video image and in 2020 we will update the electronics decoding the signal from the electrodes. This complete overhaul of the resistivity counter ensures that we can continue our long-term data series on adult counts from East Stoke going back to 1973 (see Figure 3).

The run of 2SW Atlantic salmon in 2019 was very poor but this was expected as these 2SW fish originate from the all-time low smolt run of 2017. The run of 1SW fish was also relatively weak, which was a surprise as the smolt run in 2018 was very strong. The 2018 smolts were the smallest recorded since we started monitoring: with a mean length of 128mm compared with a 10-year average of 133mm. Even though 5mm doesn't seem like a big difference, we have shown that larger smolts within the normal size range of one-year old smolts (120-160mm) on the Frome are more than three times as likely to return from the marine migration than smaller smolts. Size of the smolts in 2018 is probably part of the explanation for the poor return rate but other factors will have affected this also. The poor run of adults in 2019 and resultant low egg deposition is a serious concern for recruitment of juveniles in 2020.

KEY FINDINGS

- A disappointing smolt run in 2019 was the result of poor over-winter survival of juveniles, potentially driven by freshwater density-dependent processes.
- The adult fish counter at East Stoke was refurbished, ensuring continuation of the long-term data series going back to 1973.
- Poor recruitment from the spawning in the winter of 2015/16 and subsequent poor smolt run in 2017 resulted in a poor run of two sea winter (2SW) salmon in 2019.
- There was an unexpected poor run of one sea winter (1SW) salmon from the large 2018 smolt cohort. The high marine loss rate may be a result of small sizes of the smolts in 2018.
- The poor adult run in 2019 raises concern regarding the recruitment potential for 2020.

Rasmus Lauridsen

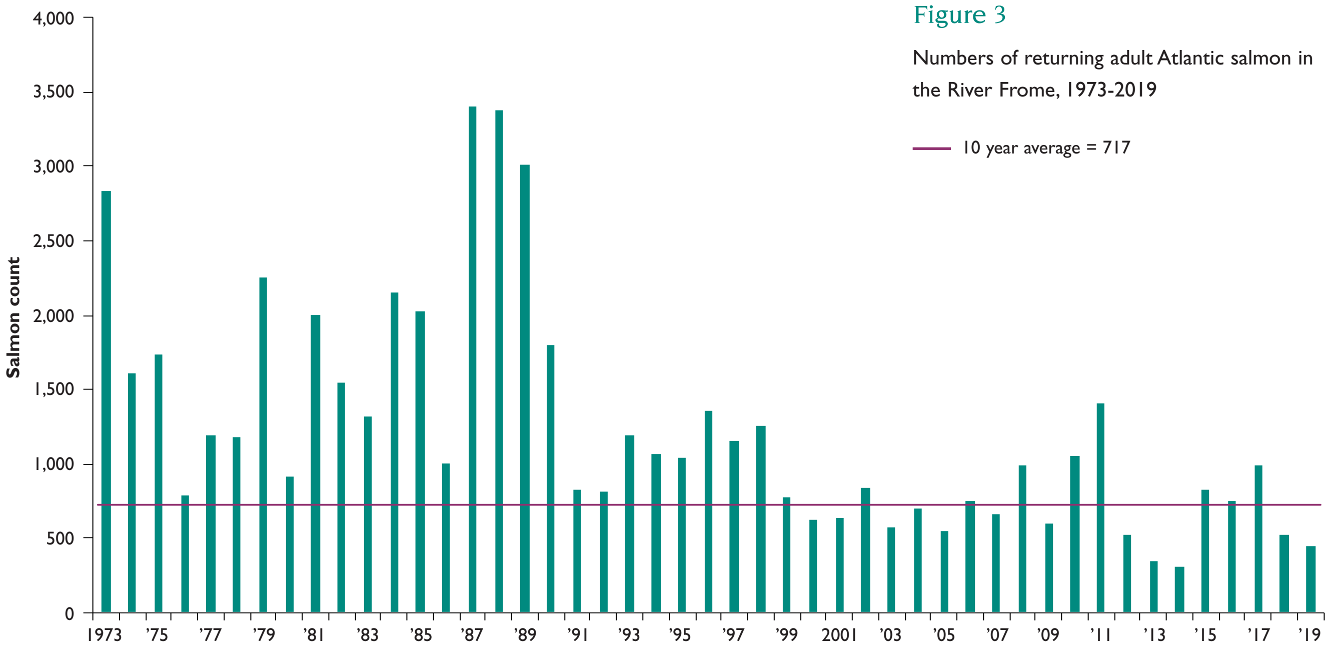


Figure 3

Numbers of returning adult Atlantic salmon in the River Frome, 1973-2019

10 year average = 717

The migration of smolts to sea

We inserted acoustic tags into smolts that enable us to follow the fish from the moment they are tagged until they reach the open sea.
© Quentin Josset/OFB

BACKGROUND

Smolts is the term used to describe individuals of young Atlantic salmon and sea trout migrating to sea for the first time. In the month leading up to their migration they undergo a smoltification process (physiological change). This smoltification enables them to live in a saline environment having been born and lived as juveniles in freshwater.

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During the springs of 2018 and 2019, we inserted acoustic tags into Atlantic salmon and sea trout smolts captured in four rivers discharging into the English Channel (Rivers Tamar and Frome in the UK and Rivers Bresle and Scorff in France) to follow their downstream migration to sea. Acoustic receivers recording the identity of individual fish and the date and the time of their passage were deployed along their migration path in the four estuaries.

The resulting data enable us to follow a fish from the moment we tagged it until it reaches the open sea, where the last acoustic receiver is located. We focused our study on the estuarine environment to investigate how important this transitional environment is for Atlantic salmon and sea trout smolts: how long they stay there and how many are lost while crossing these areas that are characterised by highly variable water parameters, predators and diverse human activities.

Across the whole study, 444 Atlantic salmon smolts and 336 sea trout smolts were detected in our study estuaries, of these 364 (82%) of the Atlantic salmon and 296 (88%) of the sea trout reached the sea. The percentage of 'successful' individuals varied among estuaries: the highest success rate was on the Tamar estuary (84% and 97% for Atlantic salmon and sea trout, respectively) and the lowest on the Frome estuary (70% and 79%, respectively). Sea trout smolts had higher migration success on each individual estuary compared with Atlantic salmon smolts (see Figure 1).

There was a progressive loss of individuals along their migration path, however none of the measured parameters of the fish themselves, including age, size and sex, could explain the patterns observed in smolt migration success. Further investigations will be necessary to understand these findings.

This study also demonstrated that sea trout smolts spent some time in estuaries (three to 16 days), perhaps to feed in this highly productive environment. In contrast,

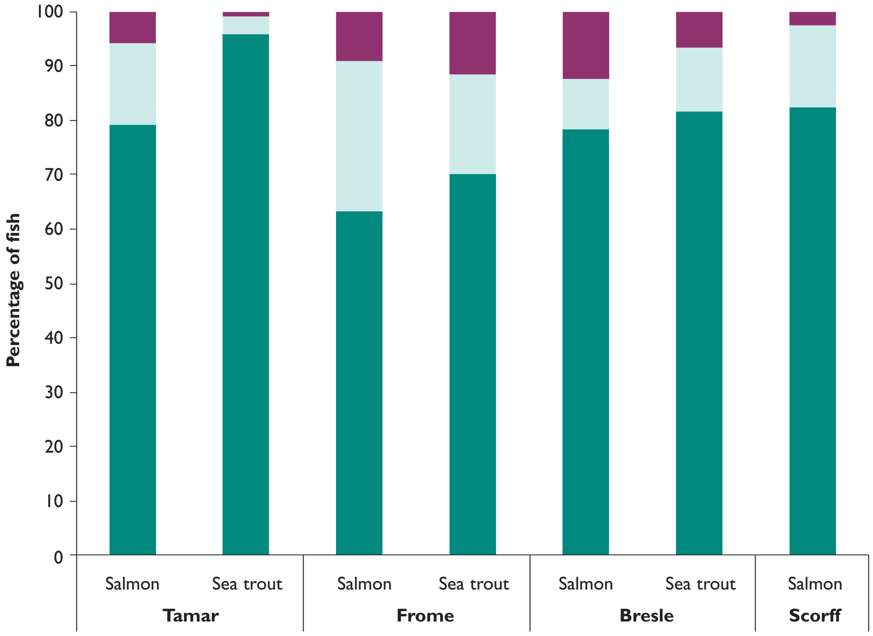

Figure 1

Percentage of migration success of Atlantic salmon and sea trout smolts in the Rivers Tamar, Frome (UK), Bresle and Scorff (France). There are no sea trout on the River Scorff, so only Atlantic salmon have been surveyed

Atlantic salmon smolts crossed this environment with minimum delay (2.5 days), to continue their migration to the North Atlantic.

We are sharing these findings and information with environmental managers in the UK and France, which will enable them to implement actions to improve local species management where necessary.

We also located smolts using a mobile hydrophone which was able to detect the acoustic tags. *© Bill Beaumont/GWCT*

KEY FINDINGS

- Depending on the estuary and year, between 16-30% of Atlantic salmon smolts and 3-21% of sea trout smolts never reach the sea.
- In the estuary, Atlantic salmon and sea trout smolts migrated to the sea at a mean speed of 1.7 and 1.2km per hour respectively.
- Atlantic salmon smolts dashed through the estuarine environment in less than 2.5 days, whereas sea trout smolts spent up to 16 days in the estuary.

Céline Artero

ACKNOWLEDGEMENTS

Thank you to our SAMARCH project partners, Institut National de la Recherche Agronomique et de l'Environnement, Office Français de la Biodiversité and the Environment Agency for having provided support during the fieldwork season.

Strengthening salmon population estimates

Forecasts of wetter and warmer winters could impact juvenile salmon overwinter growth in the UK. © GWCT

BACKGROUND

Numbers of adult salmon returning to our rivers have been declining for the last 40 years and the lowest number ever recorded was found in 2018. Managers of salmon populations on both the Atlantic and Pacific have been using models to better manage stocks. To maximise the effectiveness of these models, we need to use the best data and information currently available. Science, technology and analytical tools are moving forward rapidly; for example, we can now sex fish using genetics and gain further insights into how this can affect recruitment and changing growth rates, and ultimately stock viability. SAMARCH is producing new information on growth rates, sex ratio and survival of salmon at different life stages that will further improve the effectiveness of these models.

An unavoidable prerequisite of management actions to ameliorate the decline in Atlantic salmon populations, is to use a method to accurately assess their current status and measure their response to future management actions. Without such a method, we risk proposing management actions that are not necessary or misdirected, or perhaps more worryingly, that could worsen the situation. Such methods already exist and are being used by national agencies to set management advice that safeguard national salmon stocks. For example, the United States aims to maintain the number of salmon expected to spawn in all available spawning habitat. In England and Wales, the management advice seeks to safeguard a number of salmon expected to ensure that recruitment is highly unlikely to result in fewer salmon in the following year. Collectively, the methods used to set management advice are called salmon Stock Assessment Models or SAMs, and they should embody the 'Precautionary Principle' recommended by the North Atlantic Salmon Conservation Organisation.

The overall objective of one SAMARCH Work Package is to refine SAMs used in England and France using new information. We have set out four activities to achieve this: (1) to better understand spawning migration patterns and rod exploitation; (2) to estimate the effect of freshwater and marine growth on survival to spawning; (3) to refine and update the sex ratio and fecundity estimates used in current SAMs; and (4) to use these new information sources together with data from other international agencies to improve SAMs. Work in each activity is progressing nicely, which is illustrated here using two example projects: overwinter juvenile growth and an international life cycle approach to stock assessment.

A recent study showed that smaller River Frome smolts are less likely to survive their first winter at sea compared with their longer counterparts and recommended that management advice was updated to maximise the number and also the quality of emigrating smolts. But how do we get larger and thus better quality smolts? In general, the length of an individual juvenile salmon in September is positively related to its length when it emigrates in spring, but this relationship is highly variable. We hypothesised that overwinter growth is influenced by overwinter environmental conditions. We have confirmed our hypothesis and shown (among other effects) that highly variable overwinter flow, as might be seen during a wet winter, can negatively impact growth, perhaps because of heightened energetic costs (see Figure 1). Climate change predictions for the UK forecast warmer and wetter winters, which could impact on overwintering juvenile salmon growth. This highlights the need to reinstate natural flow regimes that mitigate flood risks by reconnecting rivers with their floodplains.

Two recent studies by SAMARCH scientists have proposed a new approach to assess salmon stocks at an international level and use it to better understand what might cause changes in regional stocks. Using data collated by the International Council for the Exploration of the Sea (ICES) Working Group on North Atlantic Salmon (WGNAS), of which GWCT is a member, the team developed a sophisticated statistical model representing the Atlantic salmon life cycle and is able to accurately predict local and regional salmon population abundances through time. But the approach offers more than just this: the team have linked regional stock abundances to measures of environmental change at sea and shown that post-smolt survival is related to changes in sea surface temperature and net primary productivity. The findings suggest that salmon management is an international issue that will require co-operation beyond geographical, and even political, borders.

ACKNOWLEDGEMENTS

We thank all the staff and volunteers in England and France for their help in making SAMARCH WP T3 a success, and the ICES WGNAS for its ongoing support.

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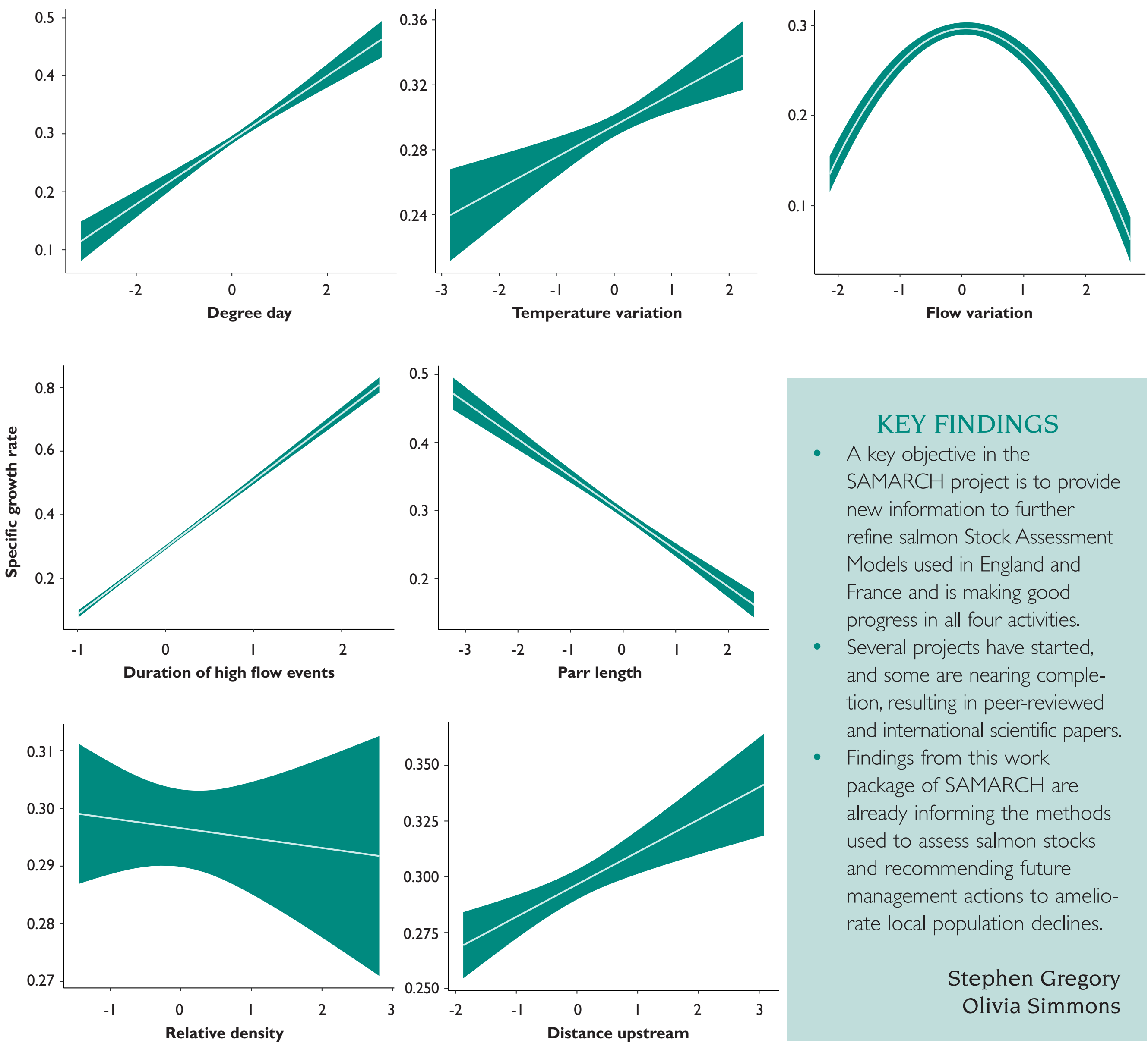
Figure 1

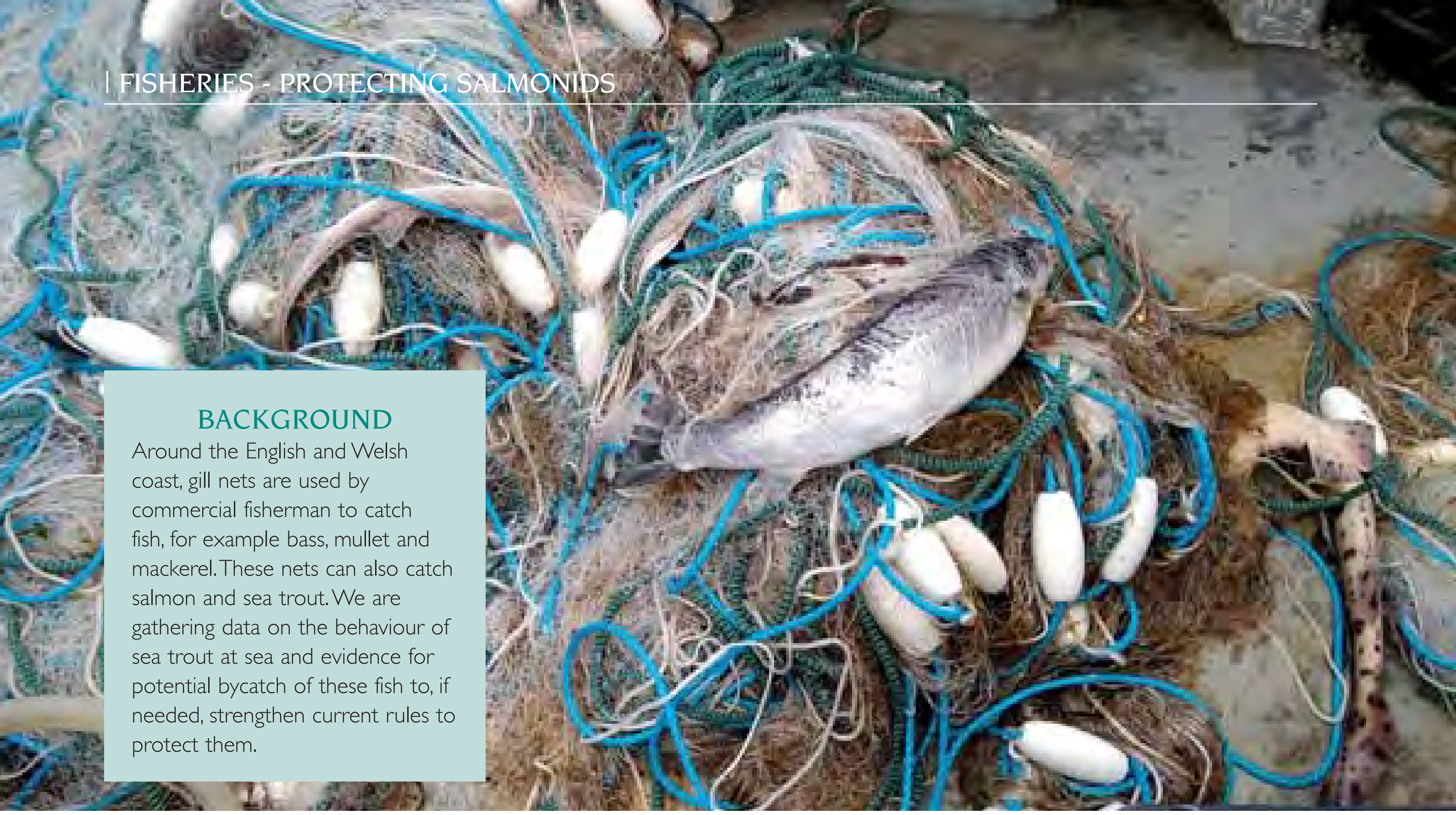
Line plots of the estimated effect of each variable when all other variables are held constant. The shaded grey area represents the uncertainty of the estimated effect



KEY FINDINGS

- A key objective in the SAMARCH project is to provide new information to further refine salmon Stock Assessment Models used in England and France and is making good progress in all four activities.
- Several projects have started, and some are nearing completion, resulting in peer-reviewed and international scientific papers.
- Findings from this work package of SAMARCH are already informing the methods used to assess salmon stocks and recommending future management actions to ameliorate local population declines.

Stephen Gregory
Olivia Simmons



We are looking at the effect of gill nets on salmon and sea trout. © Dylan Roberts/GWCT

BACKGROUND

Around the English and Welsh coast, gill nets are used by commercial fisherman to catch fish, for example bass, mullet and mackerel. These nets can also catch salmon and sea trout. We are gathering data on the behaviour of sea trout at sea and evidence for potential bycatch of these fish to, if needed, strengthen current rules to protect them.

Protecting salmon and sea trout at sea

KEY FINDINGS

- In the English Channel the rules to protect Atlantic salmon and sea trout from coastal gill nets include that the top of nets should be set at least three metres below the surface because it is assumed that sea trout swim near the surface.
- Our data suggests sea trout dive to 50 metres and spend most of their time below three metres.
- Some 2,500 gill nets are set off the coast of Cornwall each week.
- We caught 34 sea trout and six salmon while fishing just three gill nets, in 23 overnight netting sessions, off the coast of Cornwall and Dorset.

Dylan Roberts

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Populations of Atlantic salmon have declined significantly across the UK in recent years. There are also growing concerns regarding the resilience of some sea trout stocks following notable declines in numbers of older fish. There is currently much debate as to the reasons for this with the finger of blame often pointed towards climate change within the marine environment. This may well be affecting migratory pathways as well as the location, quality and quantity of their food at sea. However, to place all of the blame on climate change would conveniently underestimate the impact of other man-made activities. This is particularly relevant to Atlantic salmon and sea trout within transitional and inshore coastal waters where both species are potentially under threat from a range of activities that we could address and manage. To investigate the need for additional stock protection measures, SAMARCH seeks to shed light on the biology and behaviour of salmonids as they move through inshore and coastal waters.

Commercial fishing activity represents one such potential threat and some of the facts surrounding the extent of commercial fishing practice are rather surprising. For instance, in 2017, there were 6,148 registered UK commercial fishing vessels. Of these, 4,834 vessels were small boats of less than 10 metres in length. The vast majority of these smaller vessels are taking mid-water fish, landing an estimated 400,000 tonnes in 2017, compared with 180,000 and 130,000 tonnes of bottom-dwelling fish and shellfish respectively. Salmon and sea trout use the upper and middle levels of our oceans before returning to their natal rivers to spawn.

Many of the smaller vessels use gill nets to catch species such as mackerel, herring, bass and mullet. It is estimated that around the coast of Cornwall each week there are some 1.16 million metres (m) of nets used, which can be compared with Scotland where there is a total ban on gill netting in inshore waters using monofilament nets.

To protect stocks, bylaws are in place to prohibit fishing with gill nets in England and Wales in areas where salmon and sea trout may congregate, especially in and around estuaries. In addition, within six miles off the coast of England gill nets cannot be set within three metres and seven metres of the surface, in the south and north of England respectively. This is called a headline rule, however, in Wales, headline rules are largely not applied but nets are limited to 200m in length and must have a 100m gap between each net. The headline rule assumes that salmon and sea trout swim near the surface and are therefore protected.

These bylaws may be inadequate to fully protect these species, especially given that sea trout in particular remain close to shore and in most cases do not undergo

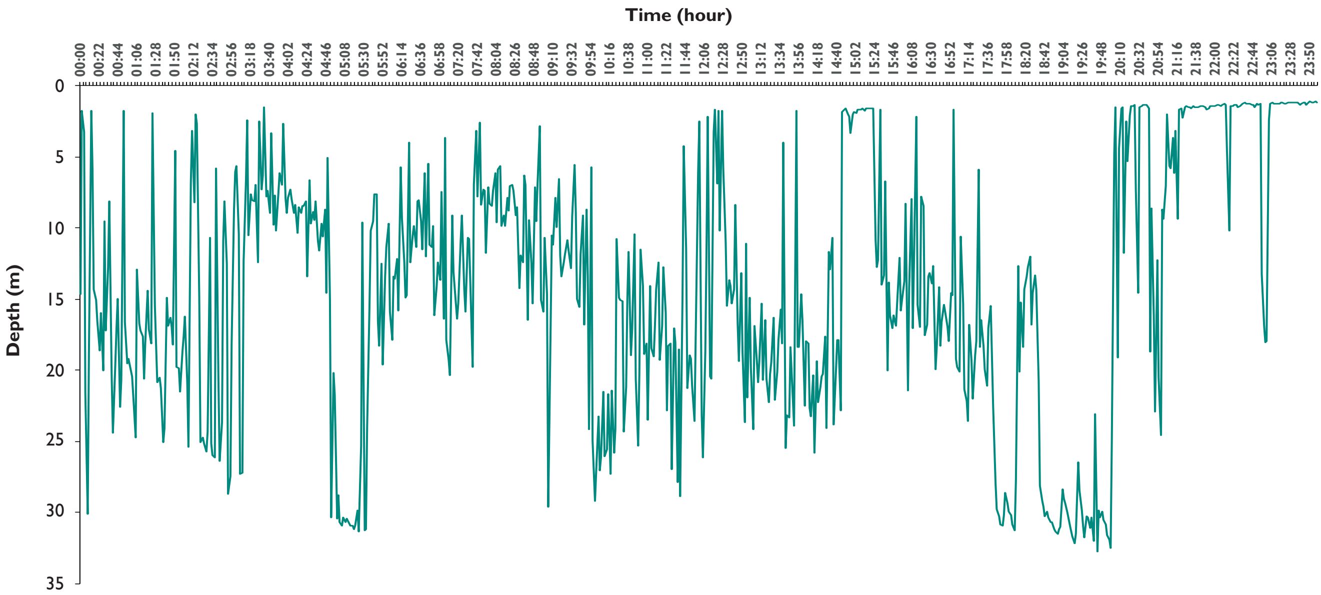


Figure 1

Example of the daily vertical behaviour of an adult sea trout during its marine migration

the long marine migration of their salmon cousins to the north and west Atlantic. There is also very limited evidence that sea trout spend all their time near the surface. Therefore, to inform future management of sea fishing activities it is crucial that we gather robust evidence on where and when these fish are at sea, together with information relating to their swimming depths.

You will have read in our *Review of 2018* (see page 30) that we are undertaking a study using specialist data tags in sea trout to obtain information on their locations and swimming depths at sea. Early results suggest that they spend most of their time below five metres, which has major implications for the current effectiveness of the headline rule.

In 2019, under dispensation from the Environment Agency, we initiated some trials which entailed setting commercial gill nets off the coast of Cornwall and Dorset. The aim was to monitor their catches and record any salmon and sea trout caught. The netsmen set 800m of nets on 23 evenings between April and July, leaving the nets overnight before recovering them. Among their catch were 34 sea trout and six salmon. We made full use of their carcasses by investigating their genetics, diet, parasitology, toxicology and even the presence of plastics.

We are working closely with our SAMARCH partners the Environment Agency, who have responsibility for managing salmon and sea trout within six miles of the coastline in England, to ensure that this information influences the current bylaw reviews being drawn up by the Inland Fisheries Conservation Authorities (IFCA), which manage coastal netting. This work is part-funded by the EU's Interreg Channel VA programme.

We found 34 sea trout and six salmon caught in gill nets over 23 evenings. © Dylan Roberts/GWCT

It is estimated that 1.16 million metres of gill nets are set off the coast of Cornwall each week. © Dylan Roberts/GWCT

ACKNOWLEDGEMENTS

SAMARCH is a €7.8m five-year project (2017-2022), part-funded by the France England Interreg Channel Programme. The project will provide new transferable scientific evidence to inform the management of salmon and sea trout (salmonids) in the estuaries and coastal waters of both the French and English sides of the Channel.

The breeding success of hen pheasants

We caught, radio-tagged and successfully tracked 35 hen pheasants in 2019. © Rufus Sage/GWCT

BACKGROUND

Game numbers have been monitored annually at the Allerton Project since 1992. An article in last year's *Review of 2018* showed how changes in management have affected pheasant numbers since then. In the late 1990s, when Malcolm Brockless, our full-time gamekeeper, implemented a comprehensive wild gamebird management programme with no releasing, the farm (about 333ha) produced 300-400 pheasant poults each year. Over one chick per hectare across an estate is the holy grail of wild pheasant management.

The Allerton Project shoot at Loddington was resurrected in 2011 as a released bird shoot, following nine years of systematic dismantling of the wild bird study, during which time we researched the significance of predator control and supplementary feeding. It has become clear from John Szczur's (the Project's long-term ecologist) systematic spring and autumn counts, that the wild or leftover pheasants from the shooting season are not breeding well. During the recent research period 2,600 cock pheasants were released annually and a part-time wild gamebird management programme was implemented by Matthew Coupe, plus largely cock-only shooting. Despite this, since 2011 there have been fewer than 20 wild pheasant chicks produced at Loddington each year. To understand why we are apparently unable to 'kick-start' a wild breeding pheasant population again on the site, we studied the breeding performance of the pheasants in 2019 and 2018.

Under a Natural England licence we caught, radio-tagged and successfully tracked 35 hen pheasants in 2019. Between mid-March and early July (see Figure 1) 32 of these birds died. Excluding bodies not found (unknown), 25 out of 28 (89%) were predated or their bodies were scavenged (see Table 1). Most of these predation events were attributed to mammals. Two dead birds recovered whole and several non-tagged birds were examined via post-mortem and had evidence of disease and parasite issues such as coronavirus, heterakis, gapeworm and egg peritonitis. As well as causing direct mortality and subsequent scavenging by predators, this could also make pheasants more susceptible to predation and less able to breed.

We recorded trail camera footage from six nests (see Table 1), three of which were predated by badgers, one by a fox and one by a small mammal. We also tracked

TABLE 1

The fate of radio-tagged hen pheasants at the Allerton Project at Loddington from early March to early/mid-summer*

Year	Tracked	Died	Predated/ scavenged	Disease	Run over	Unknown	Number of nests	Nests predated	Nests abandoned
2018	30	28	22	1	1	4	3	2	1
2019	35	32	25	2	1	4	6	5	1

**The main category of adult losses was predation or finding the body scavenged. 'Unknown' are birds we know were dead (the radios give a different signal) but radios were not recovered.*

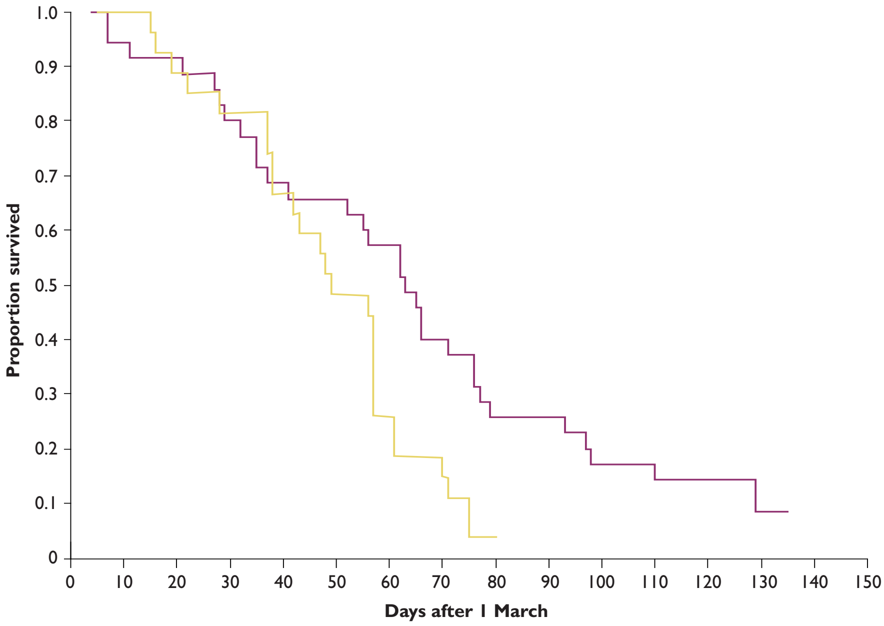


Figure 1

Survival curves for 30 radio-tagged hen pheasants at the Allerton Project at Loddington in spring 2018 and 35 in 2019. Each vertical line represents the loss of one or more birds on that date with the horizontal line indicating the proportion of surviving birds. After a similar start, the 2019 cohort survived for longer than the 2018 birds, but in neither year did any birds breed successfully

— 2019

— 2018

birds at night before the nesting period. Overall, around a third of birds observed during these sessions roosted on the ground and two-thirds in shrubs and trees.

In 2018 we tracked 30 radio-tagged hens, of which 28 had died by mid-June. Excluding unknowns, 24 (92%) were predated or their bodies were scavenged between mid-March and early June (see Table 1 and Figure 1). Three nests were monitored with cameras, of which two were taken by badgers. Owing to the lack of real nests in 2018, we put trail cameras on 60 artificial nests (each comprising 10 pheasant eggs placed in cover) for seven days each. The work provides a crude insight into the likely real-nest predators but not predation rates. Thirty-five were predated, 30 by badgers (nine in open habitats, 21 in woodland), two by crows, and one each by magpie, squirrel and an unknown.

We think that we are catching and following hens released on neighbouring estates rather than wild Loddington hens, and that these birds of unknown origin struggle despite the supplementary food and fox/corvid control provided at the Allerton Project. We suspect that badgers and other predators find nests during incubation as recorded by the cameras, but also before incubation, during the circa two-week laying period. Before nesting, adult birds roosting on the ground were being predated at night. It is possible that disease and poor body condition were more important factors than observed because few dead birds were recovered whole. Birds in poor condition are more vulnerable to predation, and disease may have killed birds and their carcasses scavenged before being found. In previous years, we have found similar loss rates during the spring on lowland release-based shoots.

KEY FINDINGS

- Hen pheasants caught on the Allerton Project farm at Loddington in the spring, radio-tagged and tracked do not survive well. Overall 90% of birds of known fate had been eaten by a predator (whether killed or scavenged was not known).
- In 2018 and 2019, of 30 and 35 tracked birds, only two and three birds respectively survived until summer, three and six birds nested, none of which produced a brood.
- Disease may have killed some birds but may also have increased the vulnerability of others to predation.
- Trail cameras revealed that badgers were the main nest predators.

Rufus Sage

ACKNOWLEDGEMENTS

We would like to thank Ellie McQuarrie (Birmingham University), Meg Speck (Manchester Metropolitan University) and Charlotte Parker (University of East Anglia) who undertook the radio-tracking work.

A badger predated nest site with broken eggs at the top of the picture and characteristic flattening of vegetation in the foreground. © Rufus Sage/GWCT

Vegetation monitoring in the Avon Valley

Hayed fields often contained larger proportions of SSSI-quality grassland. © Clive Bealey/GWCT

BACKGROUND

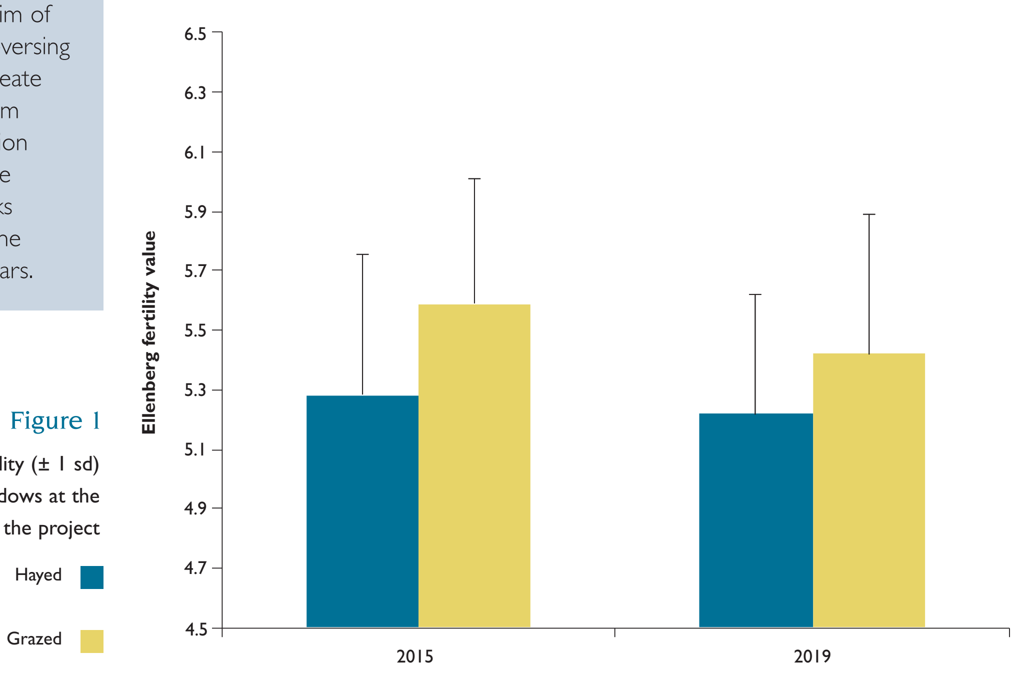
Over the past 25 years, the GWCT has documented a 70% decline in numbers of breeding lapwing and an 83% decline in breeding redshank in the Avon Valley, Hampshire. Our monitoring has provided evidence that the lapwing decline is driven by poor breeding success. The EU LIFE+ Waders for Real project was launched in 2014 with the aim of halting these declines and reversing them. Our approach is to create strategic hotspots of optimum habitat with reduced predation pressure, where the birds are able to fledge sufficient chicks to increase recruitment to the population in subsequent years.

Vegetation monitoring was started as one of our Waders for Real project targets to document changes in habitat stability and restoration of ecosystem functions following our management improvements. Two methods of assessing vegetation composition and change were used. First, detailed recording was undertaken using a fixed quadrat method (five 4m² quadrats per field recording percent cover of all vascular plant species and bryophytes, plus cover of bare ground and litter). In addition, surveys based on the Common Standards Monitoring (CSM) methodology 'quality assessment' (recording a small number of positive and negative botanical and management indicators using a structured walk) were conducted. Both surveys were carried out in the summer (June-August).

This two-pronged approach will give us information on gradual change in botanical communities as well as information on the 'quality' of the vegetation, ie. whether it is of SSSI (high) or sub-SSSI (low) quality. This information is important as we believe that breeding waders need a variety of micro-habitats that provide different elements during their breeding cycle. For example, lapwing prefer areas of bare ground for

Figure 1

Mean Ellenberg values for fertility (± 1 sd) on hayed and grazed water meadows at the beginning and end of the project



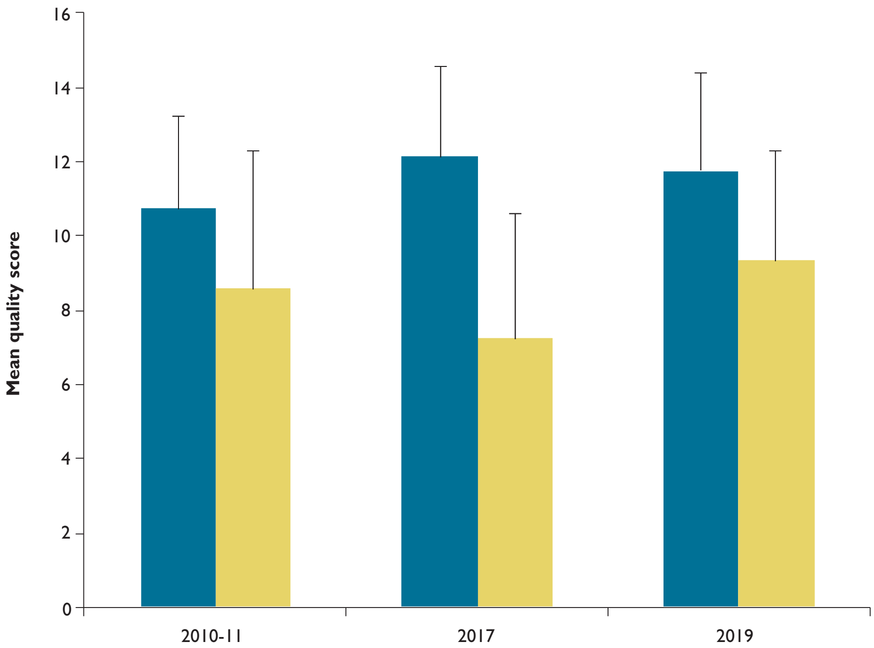


Figure 2

Mean quality scores (positive indicator species ± 1 sd) for hayed and grazed water meadows before (fields sampled over 2010-2011), during (2017) and at the end (2019) of the project

Hayed

Grazed

nesting but these need to be close to wet depressions (pools or shallow ditches) that remain wet or damp during the chick fledgling stage. There is a link between habitat and nest protection, chick safety (hiding places) and invertebrate food availability, which is key throughout the chick growth phase. Additionally, a key deliverable under the LIFE project is the 'restoration of ecosystem functions', such as water quality, which clearly includes making changes to habitat to improve conditions that will enable increased biodiversity.

Results

Plant species records from the detailed surveying were converted to Ellenberg values, which assigns a value to the position of their ecological niche along an environmental gradient. Ellenberg soil moisture, fertility and acidity (pH) values were calculated.

Data taken from the project start and its end year were compared. Comparisons were also made between fields with different management activities and conservation 'status'. The most striking differences were between grazed and hayed fields (see Figure 1), with grazed fields indicating a much higher level of fertility. The effect of being grazed or hayed is highly statistically significant. This can be explained by the management where more intensive cattle grazing throughout the spring to autumn period and a history of applying fertilizer to some fields to 'improve' them has increased the soil fertility. An overall reduction in fertility, particularly on the grazed fields may be a continuation of a trend detected in the mid-2000s due to agri-environment options, which are partly aimed at reducing fertilizer inputs.

Occurrences of positive indicator species, as selected by Natural England for their CSM programme, were converted to a single quality score for each field. Data were available from a pre-LIFE project survey (over 2010-2011) and two recent surveys (2017 and 2019). Analysis showed an overall increase in quality score over a 10-year period (see Figure 2), with hayed fields showing consistently higher scores compared with grazed ones. Again, the effect of being grazed or hayed is highly statistically significant. Hayed fields, although more prone to seasonal inundation, are closer to the river and therefore tend to be those containing larger proportions of SSSI-quality grassland. These also tend to be more resilient to drastic change when prolonged flooding occurs as they consist of wet-adapted species. In contrast, the grazed fields consist of improved vegetation which can die off or even be scoured out under flooding and therefore takes a longer time to recover. This would explain the larger difference in 2017 which was only four years after a flooding event in 2012-13.

This work will feed into analysis of data on wader breeding location, success and habitat use, and into research on the possible link between habitat 'quality' and vital invertebrate food sources, particularly at the chick stage.

KEY FINDINGS

- Each of our four hotspot sites for breeding waders has seen habitat management improvements, targeted advice to landowners and detailed monitoring of outcomes.
- An essential element of success is to provide optimum habitat for breeding waders, but it is difficult to measure improvements to habitat.
- Use of botanical indicators has proven useful for determining changes in habitats and the drivers causing these changes.

Clive Bealey
Lizzie Grayshon

ACKNOWLEDGEMENTS

We would like to thank all the landowners, farmers and keepers in the Avon Valley for their support and co-operation. We are grateful to Natural England and the Environment Agency for advice. The project is part-funded by the EU LIFE+ programme.

Migration of woodcock wintering in the British Isles

Individual woodcock did not always follow the same migration route each spring, despite returning to the same breeding site. © Serkan Mutan

KEY FINDINGS

- Satellite-tracking of woodcock has yielded important details concerning migrations, such as the timing of movements and countries that birds wintering in the British Isles pass through. This information is the first step towards better monitoring of woodcock, and dialogue between countries, at a flyway-scale.
- The main arrival period of migrant woodcock in the British Isles is during late October to late November. Peak spring departure is during the third week of March.
- North-west Russia is a key breeding area for woodcock wintering in the British Isles.
- Germany, Poland, Lithuania, Latvia, Estonia and Belarus constitute important stopover areas along the main flyway for migrant woodcock that winter in Britain and Ireland.

Andrew Hoodless
Chris Heward

Owing to the importance of the British Isles as a wintering destination for woodcock, the GWCT decided in the mid-2000s that we needed to know more about the origins and migrations of these birds. Having deduced the main breeding areas with a stable-isotope study (see *Review of 2011*, pp. 24-27), we proceeded to fit 64 woodcock with satellite tags during February-early March 2012-2018; 56 of these proved to be migrants and completed at least one spring migration. We tagged woodcock in seven geographically distinct regions, from northern Scotland to the west of Ireland, from Cornwall to Norfolk, to improve the likelihood of obtaining data representative of the range of migration routes used by individuals visiting Britain and Ireland.

Peak spring departure of our satellite-tracked woodcock was during the third week of March, but departure times spanned a five-week window from 3 March to 13 April. Spring departure date varied between years, being appreciably later in the cold spring of 2013 (average 9 April), when the mean UK temperature in March was 3.3°C below the 1981-2010 average, than in other years (average 23 March). Analysis of our data showed that periods of movement during spring migration coincided with higher air temperature, favourable wind direction and lower relative humidity.

Most of the tracked woodcock minimised the distance flown across the sea on spring migration. Except for birds breeding in Norway, which flew directly across the North Sea, woodcock typically passed through France, Belgium or the Netherlands, and then Germany, before heading up across Denmark and north of the Baltic Sea to reach Sweden or Finland, or heading south of the Baltic Sea to reach Finland, Belarus or north-west Russia (see Figure 1). Peak arrival at breeding sites was in mid-April, with tracked birds taking an average of 23 days to complete spring migration. However, the range of arrival dates spanned two months, from 21 March (Latvia) to 24 May (central Russia). The duration of spring migration was related to migration distance, such that woodcock arrived at breeding sites two days later for every 300 kilometres (km) extra travelled.

Migration routes in autumn were largely similar to those taken in spring. Consequently, Germany, Poland, Lithuania, Latvia, Estonia and Belarus constitute important stopover areas along the main flyway in April and October-November for migrant woodcock that winter in Britain and Ireland (see Figure 2). Satellite data gave a mean departure date from the breeding grounds of 10 October, with 10 November the average arrival date in the British Isles (range 3-23 November). These individuals, however, were adults (at least a year old) and we know from intensive ringing in Hampshire and mid-Wales that first-year birds usually arrive before adults. Our ringing data show that adults comprise less than 20% of the birds caught in October, rising to about 35% in November and stabilising at about 40% in December. Consequently, we estimate the peak arrival of first-year woodcock to be in late October-early November.

Individual woodcock did not always follow the same migration route each spring, despite returning to the same breeding site. A bird tagged in Wales, which took a route through Germany with a stop in central Poland to a breeding site near Vyazma, Russia (55°19'N, 33°32'E) in 2012 and 2013, then detoured further south in 2014, stopping in Slovakia and Belarus instead. In the cold spring of 2013 the migration took

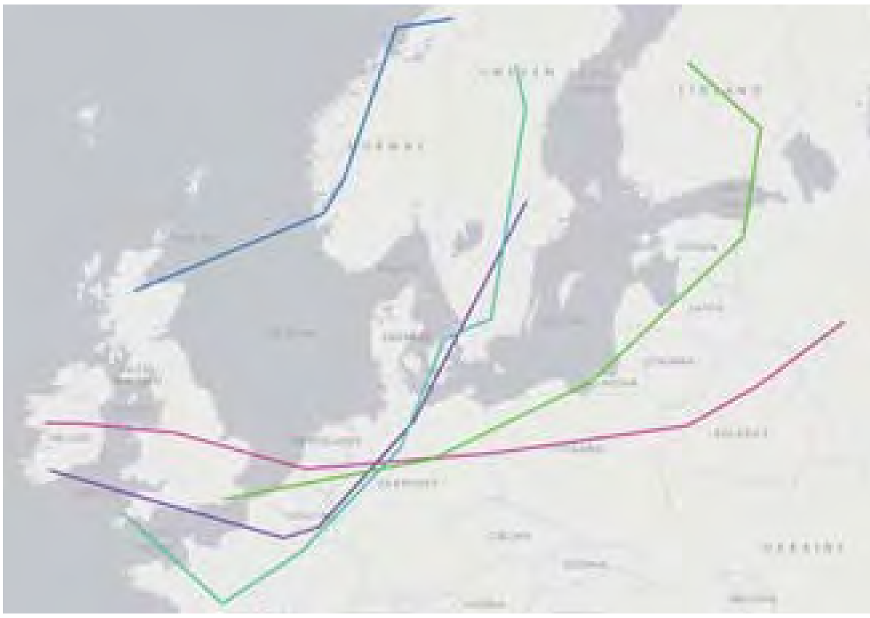


Figure 1

Comparison of spring migration routes of five woodcock wintering in Britain and Ireland. Woodcock breeding in Sweden, Finland and Russia tend to minimise sea crossings

17 days, with the bird arriving at its breeding site on 20 April, while in 2014 it arrived on 24 March, having taken eight days to fly a route 347km longer. Delays and deviations caused by bad weather are not surprising. In 2017, two woodcock travelling through western Russian back-tracked approximately 200km and 500km. Their escape movements occurred within two days of each other in mid-April, and came shortly before a sudden drop in temperature from 5°C to -8°C. For a bird that feeds mainly on soil invertebrates, it is clearly important that stopovers are made at places where feeding is possible in unfrozen ground.

The current level of shooting in the UK on migrant woodcock is judged to be sustainable from a stable UK bag trend and stable spring counts in Scandinavia and Russia. However, information from ringing and tracking provides the foundation for more focused population monitoring and discussion between countries along the main migration route about shooting practices and seasons, habitat and conservation measures. Thus, while north-west Russia, along with Scandinavia and Finland, is a key breeding area for woodcock wintering in the British Isles, migration routes of our satellite-tracked birds, viewed alongside tracks of individuals tagged in France, Spain and Italy, strongly suggest that woodcock wintering further south and east originate further east in the Baltic States, central Europe and Russia and follow broadly parallel migration routes. Increased monitoring of breeding woodcock numbers in defined zones with known links to particular wintering areas would be a step towards ensuring sustainable hunting at a flyway-scale. Another would be an assessment of flyway-scale harvest rates. For the British Isles, we now know that a large proportion of the woodcock wintering here follow migration routes just to the north or south of the Baltic Sea. Improved knowledge of the timing of woodcock passage through Belarus, Poland, Lithuania, Latvia, Estonia, Germany, Sweden, Denmark and Norway, combined with bag estimates from these countries, will enable a better understanding of shooting pressure on woodcock before they reach our shores.

BACKGROUND

The Eurasian woodcock breeds throughout western Europe, as far south as northern Spain and northern Italy and across the whole of Russia between approximately the latitudes of 50°N and 64°N. The European breeding population is estimated at seven to nine million males and shows a stable trend. In winter, Britain and Ireland receive migrant woodcock from Norway, Sweden, Finland, the Baltic States and Russia, such that they host approximately 10-15% of the birds wintering in Europe. Britain and Ireland also support a relatively small resident breeding population of woodcock estimated in the UK at 55,240 males, which has undergone a severe decline in size and range since 1970. The woodcock is currently red-listed as a 'Bird of Conservation Concern' owing to the contraction in its UK breeding range.

ACKNOWLEDGEMENTS

We are grateful to the *Shooting Times* Woodcock Club and many individual donors who continue to fund this research. We particularly appreciate the help of James Maunder-Taylor in fundraising for this project. We are grateful to Owen Williams (The Woodcock Network) and Luke Harman (University College Cork) for assistance with fitting satellite tags in mid-Wales and Ireland respectively.

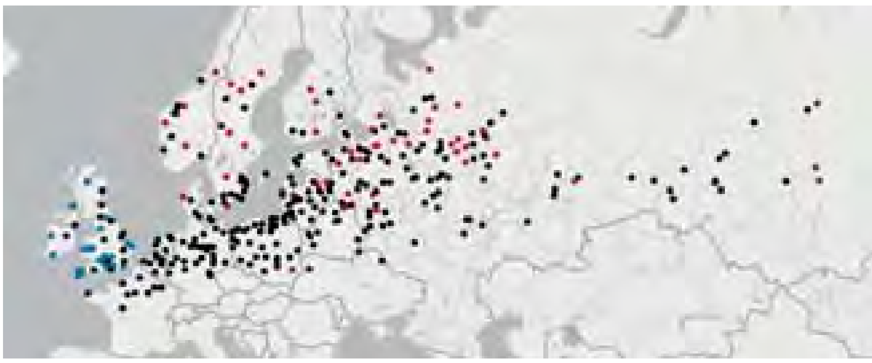


Figure 2

Map showing winter (blue), spring stopover (black) and breeding (red) sites of all woodcock that completed a spring migration during 2012-2016. For woodcock tracked in more than one year, only the locations during the first spring in which the bird was tracked are shown

Partridge & Biometrics

JOIN THE PCS

The country's wild grey partridges need more land managers, especially those with only a few grey partridges, to join the Partridge Count Scheme. Find out more at **www.gwct.org.uk/pcs**.

Partridge Count Scheme

The number of grey partridge pairs recorded in the spring of 2019 was 7,406, with a 41% increase in density since spring 2018. © Steve Round

KEY FINDINGS

- The national average spring pair density on PCS sites increased by 41% in 2019.
- Summer productivity, measured as Young-to-Old ratio, fell to just two young birds per adult.
- Nationally, the average autumn density decreased by 11%.

Neville Kingdon
Julie Ewald

Partridge Count Scheme (PCS) members returned 561 counts in spring 2019, an encouraging increase of 84 spring counts from 2018. A total of 7,406 pairs of grey partridge were counted across 174,500 hectares (ha) (431,100 acres). Average spring pair density nationally increased by 41% to 5.2 pairs/100ha (250 acres) (see Table 1). Eastern England witnessed the greatest increase in pair density. North England and Scotland each recorded positive increases as did the few participating areas in Wales and Northern Ireland. Meanwhile, the Midlands experienced a decline (-10%) but still achieved an average 2.6 pairs/100ha, but southern England suffered the largest decrease (-21%) to an average of just 1.5 pairs/100ha.

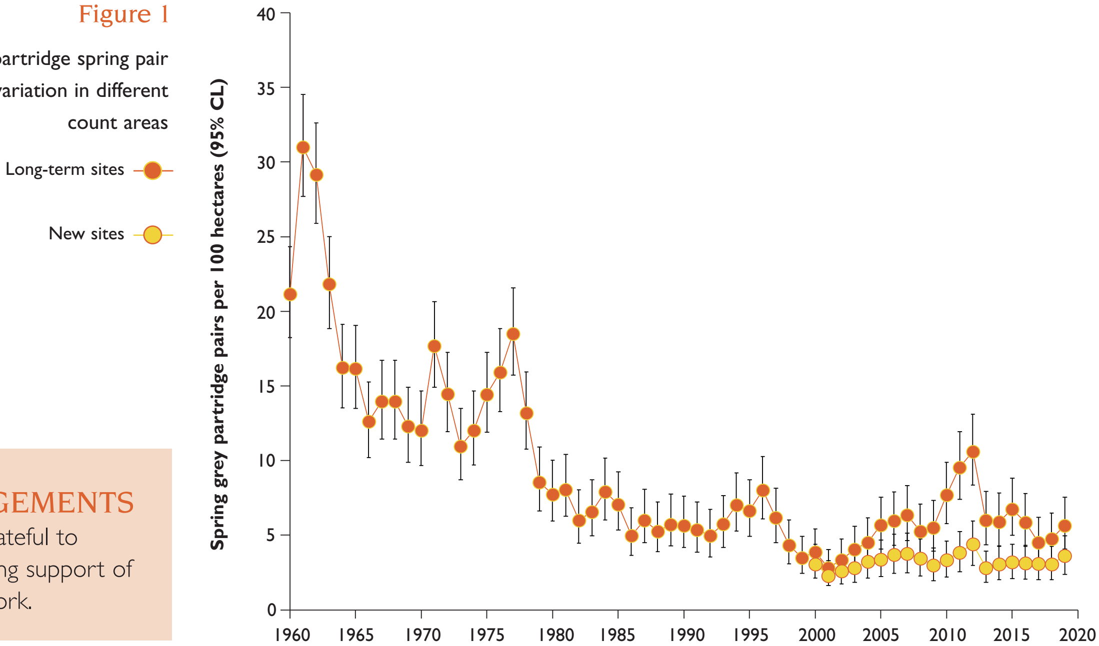
Nationally, over-winter survival (OWS) for 2018/19 decreased again (-7%) to 49%. Northern England was the only region to see an increase in OWS (13%). Scotland and southern England's OWS remained relatively stable with only small declines (less than -2%), but OWS in eastern England declined again for a second year (-20%), now achieving only 43% survival.

The long-term change in spring pair density (see Figure 1) shows that sites which participated in the PCS prior to 1999 (long-term sites) recorded an average 19% increase on the 2018 spring density, giving an average 2019 spring density of 5.7 pairs/100ha, while new sites (which joined since 1999) recorded an increase of 18%, with an average density of 3.6 pairs/100ha.

The noticeably warm dry spring offered hope of a good summer for wild partridges, but as June began Storm Miguel dragged in successive bands of wet weather to most areas for the rest of the month, hitting just as mid-June's peak hatch occurred. This inclement

Figure 1

Trends in the 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 autumn 2018 and 2019, from contributors to our Partridge Count Scheme

	Number of sites (spring)		*Spring pair density (pairs per 100ha)*			*Number of sites (autumn)*		*Young-to-old ratio (autumn)*		*Autumn density (birds per 100ha)*		
Region	*2018*	**2019**	*2018*	**2019**	**Change (%)**	*2018*	**2019**	*2018*	**2019**	*2018*	**2019**	**Change (%)**
South	63	81	1.9	1.5	-21	82	74	1.9	1.8	9.9	8.8	-11
East	146	175	5	9.1	82	151	125	2.7	2.1	22.2	25.5	15
Midlands	85	103	2.9	2.6	-10	94	87	2.4	1.8	19.6	11.7	-40
Wales	2	2	0	1.5	150*	2	2	-	-	0	0	0
North	109	123	4.8	6	25	114	112	3.0	2.2	34.2	28.7	-16
Scotland	71	76	2.2	2.6	18	71	70	2.5	2.2	11	10.9	-1
N Ireland	1	1	7.9	9.9	25*	1	1	1.0	0.8	13.3	22	65*
Overall	**477**	**561**	**3.7**	**5.2**	**41**	**515**	**471**	**2.6**	**2**	**20.7**	**18.5**	**-11**

** Small sample size. The number of sites includes all those that returned information, including zero counts. The young-to-old ratio is calculated from sites where at least one adult grey partridge was counted. The autumn density was calculated from sites that reported the area counted.*

weather, just at the wrong time, compounded any effect that the UK Government's earlier withdrawal of the General Licence would have had on nesting success.

The PCS received 471 autumn counts, 9% fewer than were returned in autumn 2018 (see Table 1). The total number of grey partridges recorded nationally was nearly 19,200, a drop of more than a quarter of the numbers recorded in autumn 2018. The national autumn density declined by 11%, from 20.7 birds per 100ha in autumn 2018 down to 18.5 birds per 100ha. Regionally, only eastern England increased its autumn grey partridge density.

Despite the frustrating summer, especially after such a promising spring count, PCS participants did report very young second or late broods, which look to have offset the worst of June's losses. The national average Young-to-Old ratio (YtO), which is an easy measure of summer partridge productivity, reached two (down 30% from 2.6 in 2018). Thankfully, despite the poor June weather, nationally productivity still exceeded a YtO of 1.6 – the minimum level required to cover adult losses into the following year. Regionally, Scotland, northern and eastern England regions achieved the highest YtO in 2019, although all regions saw declines in their grey partridge summer productivity, especially for northern England, the Midlands and eastern England.

Adverse summer weather cannot be prevented and is probably something we will face more often, but this summer's partridge productivity could have been much worse without the habitats and management PCS participants have in place, helping to minimise their losses. However, to help maximise brood survival in both good years and bad, more farms and shoots throughout the country need to address this aspect of the partridge life cycle by providing suitable nesting cover, with nearby brood-rearing habitat to provide the chick-food insects that are of paramount importance early in life.

Brood-rearing habitat is vital to provide chick-food insects for partridges. © Peter Thompson/GWCT

BACKGROUND

Partridge counts can 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:

- Record what partridges you see – using binoculars helps when examining each pair or covey.
- 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 drive around fields and then criss-cross the whole field to check the entire area, using the tramlines to minimise crop damage. www.gwct.org.uk/pcs.

The Rotherfield Demonstration Project

The number of spring grey partridge pairs in 2019 was the highest since the project began. © *Markus Jenny*

BACKGROUND

The project started in 2010 to demonstrate grey partridge recovery from zero, together with the benefits for other wild game and wildlife. It aims to be applicable to a wide range of landowners and other stakeholders wishing to recover grey partridges where they have gone extinct. Grey partridge reintroduction is based on GWCT guidelines, which follow international guidelines.

The Rotherfield Demonstration project in east Hampshire demonstrates how to recover grey partridges in an area where they went extinct in the early 1990s and shows how management tailored to grey partridge conservation benefits farmland wildlife in general. The project began in 2010 with the Trust's gamekeeper working on c. 700 hectares (ha) (Trust side) and the estate's gamekeeper on an adjacent c. 700ha (Estate side). Since the estate entered a 10-year Higher Level Agri-environment Scheme contract with Natural England in 2011, wildlife-friendly habitat tailored to grey partridges gradually increased to more than 15% in the most enhanced 100ha partridge recovery core area, alongside intensified legal predator management. Habitat improvements were focused on increasing the number and quality of wild bird seed mixes, cultivated uncropped margins, beetle banks, overwintered and extended overwintered stubbles, together with the implementation of a long-term partridge-friendly hedgerow management plan. Furthermore, block cropping has given way to a more diverse cropping plan, especially in the core partridge recovery area.

Since 2016, 500ha of the Trust's project area became part of the PARTRIDGE Interreg project (see pp. 56-57). As a result, the Rotherfield project received increased attention from a wide range of rural stakeholders. In 2019, more than 100 people visited Rotherfield (431 since 2017) on farm walks – including policy advisors from Natural England – to learn more about the management measures needed to recover grey partridges and the wider benefits to farmland wildlife generally.

On the Trust side, we counted a minimum of 27 grey partridge pairs in spring 2019. Only five pairs produced a brood, probably as a result of a very wet week around peak hatching time in mid-June, and despite suitable insect-rich foraging cover in the core area. The autumn count confirmed 63 wild grey partridges (26 males, 20 females and 17 young). On the Estate side, all three spring pairs recorded produced a brood, but only 10 young in total.

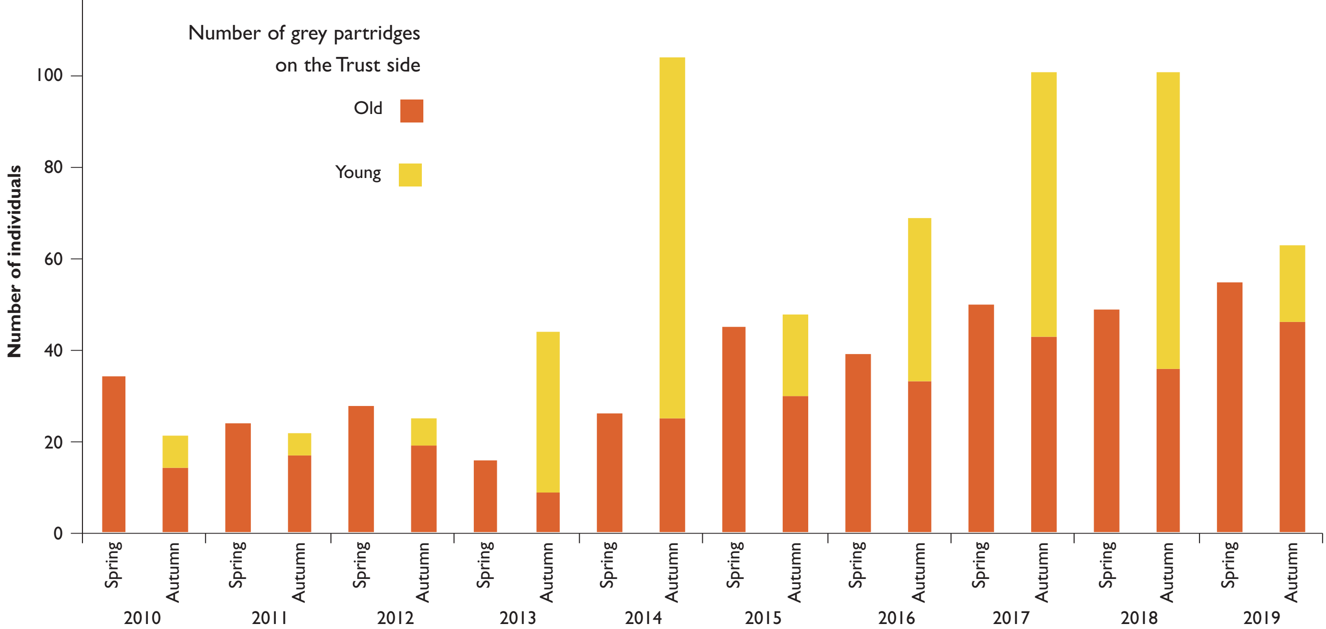


Figure 1
Number of grey partridges on the Trust side

TABLE 1

Gamebird recovery at Rotherfield, split between the Trust and Estate side

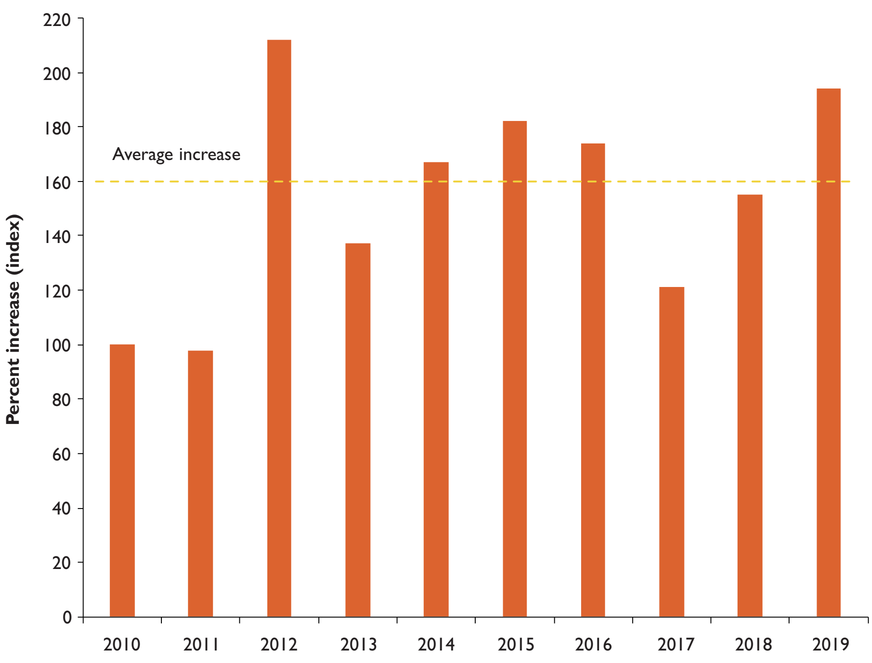
Year		Spring pairs*			Autumn stock**		
		Trust	Estate	Total	Trust	Estate	Total
Grey partridge							
2019 (2018)		27 (24)	3 (2)	30 (26)	63 (101)	17 (12)	80 (113)
Red-legged partridge							
2019 (2018)		46 (44)	28 (9)	74 (53)	119 (202)	45 (52)	164 (254)
Pheasant							
2019 (2018)	Hens	272 (207)	158 (96)	430 (303)	396 (347)	256 (145)	652 (492)
	Cocks	187 (170)	132 (92)	319 (262)			

** For grey and red-legged partridges in spring, the numbers given are pairs; for pheasants, numbers of cocks and hens are tallied separately. ** Autumn stock is the number of cocks, hens and young combined (released cocks excluded). On the Trust side, 600 wing-tagged cock pheasants have been released each year since 2011, on the Estate side 600 wing-tagged cocks have been released since 2018; they are excluded from the autumn totals.*

Like their grey 'cousins', the red-legged partridges had one of their worst breeding seasons since the project began. On the Trust side, 46 spring pairs produced only nine broods, with 17 young in total (in 2018, 24 broods produced 100 young). On the Estate side, none of the 28 spring pairs produced a brood (in 2018 seven broods had 19 young, out of nine spring pairs).

The habitat and predator management measures put in place for grey partridges since 2010 have resulted in noticeable increases in numbers of farmland songbirds of conservation concern. On the Trust side, all red- and amber-listed farmland birds that are found breeding in the project area (including yellowhammer, skylark, linnet, dunnock, song thrush, bullfinch and tree pipit), which are declining nationally, have increased at Rotherfield by an average of 60% over the past nine years (based on April, May and June counts along a 10km transect). In 2019 we recorded 94% more birds of conservation concern than at the start of the project (the second highest increase since the project began), or 40% more than in 2018.

Similarly, brown hare numbers increased 2.3-fold, from an average of 23.5 hares/100ha in 2017 to 53.2 hares/100ha in 2019. Hares were counted along a 19km transect, three to four times between December and January using two hand-held Tracer 170mm spot lamps.



KEY FINDINGS

- In 2019, the number of grey partridge spring pairs on the Trust's demonstration area was 27 pairs, three more than in 2018, and the highest since the project began.
- On the Trust's area, the grey partridge autumn stock was 63 birds, 38 fewer than in 2018.
- In 2019, farmland birds of conservation concern were up 94% compared with the baseline year in 2010, with an average increase of 60% since the project began.
- Hare numbers were up 130% since counting began in 2017.

Francis Buner
Malcolm Brockless
Nicholas Aebischer

Brown hare numbers have increased 2.3-fold to 53.2 hares per 100 hectares. © Markus Jenny

Figure 2

Recovery of farmland songbirds of conservation concern during the breeding season (April-June) on the Trust side. The index of the baseline year 2010 is set at 100%. The index of 194 in 2019 for example, means that numbers have increased by 94% compared with the baseline year

BACKGROUND

Since November 2016, the GWCT has been the lead partner of a pioneering cross-border North Sea Region Interreg programme project called PARTRIDGE that runs until 2023. Together with 12 other partner organisations from the Netherlands, Belgium, Germany, Denmark (DK), Sweden (S), Scotland and England, PARTRIDGE is showcasing how farmland wildlife can be increased by 30% at ten 500-hectare (ha) demonstration sites (two in each country, except in DK and S). In the UK, the four PARTRIDGE demonstration sites (Rotherfield and the Allerton Project in England, and Whitburgh and Balgonie in Scotland) are all managed by GWCT staff together with their local partners.

Interreg North Sea project PARTRIDGE

We measured chick food insects using D-vacs. © Julie Ewald/GWCT

PROJECT AIMS

- GWCT-led North Sea Region (NSR) cross-border Interreg project involving England, Scotland, the Netherlands, Belgium, Germany, Denmark and Sweden and is a demonstration of how to reverse farmland biodiversity loss at ten 500ha sites by 2020.
- Use the grey partridge as a flagship species for management plans at the demonstration sites.
- Influence agri-environment policy and showcase how to enthuse local stakeholders to conserve farmland wildlife.

Francis Buner
Paul Stephens
Lucy Robertson
Florian Schröer

PARTRIDGE is a cross-border North Sea Interreg project that demonstrates how to reverse the ongoing Europe-wide decline of farmland wildlife using science-based management plans based on a bottom-up approach. The project is led by the GWCT in partnership with 12 partner organisations from seven nations. These work with more than 70 farmers organised in Farmer Clusters at 10 demonstration sites, assisted by around 40 hunters and several hundred volunteers.

The project's locally adapted management plans are tailored to the grey partridge, because existing evidence shows that partridge-friendly measures, in particular wild bird seed mixes and wild flower blocks, benefit farmland biodiversity in general. PARTRIDGE has therefore developed locally adapted flower mixes for all partner countries. In the UK, the seed mixes have been developed by Oakbank and Kings Crops, in collaboration with the GWCT. In 2019, at all four UK demonstration sites, we continued to trial our new mixes to further improve the already widely available seed mixes that qualify under agri-environment scheme rules. This benefits wild game and seed-eating farmland birds not only during the winter, but also in spring (when cover supply is at its lowest), during the nesting and chick-food foraging period in summer and into the autumn.

In early July 2019, we took standardised D-vac insect samples (five samples per habitat) in PARTRIDGE wild bird seed mixes (average 10 per site), and nearby winter wheat fields (five per site) at three demonstration sites – Rotherfield (UK), Assenede (B) and Oude Doorn (NL). Preliminary results indicate that the PARTRIDGE mixes contain significantly more insects than the winter wheat crops in all three countries, despite different weather and soil conditions. Also, the number and the type of insects in the PARTRIDGE mixes appear to be sufficient to provide food resources for grey partridge chicks. Earlier work in England by the GWCT has led to the construction of the Chick Food Index (CFI), which allows researchers to determine if insect numbers are enough to maintain breeding grey partridge numbers. On average, the PARTRIDGE mixes in the three demonstration areas exceeded a CFI value of 0.7 – the value needed to provide enough food for chicks to maintain breeding abundance.

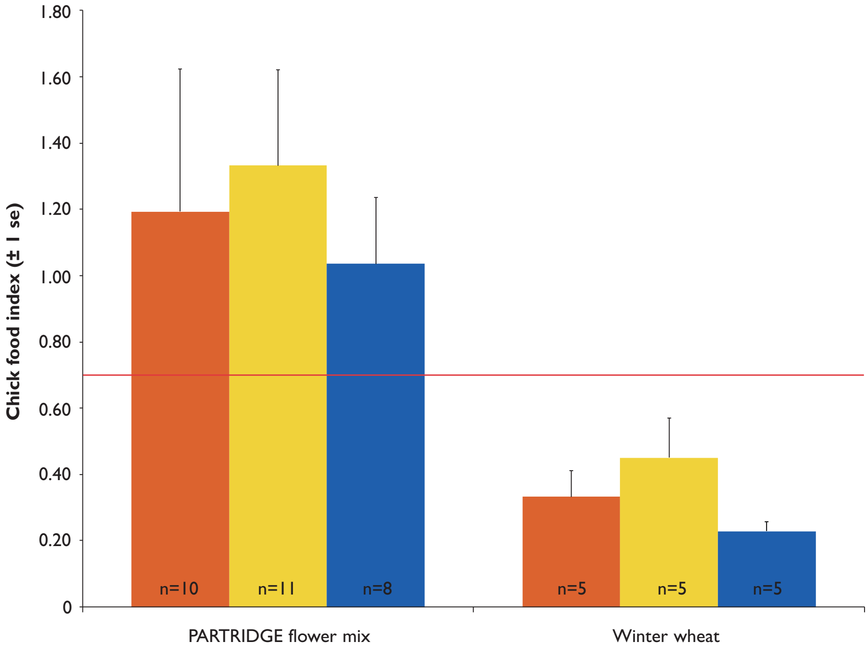


Figure 1

Suitability of two different habitat types of brood-rearing cover (PARTRIDGE wild bird seed mix versus winter wheat) for grey partridge chick food availability (expressed as Chick-Food Index) at three PARTRIDGE project demonstration sites in 2019

n = the number of habitats sampled per site, red line = the value needed to provide enough food for chicks to maintain breeding abundance, based on modelling from the GWCT's Sussex Study

Rotherfield (UK)

Assenede (B)

Oude Doorn (NL)

The CFI in winter wheat on the other hand was significantly below the required value of 0.7, highlighting its unsuitability for insect-eating farmland wildlife in general.

To promote the PARTRIDGE approach more widely across the North Sea Region (NSR) and to lobby for improved agri-environmental schemes such as ELMS in England, or under the new Common Agricultural Policy in Europe, the project puts a very strong emphasis on communication activities and in-depth advice. Since the project began, we have held 160 farm walks across our 10 demonstration sites, directly informing more than 2,400 individual people about our farmland conservation measures. We also interacted with more than 870 organisations representing our main stakeholders (farmers, hunters, NGO's, research institutes, local, regional and national authorities). Our official PARTRIDGE webpage (**www.northsearegion.eu/partridge**) has had 50,000 unique page views since the project began (more than any other NSR project) and through our strategic communication activities including social media, TV and radio, conferences and symposia, we have reached an estimated five million people to date.

ACKNOWLEDGEMENTS

This project would not be possible without the help of hundreds of supporters. We thank all participating GWCT members of staff (in particular Fiona Torrance, Dave Parish, Julie Ewald, Chris Stoate, John Szczur, Austin Weldon, Steve Moreby, Adam McVeigh, Ben Stephens and Elouise Mayall), the PARTRIDGE co-ordinating partner organisations BirdLife NL, the Flemish Land Agency (VLM), INBO and the University of Göttingen, together with their local PARTRIDGE partner organisations, all the participating farmers, hunters, volunteers, NGO's and Government agencies, the Steering Committee members, Oakbank Game and Conservation and Kings Crops for developing and promoting the UK-tailored PARTRIDGE seed mixes, and last but not least the NSR Interreg Secretariat in Denmark.

Farm walks have been held across all the demonstration sites informing more than 2,400 people about the conservation measures in place. © Francis Buner/GWCT

BACKGROUND

The National Gamebag Census (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').

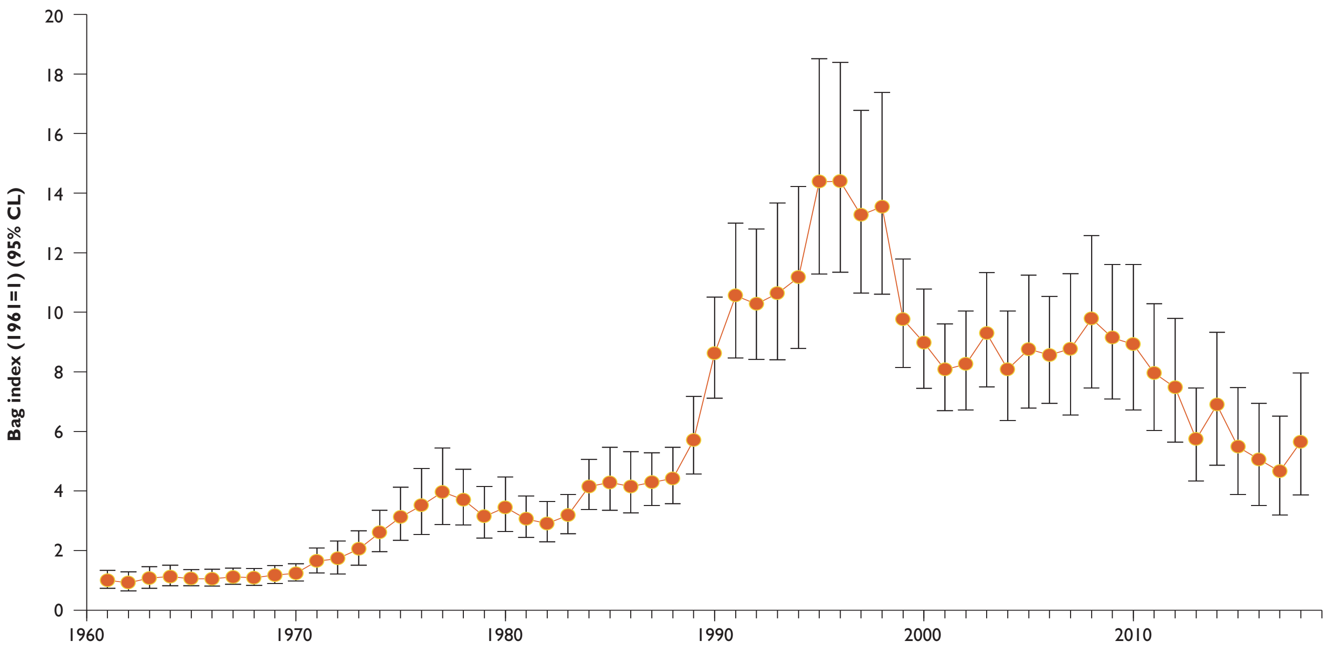
Rabbits, foxes and mustelids 1961-2018

Declines in rabbit numbers coincide with the arrival of rabbit haemorrhagic disease (RHD1) in 1992 and a new more pathogenic variant of the disease (RHD2) around 2010. © Laurie Campbell

Each year, the National Gamebag Census (NGC) collates bag records from some 700 shoots across the UK. These records include not just game species, but also a wide range of predator species that are culled legally as part of game management. Continuous series of returns over many years can be a valuable indicator of trends in abundance, especially for species like mammalian predators that are shy, nocturnal, easily overlooked and difficult to monitor alive. For instance, although mammals were recorded on 88% of the 4,022 1x1-km squares monitored across the UK by the British Trust for Ornithology's (BTO) Breeding Bird Survey (BBS) in 2018, foxes were

Figure 1

Rabbit index from NGC bags, 1961-2018



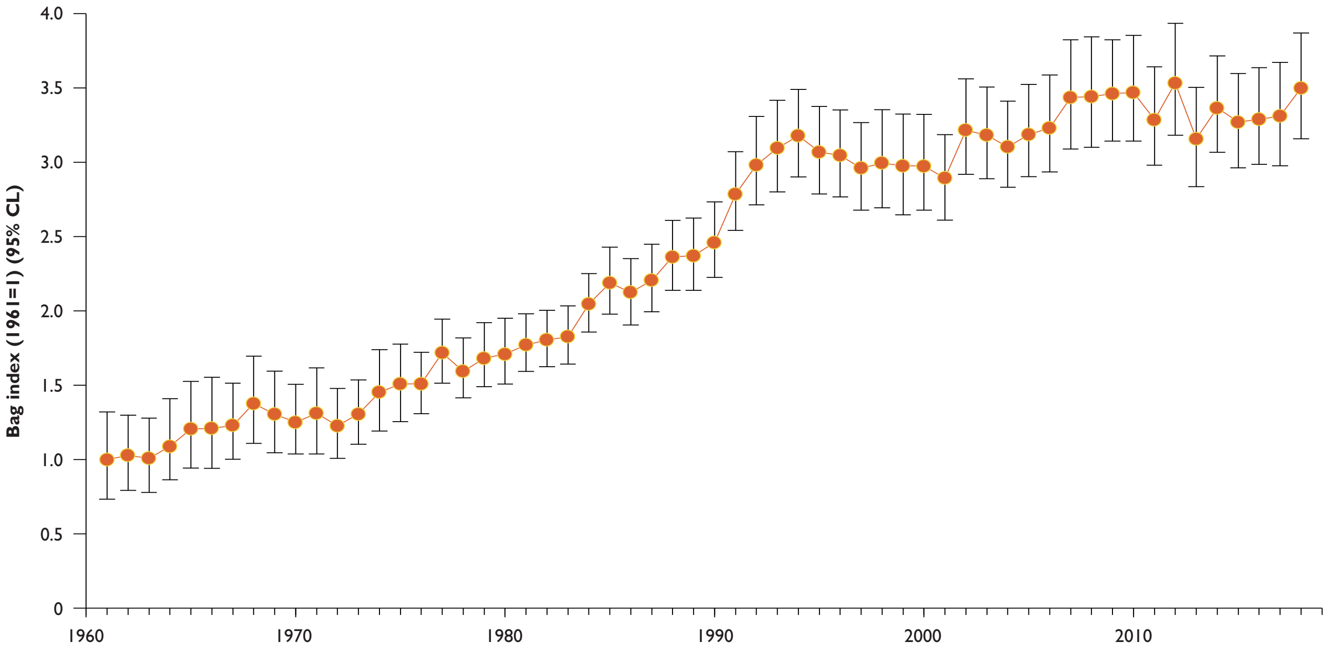


Figure 2

Fox index from NGC bags, 1961-2018

recorded on only 13%, stoats on 1% and weasels or American mink even less often. In addition, the BTO did not start surveying mammals until 1995 whereas the NGC has collected predator records since 1961, yielding trends that extend back for nearly 60 years.

Reviewed below are the UK trends from 1961 to 2018 for fox, stoat, weasel, American mink and also rabbit, an important prey item for the first two predator species. For each species, the analysis is based on shoots that have returned bag records for at least two years. The analysis standardises the bag data to unit area to allow for differences in shoot size, then summarises the year-to-year change within sites relative to the start year. This gives a series of annual bag indices that begins with a value of 1. Subsequent indices show the relative change over time, so an annual value of 2 represents a doubling of bag size since 1961.

Rabbit (Figure 1)

Rabbit bags started low in the 1960s, following the first outbreak of myxomatosis in 1953 that devastated the UK rabbit population. As resistance to the *Myxoma* virus developed, rabbit numbers recovered to a peak in the mid-1990s, when bags had increased 16-fold relative to 1961. Over the next 15 years, bags declined by about a third then appeared to stabilise, followed by a decline of another third during the most recent 10 years. The first decline coincided with the arrival of a new illness, rabbit haemorrhagic disease (RHD1), which first reached southern England in 1992 then spread north to Scotland by 1995. A new more pathogenic variant of the same disease (RHD2) reached the British Isles around 2010, tying in with the second decline phase. The BTO's BBS, which has recorded rabbit since 1995, shows a matching decline of 62% to 2017.

Fox (Figure 2)

The fox is a common generalist predator throughout the UK. Fox bags approximately tripled between 1961 and the early 1990s, with a further 18% increase to the present day. Fox numbers are also monitored by the BTO's BBS, which shows a very different 42% decline in the number of foxes seen between 1996 and 2017. The discrepancy between the NGC and BBS trends is currently unexplained. At least some of the NGC trend may reflect changing control methods, with the increasing adoption of night shooting through the 1980s, the withdrawal in 1987 of Cymag (a gassing agent widely used to destroy litters of cubs at the breeding earth), and recently the increasing use of night-vision scopes and acoustic attractants. It is possible that these changes have also made foxes more wary and less detectable during BBS surveys, which would result in an apparent BBS population decline.

KEY FINDINGS

- Rabbit bags have fallen by two-thirds since their peak in the mid-1990s, in a pattern that ties in with the spread of rabbit haemorrhagic disease.
- Fox bags are now 3.5 times higher than in 1961, though the rate of increase slowed considerably from the early 1990s onwards.
- Since 1961, stoat bags have doubled whereas weasel bags have fallen by a third. Their dynamics are probably related to changes in their prey.
- American mink bags had increased 12-fold by the early 1980s, but have since dropped by two-thirds, perhaps because of competition with otters.

Nicholas Aebischer

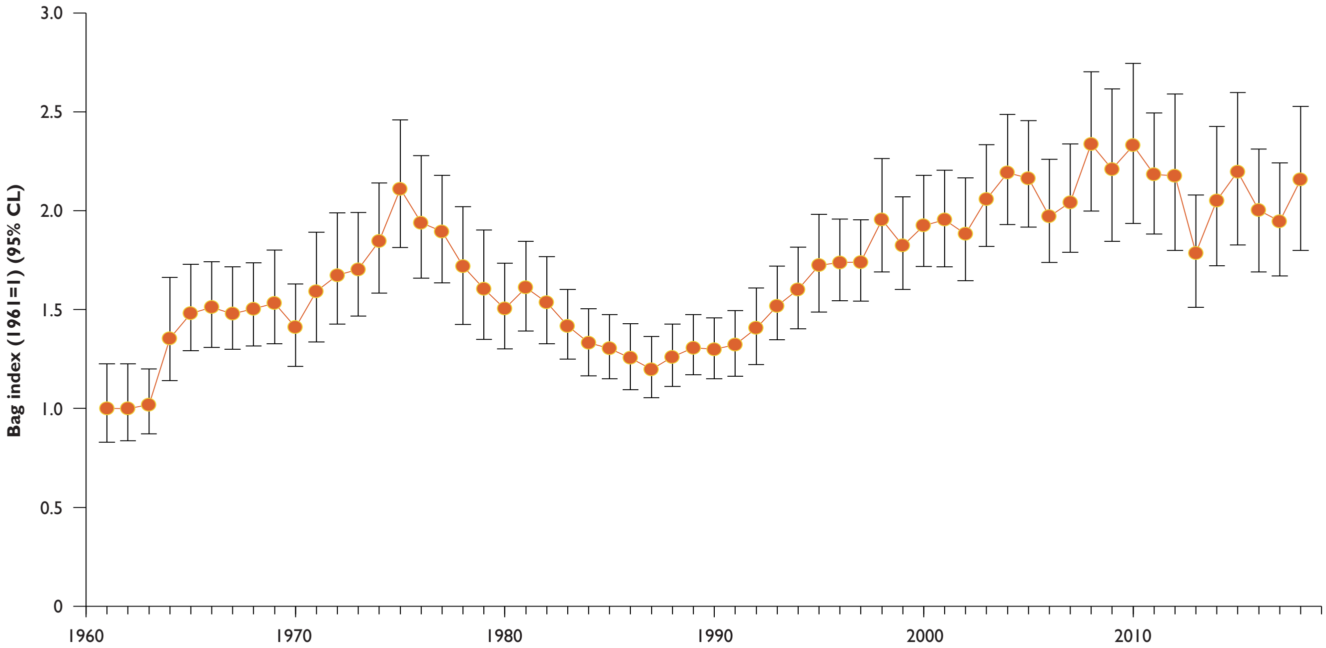


Figure 3

Stoat index from NGC bags, 1961-2018

Stoat (Figure 3)

The stoat is widespread across Britain. Its main prey is the rabbit, and numbers of stoats dropped when myxomatosis greatly reduced rabbit abundance in the 1950s and 1960s. Since 1961, stoat bags have approximately doubled, but with a broad-based dip during the 1980s followed by recovery during the 1990s. The two increase phases match the two periods of most rapid increase in rabbit bags, while the decrease phase matches a period when rabbit bags were roughly stable and fox bags were increasing. It is thus possible that the bags reflect predator-prey interactions, but if so, it is remarkable that stoat bags have remained high in recent years despite a severe drop in rabbit abundance. Stoats are not monitored by the BTO's BBS.

Weasel (Figure 4)

The weasel is also widespread, and its diet consists mainly of field voles. As reflected in the bags, weasel abundance was high in early years because voles benefited from ungrazed grassland arising from the lack of rabbits caused by myxomatosis. As rabbits recovered, so weasels declined, with a 70% fall in bags between 1961 and 1995. Since 1995, the situation has reversed: rabbit bags have fallen by two-thirds and

Weasels (above) and stoats (right) are both widespread across Britain. © Laurie Campbell

NATIONAL GAMEBAG CENSUS 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 Corinne Duggins on 01425 651019 or email **ngc@gwct.org.uk**.

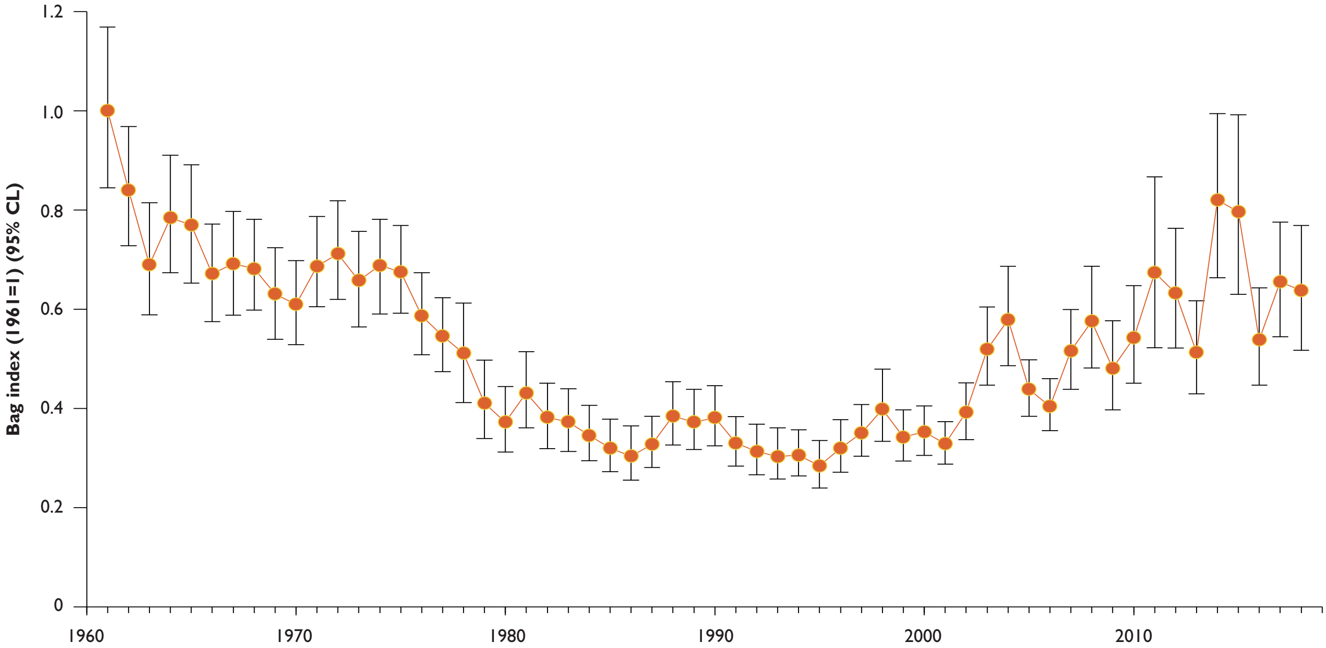


Figure 4

Weasel index from NGC bags, 1961-2018

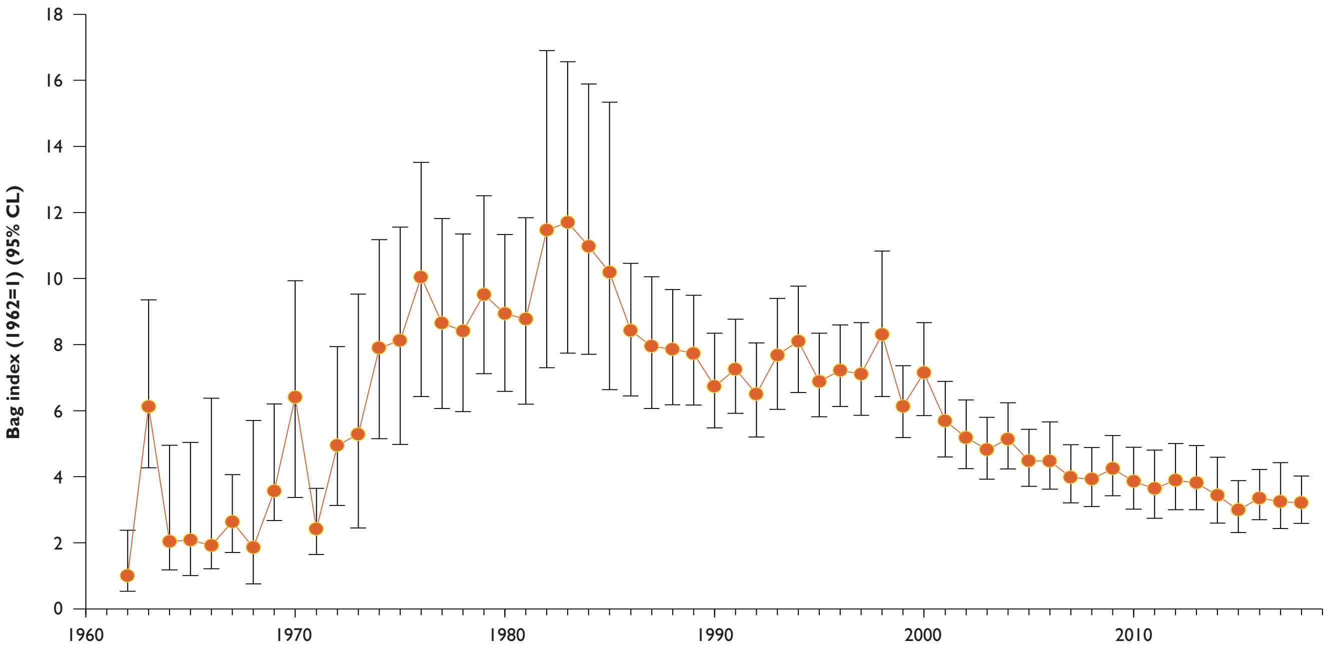
weasel bags have more than doubled. It is possible that voles have again responded to undergrazing by rabbits, but also during this period the stewardship schemes and Water Framework Directive have encouraged farmers to increase the amount of grass margins, which are likely to have benefited voles. Weasels are not monitored by the BTO's BBS.

American mink (Figure 5)

American mink spread into the wild from animals escaping from fur farms, with breeding in the wild first recorded in 1956. As mink became established across Britain, mink bags on NGC estates increased 12-fold between 1962 and the early 1980s. This was followed by a nearly continuous decline to the present day, with bag sizes now only a third of the peak. This has led to speculation that mink numbers have been drastically reduced, possibly reflecting successful use of the GWCT mink raft (introduced in 2004) in many areas of Britain. Competitive exclusion by the recovering otter population and disease are also proposed as possible factors contributing to a decline. Mink are not monitored by the BTO's BBS.

Figure 5

American mink index from NGC bags, 1962-2018



Uplands monitoring in 2019

BACKGROUND

Each year our uplands research team conduct counts of red grouse in England and the Scottish Highlands to assess their indices of abundance, their breeding success and how survival may change relative to *Trichostrongylus tenuis* parasitic worm infestations. They also count black grouse at leks and estimate productivity for black grouse and capercaillie.

These data enable us to plot long-term changes so we can recommend appropriate conservation or harvesting strategies. Such information is vitally important if we are to base such decisions on accurate estimates.

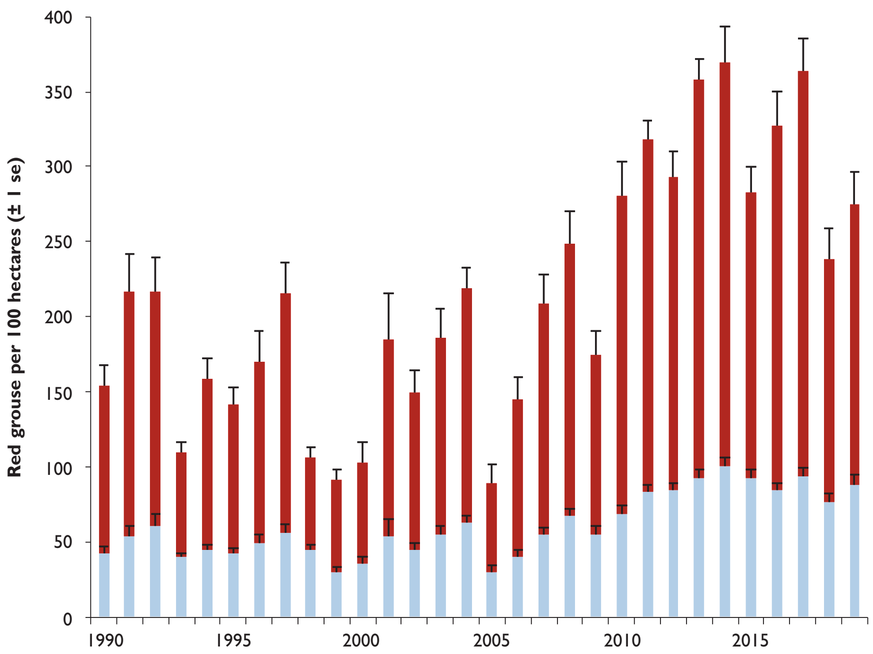
The counts of red grouse conducted in the spring and repeated in July are one of the main annual long-term monitoring tasks undertaken by the Upland Research Group. The spring counts form pre-breeding density estimates, while those in July are post-breeding density estimates, when numbers of both adults and young are recorded. The first counts began in 1980 in northern England and in 1985 in Scotland. We typically estimate grouse abundance using pointing dogs on 100 hectare (ha) blocks of predominantly heather-dominated moorland. Counts of parasitic strongyle worms from 20 shot adult grouse are conducted on the same moors in the period mid-August to mid-September.

Grouse counts - England

England: In 2019, spring densities were 13% lower than in spring 2018, with an average count of 101 birds per 100ha (114 in 2018). In spring 2019, birds appeared to be in better condition and the subsequent survival through to breeding was much better

Figure 1

Average density of young and adult red grouse in July from 25 moors in northern England 1990-2019



than in 2018. Numbers of adult birds seen on the same area in July had fallen by only 12% in 2019 to a mean of 88 birds per 100ha (33% fall in adults between spring and July in 2018). Breeding success was very similar in both years, averaging 2.1 young per adult, giving a post-breeding density in 2019 of 275 birds per 100ha, a 13% increase on 2018 associated with better breeding season adult survival (see Figure 1). Once again, the North York Moors had the highest grouse densities in 2019.

Scotland

Spring densities in 2019 averaged 52 birds per 100ha, a 29% decline from 2018. The number of adults seen on the same area in July had fallen by 31% (36 adults per 100ha in July) suggesting that up to a third of adult birds may have died during the breeding season. Breeding success in 2019 was 1.1 chicks per adult compared with 0.7 chicks per adult in 2018. Post-breeding densities averaged 77 birds per 100ha in 2019, similar to the 79 birds per 100 ha in 2018. The lower spring densities and adult survival were compensated by marginally higher breeding success in 2019 (see Figure 2).

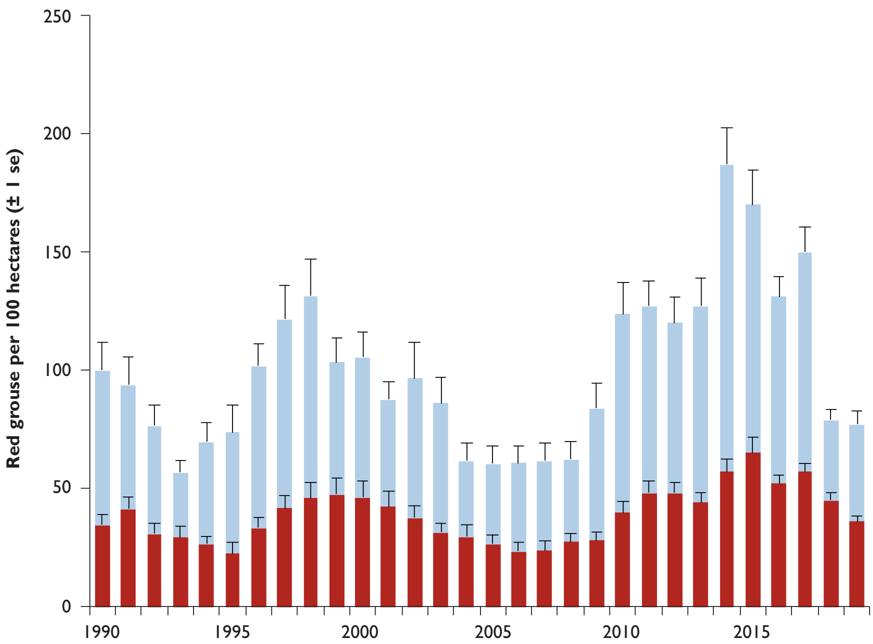


Figure 2

Average density of young and adult red grouse in July from 24 moors in Scotland 1990-2019

KEY FINDINGS

- The previous increases in grouse in northern England associated with better medicated grit appear to have plateaued.
- Strongyle worm counts remained low.
- Numbers of lekking black grouse fell again this spring following a succession of poor breeding years, but more chicks in 2019 should herald an increase in 2020.

David Newborn
David Baines
Kathy Fletcher
Nick Hesford
Michael Richardson
Phil Warren

We count grouse each year using pointing dogs and the resulting data enables us to plot long-term changes. © GWCT

Strongyle worms

Numbers of parasitic worms in grouse in both northern England and Scotland were similar to those in 2018. Overall, worm burdens have remained low on moors using medicated grit (see Figure 3: northern England, Figure 4: Scotland), despite some losses of adult grouse probably to strongyle worms in the spring in Scotland. The average number of worms per adult has been in the low hundreds on moors in England and Scotland since 2010. Again, zero worm counts were recorded in a fifth of adult grouse (22% of adult grouse sampled from English moors and 20% from Scottish moors).

Black grouse

Following four consecutive years with below-average breeding success (see Figure 5), the numbers of black grouse males attending leks in northern England were down 16% on last year. This represents a 40% decline since the last national survey in England in 2014 (1,437 males). Hence, we now estimate the English population to be c.860 males. This summer, breeding surveys using pointing dogs found 48 hens,

Figure 3

Average annual worm burden for autumn shot adult red grouse from 8-18 moors in northern England 1990-2019

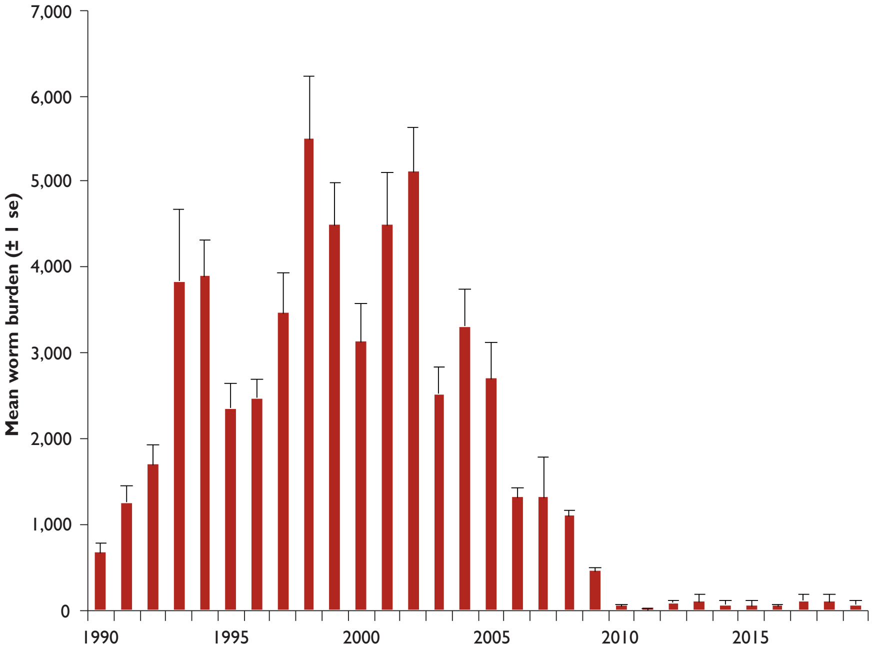
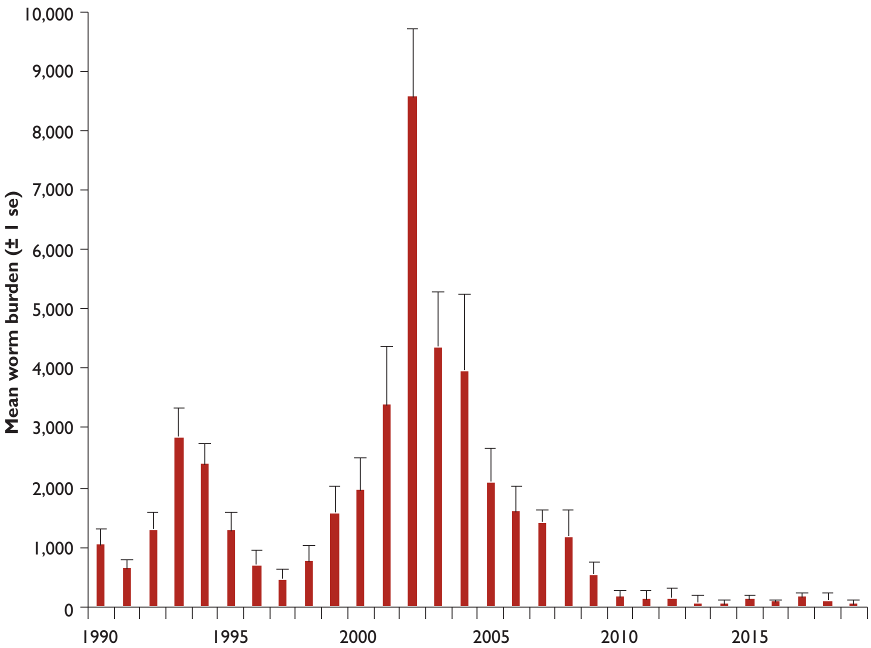


Figure 4

Average annual worm burden for autumn shot adult red grouse from 3-17 moors in Scotland 1990-2019



60% of which had broods with a total of 112 chicks, giving an average of 2.3 chicks per hen. This was a good breeding year, above the 30-year north-of-England average of 1.6 chicks per hen and accordingly we predict an increase in the numbers of males at leks in spring 2020.

2019 was a good breeding year for black grouse giving an average of 2.3 chicks per hen, well above the 30-year north-of-England average of 1.6 chicks per hen. © Laurie Campbell

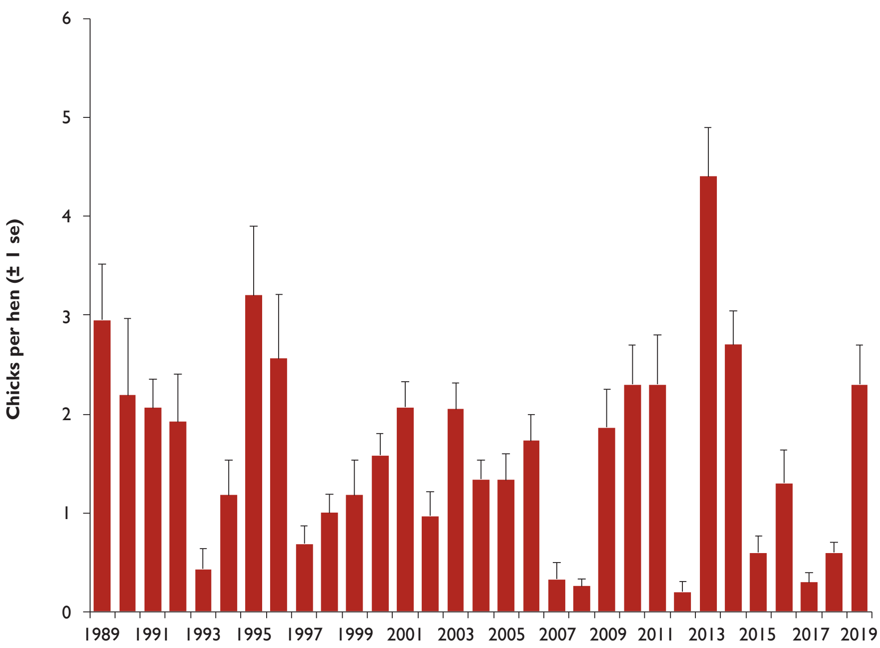


Figure 5

Black grouse breeding success in northern England between 1989 and 2019

Respiratory cryptosporidiosis in red grouse

Infection by cryptosporidiosis has impacted grouse, with infected birds having 51% lower survival and rearing 43% fewer chicks relative to healthy birds on the same moor. © Laurie Campbell

BACKGROUND

Infection by *Cryptosporidium baileyi,* a parasitic protozoan, causes respiratory cryptosporidiosis in red grouse. It was first diagnosed in 2010 and has spread with infection rates higher in young birds. Understanding underlying causes of disease emergence and routes of infection transmission are fundamental to its subsequent control.

Cryptosporidia are protozoan parasites that are widespread among vertebrates, causing gastrointestinal diseases in mammals and reptiles and enteric, renal and respiratory diseases in birds. Two species, *Cryptosporidium baileyi* and *C. galli,* are restricted to birds. In most cases, pathogenic infection has been restricted to domestic poultry, captive-reared gamebirds or other birds kept in captive collections. In 2010, red grouse in northern England were clinically diagnosed with respiratory cryptosporidiosis following infection from *C. baileyi.*

Within three years of the first outbreak, our questionnaire survey to gamekeepers showed that signs of infection were detected from grouse on half of 150 grouse moors in northern England. Reported prevalence among shot birds, confirmed in the field by catching at night and visual screening, has been low, typically averaging 4% of birds. Infection by cryptosporidiosis has impacted grouse, with infected birds having 51% lower survival and rearing 43% fewer chicks relative to healthy birds on the same moor. Thus, should prevalence increase, respiratory cryptosporidiosis could markedly impact upon shooting bags and grouse moor economics.

To monitor disease prevalence, we examined 45,914 red grouse shot between 2013-18. Birds were sampled from 30 beats of 10 driven grouse moors in northern England. Grouse were aged, sexed and visually screened for signs of infection. Prevalence varied with age, being twice as high in juveniles (4.5%) as in adults (2.4%). It also varied nine-fold between moors from 1.0 to 8.6% and three-fold between years (see Table 1). Patterns of infection among grouse age groups and across years were consistent across study moors.

TABLE 1

The mean (± one standard error (se)) annual prevalence of signs of respiratory cryptosporidiosis among shot adult and juvenile red grouse in relation to the number of birds screened

		Adults		Juveniles	
Year	N	Screened	Mean (se)	Screened	Mean (se)
2013	12	685	3.9 (1.2)	1,725	3.6 (0.7)
2014	59	4,029	3.3 (0.4)	11,205	7.4 (0.6)
2015	29	2,547	1.0 (0.3)	5,628	2.5 (0.4)
2016	24	1,809	1.1 (0.3)	4,575	2.2 (0.4)
2017	31	2,791	3.0 (0.6)	4,706	4.5 (0.7)
2018	9	919	1.2 (0.5)	1,377	2.3 (0.6)
Total	**164**	**12,780**	**2.4 (0.2)**	**29,216**	**4.5 (0.3)**

**Annual means (± one se) are based on the number of shoot days when grouse were screened (N).*

Our results are consistent with the concept that disease incidence is highest in naïve juveniles that have previously not been exposed to infection, with prevalence dropping as birds develop immunity. We found no evidence of increased disease prevalence over time. Indeed, samples taken in 2019 showed a further drop with less than 1% of shot birds examined showing symptoms. To date, fears of escalated disease prevalence, bringing with it increased mortality and lowered productivity that may have significant impacts on the economic viability of shoots, have not yet been realised. We will, however, continue annual screening for symptoms among shot birds, as our current time series of only seven years is too short to make future prevalence predictions.

On welfare grounds, we recommend the selective culling of diseased individuals, which can be distinguished by their unresponsive avoidance behaviour on approach, and improved hygiene at communal gritting stations used for strongyle worm control, which may form reservoirs of *Cryptosporidium* infection. Ultimately, respiratory cryptosporidiosis may be best managed by reducing currently high grouse densities, either through less intensive management, including only using anthelmintic treatments when necessary, increased shooting rates or both. Without it, given the increasing wider environmental concerns about the intensification of grouse moor management, such approaches may be enforced by tighter Government regulation.

KEY FINDINGS

- Respiratory cryptosporidiosis quickly spread from first diagnosis to infection of grouse on most moors in northern England, where it impacts upon their survival and productivity.
- Scares regarding the economic impact of infection on grouse shooting have to date been unfounded because prevalence has remained low, averaging 2.4% in adults and 4.5% in juveniles.
- Infection may be minimised by selective culling of diseased animals, better hygiene at communal gritting stations and reductions in overall grouse densities.

David Baines
David Newborn
Michael Richardson

Disease incidence is highest in naïve juveniles that have previously not been exposed to infection, with prevalence dropping as birds develop immunity. © Laurie Campbell

ACKNOWLEDGEMENTS

We acknowledge the generous funding provided by Roger Henderson QC on behalf of the G & K Boyes Charitable Trust.

Reducing anthelmintic intake by grouse

Medicated grit did not have to be put out every year on four of eight study moors where medication was experimentally withdrawn. © Laurie Campbell

BACKGROUND

Medicated grit has been used since the mid-1980s, but a revised formulation involving a change in benzimidazole drug from fenbendazole to flubendazole and incorporation of a more temperature-resistant binding fat, together with a new mode of grit delivery (withdrawal using flip-lid trays) occurred in 2007. Medicated grit use is popular with grouse managers who use it as an annual insurance against strongyle-induced grouse crashes rather than when it is strictly needed, causing concern that it could cause a widespread build-up of anthelmintic resistance in parasites.

The strongyle worm, a nematode parasite, can limit grouse survival and breeding success causing quasi-cyclical fluctuations in abundance. To control worms in grouse, gamekeepers provide medication, in the form of quartz grit covered with a fat coating containing a benzimidazole-based anthelmintic, in each grouse territory. Grouse consume this grit to help digest heather and by doing so, they obtain a split-dose worming treatment, which has been experimentally shown to kill 95% of worms in gamebirds.

Medicated grit has been used since the mid-1980s, but a revised formulation involving a change in benzimidazole drug from fenbendazole to flubendazole and incorporation of a more temperature-resistant binding fat, together with a new mode of grit delivery (withdrawal using flip-lid trays) occurred in 2007. These changes have proved popular and now almost all grouse managers use medicated grit every year. Accordingly, worm burdens in grouse have been uncharacteristically low since 2009, suggesting high levels of control from medicated grit. Despite this, most managers use medicated grit as an annual insurance against strongyle-induced grouse crashes rather than when it is strictly needed. This is despite a veterinary prescription being required for its use. It is evident that decisions on whether to prescribe anthelmintics are seldom based on measured abundances of parasite intensities. Over-reliance and inappropriate use of worming drugs amongst domestic livestock has rapidly resulted in a widespread build-up of anthelmintic resistance in parasites. Although resistance in strongyle worms in grouse to flubendazole has not been found, more frequent and widespread use of medicated grit in the last decade may increase the risk of it happening in grouse as well.

To encourage grouse managers to reduce anthelmintic use, we conducted a trial where we experimentally withdrew medication from parts of moors. Few participated, only seven of 25 invitees joining in northern England and only one of 18 in the Scottish Highlands. We invited grouse managers to refrain from using medicated grit over a three-year period (2012-14). However, large and sudden parasite increases in early spring 2012 led to one grouse manager resuming medicating grouse later that spring. Thereafter, we asked managers to decide whether to use medication based on actual parasite data collected from their moor in late winter in each year of the trial.

There needs to be greater awareness of parasite levels in grouse before medication is prescribed. © GWCT

We monitored parasite and grouse responses in relation to whether medication was used by counting worm eggs and adult worms and measuring indices of grouse mortality and breeding success. Rapid increases in worm egg counts in early spring culminated in resuming medication at three wet blanket-peat sites: one in the first spring of the trial and two in the second. At a fourth moor, medication was inexplicably restored by the moorland manager, despite low parasite counts. On the remaining four moors, all drier heaths in the east, parasite levels remained low in the absence of medication; there was no increase in grouse mortality, but breeding success was 16% lower. High humidity levels associated with wet blanket peat may favour survival of both worm eggs and free-living pre-infective larval stages, increasing the likelihood of an annual need for medication. At dry heath sites, particularly those in the drier eastern parts of the country, parasite pick-up rates by grouse were presumably lower and anthelmintics may be required only every two to five years.

We demonstrated that annual provision of anthelmintics is unnecessary on some moors and that there needs to be greater awareness of parasite levels in grouse among grouse managers and vets alike before medication is prescribed. Better parasite monitoring may reduce anthelmintic use, thereby helping the likelihood of drug resistance among worms, but this may be offset by reduced grouse productivity.

KEY FINDINGS

- Medicated grit did not have to be put out every year on four of eight study moors where medication was experimentally withdrawn.
- Withdrawal of medication was not associated with increased grouse mortality, but breeding success was 16% lower.
- Better monitoring of strongyle worms, including faecal egg counts in spring, may result in reduced use of anthelmintics, which in turn may delay the onset of resistance to the drug by the parasite.

David Baines
David Newborn
Michael Richardson

Medicated grit can be withdrawn by sliding the lid on grit boxes to allow grouse access to normal quartz grit. © Henrietta Appleton/GWCT

Causes and timing of low breeding success in capercaillie

We have been counting and recording the breeding success of capercaillie since 1990. © GWCT

BACKGROUND

Capercaillie in Scotland have seen a considerable decline in numbers and a range contraction since the 1970s. The latest national survey in 2015/16 concluded that they remain at a critically low level of around 1,000 birds, although many believe the number to be lower. Previous studies highlighted low breeding success as the proximate cause of declines.

We have been counting capercaillie annually in Scotland since 1990, using pointing dogs in August to find well-grown broods. In most years, we record a high proportion of hens without broods, but it is unclear at which stage of the breeding attempt failure has occurred. In partnership with Scottish Natural Heritage, Scottish Forestry, Forestry and Land Scotland and the Cairngorms National Park Authority, we embarked on a project to radio-tag well-grown hen chicks and monitor their breeding attempts in the following years.

Between 2015 and 2017, we fitted six individuals with 13 gram radio transmitters with an expected battery life of 30 months. This allowed us to follow two hens over three breeding seasons and three hens over two breeding seasons (one hen died at

Pine martens were captured on camera removing eggs from capercaillie nests. © GWCT the start of its first breeding season). Of the 12 possible breeding attempts monitored, no evidence of breeding was found for three hens, all in their first springs. Average clutch size was 6.9 eggs (n = 9, range 5-9 eggs), with estimated first egg laying dates ranging from 23 April to 20 May (n = 6). Three clutches were predated by mammals (33%). The camera near one nest captured clear images of a pine marten removing eggs, the loss of the other two nests was assumed to be from a mustelid (probably pine marten) from blurred camera images or egg remains.

Brood size at hatching averaged 6.5 chicks (n = 6, range 5-9). Two hens had chicks that died before we first checked them at nine days old, one brood was lost when chicks were four to 11 days old and one when they were 15-19 days old. One successful brood was reared in 2018 by a three-year old hen and fledged one chick; another brood reared in 2019 by a two-year old hen fledged two chicks. Mean chick survival from hatching to last flush at seven to nine weeks old was estimated to be 8%. This means that the radio-tagged hens raised 0.3 young per hen with 17% of hens fledging broods.

Annual surveys with pointing dogs over the same years in broadly the same set of forests, resulted in similar productivity of 0.5 young per hen (range: 0.2-0.9; total of 210 hens recorded) and 24% of hens fledging broods (range: 14-40%).

Radio-tagging hens provided insights into causes of breeding failure, principally predation of clutches by pine martens and low chick survival, however, it was not possible to determine the causes of low chick survival. Previous studies have identified inclement post-hatch weather, low invertebrate availability and predation as being important. Sheep ticks are also known to reduce chick survival in other ground-nesting birds so tick parasitization of capercaillie chicks is considered a priority subject for further research.

KEY FINDINGS

- We radio-tagged six juvenile capercaillie hens, which allowed us to monitor 12 subsequent breeding attempts.
- Only two breeding attempts produced fledged young (17% success). Low productivity was due to 60% of first-year hens not nesting, 33% predation of clutches and only 8% chick survival from the nests that hatched.
- Unless management is undertaken to increase productivity, a second extinction of capercaillie in Scotland looks increasingly likely.

Kathy Fletcher

Tick parasitization of capercaillie and their chicks is considered a priority subject for further research. © Frank Law

The impact of buzzards on red grouse

We looked at the year-round diet of buzzards at Langholm Moor. © Laurie Campbell

Human-wildlife conflicts often centre on economic loss caused by wildlife. Despite this being a major issue for some land managers, estimating total prey losses to predation, including that by legally protected predators, can be difficult. Estimating impacts of protected wildlife on economically important prey can also help management decisions to be evidence-led. The recent recovery in numbers and range of common buzzards in Britain has brought them into conflict with some gamebird managers. The magnitude of any impact is poorly understood, having seldom been quantified by empirical field data. A three-year PhD studentship funded by the Langholm Moor Demonstration Project, was conducted with Newcastle University to consider the year-round diet of buzzards at Langholm Moor. Taking into account buzzard abundance and foraging range, the study examined whether buzzards may have impacted the project aim of restoring red grouse numbers sufficiently to re-establish driven grouse shooting.

Experimental culling of buzzards to measure their potential impact on grouse was deemed unacceptable for both welfare and logistic reasons. In their absence, bioenergetics models were used that combined measures of buzzard abundance from field surveys with studies of their diet assessed by using cameras and prey remains at nests and pellet analysis over the winter. The resultant measures of seasonal grouse consumption by buzzards were used in conjunction with sample counts of grouse abundance to estimate potential impact on red grouse on Langholm Moor, a 115km² moor in south-west Scotland, managed to restore red grouse shooting.

Grouse consumption by an individual pair of breeding buzzards and their chicks varied between pairs and years, averaging 0-5 adult grouse and 0-6 grouse chicks per annum depending on assessment method. This rate was lower than previous estimates for two other raptor species, hen harrier and peregrine, present on the study site. Total consumption by buzzards could, however, have been greater given that an estimated 55-73 buzzards were present on the study site year-round during the study period, making buzzards three-times more abundant than both hen harrier and peregrine combined. Averaging across diet assessment methods, consumption models estimated that during each of the three breeding seasons (April-July 2011-2013), the

BACKGROUND

The Langholm Moor Demonstration Project (2008-2017) aimed to restore economically sustainable driven grouse shooting while maintaining a viable population of hen harriers and to extend and improve the heather habitat.

ACKNOWLEDGEMENTS

This study was funded by Buccleuch Estates, Game & Wildlife Conservation Trust, Scottish Natural Heritage and Natural England through contributions to the Langholm Moor Demonstration Project.

buzzards foraging on our study site consumed 73-141 adult grouse and 77-185 chicks (depending on year). This represented 5-11% of adult grouse present in April (22-67% of estimated adult mortality) and 2-5% of chicks that hatched (3-9% of estimated chick mortality). During two non-breeding seasons (August-March), consumption models using pellet analysis estimated that buzzards ate a total of 242-400 grouse, equivalent to 7-11% of those present at the start of August and 14-33% of those estimated to have died during the non-breeding season.

We concluded that consumption of red grouse by buzzards had the potential to lead to non-trivial economic loss to grouse managers. This was one of several factors associated with the incomplete restoration of grouse numbers and the inability of the project to restore sustained driven grouse shooting within the 10-year project duration. This conclusion assumed that buzzards killed the grouse that they ate, and that such grouse mortality was additive to other causes. Buzzards are widely recognised as a scavenger, and the proportion of grouse that they consumed through scavenging birds that were already dead, as opposed to the proportion that they killed, is unknown. Similarly, it is unlikely that all grouse killed and consumed by buzzards would have survived long enough to breed. Instead, a proportion would have succumbed to another source of mortality. Furthermore buzzards eat predators of grouse such as crows and small mustelids, so they may have helped offset the impact of these species. Thus, the impact estimates presented here, while supporting the suggestion that buzzards could have been a factor limiting grouse numbers at Langholm, must be treated with caution. Further experimental evidence, from either a buzzard removal study or one associated with supplying buzzards with diversionary food, would be required before more definitive conclusions on impacts could be drawn.

KEY FINDINGS

- Red grouse formed a minor part of buzzard diet at Langholm Moor.
- The high numbers of buzzards present meant that collectively their year-round consumption of red grouse could have contributed to the incomplete grouse recovery.
- Stronger experimental evidence involving buzzard removal or diversionary feeding would be required to provide more accurate estimates of buzzard impact on grouse and test the assumptions described here.

Richard Francksen
David Baines
Sonja Ludwig

© Tim Chamberlain

Research projects

by the Game & Wildlife Conservation Trust in 2019

FARMLAND RESEARCH IN 2019

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*	*John Holland, Steve Moreby, Belinda Bown, Jade Hemsley, Dan Kosky, Clementine Bourgeois*	*Private funds*	*2015- ongoing*
Long-term trends in beetles	*Beetle abundance and diversity in Sussex 40 years on*	*John Holland, Steve Moreby, Julie Ewald, Adam McVeigh*	*Core funds*	*2016-2019*
Long-term monitoring	*Monitoring of wildlife on BASF demonstration farms*	*John Holland, Niamh McHugh, Belinda Bown, Amy Corrin, Ellen Knight, Jayna Connelly, Ellie Jackson-Smith, Dan Kosky, Clementine Bourgeois*	*BASF*	*2017- ongoing*
Chick-food invertebrate levels	*Chick-food invertebrate levels in crops and non-crop habitats on three estates*	*John Holland, Steve Moreby, Belinda Bown, Adam McVeigh, Amy Corrin, Ellen Knight, Jayna Connelly, Ellie Jackson-Smith*	*Private funds, The Millichope Foundation*	*2017- ongoing*
Evaluation of cultivated margin option effectiveness and exploration of their natural capital	*Evaluation of invertebrate and botanical composition of annually cultivated and floristically-enhanced margins*	*John Holland, Niamh McHugh, Belinda Bown, Adam McVeigh, Jade Hemsley, Amy Corrin, Ellen Knight, Susan Hammond, Jayna Connelly, Ellie Jackson-Smith*	*NE*	*2018-2020*
Pilot within-field monitoring study to predict Barley Yellow Dwarf Virus (BYDV) risk (see p14)	*Pilot study to evaluate sticky traps as a potential within-field monitoring and decision support system to predict the risk of BYDV*	*John Holland, Niamh McHugh, Belinda Bown, Adam McVeigh, Ellen Knight, Amy Corrin, Clementine Bourgeois*	*AHDB*	*2018-2020*
Acoustic detectors for monitoring woodcock (see p16)	*Evaluation of acoustic detectors for monitoring woodcock*	*Niamh McHugh, Chris Heward, Andrew Hoodless, Dionne Jenkins*	*Dick Potts Legacy Fund*	*2018- ongoing*
Invertebrate sampling methods	*Comparison of Dvac, sweep net and vortis suction sampling techniques*	*Steve Moreby*	*Core funds*	*2018- ongoing*
Farmland bumblebee project	*Monitoring of bumblebee distributions*	*John Holland, Matt Holland, Ellen Knight, Amy Corrin, Clementine Bourgeois*	*NFU*	*2019*
BEESPOKE	*Increasing the area of pollinator habitat and pollination*	*John Holland, Niamh McHugh, Adam McVeigh, Jade Hemsley, Jayna Connelly, Ellie Jackson-Smith*	*EU Interreg NSR*	*2019-2023*
PhD: Solitary bees	*Seed mixes for solitary bees*	*Rachel Nichols. Supervisors: John Holland, Prof Dave Goulson (University of Sussex)*	*NERC/GWCT*	*2018- ongoing*
PhD: Biodiversity footprint of foods	*Creating an index of crop-farming traits to assess the biodiversity footprint of foods*	*Helen Waters. Supervisors: John Holland, Alfred Gathorne-Hardy (University of Edinburgh), Barbara Smith (Coventry University)*	*NERC/GWCT*	*2019- ongoing*

ALLERTON PROJECT RESEARCH IN 2019

Project title	Description	Staff	Funding source	Date
Monitoring wildlife at Loddington (see p18)	*Annual monitoring of game species, songbirds, invertebrates, plants and habitat*	*Chris Stoate, John Szczur, Alastair Leake, Steve Moreby, Jamie 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 Briggs, Penny Williams, (Freshwater Habitats Trust), Professor Colin Brown (University of York)*	*EA, Regional Flood and Coastal Committee*	*2011- ongoing*
School farm catchment	*Practical demonstration of ecosystem services*	*Chris Stoate, John Szczur*	*Allerton Project, EA, Anglian Water, Agrii*	*2012- ongoing*
Soil monitoring	*Survey of soil biological, physical and chemical properties*	*Chris Stoate, Jenny Bussell, Alastair Leake, Phil Jarvis, Gemma Fox*	*Allerton Project*	*2014- ongoing*
SoilCare (see p26)	*Soil management to meet economic and environmental objectives across Europe*	*Chris Stoate, Jenny Bussell, Gemma Fox John Szczur*	*EU H2020*	*2016-2020*
Soil biology and soil health	*The role of soil biology in crop production systems*	*Chris Stoate, Jenny Bussell, Gemma Fox*	*AHDB*	*2016-2020*
Conservation Agriculture	*Economic and environmental impacts of three contrasting crop production approaches*	*Alastair Leake, Phil Jarvis, Chris Stoate, Jenny Bussell, Gemma Fox*	*Syngenta*	*2017-2021*
Sustainable Intensification Platform scoping study	*Reducing greenhouse gas emissions from grazing livestock systems*	*Chris Stoate, Exeter and Nottingham Universities and other partners*	*Defra*	*2018-2019*
Sustainable Intensification Platform scoping study	*Integrating livestock into arable systems*	*Chris Stoate and NIAB partners*	*Defra*	*2018-2019*
The effect of cereal tillage systems on invertebrates in the autumn	*Measuring aphid abundance and Barley Yellow Dwarf Virus infection under different cultivation regimes*	*Alastair Leake, John Holland*	*Bayer CropScience/ASDA*	*2018-2019*
RePhoKUs	*Understanding food system phosphorus balance at a range of scales*	*Chris Stoate, Paul Withers and partners*	*Research Councils*	*2018-2020*
Agroforestry	*Optimising tree densities to meet multiple objectives in grazed pasture*	*Chris Stoate, Jenny Bussell, Gemma Fox, Alastair Leake*	*Woodland Trust*	*2018- ongoing*

Tree leaves as ruminant fodder	Assessing the nutritional value of tree leaves for ruminants	Chris Stoate, Nigel Kendall (Nottingham University)	Woodland Trust	2019-2020
PhD: Soil compaction and biology	The relationship between arable soil compaction, earthworms and microbial activity	Falah Hamad. Supervisors: Chris Stoate, Dr David Harper (Leicester University)	Leicester University	2014-2019
PhD: Farmer and scientific knowledge of soils	A comparison of farmers' perceptions of soils and researchers' assessment of soil properties	Stephen Jones. Supervisors: Chris Stoate, Dr Carol Morris, Dr Sacha Mooney (Nottingham University)	ESRC	2015-2019
PhD: Mapping ecosystem services	Mapping ecosystem services across the Welland river basin	Max Rayner. Supervisors: Chris Stoate, Dr Heiko Balzter (Leicester University)	NERC	2017-2020

AUCHNERRAN PROJECT RESEARCH IN 2019

Project title	Description	Staff	Funding source	Date
Core biodiversity monitoring (see p28)	Monitoring of key groups to assess impacts of farming changes	Dave Parish, Marlies Nicolai, Beth Conway, Katherine Thorne, Elizabeth Ogilvie, Max Wright	Core funds	2015- ongoing
Rabbit population monitoring	Assessing rabbit numbers in relation to control methods and impacts on grass and other species	Dave Parish, Marlies Nicolai, Beth Conway, Katherine Thorne, Elizabeth Ogilvie, Max Wright	Core funds	2016- ongoing
GWSDF Tarland Farmer Cluster	Establishing the first Farmer Cluster in Scotland	Dave Parish, Marlies Nicolai, Ross MacLeod	Core funds	2016- ongoing
LIFE Laser Fence	Experimental trials of laser technology as a deterrent for various mammals	Dave Parish, Marlies Nicolai, Beth Conway Katherine Thorne, Elizabeth Ogilvie, Max Wright	LIFE+, Core funds	2016-2020
Liming experiment	Split-field experiment investigating impacts of liming on invertebrates, including mud snails	Dave Parish, Marlies Nicolai, Beth Conway, Katherine Thorne	James Hutton Institute, Core funds	2016-2021
Thrush population monitoring	Detailed investigation of thrush habitat use, distribution and productivity	Dave Parish, Marlies Nicolai, Katherine Thorne	Core funds, SongBird Survival	2017-2019
Wader population monitoring	Surveying of wader numbers, distribution and productivity, radio-tagging lapwing chicks, GPS tagging curlew and lapwing	Dave Parish, Marlies Nicolai, Andrew Hoodless, Beth Conway, Katherine Thorne, Elizabeth Ogilvie, Max Wright	Core funds, Working for waders	2017- ongoing
Mud snail and liver fluke interactions	Investigating the importance of intermediate/ alternative fluke hosts and land-use	Dave Parish, Marlies Nicolai	Core funds, Moredun Research Institute	2017- ongoing

PREDATION RESEARCH IN 2019

Project title	Description	Staff	Funding source	Date
Pest control strategy (see p32)	Use of Bayesian modelling to improve control strategy for vertebrate pests	Tom Porteus, Jonathan Reynolds, Dr Murdoch McAllister (University of British Columbia, Vancouver)	Core funds, University of British Columbia	2006-2019
Foxes in the Avon Valley	Use of GPS tagging to determine breeding density, territory size and movement behaviour of foxes in the Avon Valley, in the context of declining wading bird populations	Mike Short, Tom Porteus, Jodie Case, Jonathan Reynolds	LIFE+ Waders for Real, Core funds	2015-2019
Diet of foxes in the Avon Valley	Stomach and faecal analysis to determine main dietary components supporting foxes in the Avon Valley	Mike Short, Jodie Case	LIFE+ Waders for Real, Core funds	2019

FISHERIES RESEARCH IN 2019

Project title	Description	Staff	Funding source	Date
Fisheries research	Develop wild trout fishery management methods including completion of write-up/reports of all historic fishery activity	Dylan Roberts	Core funds	1997- ongoing
Salmonid life-history strategies in freshwater (see p38)	Understanding the population declines in salmon and sea trout	Rasmus Lauridsen, Dylan Roberts, William Beaumont, Luke Scott, Stephen Gregory	Core funds, EA, CEFAS, Mr A Daniell, Winton Capital	2009- ongoing
Grayling ecology	Long-term study of the ecology of River Wylye grayling	Stephen Gregory, Luke Scott, Tea Basic (Cefas)	NRW, 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, Stephen Gregory, Will Beaumont, Bill Riley	Cefas/Defra, Core funds	2015-2019
Salmon and trout smolt tracking (see p40)	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, William Beaumont, Luke Scott, Dylan Roberts, Stephen Gregory, Elodie Reveillac (Agrocampus Ouest), Will Beaumont	EU Interreg, Core funds, Atlantic Salmon Trust	2017-2022
Sea trout kelt tracking	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, Elodie Reveillac, Will Beaumont	EU Interreg, Core funds, Atlantic Salmon Trust	2017-2022
Genetic tools for trout management	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 (INRA), Dylan Roberts, Rasmus Lauridsen	EU Interreg, Core funds	2017-2022
New salmon stock assessment tools (see p42)	Providing new information for stock assessment models and new stock assessment tools in England and France as part of the SAMARCH project	Stephen Gregory, Marie Nevoux (INRA), Etienne Rivot (Agrocampus Ouest), Rasmus Lauridsen, William Beaumont, Luke Scott, Dylan Roberts, Will Beaumont	EU Interreg, Core funds	2017-2022

New policies for salmon and sea trout in coastal and transitional waters (see p44)	*Developing new policies for the better management of salmon and sea trout in coastal and transitional waters based on the outputs of SAMARCH*	*Dylan Roberts, Will Beaumont, Lawrence Talks and Simon Toms (EA), Laurent Beaulaton (Association of French Biodiversity), Gaelle Germis (Bretagne Grands Migrateurs), Paul Knight, Lauren Mattingley (S&TC, UK), Jerremy Corr (Normandie Grands Migrateurs)*	*Interreg FCE, Core funds*	*2017-2022*
Pink salmon	*Use new eDNA methods to determine distribution of non-native pink salmon in the UK and to use stable isotopes to study the ecosystem effect of pink salmon where present.*	*Rasmus Lauridsen, Gordon Copp (Cefas), Iwan Jones (QMUL) , Phil Davidson (Cefas), Michał Skóra, Hui Wei*	*Cefas, Core funds*	*2019-2020*
MSc In-river migration patterns and loss rates of smolts	*Using detection data from the Frome PIT-tag readers to investigate freshwater migration of smolts*	*Alexander Harris. Supervisors: Rasmus Lauridsen, Stephen Gregory, Guy Woodward (Imperial)*	*Imperial, Core funds*	*2019*
PhD: Beavers and salmonids	*Impacts of beaver dams on salmonids*	*Robert Needham. Supervisors: Dylan Roberts, Paul Kemp (Southampton University)*	*Core funds, Southampton University, SNH, S&TC, UK*	*2014-2020*
PhD: Impact of low flows on salmonid river ecosystems	*Investigate fish prey availability, the diet of trout and salmon, stream food webs and ecosystem dynamics under differing, experimentally manipulated flow conditions*	*Jessica Picken. Supervisors: Rasmus Lauridsen, Dr Iwan Jones, Pavel Kratina (QMUL), Bill Riley (Cefas), Sian Griffiths (Cardiff University)*	*QMUL, Cefas, Core funds*	*2015-2020*
PhD: Ranunculus *as a bioengineer in chalkstream ecosystems*	*Investigate the role of* Ranunculus *as a bioengineer, driving the abundance and diversity of plants, invert-ebrates and fish, with particular focus on salmonids*	*Jessica Marsh. Supervisors: Rasmus Lauridsen, Dr Iwan Jones, Pavel Kratina (QMUL)*	*G and K Boyes Trust*	*2015-2019*
PhD: Effects of smolt-characteristics on their migration and survival	*Quantify the effects of smolt characteristics, among other factors, on their migration and marine survival in the Frome and elsewhere*	*Olivia Simmons. Supervisors: Robert Britton & Phillipa Gillingham (Bournemouth University) Stephen Gregory*	*EU Interreg, Bournemouth University*	*2018-2021*
PhD: Trout metal tolerance	*Disentangling the three main factors affecting trout ability to tolerate metals: evolution, local adaption and pollution*	*Daniel Osmond. Supervisors: Rasmus Lauridsen, Jamie Stephens (Exeter University), Mike Bruford (Cardiff University), Bruce Stockley (WRT)*	*GW4 FRESH CDT, Core funds*	*2019-2023*

LOWLAND GAME RESEARCH IN 2019

Project title	Description	Staff	Funding source	Date
Pheasant population studies	*Long-term monitoring of breeding pheasant populations on releasing and wild bird estates*	*Roger Draycott, Maureen Woodburn, Rufus Sage*	*Core funds*	*1996- ongoing*
Game marking scheme and enhanced pheasants	*Study of factors affecting return rates of enhanced pheasants and effect of release pens*	*Rufus Sage, Maureen Woodburn*	*Core funds*	*2008- ongoing*
Pheasant survival and breeding success (see p46)	*Radio-tracking pheasant populations at the Allerton Project Farm, Loddington, after the shooting season*	*Rufus Sage, Maureen Woodburn, Austin Weldon, Matt Coupe, Charlotte Parker, Ellie McQuarrie*	*Core funds*	*2018-2020*
Consequences of releasing	*Literature review and synthesis on ecological consequence of releasing for shooting*	*Rufus Sage, Dr Joah Madden, (Exeter University)*	*Core funds, NE*	*2019-2020*
Pilot for study of predators of woodland birds	*Using trail cameras to monitor squirrels*	*Rufus Sage, Matthew Beedle, William Sage*	*Songbird Survival*	*2019-2020*
PhD: Improving released pheasants	*Using improved hand-reared pheasants to increase survival and wild breeding post-release*	*Andy Hall. Supervisors: Rufus Sage, Dr Joah Madden (Exeter University)*	*Exeter University, Core funds*	*2015-2019*

WETLAND RESEARCH IN 2019

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*
LIFE+ Waders for Real (see p48)	*Wader recovery project in the Avon Valley*	*Lizzie Grayshon, Jodie Case, Ryan Burrell, Mike Short, Tom Porteus, Jonathan Reynolds, Clive Bealey, Paul Stephens, Andrew Hoodless*	*EU LIFE+ programme, Core funds*	*2014-2019*
Woodcock migration (see p50)	*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*	*2017-2020*
Habitat use by breeding woodcock	*Use of GPS tags to examine fine-scale habitat use by breeding woodcock and the value of habitat management*	*Chris Heward, Andrew Hoodless*	*Private donors, Core funds*	*2018-2021*
Lapwing on the South Downs	*Monitoring of lapwing breeding success on the South Downs*	*Lucy Capstick, Andrew Hoodless, collaboration with RSPB and South Downs National Park*	*Core funds*	*2018-2022*
Landscapes for curlews	*Use of GPS tracking to determine foraging areas of breeding curlews, brood ranges and winter movements*	*Andrew Hoodless, Ryan Burrell, Marlies Nicolai, Dave Parish, collaboration with Farlington Ringing Group and FC*	*Hampshire Ornithological Society, Forestry England, private donors*	*2018-2022*
Use of Special Protection Area habitats by waders	*GPS tracking of oystercatchers and curlews on the Exe Estuary*	*Andrew Hoodless, Ryan Burrell, collaboration with NE and University of Exeter*	*NE*	*2018-2021*
Use of Southampton Water by waders, ducks and geese	*Winter GPS tracking of curlew, oystercatcher, wigeon, teal, Brent goose to examine use of shore and field habitats*	*Andrew Hoodless, Lizzie Grayshon, Ryan Burrell, Chris Heward, Lucy Capstick, Jodie Case, collaboration with Farlington Ringing Group and ABPmer*	*Associated British Ports*	*2019-2020*
PhD: Factors influencing breeding woodcock abundance	*Landscape-scale and fine-scale habitat relationships of breeding woodcock and investigation of drivers of decline*	*Chris Heward. Supervisors: Andrew Hoodless, Prof Rob Fuller/BTO, Dr Andrew MacColl/Nottingham University*	*Private funds, Core funds*	*2013-2019*

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*	*2019-2022*
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*	*2019-2022*

PARTRIDGE AND BIOMETRICS RESEARCH IN 2019

Project title	Description	Staff	Funding source	Date
Partridge Count Scheme (see p52)	*Nationwide monitoring of grey and red-legged partridge abundance and breeding success*	*Natalie Harvey, Neville Kingdon, Nicholas Aebischer, Julie Ewald, Tom Bristow, Jemma Gibson, Kit Lawson, Samantha Skinner*	*Core funds, GCUSA*	*1933- ongoing*
National Gamebag Census (see p58)	*Monitoring game and predator numbers with annual bag records*	*Nicholas Aebischer, Gillian Gooderham, Corinne Duggins, Cameron Hubbard, Sam Gibbs, Tom Bristow, Jemma Gibson Kit Lawson, Samantha Skinner*	*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, Sam Gibbs*	*Core funds, Ernest Kleinwort Charitable Trust*	*1968- ongoing*
Wildlife monitoring at Rotherfield Park (see p54)	*Monitoring of land use, game and songbirds for the Rotherfield Demonstration Project*	*Francis Buner, Malcolm Brockless, Julie Ewald Adam McVeigh, Elouise Mayall, Lucy Robertson*	*Core funds, Interreg (EU North Sea Region)*	*2010-2023*
Grey partridge management	*Researching and demonstrating grey partridge management at Whitburgh Farms*	*Dave Parish, Hugo Straker, Adam Smith, Merlin Becker, Fiona Torrance, Hannah Brunsden, Markos Nicolaou*	*Whitburgh Farms, core funds*	*2011-2020*
Capacity building in Himachal Pradesh, India	*Bird ringing, monitoring and Galliform re-introduction capacity building for Himachal Pradesh Wildlife Department*	*Francis Buner*	*Forest and Wildlife Department of Himachal Pradesh*	*2013- ongoing*
Cluster Farm mapping	*Generating cluster-scale landscape maps for use by the Advisory Service and the Farm Clusters*	*Julie Ewald, Neville Kingdon, Sam Gibbs, Cameron Hubbard, Tom Bristow, Jemma Gibson, Kit Lawson, Samantha Skinner*	*Core funds*	*2014- ongoing*
Developing novel game crops	*Developing perennial game cover mixes*	*Dave Parish, Fiona Torrance, Hugo Straker, Hannah Brunsden, Markos Nicolaou*	*Balgonie Estates Ltd, Core funds, Kingdom Farming, Kings Seeds*	*2014-2020*
Grey partridge recovery	*Monitoring grey partridge recovery and impacts on associated wildlife*	*Dave Parish, Hugo Straker, Fiona Torrance, Hannah Brunsden, Markos Nicolaou*	*Balgonie Estates Ltd, Core funds, Kingdom Farming, Kings Seeds*	*2014-2020*
Invertebrate database management	*Modernise and standardise the software for the Sussex and Loddington invertebrate databases*	*Julie Ewald, Nicholas Aebischer, Sam Gibbs Cameron Hubbard, Sophie Walker, Daniel Kosky, Jamie Holland*	*Core funds*	*2015-2019*
PARTRIDGE (see p56)	*Co-ordinated demonstration of management for partridge recovery and biodiversity in the UK, the Netherlands, Belgium, Germany, Denmark and Sweden*	*Francis Buner, Paul Stephens, Ben Stephens, Elouise Mayall, Lucy Robertson, Julie Ewald, Sam Gibbs, Cameron Hubbard, Ryan Burrell, Nicholas Aebischer, Chris Stoate, Dave Parish, Roger Draycott, John Szczur, Austin Weldon, Fiona Torrance, Hannah Brunsden, Markos Nikolaou, Francesca Pella*	*Interreg (EU North Sea Region) Core funds*	*2016-2023*
Recovery of grey partridge populations in Scotland	*Encouraging grey partridge management and monitoring across Scotland*	*Dave Parish*	*Core funds*	*2017- ongoing*
Gamekeeper survey	*Online and postal survey of management activities carried out by gamekeepers in the UK*	*Julie Ewald, Sam Gibbs, Natalie Harvey, Louise Shervington*	*NGO, SGA*	*2019*
Lowland Gamebird Impact Study	*Landscape level analysis of the effects of lowland gamebird shoots*	*Neville Kingdon, Julie Ewald, Nicholas Aebischer, Nick Sotherton*	*Core funds*	*2019*

UPLANDS RESEARCH IN 2019

Project title	Description	Staff	Funding source	Date
Grouse Count Scheme (see p62)	*Annual grouse and parasitic worm counts in relation to moorland management indices and biodiversity*	*David Baines, David Newborn, Phil Warren Mike Richardson, Kathy Fletcher, Nick Hesford*	*Core funds, Gunnerside Estate*	*1980- ongoing*
Long-term monitoring of breeding ecology of waders in the Pennine uplands	*Annual measures of wader density, lapwing productivity, recruitment and survival*	*David Baines*	*Core funds*	*1985- ongoing*
Black grouse monitoring	*Annual lek counts and brood counts*	*Philip Warren, David Baines, David Newborn*	*Core funds*	*1989- ongoing*
Capercaillie brood surveys	*Surveys of capercaillie and their broods in Scottish forests*	*Kathy Fletcher, David Baines, Phil Warren*	*Cairngorms National Park Authority*	*1991- ongoing*
Impacts of ticks on red grouse chick survival	*Use of acaricide-treated sheep to suppress ticks in a multi-host system*	*Kathy Fletcher, David Baines*	*The Samuels Trust, Core funds*	*1995-2019*
Langholm Moor Demonstration Project (post-LMDP monitoring and write-up) (see p72)	*Grouse moor restoration: is it possible to achieve economically-viable driven grouse shooting and sustainable numbers of hen harriers*	*Sonja Ludwig, David Baines*	*Core funds, Buccleugh Estates, SNH, NE, RSPB*	*2008-2019*
Capercaillie: causes of poor breeding (see p70)	*Radio-tracking females to ascertain habitat use and causes of low breeding success*	*Kathy Fletcher*	*SNH, Forest Enterprise Scotland, Cairngorms National Park Authority*	*2015-2019*

Curlews and grouse moors	*A paired site comparison of curlew breeding success between grouse moors and non-grouse moors*	*David Baines, David Newborn, Nick Hesford, Mike Richardson*	*Core funds*	*2016-2019*
Grey partridge	*Using call-back surveys to estimate spring densities*	*David Baines*	*Core funds*	*2018- ongoing*
Mountain hares	*10-yearly questionnaire on mountain hare abundance and distribution*	*Nick Hesford, Julie Ewald, David Baines*	*Core funds*	*2018-2019*
Post-burning vegetation recovery on blanket peat at Langholm	*Using aerial images and field surveys to assess chrono-sequences of vegetation responses to heather burning*	*Sian Whitehead, Hannah Weald*	*Core funds*	*2019*
Repeat moorland bird surveys	*Repeat of bird and vegetation surveys conducted on circa 90 UK moors 2007-2012*	*David Baines, David Newborn, Mike Richardson, Kathy Fletcher, Nick Hesford*	*Core funds*	*2019-2020*
Measuring rises in strongyle worms (see p68)	*Fortnightly grouse faecal egg counts Dec'-May in relation to weather and medication*	*David Newborn*	*Core funds*	*2019-2020*
Development of Black Grouse Study Groups in Scotland	*Co-ordinating volunteer inputs into annual lek monitoring across several regions of Scotland*	*Philip Warren*	*Heritage Lottery Fund*	*2019-2020*
Development of long-term heather burning 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*	*Core funds*	*2019-2028*

Key to abbreviations: AHDB = Agriculture and Horticulture Development Board; AONB = Areas of Outstanding Natural Beauty; BBSRC = Biotechnology and Biological Sciences Research Council; BTO = British Trust for Ornithology; CASE = Co-operative Awards in Science & Engineering; CEFAS = Centre for Environment, Fisheries & Aquaculture Science; CSF = Catchment Sensitive Farming; Defra = Department for Environment, Food and Rural Affairs; EA = Environment Agency; ESRC = Economic & Social Research Council; EU = European Union; FC = Forestry Commission; GCUSA = Game Conservancy USA; GWSDF = Game & Wildlife Scottish Demonstration Farm; H2020 = Horizon 20:20; INRA = Institut National de la Recherche Agronomique; Interreg = European Regional Development Board; NARGC = National Association of Regional Game Councils; NE = Natural England; NERC = Natural Environment Research Council; NERC SARIC= Sustainable Agriculture Research and Innovation Club; NGO = National Gamekeepers' Organisation; NRW = Natural Resources Wales; ONCFS = Office National de la Chasse et de la Faune Sauvage; PARTRIDGE = Protecting the Area's Resources Through Researched Innovative Demonstration of Good Examples; QMUL = Queen Mary University of London; RSPB = Royal Society for the Protection of Birds; SAMARCH = SAlmonid MAnagement Round the CHannel; SGA = Scottish Gamekeepers' Association; SNH = Scottish Natural Heritage; S&TC, UK = Salmon & Trout Conservation UK.

Scientific publications

by staff of the Game & Wildlife Conservation Trust in 2019

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GWCT staff in bold.

Financial report
for 2019

The summary report and financial statement for the year ended 31 December 2019, set out below and on pages 82 to 83, 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 and GWCT Events Limited. They do not comprise the full statutory Trustees' report and accounts, which were approved by the Trustees on 29 May 2020 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.

The Trust showed a small surplus on unrestricted funds in 2019 due once again to the generosity of our supporters and effective cost management by our staff. The increase in net assets was due to gains and losses on the Trust's investments, reflecting the performance of the stock market in the final quarter of 2019.

The Trustees continue to keep the Trust's financial performance under close review and to take appropriate measures to protect the Trust against the inevitable uncertainty in fundraising in the current climate. They continue to be satisfied that the Trust's overall financial position is sound. The Trust's reserves policy is that unrestricted cash and investments should exceed £1.5 million and must not fall below £1 million. At the end of 2019 the Trust's reserves (according to this definition) were £1.3 million, compared to £1.3 million at the end of 2018.

KEY POINTS

- Income was £9.08 million, a 7.5% increase over 2018.
- Expenditure on charitable activities was £5.84 million (an increase of 5.3%).
- There was a surplus of £20,684 on unrestricted funds.
- The Trust's net assets were £8.8 million at the end of the year.

Plans for future periods

A new five year business plan was approved in July 2016. The key aims are:

1. **Understanding wildlife management**. To develop understanding of wildlife management as a policy and practical conservation concept.
2. **Developing sustainable game management**. To tackle the current challenges around sustainable game management.
3. **Achieving conservation in the wider countryside**. To encourage individual stewardship for conservation to help reverse biodiversity loss.
4. **Improve profile and voice**. To raise the profile of the GWCT as a conservation organisation and to speak with more authority to a wider audience.
5. **Grow our income**. To increase fundraising income to allow us to meet our strategic objectives.
6. **Enthuse and motivate our staff and volunteers**. To deliver our strategic objectives through providing strong leadership, personal development opportunities and improved administrative support.

These continue to direct our work; our research and policy initiatives aim to deliver effective wildlife conservation alongside economic land use and in the light of the new challenges of food security and climate change. Our focus on practical conservation in a working countryside makes our work even more relevant as these challenges unfold.

Sir Jim Paice
Chairman of the Trustees

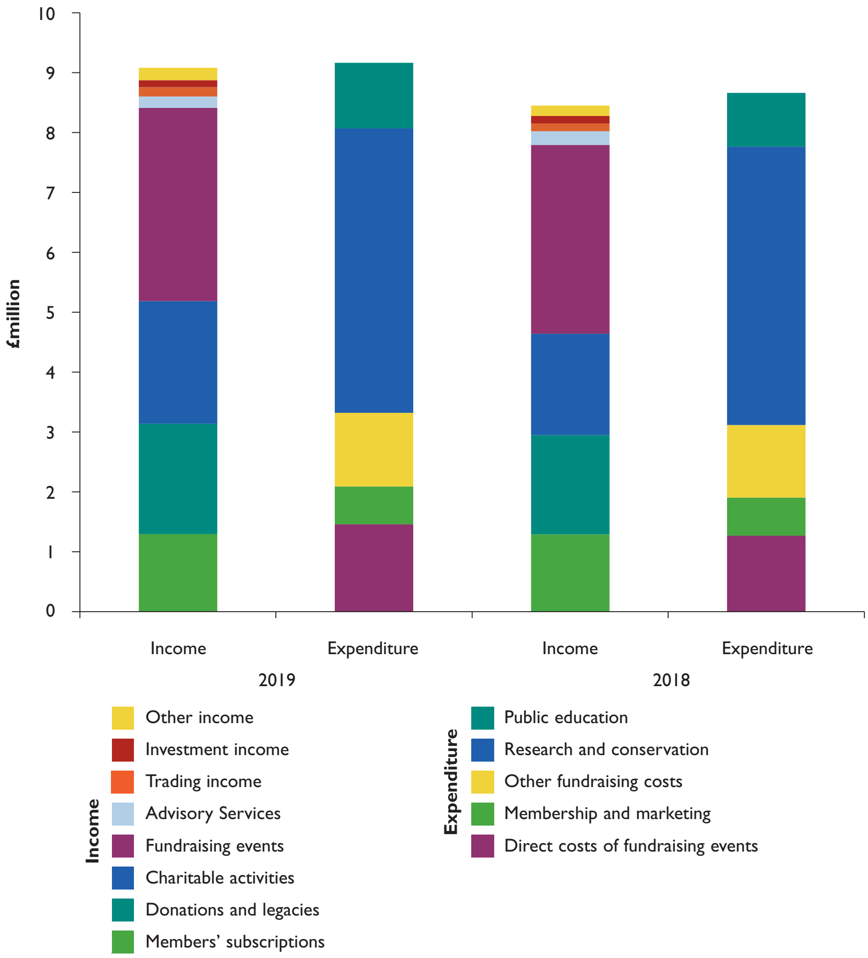

Figure 1

Total incoming and outgoing resources in 2019 (and 2018) 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 2019 which is set out on pages 82 and 83.

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 2019 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 May 2020

Consolidated

Statement of financial activities

	General Fund £	Designated Funds £	Restricted Funds £	Endowed Funds £	**Total 2019 £**	Total 2018 £
INCOME AND ENDOWMENTS FROM:						
Donations and legacies						
Members' subscriptions	1,294,025	-	-	-	**1,294,025**	1,289,957
Donations and legacies	713,369	-	1,129,287	-	**1,842,656**	1,657,126
	2,007,394	-	1,129,287	-	**3,136,681**	2,947,083
Charitable activities	-	-	2,049,168	-	**2,049,168**	1,693,813
Other trading activities						
Fundraising events	3,206,602	-	18,480	-	**3,225,082**	3,153,515
Advisory Service	190,836	-	-	-	**190,836**	229,679
Trading income	158,111	-	-	-	**158,111**	127,266
Investment income	7,170	-	108,551		**115,721**	129,366
Other	141,980	-	67,224	-	**209,204**	170,917
TOTAL	5,712,093	-	3,372,710	-	**9,084,803**	8,451,639
EXPENDITURE ON:						
Raising funds						
Direct costs of fundraising events	1,457,737	-	-	-	**1,457,737**	1,267,053
Membership and marketing	634,562	-	-	-	**634,562**	638,639
Other fundraising costs	1,228,297	-	-		**1,228,297**	1,210,764
	3,320,596	-	-	-	**3,320,596**	3,116,456
Charitable activities						
Research and conservation						
Lowlands	1,232,109	-	869,577	-	**2,101,686**	1,931,213
Uplands	162,865	-	373,736	-	**536,601**	494,766
Demonstration	208,421	-	1,084,600	4,150	**1,297,171**	1,373,144
Fisheries	197,901	-	618,357	-	**816,258**	851,440
	1,801,296	-	2,946,270	4,150	**4,751,716**	4,650,563
Public education	569,517	-	522,782	-	**1,092,299**	897,808
	2,370,813	-	3,469,052	4,150	**5,844,015**	5,548,371
TOTAL	5,691,409	-	3,469,052	4,150	**9,164,611**	8,664,827
Income/(expenditure) before investment gains	20,684	-	(96,342)	(4,150)	**(79,808)**	(213,188)
Net gains/(losses) on investments:						
Realised	3,982	-	11,977	31,182	**47,141**	(20,006)
Unrealised	10,373	-	5,296	186,831	**202,500**	(235,407)
NET INCOME/(EXPENDITURE)	35,039	-	(79,069)	213,863	**169,833**	(468,601)
Transfers between funds	(1,000)	-	1,000	**-**	-	-
NET MOVEMENT IN FUNDS	34,039	-	(78,069)	213,863	**169,833**	(468,601)
RECONCILIATION OF FUNDS						
Total funds brought forward	3,153,266	11,492	878,621	4,592,087	**8,635,466**	9,104,067
TOTAL FUNDS CARRIED FORWARD	£3,187,305	£11,492	£800,552	£4,805,950	**£8,805,299**	£8,635,466

Consolidated

Balance sheet

as at 31 December 2019

		2019		2018
	£	£	£	£
FIXED ASSETS				
Tangible assets		3,658,675		3,742,438
Investments		2,931,480		3,254,913
		6,590,155		6,997,351
CURRENT ASSETS				
Stock	424,001		401,697	
Debtors	2,057,030		1,481,921	
Cash at bank and in hand	1,177,934		1,024,917	
	3,658,965		2,908,535	
CREDITORS:				
Amounts falling due within one year	843,497		765,753	
NET CURRENT ASSETS		2,815,468		2,142,782
TOTAL ASSETS LESS CURRENT LIABILITIES		9,405,623		9,140,133
CREDITORS:				
Amounts falling due after more than one year		600,324		504,667
NET ASSETS		£8,805,299		£8,635,466
Representing:				
CAPITAL FUNDS				
Endowment funds		4,805,950		4,592,087
INCOME FUNDS				
Restricted funds		800,552		878,621
Unrestricted funds:				
Designated funds	11,492		11,492	
Revaluation reserve	210,978		205,216	
General fund	2,940,558		2,908,494	
Non-charitable trading fund	35,769		39,556	
		3,198,797		3,164,758
TOTAL FUNDS		£8,805,299		£8,635,466

Approved by the Trustees on 29 May 2020 and signed on their behalf

J PAICE
Chairman of the Trustees

Staff

of the Game & Wildlife Conservation Trust in 2019

CHIEF EXECUTIVE	Teresa Dent BSc, FRAgS, CBE
Personal Assistant	Laura Gell; Liz Scott *(until March)*
Chief Finance Officer	Nick Sheeran BSc, ACMA, CGMA
Accountant	Leigh Goodger
Finance Senior	Hilary Clewer BA
Finance Assistant	Lindsey Chappé De Leonval
Accounts Assistant (p/t)	Helen Aebischer *(until October)*
Head of Database	Corinne Duggins Lic ès Lettres *(until June)*
Head of Administration & Personnel	Alastair King Chartered MCIPD, MAHRM
Health & Safety Officer (p/t)	John Owen *(until March)*
Head Groundsman (p/t)	Craig Morris
Headquarters Site Maintenance	Steve Fish
Cleaner	Theresa Fish
Head of Information Technology	James Long BSc
IT Assistant	Dean Jervis HNC, BA
DIRECTOR OF RESEARCH	Prof. Nick Sotherton BSc, PhD, ARAgS
Personal Assistant (p/t)	Lynn Field
Public Sector Fundraiser	Paul Stephens BApp.Sc
Public Sector Fundraiser Administrator	Ben Stephens MAAT
Head of Fisheries	Dylan Roberts BSc
Head of Fisheries – Research	Rasmus Lauridsen BSc, MSc, PhD
SAMARCH Senior Fisheries Scientist	William Beaumont MIFM
Fisheries Scientist	Stephen Gregory BSc, MPhil, PhD
SAMARCH Fisheries Ecologist	Luke Scott
SAMARCH Project Scientist	Céline Artero BSc, MSc, PhD
SAMARCH Fisheries Project Officer	Will Beaumont BSc
SAMARCH Research Assistant	Thomas Lecointre
PhD Student *(University of Southampton)* - beavers and salmonids	Robert Needham BSc
PhD Student *(Queen Mary University of London)* - *Ranunculus*	Jessica Marsh BSc, MSc
PhD Student *(Queen Mary University of London)* - low flows on salmonids and river ecosystems	Jessica Picken BSc, MSc
PhD Student *(Bournemouth University)* - smolt migration and survival	Olivia Simmons BSc, MSc
PhD Student *(University of Exeter)* - adaption of trout to metal polluted rivers	Daniel Osmond BSc, MSc
Head of Lowland Gamebird Research	Rufus Sage BSc, MSc, PhD
Ecologist - Pheasants, Wildlife (p/t)	Maureen Woodburn BSc, MSc, PhD
PhD Student *(Exeter University)* - pheasant release pens	Andy Hall MSc
Research Assistant	Charlotte Parker BSc *(March-July)*
MSc Student *(Birmingham University)* - pheasant survival	Ellie McQuarrie BSc *(until July)*
Placement Student *(Brighton University)*	Matthew Beedle *(from September)*
Head of Wetland Research	Andrew Hoodless BSc, PhD
Research Ecologist	Lucy Capstick BSc, PhD
Ecologist – LIFE Waders for Real	Lizzie Grayshon BSc
Research Assistant	Ryan Burrell BSc
Research Assistant	Jodie Case BSc
Research Assistant/PhD Student *(p/t University of Nottingham)* - woodcock	Chris Heward BSc
PhD student *(University College Cork)* - woodcock	James O'Neill BSc
PhD student *(University of Exeter)* - lapwing nest crypsis	George Hancock BSc, MSc
MSc Student *(University of Reading)* - lapwing chick survival	Beth Ellison-Perrott BSc
MSc Student *(University of Reading)* - invertebrates in wet grasslands	Beth Gadd BSc
Placement Student *(Bournemouth University)*	Thomas Weston *(from September)*
Head of Predation Control Studies	Jonathan Reynolds BSc, PhD
Senior Field Ecologist	Mike Short HND
Research Ecologist	Tom Porteus BSc, MSc, PhD
Head of Farmland Ecology	Prof. John Holland BSc, MSc, PhD
Senior Entomologist	Steve Moreby BSc, MPhil
Postdoctoral Scientist	Niamh McHugh BSc, MSc, PhD
Research Assistant	Belinda Bown *(until August)*
Research Assistant	Adam McVeigh *(from February)*
Research Assistant	Matt Holland BSc *(June-July)*
Technical assistant (p/t)	Jamie Holland *(Jan-May)*
PhD Student *(University of Sussex)* - solitary bees	Rachel Nichols BSc, MSc
PhD Student *(University of Edinburgh)* - biodiversity footprint of foods	Helen Waters BSc *(from September)*
Graduate Student *(National School of Agricultural Science and Engineering)*	Clémentine Bourgeois BSc *(March-July)*
Placement Student *(University of Exeter)*	Ellen Knight *(until September)*
Placement Student *(University of Cumbria)*	Amy Corrin *(until September)*
Placement Student *(University of Reading)*	Jayna Connelly *(from September)*
Placement Student *(University of Bath)*	Ellie Jackson-Smith *(from September)*
Director of Upland Research	David Baines BSc, PhD
Office Manager, Uplands	Sarah Grondowski
Senior Research Assistant - Scotland	Nick Hesford BSc, PhD
Research Ecologist Langholm	Sonja Ludwig MSc, PhD
Senior Scientist - North of England Grouse Research	David Newborn HND
Senior Scientist - Scottish Upland Research	Kathy Fletcher BSc, MSc, PhD
Research Assistant	Michael Richardson BSc
Senior Scientist	Phil Warren BSc, PhD
Placement Student *(University of Nottingham)*	Megan Roberts *(until July)*
Internship	Madeleine Benton BSc *(from October)*
Senior Scientist	Sian Whitehead BSc, DPhil
Placement Student *(University of West of England)*	Hannah Weald *(until July)*
Placement Student *(Anglia Ruskin University)*	Sandy Jasper *(from August)*
Head of Scottish Lowland Research	David Parish BSc, PhD
Research Assistant - GWSDF Auchnerran	Marlies Nicolai BSc
Research Assistant - Scottish Grey Partridge Recovery Project	Fiona Torrance BSc
MSc Student *(Harper Adams)* – aquatic invertebrates	Neive Percival BSc
Placement Student *(University of Plymouth)*	Katherine Thorne *(until August)*
Placement Student *(University of Swansea)*	Bethany Conway *(until August)*
Placement Student *(University of Leeds)*	Hannah Brunsden *(from September)*
Placement Student *(University of Leicester)*	Markos Nikolaou *(from September)*

Placement Student *(University of Brighton)*	Max Wright *(from September)*
Placement Student *(University of Birmingham)*	Elizabeth Ogilivie *(from September)*
Head of Advisory	Roger Draycott HND, MSc, PhD[2]
Co-ordinator Advisory Services (p/t)	Lynda Ferguson *(until July)*; Lizzie Herring *(from July)*
Biodiversity Advisor – Farmland Ecology	Peter Thompson DipCM, MRPPA (Agric) *(until March)*
Biodiversity Advisor – Farmland Ecology	Jessica Brooks, BSc, MSc, ACIEEM
Head of Education	Mike Swan BSc, PhD[3]
Regional Advisor – central England	Austin Weldon BSc, MSc[4]
Game Manager (p/t) – Allerton Project	Matthew Coupe
Biodiversity Advisor – northern England	Jennie Stafford BSc
Game Manager – Rotherfield Park	Malcolm Brockless
DIRECTOR OF POLICY, PARLIAMENTARY AFFAIRS & THE ALLERTON PROJECT	Alastair Leake BSc (Hons), MBPR (Agric), PhD, FRAgS, FIAgrM, CEnv
Secretary (p/t)	Sarah Large/Katy Machin
Policy Officer (England) (p/t)	Henrietta Appleton BA, MSc
Head of Research for the Allerton Project	Prof. Chris Stoate BA, PhD
Ecologist	John Szczur BSc
Soil Scientist (p/t)	Jennifer Bussell BSc, PhD *(from May)*
Research Assistant (p/t)	Gemma Fox
Welland Project Officer	Chris French
PhD student *(Leicester University)* - ecosystem services mapping	Max Rayner BSc
PhD Student *(Leicester University)* - soil biology	Falah Hamad BSc, MSc *(until October)*
PhD Student *(University of Nottingham)* - soil properties	Stephen Jones BSc, MSc
Head of Education and Development	Jim Egan *(until May)*
Project Development Officer	Amelia Woolford BSc *(until February)*
Head of Farming, Training & Partnerships	Philip Jarvis MSc
Assistant Farm Manager	Oliver Carrick BSc *(from April)*
Farm Assistant	Michael Berg
DEPUTY DIRECTOR OF RESEARCH	Nicholas Aebischer Lic ès Sc Math, PhD, DSc
Librarian, National Gamebag Census Co-ordinator & Head of CRM	Gillian Gooderham *(until June)*; Corinne Duggins Lic ès Lettres *(from June)*
Senior Conservation Scientist & Head of PARTRIDGE	Francis Buner Dipl Biol, PhD
PARTRIDGE placement student (University of East Anglia)	Elouise Mayall *(until August)*
PARTRIDGE placement student (University of Swansea)	Lucy Robertson *(from September)*
Erasmus Student (University of Osnabrück, Germany)	Florian Schröer *(from October)*
Head of Geographical Information Systems	Julie Ewald BS, MS, PhD
Partridge Count Scheme Co-ordinator	Neville Kingdon BSc, Natalie Harvey, BSc, MSc *(March-October)*
Biometrics/GIS Assistant	Sam Gibbs BSc *(until October)*; Cameron Hubbard BSc, MSc *(from November)*
Placement Student shared with Wetland *(University of Southampton)*	Kit Lawson *(until August)*
Placement Student shared with Wetland *(University of Sheffield)*	Samantha Skinner *(until August)*
Placement Student shared with Wetland *(University of Southampton)*	Thomas Bristow *(from September)*
Placement Student shared with Wetland *(University of Plymouth)*	Jemma Gibson *(from September)*
Computer Science Placement Student *(University of York)*	Daniel Kosky *(until August)*
Computer Science Placement Student *(Bournemouth University)*	Sophie Walker *(from September)*
DIRECTOR OF FUNDRAISING	Jeremy Payne MA, MInstF
Prospect Researcher	Tara Ghai
London Events Manager	Jo Langer
London Events Co-ordinator	Eleanor Usborne
Northern Regional Fundraiser (p/t)	Sophie Dingwall
Southern Regional Fundraiser	Max Kendry
Eastern Regional Fundraiser (p/t)	Lizzie Herring
Regional Organiser (p/t)	Gay Wilmot-Smith BSc
Regional Organiser (p/t)	Charlotte Meeson BSc
Regional Organiser (p/t)	David Thurgood
Regional Organiser (p/t)	Pippa Hackett
Regional Organiser (p/t)	Fleur Fillingham
Administration Assistant	Daniel O'Mahony
DIRECTOR OF COMMUNICATIONS, MARKETING & MEMBERSHIP	Andrew Gilruth BSc
Team Assistant	Teresa Jolly *(until March)*; Helen Smith *(from October)*
Membership & Marketing Administrator (p/t)	Beverley Mansbridge
Membership Assistant	Heather Acors
Administration Assistant	Emily Norris *(from October)*
Press & Publications Manager	James Swyer
Publications Officer (p/t)	Louise Shervington
Communications Officer	Joel Holt *(until December)*
Direct Mail Marketing Officer	Amber-Rose Rawlings *(until May)*
Graphic Designer	Chloe Stevens *(from June)*
Online Marketing Manager	Rob Beeson
Website Editor	Oliver Dean
Online Marketing Officer	Danny Sheppard
National Recruitment Manager	Andy Harvey *(until March)*; Les Fisher *(from March)*
Writer & Research Scientist (p/t)	Jen Brewin BSc, MSc, PhD
Specialist Writer	Joe Dimbleby
DIRECTOR SCOTLAND	Adam Smith BSc, MSc, DPhil *(until April)*; Bruce Russell BSc, MBE, DL *(from April)*
Scottish HQ Administrator (p/t)	Irene Johnston BA
Director of Policy (Scotland) (p/t)	Adam Smith BSc, MSc, DPhil *(from April)*
Head of Policy (Scotland)	Ross Macleod MA, MBA
Head of Events (Scotland)	Sarah Ballantyne BSc
Regional Organiser	Rory Donaldson
Events and Education Officer (p/t)	Iona Laing *(until February)*
Senior Scottish Advisor & Scottish Game Fair Chairman	Hugo Straker NDA[1]
Trainee Advisor (Scotland)	Merlin Becker BSc
Shepherd Manager GWSDF Auchnerran	Allan Wright
DIRECTOR WALES	Sue Evans
Curlew Country	Amanda Perkins
Advisor	Matthew Goodall[5]

[1] Hugo Straker is also Regional Advisor for Scotland and Ireland; [2] Roger Draycott is also Regional Advisor for eastern and northern England; [3] Mike Swan is also Regional Advisor for the south of England; [4] Austin Weldon also runs the Allerton Project shoot; [5] Matt Goodall is also a Regional Advisor.

External committees with GWCT representation

© Jannie Timmer

1.	Advanced NFP OpenEngage User Group Executive	James Long
2.	Agriculture and Rural Development Stakeholder Group	Ross Macleod
3.	Agri-environment England Technical Stakeholder Group	Jim Egan
4.	Animal Network Welfare Wales Group	Matt Goodall
5.	Arun to Adur Farmer Cluster Steering Group	Julie Ewald
6.	BASC Gamekeeping and Gameshooting	Mike Swan
7.	BBC Rural Affairs Committee	Mike Short
8.	BBC Scottish Rural and Agricultural Advisory Committee	Bruce Russell
9.	BBSRC Agriculture and Food Security Strategy Advisory Panel	Phil Jarvis
10.	Bird Expert Group of the England Biodiversity Strategy	Nicholas Aebischer
11.	British Ecological Society Scottish Policy Group	Adam Smith
12.	British Game Alliance Advisory Group	Roger Draycott
13.	Business in the Community (BiTC) Sustainable Soils Group	Alastair Leake
14.	CFE Hampshire Co-ordinator	Peter Thompson
15	CFE National Delivery Group (Chair)	Jim Egan
16.	CFE National Strategy Group	Jim Egan
17.	Camlad Valley Project	Matt Goodall
18.	Capercaillie BAP Group	David Baines/Adam Smith/Kathy Fletcher
19.	Capercaillie Research Group	David Baines
20.	CNPA Cairngorm Upland Advisory Group	Adam Smith
21.	Code of Good Shooting Practice	Mike Swan
22.	Cold Weather Wildfowling Suspensions	Mike Swan/Adam Smith/Matt Goodall
23.	Cornish Red Squirrel Project	Nick Sotherton
24.	Cors Caron Project	Matt Goodall
25.	Deer Initiative	Austin Weldon
26.	Deer Management Qualifications	Austin Weldon
27.	Defra AIHTS Technical Working Group	Jonathan Reynolds
28.	Defra Hen Harrier Action Plan Group	Adam Smith/Teresa Dent
29.	EA Salmon Technical Group	Stephen Gregory
30.	Defra Upland Stakeholder Forum and Upland Management sub-group	Adam Smith/David Newborn/Teresa Dent/Sian Whitehead
31.	Echoes Project Advisory Board	Matt Goodall
32.	Ecosystems and Land Use Stakeholder Engagement Group (Scotland)	Ross Macleod
33.	English Black Grouse BAP Group	Phil Warren/David Baines
34.	Environmental Land Management Scheme Practitioner Stakeholder Engagement Group	Jim Egan
35.	European Sustainable Use Group	Nicholas Aebischer/Julie Ewald (Chair)
36.	Executive Board of Agricology	Alastair Leake
37.	Farmer Cluster Steering Committees	Peter Thompson
38.	Fellow of the National Centre for Statistical Excellence	Nicholas Aebischer
39.	Fish Welfare Group	Dylan Roberts
40.	Freshwater Fisheries CEO Meetings	Nick Sotherton
41.	Freshwater Fisheries Defra Meetings	Rasmus Lauridsen
42.	Frome, Piddle & West Country Fisheries Association	Rasmus Lauridsen
43.	Futurescapes Project: North Wales Moorlands	David Baines
44.	FWAG (Administration) Ltd	Alastair Leake
45.	Gamekeepers Welfare Trust	Mike Swan
46.	Gelli Aur Slurry Project Steering Group	Sue Evans
47.	Glamorgan Rivers Trust	Dylan Roberts
48.	Hampshire Ornithological Society, Scientific Committee	Ryan Burrell
49.	Honorary Scientific Advisory Panel of the Atlantic Salmon Trust	Rasmus Lauridsen
50.	Honorary Scientific Advisory Panel of the S&TC	Nick Sotherton
51.	International Association of Falconry Biodiversity Working Group	Julie Ewald/Francis Buner
52.	ICES Trout Working Group	Rasmus Lauridsen
53.	ICES WKSALMON	Stephen Gregory
54.	ICES Working Group on North Atlantic Salmon	Stephen Gregory
55.	International Organisation for Biological and Integrated Control - WPRS Council	John Holland
56.	International Wader Study Group, scientific panel	Ryan Burrell
57.	Interreg PARTRIDGE Steering Group	Roger Draycott
58.	IUCN Species Survival Commission Galliformes Specialist Group	Francis Buner/Nicholas Aebischer
59.	IUCN Species Survival Commission Grouse Specialist Group	David Baines
60.	IUCN Species Survival Commission Re-introduction Specialist Group	Francis Buner
61.	IUCN Species Survival Commission Woodcock & Snipe Specialist Group	Andrew Hoodless
62.	IUCN Sustainable Use and Livelihoods Specialist Group (SULI)	Nicholas Aebischer/Julie Ewald
63.	John Spedan Lewis Trust for Natural Sciences	Nick Sotherton
64.	Joint Hampshire Bird Group	Peter Thompson
65.	Langholm Moorland Demonstration Project	Teresa Dent/Adam Smith/Dave Baines/Nick Sotherton
66.	LEAF Marque Technical Advisory Committee	Jim Egan

67.	LEAF Policy and Communications Advisory Committee	Alastair Leake
68.	Mammal Expert Group of the England Biodiversity Strategy	Jonathan Reynolds
69.	Missing Salmon Alliance Management Group	Teresa Dent/ Dylan Roberts
70.	Missing Salmon Alliance Technical Group	Rasmus Lauridsen
71.	Moorland Gamekeepers' Association	David Newborn
72.	Mountain Hare Monitoring Group	Ross Macleod
73.	National Trust for Scotland, Natural Heritage Advisory Group	Adam Smith
74.	Natural Resources Wales Fisheries Forum	Dylan Roberts
75.	Natural Resources Wales General Licences Stakeholder group	Matt Goodall
76.	NE – Main Board	Teresa Dent
77.	NE National Agri-Environment Stakeholder Group	Jim Egan
78.	NFU East Midlands Combinable Crops Board	Phil Jarvis
79.	NFU National Crops Board	Phil Jarvis
80.	NFU National Environment Forum	Phil Jarvis
81.	NGO Committee	Mike Swan
82.	Norfolk CFE Local Liaison Group	Roger Draycott
83.	North Wales Moors Partnership	David Baines
84.	Northern Uplands Local Nature Partnership	Sian Whitehead
85.	NRW General Licences Stakeholder group	Sue Evans/Matt Goodall
86.	Oriental Bird Club, Conservation Committee	Francis Buner
87.	Perthshire Black Grouse Group	Kathy Fletcher
88.	Pesticides Forum Indicators Group of the Chemicals Regulation Directorate	Julie Ewald
89.	Poole Harbour Catchment Initiative	Stephen Gregory
90.	Powys Moorland Project	Sue Evans
91.	Principles of Moorland Management Steering Group	Adam Smith/ Ross Macleod
92.	Purdey Awards	Mike Swan
93.	RASE Awards Panel	Alastair Leake
94.	Resilient Dairy Landscapes Stakeholder Advisory Group	Alastair Leake
95.	River Deveron Fisheries Science	Dylan Roberts
96.	River Otter Beaver Trial	Dylan Roberts/Mike Swan
97.	Rothamsted Research	Alastair Leake
98.	Rural Environment and Land Management Group	Adam Smith/Ross Macleod/Bruce Russell
99.	Rutland Agricultural Society	Alastair Leake
100.	Scientific Advisory Committee of the Office National de la Chasse et de la Faune Sauvage	Nicholas Aebischer
101.	Scientific Advisory Committee of the World Pheasant Association	Nick Sotherton
102.	Scotland's Moorland Forum and sub-groups	Adam Smith/Ross Macleod
103.	Scotland's Rural College Council	Adam Smith
104.	Scottish Black Grouse BAP Group	Phil Warren/David Baines
105.	Scottish Farmed Environment Forum	Ross Macleod
106.	Scottish Land & Estates Moorland Working Group	Adam Smith
107.	Scottish Moorland Groups (four regional groups)	Adam Smith/Hugo Straker/Merlin Becker
108.	Scottish Muirburn Code Review Group	Merlin Becker
109.	Scottish PAW Executive, Raptor and Science sub-groups	Adam Smith
110.	Scottish Principles of Moorland Management Group	Adam Smith/Merlin Becker/Ross Macleod
111.	SGR Monitoring Group	Alastair Leake
112.	SNH Deer Management Round Table	Adam Smith
113.	SNH National Species Reintroduction Forum	Adam Smith
114.	SNH Scientific Advisory Committee Expert Panel	Nicholas Aebischer
115.	SNH South of Scotland Golden Eagle Reintroduction Project Scientific Steering Group	Adam Smith
116.	South Downs Farmland Bird Initiative	Julie Ewald
117.	Southern Curlew Forum	Andrew Hoodless/ Amanda Perkins
118.	Stiperstones and Cordon Hill Curlew Recovery Project	Roger Draycott/ Andrew Hoodless
119.	Strathbraan Wader Conservation Group	Adam Smith/Ross Macleod/Merlin Becker
120.	Strathspey Black Grouse Group	Kathy Fletcher
121.	Sustainable Intensification Research Platform	Chris Stoate
122.	The Bracken Control Group	Alastair Leake
123.	The CAAV Agriculture and Environment Group	Jim Egan
124.	The Curlew Country Board	Amanda Perkins/Sue Evans
125.	The England Terrestrial Biodiversity Group	Jim Egan
126.	The FWAG Association Steering Committee	Jim Egan
127.	Tree Charter Steering Group	Austin Weldon
128.	UK & Ireland Curlew Action Group	Sian Whitehead
129.	UK Avian Population Estimates Panel (JNCC-led)	Nicholas Aebischer
130.	UK Birds of Conservation Concern Panel (RSPB-led)	Nicholas Aebischer
131.	UK Upland Liaison Committee	Adam Smith
132.	Voluntary Initiative National Steering Group	Jim Egan
133.	Voluntary Initiative National Strategy Group	Jim Egan
134.	Voluntary Initiative Water sub-Group	Chris Stoate
135.	Waitrose Responsible Efficient Production Expert Panel	Alastair Leake
136.	Welland Rivers Trust	Chris Stoate
137.	Welland Valley Partnership	Chris Stoate
138.	Welsh Curlew Forum	Amanda Perkins/Sian Whitehead/Matt Goodall
139.	Welsh Government Fox Snaring Advisory Group	Mike Swan/Matt Goodall
140.	Welsh Government Land Use group	Sue Evans
141.	Wildlife Estates England Steering Group	Roger Draycott
142.	Wildlife Estates, European Scientific Committee	Alastair Leake
143.	Wildlife Estates Scotland Board & Sub Groups	Adam Smith/Ross Macleod
144.	World Pheasant Association Scientific Advisory Committee	David Baines
145.	Working for Waders	Adam Smith/Ross Macleod

Key to abbreviations: AIHTS = Agreement on International Humane Trapping Standards; BAP = Biodiversity Action Plan; BASC = British Association for Shooting and Conservation; CAAV = Central Association of Agricultural Valuers; CAP = Common Agricultural Policy; CFE = Campaign for the Farmed Environment; EA = Environment Agency; FWAG = Farming & Wildlife Advisory Groups; IAF = International Association for Falconry; 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, JNCC = Joint Nature Conservation Committee; LEAF = Linking Environment And Farming; MESME =Making Environmental Stewardship More Effective; NE = Natural England; NEP = Natural Environment Partnership; NFU =National Farmers' Union; NGO = National Gamekeepers' Organisation; NIA = National Improvement Area; PAW = Partnership for Action Against Wildlife Crime; RASE = Royal Agricultural Society of England; RSPB = Royal Society for the Protection of Birds; SGR = Second Generation Rodenticide; S&TC= Salmon & Trout Conservation UK; SSC = Species Survival Commission; SNH = Scottish Natural Heritage.

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