Review
of 2018

A full report of the activities

of the Game & Wildlife

Conservation Trust

www.gwct.org.uk

Game & Wildlife
CONSERVATION TRUST

Make an impact. Leave a legacy.

Safeguard Britain's rich biodiversity and traditional uses of the countryside.

Making a difference

Gifts in wills are a wonderful way to make a lasting difference to Britain's countryside. And although thinking about what happens after our time is done isn't a natural thing for everyone, we use the legacies we get to ensure that there is more game and more wildlife on our land and in our waterways, so that those who come after us can have the same, or even more enjoyment out of the natural landscape.

Our undertaking to you is that we'll keep doing the vital science, keep influencing policy and policy makers, and keep working with landowners and land managers to achieve biodiversity by design, not by accident.

The GWCT promise

We respect that writing a will is a personal process and promise to treat you and your family with courtesy, sensitivity and respect.

All personal information that you choose to give us will be handled confidentially and never shared with other parties. Should you have any questions or wish to learn more about our work, we will always be happy to help.

Those who have chosen to support us in their will are also made Honorary Fellows of the GWCT and invited to events

If you would like to know more about leaving a legacy, please call James Swyer on **01425 651021** or email **legacies@gwct.org.uk**

Game & Wildlife
CONSERVATION TRUST

Photo: Orange tip by Pete Thompson

REVIEW OF 2018

Game & Wildlife Conservation Trust

Issue 50

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 2019

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Wales

Ceredigion	Owen Williams
North Wales	Rupert Bevan *(Will Richards)*
Powys	Julian Salmon
South-East Wales	Roger Thomas

Names in brackets were chairmen that stepped down during 2018.

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Game & Wildlife CONSERVATION TRUST

Facing the future challenges

by Teresa Dent CBE,
Chief Executive

© Hugh Nutt

Alastair Leake, our director of policy and Sir Jim Paice, our chairman of trustees, are set to face the future policy challenges ahead. © Tim Scrivener

- Jim Paice MP joins as new chairman of trustees.
- Greater emphasis on policy work in all three countries.
- Wonderful job done by all the GWCT staff, supported by loyal members, donors and supporters.

July 2018 saw the handing on of the baton; our longest serving chairman of trustees, Ian Coghill, stepped down and Sir James Paice was elected in his stead. We are enormously grateful to Ian Coghill for the eight years he was our chairman, but also for his three stints before that as a trustee. His enthusiasm for all aspects of country sports and wildlife conservation, born in his boyhood despite an urban upbringing, remained undimmed, and that passion was reflected in his extraordinary commitment, as chairman, to seeing GWCT grow, raise income and achieve good outcomes under his tenure. Ian combined a deep knowledge of the countryside and its wildlife with the ability to communicate simply but eloquently his passion for country sports, together with the contribution they make to our environment, our rural economy and our culture – the three classic pillars of sustainability. He did a wonderful job for us and we will miss him enormously.

Many members will know Sir Jim Paice from his time as MP for south-east Cambridgeshire and his record as a Minister in Defra. Like Ian, Jim has had a very long-standing connection with the GWCT, with a long-term involvement as a trustee and a connection to the Trust going back to his childhood. Jim is also a passionate countryman and keen shot.

Jim becomes chairman at a time when shooting is facing probably more threats and challenges than it has since the ban on hunting. Jim's long political experience (30 years as an MP) will be extremely useful and help us steer a path over the next five years to get GWCT research into policy, achieve changes and improvements in practice, and help connect our organisation to the wider public.

Looking back over 2018, the issues that stand out are mainly policy issues. The investment we made a decade ago in ensuring we had staff with the knowledge and skills to take our research into policy has proven to be an enormously valuable investment. This combines with our more recent investment in building policy work capacity in both Scotland and Wales.

2018 saw an enormous amount of policy work in all three countries in connection with the UK's exit from the EU, and the design of new agri-environment schemes that will replace our current Common Agricultural Policy (CAP) derived schemes. It saw the publication of the long-awaited Defra *25 Year Environment Plan*. We were delighted to see GWCT's initiative of Farmer Clusters specifically mentioned as an example of the type of Nature Recovery Network that the Westminster Government wishes to see in the future. GWCT's special alchemy of science and practice has made our policy team valued advisors and partners for the creation of future policy in England, Scotland and Wales this year.

We consider ourselves to be ecologists, not social scientists, but it has become clear in recent years that working in the way we do – closely with gamekeepers, shoot managers, farmers and other land managers – that we have acquired considerable social science skills in terms of understanding how to persuade and inspire those people to do more for conservation today than they did yesterday. In achieving that we owe a considerable amount to one man, our biodiversity advisor for the last 30 years, Peter Thompson, who will be retiring just as this *Review of 2018* hits your doorstep. Peter has been an inspiration to many farmland conservationists, he has done fantastic work for the Trust and all the people we work with. We will miss him enormously.

Peter epitomises the wonderful job done by all our staff and their hard work in 2018 is amply illustrated in the pages that follow. None of this work would be possible without the tremendous support of our members, donors, the charitable trusts and others who support us, and the county groups who do such a wonderful job raising income throughout the year. To all of them my thanks, the thanks of all the staff and the thanks of Ian and Jim.

Our retiring biodiversity officer, Peter Thompson, has been an inspiration to many farmland conservationists over the last 30 years and will be missed enormously. © Tim Scrivener/Farmers Weekly

The value of farming for food and the environment

by Adam Smith,
Director Scotland

Scottish Government Minister Mairi Gougeon MSP and the head of Scottish Government's biodiversity team visited our Scottish demonstration farm Auchnerran, to discuss the benefits and challenges of farming and adaptive wildlife management. © Adam Smith/GWCT

Scotland

- The Scottish Government Grouse Moor Management Review was a key focus.
- Our research findings from the Langholm Moor Demonstration Project were important evidence.
- Policy contacts helped develop thinking on 'natural capital'; how to assess the public value of farming for food and the environment.
- New approaches to wildlife management licensing were explored to conserve wading birds.

Last year's *Review* recorded that by the close of 2017 we were aware 2018 was to be the year of a major review of Scottish grouse moor management practice, led by Professor Alan Werritty. We were reassured that the maintenance of moorland management practices in Scotland was in the terms of reference of this review, and not an immediate move toward licensing grouse shooting. Our focus has been to ensure the panel have the facts on the raptor, mountain hare, medicated grit and muirburn issues it has been considering, and we have worked closely with other bodies to ensure that the information sought from practitioners has been accurate and useful. The report will be published this summer.

Our research team has been essential to this effort, preparing new work on topics from tick borne disease, mountain hares and buzzard predation against stringent deadlines. The Langholm Moor Demonstration Project made a valuable contribution with six papers submitted and it also hosted a visit from the 'Werritty Review' panel. The final report of the Demonstration Project will be published this summer.

We reinforced our various projects with direct political contacts. There were meetings with Scotland's new Minister for Natural Environment and Rural Affairs, Mairi Gougeon MSP. We met the convenors of the two Holyrood committees that oversee environmental and land management and our new chairman Sir Jim Paice, a former Minister of Agriculture, lunched with Fergus Ewing MSP the Cabinet Secretary for Rural Affairs at the GWCT Scottish Game Fair. Our theme for the 30th anniversary year of the fair was game conservation's role in lowland farming, focusing on our emblematic species the grey partridge. Farmland conservation faces many challenges. We produced papers on what the next generation of farm environment support should look like in Scotland and set up farm visits for a range of agencies involved in agri-environment design to demonstrate key aspects of our proposals. Consultation responses covered future farming, environment strategy and forestry and engaged with 11 advisory panels and bodies on a wide range of fronts. Work also began on defining the role that 'Natural Capital' assessment will have in identifying farming and sporting's contribution to the management of public goods such as soils, clean water, species

and habitats. Such an approach seems likely to be used across the UK in the future to justify public payments to farmers.

The hill edge continues to be a key testbed for many new policies. This 'squeezed middle' ground is expected to host wading birds, new tree plantations, sheep and cattle and act to manage water flow to lower ground. Testing management and policy approaches, and offering practitioners insight and training so we might resolve these sometimes conflicting requirements is ongoing work. In 2018 the contribution that game management and farming can make to lapwing and curlew conservation was a particular focus. The first management licence to protect breeding wading birds from raven predation pressure was granted to a community group in Perthshire which we advised on monitoring and licence application. Seen as controversial by some and long overdue by others, such an adaptive approach to wildlife and other land management will be needed in the future as our demands on the countryside change.

England

- **Balancing environmental payments and trade will be key in a post Common Agricultural Policy (CAP) regime.**
- **Government strategies for industry, farming, food and the environment need to interlink.**
- **Widespread uptake from farmers is needed if Environmental Land Management schemes are to be successful.**
- **Simplicity, smoother administration and adequate reward are essential for future schemes.**

by Alastair Leake
Director of Policy and Parliamentary Affairs

© Hugh Nutt

Unsurprisingly the year has been dominated by discussions and consultations as to the shape of our future agriculture and environmental policies once we leave the EU. There is a focused effort to try and ensure that policy is more 'joined up' than previously. During the year we saw the publication of the Government's Industrial Strategy, the *25 Year Environment Plan*, engaged in discussions on the future of Environmental Governance and the Agriculture Bill, with the Food Strategy to follow.

We complemented our consultation responses by holding several All-party Parliamentary discussions in Westminster. In the first we looked at the importance of any future trade agreements and how these needed to balance our aspirations to improve the environment, while still ensuring trade agreements meet with World Trade Organisation (WTO) rules. By holding such debates, we can draw on the expertise of academics and political commentators while still tackling subjects relevant to the GWCT, often informed by our own science and knowledge.

In the second debate we looked at what the essential ingredients of a successful Environmental Land Management Scheme might be. Much of the thinking for this came from our *Beyond Brexit* policy statement which we initially discussed with the Secretary of State in February. So, it is very re-assuring to see that when we start to decide on the detail, we find much of the Government's thinking is closely aligned with our own. This also includes allowing the farmer the freedom to choose his own options, and to do as much or little as he wants to do – the more he does the more he gets paid. The scheme will focus on outcomes rather than on prescriptions, leaving the agreement holder the freedom to deliver the environmental purpose the way that they want to. We are promised a 'simple' application process but keeping things simple has been challenging. However, we are assured that the new Environmental Land Management Schemes will not only pay for income forgone and cost incurred, but also include a reward element which could be escalated where very good outcomes are achieved – a so called 'payment by results' approach. This is very much to be welcomed and in the pilot trials it's interesting to see how this encourages a degree of healthy competition between the participants. If this brings rewards to farmers and improves the habitat for our wildlife, then everyone wins.

Finally, during the year the review of the Farm Inspection Regimes was published, and this too shows a refreshing and constructive approach to future regulation. So, if we can keep our approach simple, avoid unnecessary red tape and forensic inspections, reward where good outcomes are achieved, keep contracts unchanged through their agreed term and pay people correctly and on time, we have the basis for an excellent future scheme.

The new Environmental Land Management Schemes will include a payment by results approach where good outcomes will be rewarded. © Kings

Wales demonstrates the biodiversity net gain

by Sue Evans, Director of Wales

(L-R) Simon Thorpe and Craig Hope; Duncan Sinclair Willis, David Thomas, Amanda Perkins and Huw Lavin. © Sue Evans/GWCT

Wales

- Natural Resources Wales (NRW) shooting review dominated 2018 with the Minister for Environment announcing that she would not support NRW's consultation conclusions to continue shooting leases on public land.
- GWCT's evidence was commended in demonstrating the positive biodiversity net gain from shooting.
- Our poll results highlighted support for continued shooting and highlighted the fact that the positive outcomes from shooting are poorly understood.
- Responded to the Welsh Government's consultation on 'Brexit and our land' with a call for future schemes to be simple, voluntary and inclusive.
- GWCT Wales event at the Senedd in May allowed us to showcase GWCT's research to Assembly Members (AM) and Ministers.
- Regular meetings held with the Welsh Government and NRW.
- Working with the farming unions, fishermen and farmers, the GWCT is using Farmer Clusters to help combat the issues of slurry pollution of our watercourses.

Former Welsh Environment Minister, Hannah Blythyn, cancelled her meeting with the GWCT after we published a poll which revealed 61% of the Welsh public thought she was wrong to end pheasant shooting on some of their land. Eighty-five percent of those questioned felt the wider conservation, social and employment benefits that stem from pheasant shooting were poorly understood by the public. We continue to communicate to AM's, Ministers, Welsh Government and NRW officials to put forward the evidence that shooting can deliver great biodiversity net gain.

Brexit and our land

Our response to the Welsh Government's 'Brexit and our land' consultation last October made the points that it needs to be simple, voluntary and inclusive. We expressed concern that having two support schemes could produce unintended consequences such as placing farming and food production into silos; creating confusion where overlapping benefits exist.

GWCT Wales urged the Welsh Government not to prioritise one public good over another and be prepared to consider how it will manage conflicting outcomes such as climate change versus biodiversity. For example, it may be easier to sequester carbon by planting trees on moorlands, but this has a detrimental effect on the habitats and species which are also valued.

Farmer Clusters

GWCT Wales has been working with several groups of farmers, landowners, shooters, fishermen and others, developing Farmer Cluster groups that will deliver biodiversity net gain at a landscape scale. Numerous groups have successfully applied to the Welsh Government's Sustainable Management Scheme which is funded through the Rural Development Programme. These are three-year, landscape-scale collaborative projects which the GWCT are engaging with to promote a bottom up farmer-led approach.

Manydown: The farmland partridge story

Trustee, Hugh Oliver-Bellasis, charts the journey of modern pesticide use and the creation of conservation headlands to help grey partridges

My story of Manydown starts in the 1950s, on our family's farm in Hampshire. I grew up learning to shoot and spent much of my time with gamekeepers. This time was formative, and footprints were left and, in my case, the footprint was the grey partridge. The farm consisted of three keepered beats and lay on the very edge of the South Downs – reasonable partridge country and they were a common sight on the farm.

I left in 1962, but returning to Manydown in 1978, I was immediately aware that things had changed. Farming was different. There was a greater emphasis on crop production, which was being well rewarded, with increased mechanisation and yields, resulting in far fewer partridges than before.

Some things had not changed. The keepers still controlled predators and hedges were still well managed. There may have been more pheasants, but not many, but efficient crop production was very different. The sheep flock had gone, together with stubble turnips in autumn. The switch to winter cereals was stark with spring crops reduced by 70%, replaced by higher yielding winter-sown barley and wheat, thus critically losing stubble fields over winter.

Dick Potts and the GCT

In 1979, I had a meeting with Charles Coles, the director at The Game Conservancy Trust, and Dr Dick Potts, the director of research. Dick had been conducting monitoring work in Sussex since 1968, designed to measure the impact of changes in farming on the fauna and flora of arable land. Because of the detailed data collection over an uninterrupted time-span, the Sussex Study allowed sophisticated analyses of the environmental impact and conservation implications of pesticide use.

After more than a decade, clear evidence was emerging that the insects that young partridge chicks needed were no longer present, and this was likely to be a cause of partridge declines. It became clear that this needed to be rigorously tested.

If Dick's hypothesis was correct and insects were important to grey partridge chicks, what could be done to support them without a major impact on crop production? The double hit of modern pesticide use was that insecticides directly removed the chick-food insects, while herbicides removed their host plants. But no one understood this complicated indirect effect. Farmers were rapidly changing their cropping patterns and did not understand that this was seriously harming wildlife. Fortunately, Dick and his Sussex work was way ahead of its time (see page 48).

Another study by Professor Nick Sotherton on the knotgrass beetle, a key component in the diet of young partridge chicks, also showed that this species was declining. The beetle only feeds, lays its eggs and rears its young on two species of broad-leaved weed: knotgrass and black bindweed. Both weed species were targets of the new herbicide chemistry. Knotgrass is a very difficult agricultural weed, so was a crop competitor weed that needed to be removed.

This was the dilemma: a bird needing insects for its chicks in the summer, and farmers removing the plants on which these insects rely. Dick was convinced that the problem lay in the change in cropping from spring to winter and the management needs of winter-sown crops to control weeds and pests. This needed to be tested at farm level. So, the hunt was on to find a farm with grey partridges, with keepering and good nesting habitat, and a farmer that would let him manipulate crops.

We looked at the specificity of all the insecticides available for use in cereal crops. © GWCT

The Cereals and Gamebirds Research Project

Before the war, partridges were plentiful at Manydown; but numbers had declined following the national trend. Our spring breeding density had fallen from 18 to five pairs per km², so it was perfect to host the new experiment. Dick proposed an experiment on a farm scale with the core unsprayed headlands. In 1982, the first headland manipulation experiment took place with farm manager, Allen Dabinett, very nervously accepting the scale of the experiment and its probable implications. The result was a big rise in chick survival, but headlands were weedy with both grass weeds and broad-leaved weeds and very difficult to combine – impractical for modern farming.

However, out of this first experiment arose the Cereals and Gamebirds Research Project (CGRP) which started in 1983. The brainchild of both Suffolk farmer, John Wilson and Manydown. Farmers joined the project and paid an acreage levy for membership. The target supporters were farmers who still had grey partridges but had experienced the decline and were unable to shoot. The aims were simple:

- To provide practical management plans for conserving gamebirds and other wildlife on arable farms, without compromising standards of cereal grain production. Research was needed to show how habitat improvement and changes in pesticide use could be employed with the greatest benefit.
- To offer alternatives to over reliance on pesticides in arable farming, by encouraging valuable predatory insects, which can help prevent aphid pest outbreaks. To identify pesticides that did the least harm to these beneficial insects.

Over the next three years, 500 farmers and landowners joined the project raising nearly a million pounds. The selective spraying of crop edges called conservation headlands was born. As were other easy management techniques such as beetle banks, which provided ideal habitat for aphid predators like *Tachyporus*. In addition it split larger fields without inconvenience to ever larger machinery. Beetle banks were researched and designed by the CGRP/GWCT and are now widely used.

> "...herbicides that would kill the grass weeds but leave the broad-leaved species; and insecticides that would remove the cereal aphids but leave the chick-food insects"

CGRP sought to work closely with the agrochemical companies that were researching and developing new herbicides and insecticides. We needed more specificity: herbicides that would kill the grass weeds but leave the broad-leaved species; and insecticides that would remove the cereal aphids but leave the chick-food insects and beneficial predatory insects.

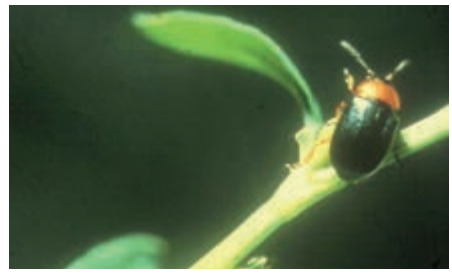
Manydown's agronomists, Alan Bide and Seamus Foster, were supportive and helped develop this new approach. However, many big farming businesses openly derided the need for such research, let alone the change in management it would lead to. In fact, the whole approach was ridiculed by all but a few.

The next step was to test the effects of conservation headlands and radio-track the partridge broods once they hatched. Manydown farm was divided up into the three gamekeeper beats and each beat divided into two. Within pairs, each half was randomly allocated to a treatment: either spray the cereal crop edges right up to the field edge as usual or leave the outermost six-metres unsprayed. This was experimental conservation ecology on a grand scale. In some pairs of plots, more than 100 hectares of cereal crops had the crop edges left selectively sprayed which showed clearly the benefit of crop headlands receiving lower pesticide impacts.

Partridge chick survival improved where chicks had access to insect-rich conservation headlands. The numbers of insects between crops with our managed headlands was compared with those that were fully treated. The difference was stark, even when insecticides were still used

Many arable flowers are now rare and deemed to be of conservation concern. (L-R) Prickly poppy, flower mix, Venus looking glass and rough poppy. © GWCT



(Clockwise from above) Partridge chick survival improved where chicks had access to insect-rich conservation headlands; knotgrass beetle; beetle banks were used to encourage beneficial predators; butterflies such as the small tortoiseshell benefited from the management. © Peter Thompson/GWCT

but just herbicides were omitted. In year two, we simply reversed the treatments. Those areas sprayed normally in year one became conservation headlands in year two and vice versa. In year two partridge chick survival continued to improve.

The conventional wisdom in crop management was to prophylactically spray a summer insecticide when the crop was receiving its last fungicide, just at the time when partridge chicks needed abundant insects to eat. Most available insecticides were very broad spectrum, therefore killing all insects – chick-food insects and crop pests alike. The only product that was specific to aphids was Aphox (Pirimicarb), which was expensive and farmers were reluctant to use it. It became apparent that farmers were facing another challenge: deciding between wildlife and profitable farming.

It was clear that Dick Potts' hypothesis was hugely powerful. Inadvertently, farmers had been damaging the ecological food chain through the indirect effects of pesticides, not to mention their direct effects. It was decided that butterflies, harvest mice, songbirds, wildflowers and beneficial insects should also be investigated. The work on rare arable wildflowers was funded by the trade body of the UK pesticide industry, but the rest was largely funded by farmers and landowners.

This highlighted the necessity to look at the specificity of all the insecticides available for use in cereal crops. Of the 100+ chemicals approved for use in UK cereals, which ones were 'safe' to beneficial insects or their host plants? Nobody knew. This was uncharted territory for the regulators who have never assessed any product for indirect effects or differentiated between beneficial insects and crop pests.

Bringing change to industry

CGRP conducted the research and told farmers which insecticides killed beneficial insects (ladybirds et al) and which did not. We published the list of specific herbicides approved for use on our headlands, we identified the specificity of Aphox as an insecticide and we screened all the fungicides on the approved list. We agreed with the manufacturers that we would list the products we liked alongside the list of those we didn't, if we had the science to prove it.

Work continued to refine the pesticide list for conservation headlands, to enable broad-leaved weeds to remain as hosts for insects, while removing others. Grass weeds were of little ecological value and were a serious yield threat and contaminant to cereal crops, so work was done to look at herbicide specificity, to enable some of the least desirable broad-leaved weeds to be selectively removed.

It is said that a weed is just a plant in the wrong place, and this is indeed the case with many arable plants. Some previously common plants are now rare and are deemed to be of conservation concern. Conservation headlands gave a lifeline to their survival, but few could afford to manage crops in a way that enabled them to survive.

The songbird and the butterfly stories were similar with both benefiting from conservation headlands. The research was conclusive but the problem remained persuading farmers to utilise them. That is as true today as it was in 1989.

So, what of the future? The GWCT is still funded mainly by private individuals and is continuing to research many practices and management options that are useful to farmers and wildlife today and for tomorrow. The influence of the organisation should be judged against its delivery.

The influence GWCT has had on Government policy in relation to stewardship schemes is pivotal, and the same will be true with future agri-environment schemes thanks to the Allerton Project's demonstration farm at Loddington.

If you have not visited the Allerton Project, go soon. It is hugely impressive. Please, at the very least, join the GWCT.

To read the full version of the Manydown story go to **www.gwct.org.uk/manydown**.

Thank you for your support

by Jeremy Payne, Director of Fundraising and Adam Smith, Director Scotland

© Fieldsports

(L-R) The Debs Delight clay shoot team; the Rapid Bunch army team at Euston; Michel Roux Jr serves up a treat at Le Gavroche.

- County committees have had another strong year, projected at £870,000.
- London events raised £300,000.
- Major donor income at just under £700,000.
- £265,000 from the New York auction (subject to exchange rate fluctuations).
- An amazing £152,000 raised by the North Yorkshire committee.

The fundraising department had another good year, with an estimated income of £2.13 million. North Yorkshire smashed all records raising more than £152,000 thanks to a huge amount of hard work, and considerable generosity from both donors and auction lot buyers. But every county's income is important to us, including those which are a fraction of the Yorkshire total, so thank you to everyone involved at county level.

Sweepstake income has gone up in 23 counties over the 2016/17 shooting season and we are hoping the trend will continue. It is now worth more than £140,000 with Norfolk alone raising an incredible £30,000. Please do not overlook this easy way of supporting the Trust and having a bit of fun on a shoot day.

Our very generous major donors were again a vital source of income and maintained their support in increasingly uncertain financial times, and with more organisations competing for their support.

GCUSA made a very healthy £265,000 for the last time with Bruce Sargent as its President as he hands the baton over to Ron Beck. Those present on the evening in New York were treated to a talk about Highclere by the Earl of Carnarvon.

GWCT London events had a bumper year with the Macnab Ball successfully switching venue to The Savoy, and the Le Gavroche dinner hosted by Michel Roux Jr. The year also benefited from two special events – a dinner and auction at Highgrove in aid of woodcock research, and what we hope will be the inaugural dinner and auction at the City Club.

Thanks to all of you who were part of our fundraising effort in 2018, we're indebted to everyone whether donor of a grouse day, or someone who just called a friend for a favour or even gave someone a lift. It doesn't happen without support at every level, and the immediate future suggests an increasing need for robust science, balanced communication, together with highly respected advisory and policy input.

© Sandy Young

Our Scottish Game Fair attracts more than 30,000 attendees and is a showcase for the Trust's work.

In Scotland

Our donors and volunteers helped us achieve a very important fundraising performance in 2018 and we are profoundly grateful to them all. Our income was evenly split over the year, which indicates our success in producing a resilient base in these uncertain times. Events such as The Scottish Game Fair attract more than 30,000 attendees and are run to make a net contribution to the parent charity. Importantly, they are also a showcase for the Trust's work and for the importance of practical game and wildlife conservation.

This profile helps confirm the role the Trust has to play in Scotland, encouraging the very generous donations of auction lots to our events at Prestonfield House in Edinburgh and Oran Mor in Glasgow, and to the excellent buffet and auction organised by the Grampian committee. After a long and fruitful stint as Highland chairman, Chris Swift has handed over to James Macpherson-Fletcher.

Cash donations from donors at all levels were also strong, indicating a high level of awareness of the challenges facing our interests and the confidence there is that the Trust has a meaningful approach to these issues.

Tackling challenges with informed evidence

- GWCT research is tackling the current challenges the world of game management faces.
- The GWCT provides informed evidence and objectivity.

Wader monitoring at the Game & Wildlife Scottish Demonstration Farm, Auchnerran. © Marlies Nicolai/GWCT

by Nick Sotherton, Director of Research and Roger Draycott, Head of Advisory

© Hugh Nutt

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

The world of game management faces many challenges. Some of them are addressed in articles in this *Review,* highlighting some of the research undertaken to provide evidence (based on sound science) for policy makers and land managers making decisions about species management. Of course, all our long-term programmes of species monitoring provide accurate estimates of species numbers and long-term changes in their abundance. These include grey partridge, red grouse, black grouse, capercaillie, salmon, insects on farmland and gamebag statistics and now also mountain hare, woodcock and some wader species.

Contentious issues addressed in this *Review* include burning heather on peatlands (see page 64), mountain hare abundance (see page 66), indices of released pheasant abundance and return rates (see page 56) and species recovery using techniques used by game managers (see page 48-51).

Debates regarding such issues are often plagued by a lack of informed evidence and objectivity. GWCT provides this evidence in spades as demonstrated by our list of papers published in the science journals during 2018 (see page 80).

Disseminating research into advice

A key aim of the Advisory Service is to disseminate the findings of GWCT research to a wide audience. In 2018 we helped the British Game Alliance (BGA) develop its standards to provide assurance to guns, game retailers and consumers that shoots are run well. Many of the BGA standards are based on the Code of Good Shooting Practice which relies heavily on the findings of GWCT research. We are frequently asked to provide technical advice for land managers and conservation agencies on issues relating to sustainable gamebird management. Having access to peer-reviewed GWCT science in this area, alongside our practical experience, means we are well placed to offer informed and independent advice.

Our involvement with Farmer Clusters – landscape-scale conservation – goes from strength to strength. In 2018 we held the second national Farmer Cluster conference in Birmingham and launched a website **www.farmerclusters.com** which is a one-stop-shop for anyone interested in Farmer Clusters. Our Martin Down cluster received national recognition from Defra in the form of visits from senior staff and through funding, as it was included as a Defra Nature Recovery Network Pilot study – one of only five in the country. Another significant achievement in our landscape-scale projects was the completion of our biodiversity audit across the entire Duchy of Lancaster rural land holdings.

Jess Brooks our farmland biodiversity advisor has been key to helping with the Farmer Cluster at Martin Down, which has received national recognition for its achievements. © Peter Thompson/GWCT

Research and demonstration farms - Allerton Project

Allerton Project: game and songbirds

Wild bird seed mixtures designed to provide habitat and food for game and songbirds can be adapted to provide additional benefits to pollinators. © 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, which was preceded by nine years of wild game management. The current regime includes habitat management and winter feeding, as in the former period of wild game management. Targeted predator control is undertaken from March to June and this level of effort is intermediate between that in the wild game management phase of the project, and that of a conventional released bird shoot. Our previous research has demonstrated the benefits of predator control to some songbird species, hares and breeding gamebirds.

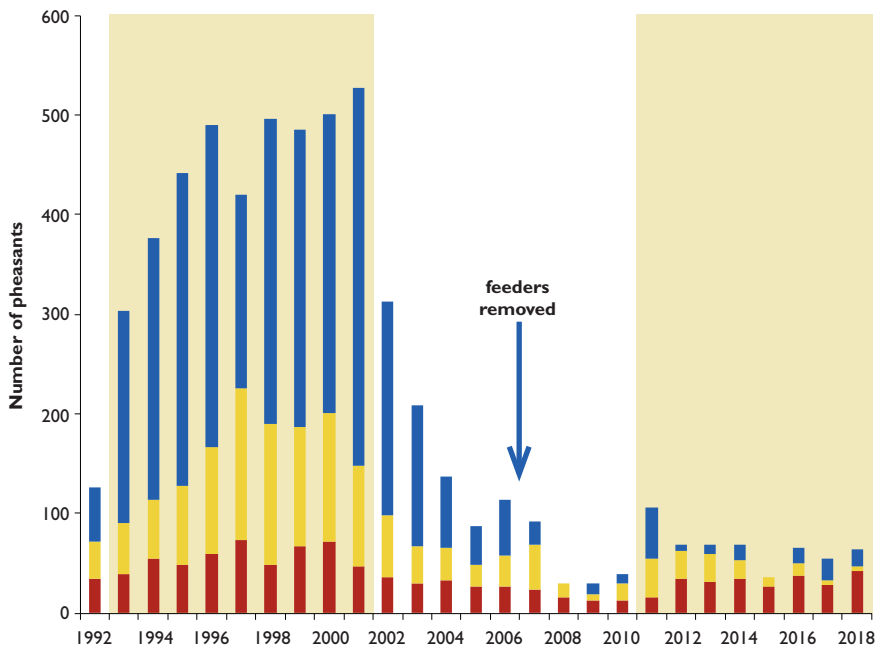
The Allerton shoot days are exceptional events, but we continue to struggle to increase the numbers of wild gamebirds. Our cull records and wildlife monitoring indicate that the number of both generalist predators which we can control legally, and protected species, have increased in number locally.

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). In 2018 only five hen pheasants were recorded with broods, compared with up to 87 broods counted during the wild game management period. This year we started to investigate why the productivity has dropped so that we can consider how to address it. By radio tagging 33 hen pheasants we found that very few nesting attempts were made and that all but one of the hens had died by early June. Coronavirus was identified in two birds found dead and this may be a contributing factor in birds failing to nest. We will continue to look at this in 2019 to try to understand better the role that disease has in limiting nesting attempts. Disease and predation are also likely to be closely linked.

Our count data suggest that grey partridges have not bred on the farm since 2014, and although two pairs were recorded in the spring, none were present in the autumn count. Winter hare numbers, however, are nearly six times higher than on the comparison site but only 18% of the maximum number recorded in the past, possibly in part because of illegal coursing, the incidence of which is increasing.

Figure 1

Autumn wild pheasant numbers from 1992 to 2018



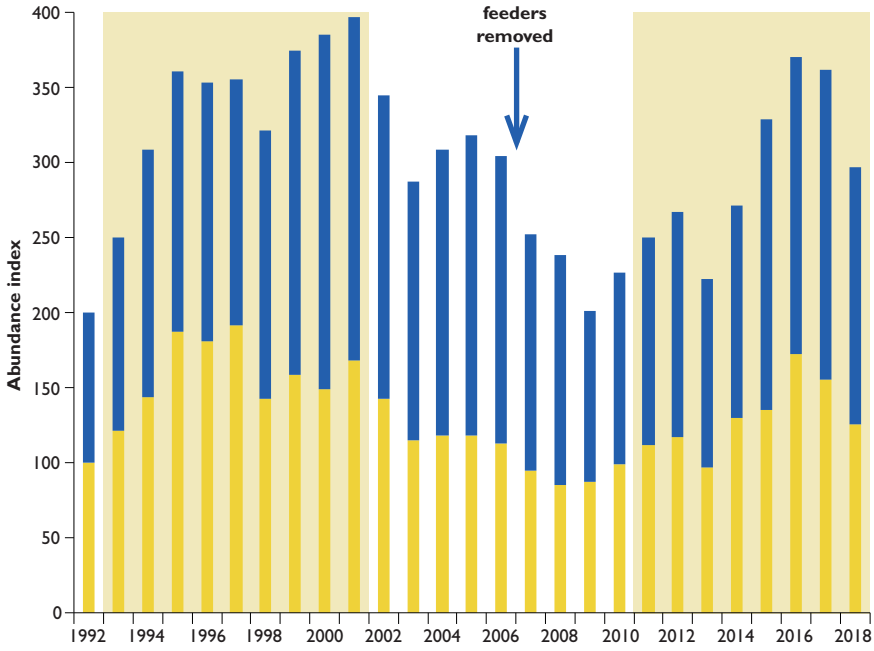


Figure 2

Songbird abundance

Biodiversity Action Plan species

Others

Keepered period

Overall songbird numbers were 58% above the 1992 baseline but 17% lower than in 2017 (see Figure 2). This apparent decline since last year may reflect reduced breeding activity following the cold late spring and then the summer drought conditions. Some species such as blackbird, song thrush, linnet and whitethroat had been showing consistent increases in recent years, although others have not responded to the recent management. Most notably, yellowhammer numbers remain at the 1992 baseline, despite an initial increase in numbers in the early years of the project. Changes in hedge management may be a contributing factor, so targeted management has been put in place to boost this species.

Habitat management continues to include the planting of stewardship funded wild bird seed mixtures, although dry soil conditions in 2018 meant that establishment of spring-sown crops was often poor. MSc student Fiona Tomlin conducted transects to monitor the use of a range of wild bird seed crops by pollinating insects and found that bee numbers in kale-based mixtures containing yellow melilot (sweet clover), were twice as high as those in hedges and perennial wild flower mixtures on the farm (see Figure 3), and that the number of bee species present was similar across these habitats. Other wild bird seed mixtures supported bees, but in lower numbers. Wild bird seed mixtures designed to provide habitat and food for game and songbirds can therefore be adapted to provide additional benefits to pollinators.

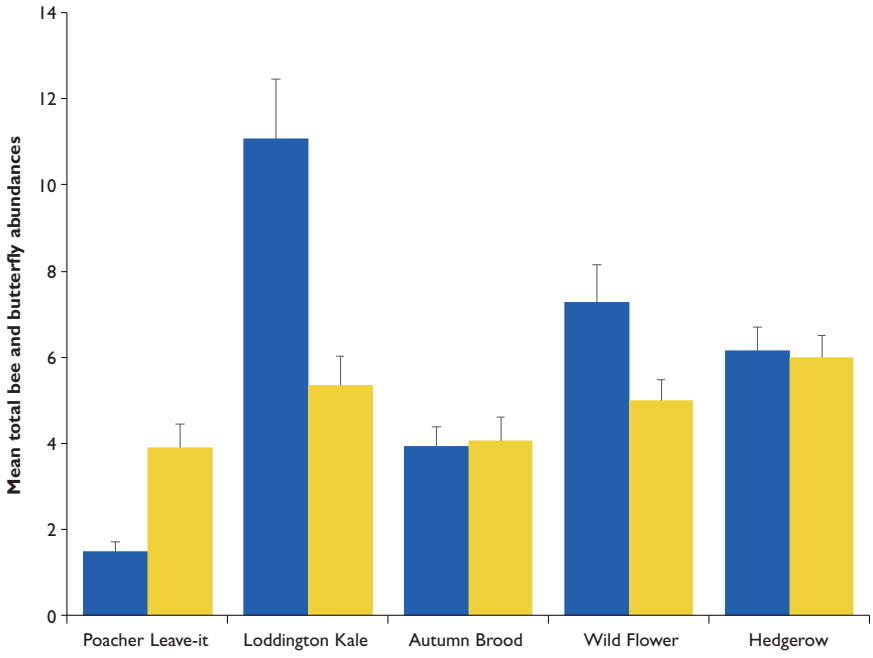


Figure 3

Pollinators in wild bird seed mixtures

Poacher Leave-it: *Coleor kale, utopia, Gold of pleasure, reed canary grass, perennial chicory, phacelia, sweet clover, lucerne*

Loddington Kale: *Coleor kale, Goldeneye kale, 1000 head kale, brown mustard, white mustard, Kings kale rape, utopia*

Autumn Brood Mix: *Coleor kale, triticale, linseed, fodder radish, barley, phacelia, Gold of pleasure, perennial chicory*

Total bee abundance

Total butterfly abundance

KEY FINDINGS

- Songbird numbers are currently 58% above the 1992 baseline, down from 92% above the baseline in 2017.
- Only five broods of pheasants were recorded in 2018.
- Radio-tracking of hen pheasants revealed that all but one of 33 tagged hen pheasants died before attempting to nest.
- Some wild bird seed mixtures support twice as many pollinating insects as hedges do.

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.

The farming year at the Allerton Project

The work we do at the Allerton Project is helping to shape the future of countryside management. © Amelia Woolford/GWCT

BACKGROUND

The Allerton Project is based around an 333-hectare (800 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.

In 2017 we celebrated 25 years at the Allerton Project and a year later the UK Government unveiled its goals for the environment for the next 25 years. This *25-Year Environment Plan* sets out how the Government will deliver a green Brexit and address some of the issues surrounding climate change. However, it is the sustainable use of soil and water, their interactions with biodiversity and the food we produce, that has always been close to the Allerton Project's objectives.

Much of our work in 2018 revolved around evaluating sustainable rotations and developing further the practices of Conservation Agriculture. Reduced cultivations, continuous ground cover and additional crops in the rotations are being used in conjunction with an increased area of temporary mixed-species leys. Defra is looking for new ideas for Environmental Land Management options and the work we do at the Allerton Project will help shape the future of countryside management.

Within the *25-Year Environment Plan* and the proposed Agriculture Bill, the role of our soil and the food that is grown in it had thrown up some interesting commentary. Yes, they provide a so-called 'ecosystem service', but no, they are not to be classified as a 'public good' which means no public support for a national soils policy. There are several important fundamentals to farming, and soil management and producing food are key to any farm's success. We must make sure that we do not undervalue healthy safe affordable food and we should count soil among our nation's assets.

TABLE 1

Arable gross margins (£/hectare) at the Allerton Project 2010-2018

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

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

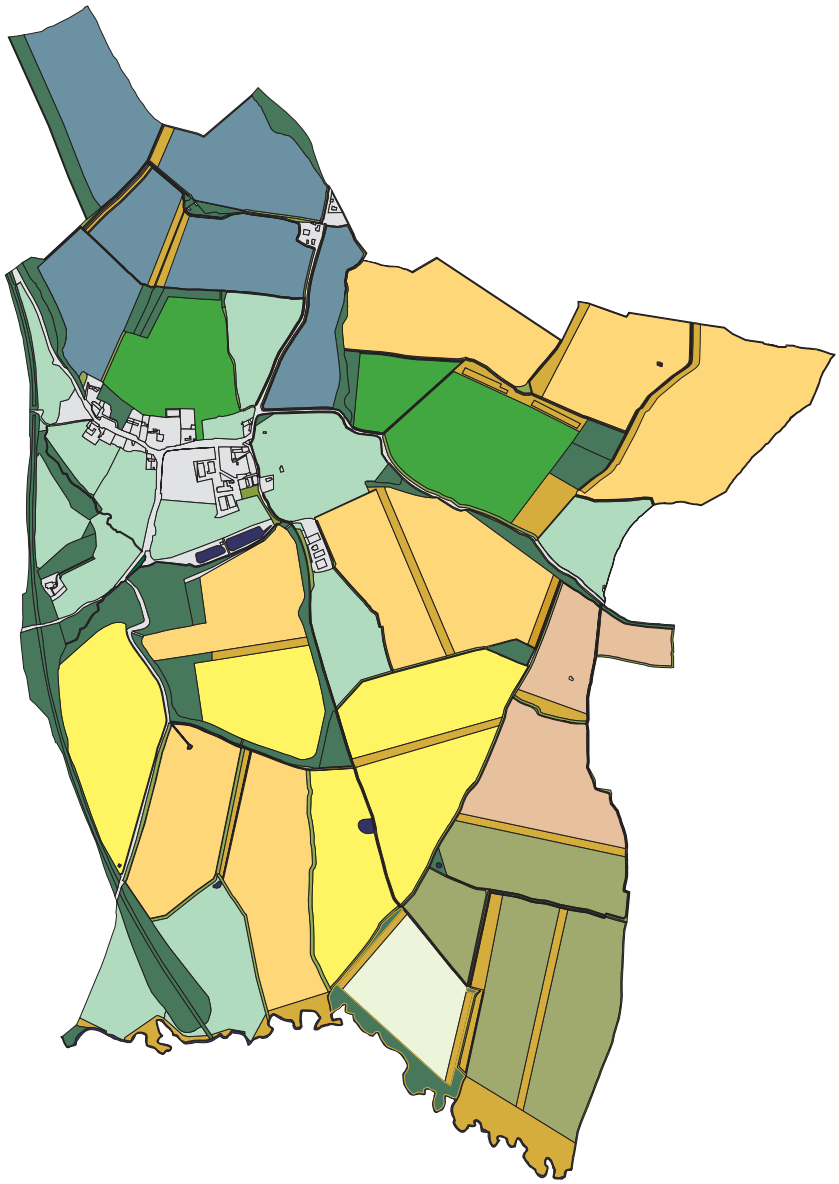


Figure 1

Allerton Project cropping 2017/18

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

The role of soil cannot be under estimated and is key to a farm's success. © Amelia Woolford/GWCT

KEY FINDINGS

- Our farming decision making process, is beginning to be influenced by the Government's *25-Year Environment Plan.*
- Healthy soil is the cornerstone of our farming systems.
- Mixed species leys have been added to our crop rotation.

Phil Jarvis
Alastair Leake

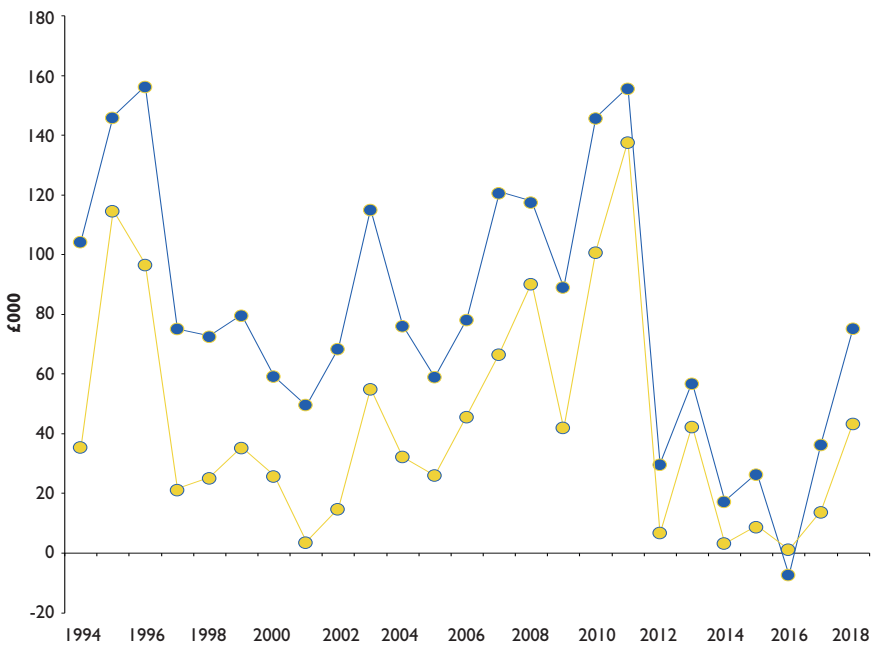
Rainfall to replenish subsoil moisture has been scarce with visible cracks in our arable and pasture fields. © Peter Thompson/GWCT

Climate change is also very firmly on the Government's radar, and weather conditions in Leicestershire certainly tested our cropping systems this year. With the aptly named 'beast from the east' bringing in cold weather to delay spring plantings, we then witnessed some of the driest and warmest summer and autumn weather on record. Indeed, the snow melt provided some of the last moisture that our crops received for many months. Throughout winter 2018, rainfall to replenish subsoil moisture, ponds and lakes was scarce and visible cracks remain in our clay-soiled pastures.

Figure 2

Gross profit* and farm profit at the Allerton Project 1994-2018

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



With a dry period before harvesting, our spring-sown crops were disappointing. Winter crops fared better and had a bonus of requiring very little drying. Autumn-sown cereal crops for the 2019 harvest were planted a month later than in the early 1990s to try and combat black-grass. The negative side of this management decision is less well-established tiller number and soil plant cover. Higher tiller numbers tend to lead to higher yields and better soil protection.

We have reduced our area of spring crops and by default cover crops and introduced more grass, clover and mixed-species leys (see Figure 1). We are looking to reduce our use of inorganic nitrogen and plant protection products by maximising the benefits of grass in the rotation. Some will be grazed and some of our grass trials will be mulched to build fertility. The benefits to businesses that have no livestock, fencing or housing are obvious, but do the economics stack up and how might such practices be encouraged?

We are beginning to see some benefits to our soil as a result of our reduced cultivations and organic additions (crop residues, grass and cover crops). Soils seem to be more workable, friable and drain quicker. Soil improvements can take many years to show build up, but our results are heading in the right direction. Testing and analysis of soils will come under much more scrutiny over the next few years, so educating ourselves and others in the use of such soil indicators will be an interesting challenge.

Our work with industry partners such as Syngenta, Nestlé, Kellogg's, Organic Research Centre, Agricultural & Horticultural Development Board, National Farmers' Union and many academic institutions shows the wide-ranging scope of our research and demonstration projects. In 2018 our farming projects involved a major study involving cultivation comparisons, compaction, aphid and cabbage stem flea beetle monitoring, mycorrhizal fungi, stockless leys and cover crops.

The *25-Year Environment Plan* signposts the UK Government's direction of travel, it aims for a greener future and a cleaner environment. The Allerton Project will continue to research the interactions between wildlife and farming and provide a rural landscape which assists our politicians and society's aspirations.

TABLE 2

Farm conservation costs at the Allerton Project 2018 (£ total)

Higher Level Stewardship costs (including crop income forgone)	-22,618
Higher Level Stewardship income	26,516
Woodland costs	-5,859
Woodland income	1,560
Farm Shoot expenses	-4,220
Farm Shoot income	-4,220
Grass strips (not in Stewardship)	-656
Total profit forgone	
- conservation	**-1,057**
- research and education	**-32,000**
	-33,057

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

Mixed species leys will play a more important part in our crop rotations. © Phil Jarvis/GWCT

Social science at the Allerton Project

It is important to understand how farmers think about their natural environment.
© Peter Thompson/GWCT

BACKGROUND

Hosting visits from around 3,000 agricultural professionals each year provides a great opportunity to get their feedback on the research at the Allerton Project at Loddington, and to apply their knowledge and values to guide our future research. So we have been adopting a structured approach to this process. We also increasingly involve local farmers and other interested parties in the work we do. This ensures that our research is relevant to them, increasing the chances of adoption on farm and in policy. Here we summarise the findings of Susanne Jarratt and Stephen Jones, two recent PhD students, from Nottingham University and the Allerton Project. They represent examples of how social science can help to guide both policy and practice.

Farmers' environmental learning through Stewardship

Susanne Jarratt interviewed 43 East of England farmers about their varying involvement in agri-environment schemes from the Environmentally Sensitive Areas Scheme (one of the earliest schemes), through to those with the most recent Environmental Stewardship scheme agreements. She was interested in how farmers develop their environmental knowledge and values through a 'career' of involvement in such schemes.

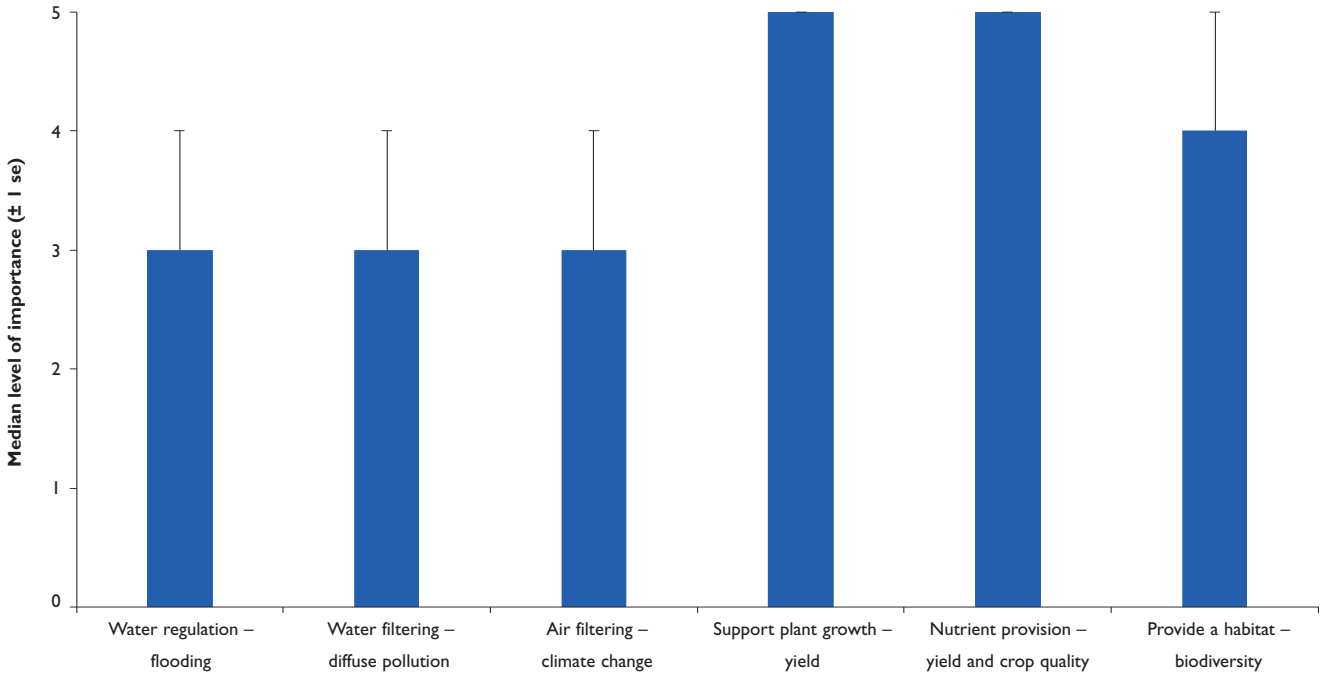
Susanne identified two career pathways. There was one in which payments for wildlife conservation were the primary incentive, and one in which such payments provided an opportunity for farmers with a pre-existing interest in wildlife to start or develop existing wildlife conservation activity.

Farmers progressed along these career pathways from a basic level of knowledge to more advanced activity, sometimes developing considerable interest in individual species (especially where farmers had a pre-existing interest in wildlife), and encouraging neighbouring farmers to carry out similar management. Along the way, farmers were influenced by contingencies such as succession or the introduction of new schemes. Trusted advisors also played a major part. Farmers on both career pathways therefore accumulate knowledge and ownership of wildlife conservation and other environmental management through their active involvement in agri-environment schemes and can be supported through improvements to the schemes and advice provision.

Characterisation of soil by farmers

Stephen Jones interviewed 20 East Midlands farmers about their soils, analysed soil samples and discussed the results with the farmers. Most fundamentally, he considered with them what makes 'good' and 'bad' soils. Where farmers considered a soil in an abstract sense, characterisation was dominated by aspects which change over time because of land use or management, mainly physical structure and organic matter. Where farmers spoke about their own farm and were asked about their 'good' and 'bad' soil, they were more likely to discuss inherent characteristics of their soil such as texture. See Figure 1 where farmers were asked to score the importance of soil to various functions defined by researchers.

These judgements are subject to complexities that can make identifying a 'good' or a 'bad' soil a challenge. In wet years, faster draining 'lighter' soils might be 'good' because they allow the water to drain away and prevent waterlogging and compaction, but the same soil in a dry period will become 'bad' because it will not retain the water, causing crops to suffer. There was also a tension between 'good' soils that were easier to work



but had lower moisture retention capacity, and soils on which it was hard to establish a seedbed, but which might perform better in a dry year. A further complexity was associated with trying to reconcile farmers' practice-based views with how their soil had been categorised scientifically within the Agricultural Land Classification, because soil management practice can override the inherent physical characteristics that are normally measured.

These studies highlight the importance of understanding how farmers think about their natural environment, whether this comprises habitats managed for wildlife or the soils on which farm businesses depend. Knowledge of how farmers relate to these natural resources is going to be key to the delivery of public benefits through the new Environmental Land Management system.

Figure 1

Farmers' scoring of the importance of soil to various functions defined by researchers, based on a 5-point score where 1 = not important, and 5 = very important

KEY FINDINGS

- Social science complements the natural science activities of the Allerton Project.
- Farmers develop knowledge and ownership of environmental management through involvement in agri-environment schemes.
- Farmers' characterisation of soils is influenced by physical conditions and their practical implications.
- Research results can help inform the engagement of farmers in new environmental land management.

Chris Stoate
Susanne Jarratt
Stephen Jones

Understanding how farmers characterise soils helps to guide research and its interpretation.
© Chris Stoate/GWCT

Scottish demonstration farm - Auchnerran

Auchnerran: game and songbird counts

Thrushes such as blackbirds are thriving at Auchnerran. © Marlies Nicolai/GWCT

BACKGROUND

We have been monitoring game and wildlife at the Game & Wildlife Scottish Demonstration Farm, Auchnerran (GWSDF) since early 2015 when we took over the tenancy. 2015 and 2016 were our baseline years: changes to farm management were kept to a minimum to allow extensive monitoring to determine the variety and abundance of wildlife present before we began to make changes to the farm (see *Review of 2016*). This showed that the farm supported a wide diversity of wildlife, much of it at high densities. This almost certainly resulted from the historical low-intensity farming and high level of predator control conducted over the area. Core monitoring is now more focused on key species and groups to help illustrate how wildlife responds to management changes on the farm.

Lapwing breeding numbers are increasing despite the management of some grass fields. © GWCT

Conditions at GWSDF Auchnerran were challenging this year, with a late very cold spring (the 'beast from the east') followed swiftly by an unusually dry spring and summer. This created problems across the farm (see pages 24-25 for our farming summary), but also meant that our routine fieldwork monitoring the biodiversity on the farm was largely unimpeded this year.

One of the first tasks Marlies Nicolai and the team face in spring is counting our game species. At Auchnerran this means searching mainly for pheasants and brown hares, while keeping an eye open for partridges and black game (which lek just up the hill from the farm). Grey partridges are scarce in the Howe of Cromar (the area that Auchnerran sits within), while red-legged partridges are released nearby and drift onto the farm quite frequently in small numbers. This year's counts suggest that our pheasant numbers have probably stabilised after a period of decline since our tenancy began (see Table 1). This follows the steady loss of the huge number of residual released birds we inherited and suggests that our modest population might now be self-sustaining – good news for Merlin Becker who runs the farm's small shoot, as is the increase in brown hares this year.

Following hot on the heels of the game counts is our wader monitoring. From March/April, when the weather allows, we try to identify wader breeding territories, nesting attempts and how successful these are. This is a difficult task because with around 70 pairs of lapwing alone breeding on site (see Table 2), it is hard to keep up with them all, especially when first clutches fail and are replaced, and when chicks start to hatch and wander about. We are all very aware of how lucky we are to have this 'problem'.

In 2018 lapwing continued to increase in abundance at Auchnerran, whereas we recorded the first declines for the other three species monitored (see Table 2). Not only are lapwing breeding numbers steadily increasing, despite changes to the management of some grass fields where the birds breed, but they have also begun wintering on site. The birds move away in response to bad weather (we do not yet

TABLE 1

Game densities (individuals/100 ha) at Auchnerran

	2015		2016		2017		2018	
Species	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Pheasant, male	24.3	42.0	22.7	9.4	19.0	18.8	18.4	11.8
Pheasant, female	14.4	25.2	5.8	0.4	4.6	9.4	1.5	10.8
Black grouse	0.4	0	0.4	0	0	0	0	0
Red-legged partridge	0	3.1	1.3	0	0.9	1.0	0	2.7
Grey partridge	0	0	0	0	0	0	0	0
Brown hare	3.7	1.0	1.7	0.2	1.4	0	2.5	4.8

TABLE 2

Wader pair density at Auchnerran per 100 hectares. Data for woodcock are numbers of roding males

	2015		2016		2017		2018	
	Pairs	% change	Pairs	% change	Pairs	% change	Pairs	% change
Lapwing*	12.9	-	19.4	51	25.9	34	33.3	29
Oystercatcher*	7.8	-	17.7	127	19.8	12	15	-25
Curlew	2.5	-	3.8	50	4.2	11	3.8	-10
Woodcock	-	-	4.3	-	6.2	44	5.5	-11

** Lapwing and oystercatcher densities indicate GWSDF is a key site for these species in Scotland (O'Brien & Bainbridge 2002). Note the different summary for woodcock.*

know where they go at these times) but move quickly back – and more than 300 birds were counted on the farm in winter 2018. We are hoping to explore this in more detail in future by colour-ringing birds breeding on site and following their movements.

Despite the dry conditions, chick production by lapwing and curlew was still relatively high (see Table 3). The low productivity of oystercatchers reflects an apparent high proportion of birds that don't appear to breed (so we have lots of pairs, but few nests and therefore chicks). This is another feature that we hope to explore in more detail next year.

Another group of birds that we put extra monitoring effort into is the thrushes. Blackbirds, song and mistle thrushes are present at relatively high abundance, and with support from SongBird Survival, we began investigating why this might be. With the help of Minna Ots, one of our placement students from Southampton University, we began following breeding attempts and the foraging behaviour of adults. Minna found that, rather like the waders, productivity at GWSDF is good with relatively low rates of predation, which averaged 63% at Auchnerran versus 83% on other farmland sites nearby. Our future work will include exploring what adult thrushes eat on the farm and in which fields.

KEY FINDINGS

- Despite challenging weather conditions, pheasant and brown hare numbers were up or stable in 2018 relative to 2017.
- Numbers of breeding lapwing were up 29% on 2017 and this species has begun partially wintering on site.
- Breeding numbers of curlew, oystercatcher and woodcock declined relative to 2017.
- Overall wader productivity was probably sufficiently high to at least maintain a stable population.

Dave Parish
Marlies Nicolai

TABLE 3

Wader productivity (fledged chicks per pair) at GWSDF Auchnerran

	2017	2018
Lapwing	1.3	0.9
Curlew	0.9	0.9
Oystercatcher	0.3	0.4

ACKNOWLEDGEMENTS

Thank you to SongBird Survival who support our research on thrushes at GWSDF Auchnerran.

(Left) Curlew chick. (Below) Mistle thrush brood.
© Marlies Nicolai/Minna Ots/GWCT

The farming year at Auchnerran

The farming and research team met more than 170 visitors in 2018, including this visit with the SNH chief executive and NFU Scotland regional members. © GWCT

BACKGROUND

Livestock and grass-dominated agriculture on the edge of the hill are important across the UK, but this farming is hard pressed to be both economically sustainable and home to increasingly vulnerable species such as curlew, grey partridge and hares. By integrating, researching and demonstrating game, wildlife and farm conservation approaches, we believe there are practical solutions to this challenge.

We did not think it possible to have another year when the weather was completely different to the previous year. We had forgotten drought; and the glacial sand and gravel that underlies the farm, ideal in a wet year like 2017, brought significant challenges for farm livestock and farm conservation alike in 2018.

The farming operation remains the key part of the Game & Wildlife Scottish Demonstration Farm (GWSDF). It underpins and brings to life the research and policy work of the GWCT in Scotland, and throws up a number of challenges of its own.

We tupped 980 ewes in December 2017 to ensure income held up, but this was a higher than ideal stocking rate. The close contact of sheep to sheep and sheep to rabbit seems to be associated with the mycoplasma-derived pneumonia symptoms that have affected the flock for a number of years. Treating this spring illness needed a 50% increase in our veterinary and medicine budget, and at the end of 2018 we chose to 'away-winter' two-thirds of the hogg flock to reduce disease and grazing pressure. Some of these hoggs are on a farm on the Aberdeenshire coast close to the US President's golf course so we hope this is a 'Trump' card.

As well as increased health plan costs, the 2017-18 winter seemed to last forever. There were 30 days of continuous snow cover in March and despite the record cut

TABLE 1

Sheep flock and grass productivity

	Ewes	% weaned	Silage	Per acre
2015	1,440	60%	730	7 bales
2016	1,205	97%	717	8 bales
2017	1,126	120%	1,100	10 bales
2018	1,000	126%	460	5 bales

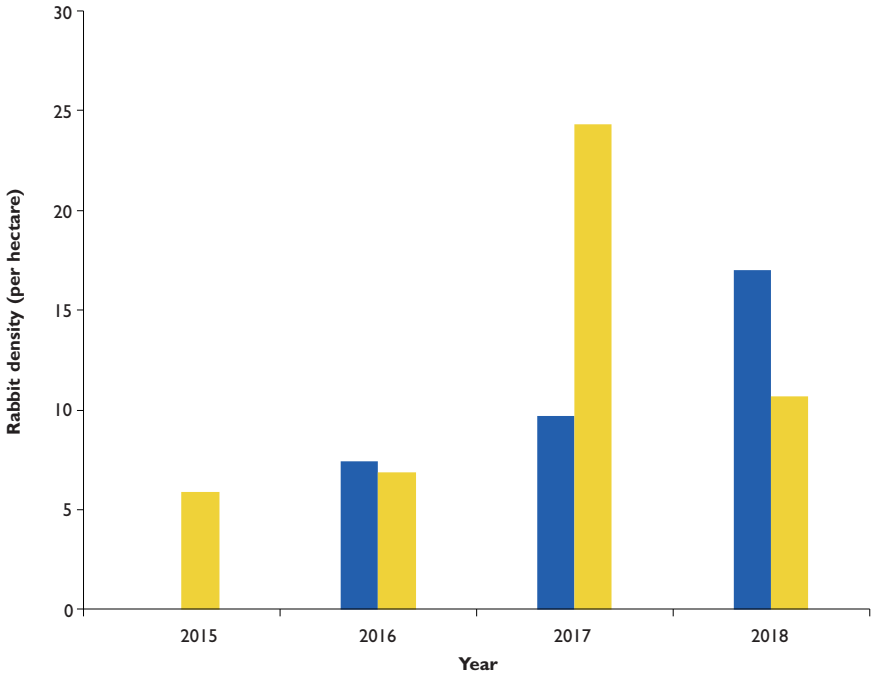


Figure 1
Rabbit density from night counts

Spring

Autumn

of 1,100 bales of silage in 2017, extra forage was needed to see the flock through to May lambing.

An excellent scanning of 147% was followed through and the final weaning rate (lambs taken from ewe) was 126%, well up for a hill black-face flock (see Table 1). Allan Wright, our shepherd manager, gave himself something of a headache by having 44% twins in 2017. Although this was good for building up the flock size toward the economic and agreed tenancy levels, 2018's long winter gave way, via a week's worth of rain, to a near drought for three months. Grass hardly began to grow before it stopped, which was a concern for twins being kept on the farm. The 11 hectares (ha) of grass re-seeds gave way to significant creeping and scotch thistle burdens. Even the hardy 20ha of turnip and kale forage was held back, with meaningful growth starting only in October. A measure of the impact of the weather can be seen in Table 1, which shows the 2018 silage crop to be half that of 2017 – another reason to away-winter the hoggs. The hot dry weather also showed up an ongoing challenge of too many decrepit hill fences, allowing some of the hill flock to leave the hill heft, wasting time when there is much else to do on the farm.

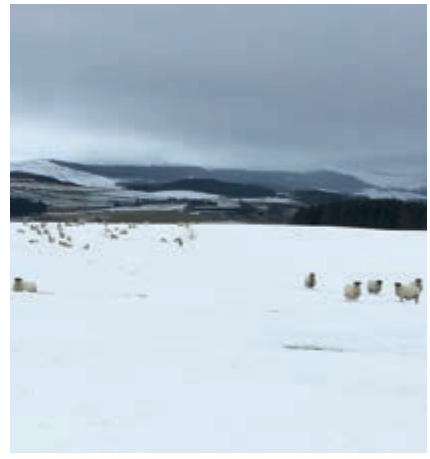
The free-draining sand and gravel did not help hold moisture, though it did help the rabbits reach very high levels (see Figure 1). The rabbit cull for 2018 was more than 4,000, an extraordinary effort for the farm and shoot management team. Merlin Becker, policy and advisory officer in Scotland, organised seven guest rabbit shoot days this year as well as the mixed species days, all auctioned through GWCT Scotland regional events. We have been very grateful to local farms who have supplied grain for the feed hoppers, and Kings Seeds who again supported us with the game crop seeds.

The Auchnerran farm team have been delighted to see that the grass reseeds, forage and game crops, planned with the research and demonstration team, are well used for wintering and summer foraging by the other farm crop, namely wading birds. This was a small compensation for sparse growth and low ultimate yields of the crops. But it illustrated to our 173 visitors including Scottish Natural Heritage, National Farmers Union' Scotland and Scottish Government, notably the new Minister for Rural Affairs and Natural Environment, Mairi Gougeon MSP, that nature conservation and good farming practice are achievable, but that these come with compromises. Planning careful crop rotations, limiting areas of grass improvement, marking and avoiding wader nests, restricting rolling, topping and cutting until after the waders were clear, and effective predator control, means that Auchnerran has nationally important wading bird densities. Our efforts on the policy front are going into showing how this 'natural capital' can be assessed and valued, so farmers making such contributions to public goods do not have to do it from their own pocket, or for love.

KEY FINDINGS

- GWSDF Auchnerran farm seeks to integrate economic hill farming with successful wildlife conservation.
- Intensifying farm management while retaining 'natural capital value' was challenging in the dry conditions of 2018.
- In 2018, sheep flock productivity increased to 1.26 lambs reared per ewe.
- We welcomed more than 170 visitors included a Scottish Government Minister and the CEO of SNH and NFUS.

Adam Smith
Allan Wright



There were 30 days of continuous snow cover in March so extra forage was needed to see the flock through to lambing in May. © GWCT

The importance of cover at Whitburgh

Good cover crops are important as around a third of grey partridge hens are taken by raptors.
© Dave Parish/GWCT

BACKGROUND

The GWCT have been working with the team at Whitburgh Farms now for eight years The focus is on increasing grey partridge numbers through habitat management and good predation control. Whitburgh has also provided an excellent means of demonstrating key issues to Scottish environmental policy influencers and makers.

2018 represents our eighth year of collaboration with Mr Salvesen and the Whitburgh Farms team on their grey partridge project. We have been monitoring the progress of efforts to increase grey partridge numbers with the aim of starting a small sustainable shoot of wild birds. Historically, reared grey partridges were released on the farm to sustain the shooting, but this stopped in 2008 when Alastair Salvesen, the owner, decided to focus on wild production. With advice from our senior Scotland advisor, Hugo Straker, three-metre grass margins were installed around most fields alongside the 26 miles of hedges, with around four-metres of cover crop adjacent to it – providing excellent nesting sites alongside year-round escape cover and food supplies. The cover crops are typically in place for one to three years before being replaced, which is done on rotation so that there is always plenty of cover in most fields and likewise, one side of each hedge is cut in alternate years to minimise disturbance.

In addition to the new habitats, Graham Rankine, Whitburgh's gamekeeper of many years, runs an extensive programme of predator control and stocks hundreds of feeders from October to May. He also manages a relatively small shoot of released pheasants, which provide around half a dozen shoot days annually.

Our monitoring, along with Graham's detailed spring and autumn counts (see Table 1), shows that grey partridges have done well over recent years but with significant knock-backs. Most notable was the poor survival and productivity during 2012 and to a lesser degree 2013, when extreme cold wet weather during the summer reduced grey partridge numbers – from which they are still recovering. The effect of the poor weather was exacerbated by increased predation rates on the hens during this period; our radio-tracking showed that all our tagged hens that year were killed by raptors. Whitburgh has a high density of raptors, especially buzzards, whose densities peak at around 1.3 territories per square kilometre. On average a third of hens are taken by raptors – making good cover crops particularly important.

Whitburgh is now one of the 10 demonstration sites for the Interreg North Sea Region PARTRIDGE project, an EU-funded venture showing how grey partridge

TABLE 1

Grey partridge densities (per100ha) at Whitburgh Farms

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Spring pairs	15.9	8.97	7.72	2.7	3.2	4.62	4.5	4.8	5.02
Autumn total	45.2	38.2	8.1	11.3	30.8	31.8	27.7	26.7	43.0

Mr Salvesen (centre right) discussing management at Whitburgh with other PARTRIDGE partners during a site visit in May. © Dave Parish/GWCT

management can improve farmed landscapes for a range of wildlife (see pages 54-55). A key part of this is the introduction of new long-term cover crops that should provide all the resources grey partridge need, all year round. As well as providing additional cover from raptors, this cover may be particularly pertinent at Whitburgh because these crops can provide quality nesting habitat, of importance because badger numbers have increased to the point where they are now probably the most significant nest predators and are preventing the snaring of foxes because of the risk of by-catch. The new PARTRIDGE cover crops offer good nesting cover in large blocks or wide strips making it harder for badgers and other predators to find nests located within them. These were introduced at Whitburgh in 2017 and 2018 and we are watching with interest how partridge numbers respond.

Encouragingly, the number of grey partridges at Whitburgh is now able to sustain a small shoot. In 2017/18, small numbers were shot for the first time, with this continuing in 2018/19. A fair reward for the years of hard work that the farm team have put into managing the site.

KEY FINDINGS

- Monitoring has highlighted some of the challenges that grey partridges face at Whitburgh, like poor weather and predation.
- Whitburgh is now one of 10 PARTRIDGE demonstration sites and has introduced new long-term cover crops.
- Grey partridge numbers can now sustain a modest shoot, one of few in Scotland.

Dave Parish

New long-term cover crops have been introduced that should provide the resources that grey partridges need all year round. © Dave Parish/GWCT

© Jack Hills/The Times

River Frome salmon population

BACKGROUND

At the Salmon & Trout Research Centre at East Stoke we carry out research on all aspects of 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 facilitated the study of life-history traits of salmon and trout at not only population level, but also at the level of individuals. 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 to report on the marine survival of wild Atlantic salmon.

Smolts

The estimated number of smolts leaving the River Frome in the spring of 2018 was 11,875, which is more than double the number leaving in 2017 (4,381) and well above the 10-year average (9,511, see Figure 1).

Heavy rain in March and April resulted in high flows during the smolt run. Consequently, for the first time in 13 years, we were unable to deploy our Bioacoustics Fish Fence (BAFF). The BAFF guides the smolts from the main river down the Millstream, where we have our smolt trap. In place of the BAFF we resorted to installing a fence consisting of bubbles only, which deflected smolts albeit less efficiently, operating at 48% deflection compared with 70+% for the BAFF where the bubbles have sound entrained.

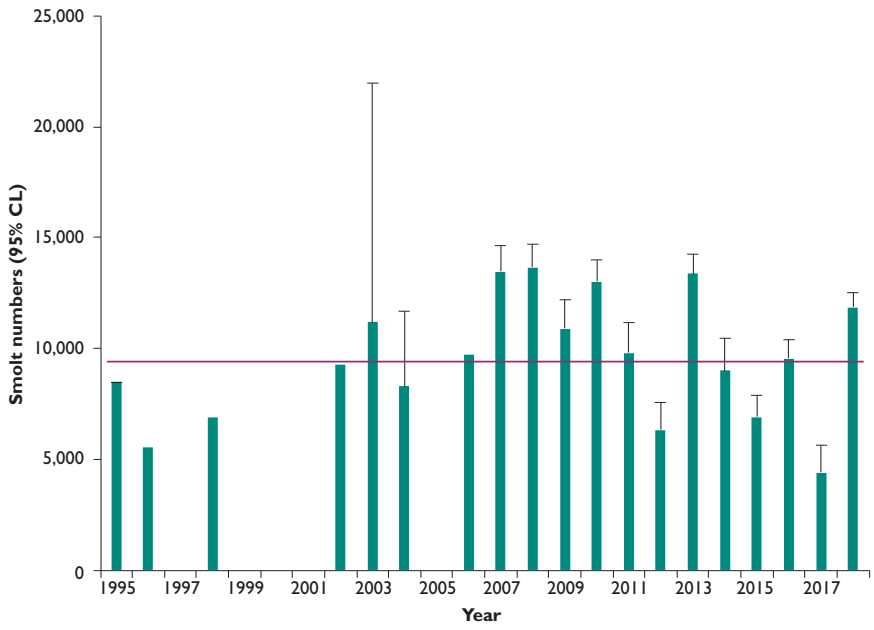
Despite the logistic issues caused by the unusual high river levels, we were able to catch enough individuals in the trap to get good smolt biometric data, to estimate the tagged to non-tagged ratio and successfully estimate the size of the 2018 smolt cohort.

Adults

Given the very low number of smolts leaving the River Frome in 2017 we expected very few one-sea-winter (1SW) fish to return to the River Frome in 2018. This unfor-

Figure 1

Estimated spring smolt population 1973-2018



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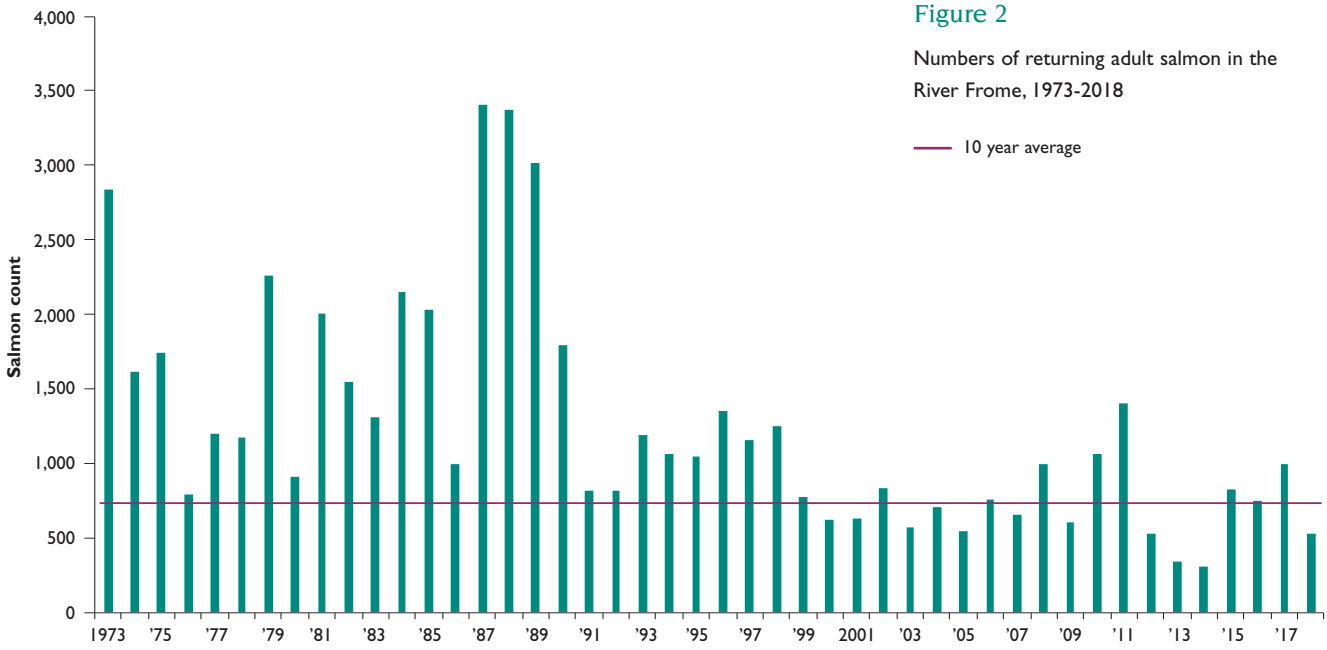

Figure 2

Numbers of returning adult salmon in the River Frome, 1973-2018

10 year average

tunately came true. Even though the number of returning 2SW and 3SW fish was reasonable, the total number of adults returning in 2018 was 524 which is well below the 10-year average (732) owing to the very low number of 1SW fish (see Figure 2). As a result of the low number of adults returning to the River Frome in 2018, the recruitment potential for juveniles emerging from the redds in 2019 is very low, which is also likely to be the case in 2020 when the very small smolt cohort of 2017 return as 2SW fish. Hopefully the large 2018 smolt cohort can ameliorate the low recruitment potential from the 2017 smolt cohort in 2020.

Parr

Following heavy rain in March and April, the summer (May-October) of 2018 was the driest on record in Wessex since 1948. Conditions during the tagging campaign in late summer were excellent for electric fishing because we had no rain. Furthermore, the combination of heavy spring rain recharging the groundwater reservoirs and good growth of *Ranunculus* ensured good juvenile habitat (see page 36 for more information on the importance of *Ranunculus* for juvenile salmonids in the River Frome). As in 2017, we encountered good numbers of young of the year parr in the catchment during our 2018 parr tagging campaign and over the 23 days of the electric fishing we PIT-tagged in excess of 10,000 salmon and 3,500 trout.

Hopefully good survival and density dependent process in the freshwater stage can help compensate for the low recruitment potential from the very small 2017 smolt cohort in the next couple of years.

KEY FINDINGS

- As we predicted, the very low number of smolts leaving the River Frome in 2017 resulted in a very poor run of one-sea-winter (1SW) fish returning in 2018.
- The knock-on effect of the poor recruitment from the spawning in the winter of 2015/16 is that juvenile recruitment in 2019 and 2020 will be compromised.
- In 2018 we recorded a large smolt run, which might ameliorate the low recruitment potential from the 2017 smolt cohort in 2020.
- Poor recruitment from the 2015/16 spawning season was reported widely across much of England and Wales. Other rivers affected by this poor spawning season are likely to see the same effect on the number of returning adults next year as chalk stream smolts are generally a year younger than smolts from other rivers.

Rasmus Lauridsen

Salmon kelt captured during fishing for sea trout kelts. © Jack Hills/The Times

We inserted two tags in sea trout kelts to help us understand more about their journeys at sea and in estuaries. © Céline Artero/GWCT

Sea trout behaviour in the marine environment

BACKGROUND

As part of the SAMARCH project, a tracking study aimed at following salmonid migration in estuaries and coastal waters started in October 2017. We are seeking to shed light on the ecology of salmonids in transitional and coastal waters to improve management of Atlantic salmon and sea trout in this habitat.

At the end of the calendar year, sea trout come back to the spawning grounds of their natal rivers to reproduce. After spawning the sea trout migrate back downstream to start another marine phase. This provides an opportunity to intercept post-spawning sea trout before they re-enter the sea.

During 2017, the pilot phase of this project, we captured 16 sea trout, eight on the River Tamar, three on the River Frome and five on the River Bresle in France. Each of these 16 fish had two tags implanted into their body cavity.

The first tag is an acoustic tag that pings every 30 seconds; these pings are detected by acoustic receivers deployed around the studied estuaries. When an acoustically tagged fish is within range of an acoustic receiver, its presence will be detected and the tag ID, date and time is logged. The data downloaded from the receiver network enable us to study the migration timing, speed and mortality of sea trout in transitional waters, an area where they encounter steep gradients in water temperature and salinity.

The second tag, a data storage tag (DST), records temperature and pressure every two minutes. As fish are ectothermic (they don't regulate their internal temperature) the temperature recorded inside the body cavity of the fish reflects the temperature

Figure 1

Daily maximum depth reached by a sea trout from the River Tamar from January to May 2018 based on pressure logged by an implanted tag

of the water. Relating the temperature recorded by the DST to environmental records will enable us to reconstruct the most likely migration path of the sea trout while at sea. In the same way, the pressure recorded by the DST enables us to determine the depth at which the fish is swimming, providing information on their vertical activity. To recover the data from the DST, we need to recapture the fish, so we offer a £50 reward to anyone that recovers a DST or a tagged fish (see poster below). This far we have recovered four DSTs (25% recovery rate): three individuals from the Bresle and one from the Tamar.

The preliminary data indicate that sea trout not only swim near the surface as is currently assumed by specialists for management purposes, but frequently dived as deep as 50 metres (see Figure 1). All four fish displayed similar behaviour with at least one dive a day, with most dives occurring during daylight hours. However, there were slight differences in daily diving pattern between the individuals from the Bresle and the one recovered Tamar tag: the Tamar fish stayed close to the surface at night whereas the Bresle fish displayed some vertical activity at night.

We do not know yet if these vertical movements are a result of predator avoidance, feeding behaviour or other factors. In November/December 2018 we implanted tags in 99 sea trout from the three rivers and will repeat this in 2019. If we continue to have good recovery rates, we will gain unprecedented knowledge of marine behaviour and migration patterns of sea trout in the English Channel, enabling better management of a fish species that is currently in decline.

KEY FINDINGS

- Sea trout are anadromous which means they spend part of their life in freshwater and part in marine water. Whereas their freshwater phase is relatively well understood, very little is known about their ecology in marine water.
- The aim of this tracking project is to improve our knowledge of sea trout migration, swimming behaviour and feeding grounds.
- From the pilot phase of this project we have already recovered data from four fish and discovered that sea trout, while at sea, undertake intense daily diving activity to a depth of up to 50 metres.

Céline Artero

ACKNOWLEDGEMENTS

We thank the Atlantic Salmon Trust and Natural England for their contribution towards the tags. The SAMARCH – SAlmonid MAnagement Round the CHannel project, is part-funded by the EU's Interreg France England Channel 5A programme. SAMARCH is a five-year (2017-2022) project and has 10 partners: GWCT (lead), INRA, Agrocampus, Normandie Grands Migrateurs, Bretagne Grands Migrateurs, Agence Française de la Biodiversité, Environment Agency, Bournemouth University, University of Exeter and Salmon and Trout Conservation.

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Poster: please contact us if you find a sea trout with an external tag and/or a blue tattoo as it could be carrying valuable data.

European grayling recruitment in the River Wylye

We surveyed juvenile grayling and trout at six long-term 200 metre sites on the River Wylye. © Dick Hawkes

BACKGROUND

As part of the ongoing Wylye Grayling Study (WGS), GWCT, together with Natural Resources Wales and the Piscatorial Society, have monitored European grayling abundance on the River Wylye, a tributary of the Hampshire Avon since 1996. During that period, numbers of grayling have been declining, albeit episodically, and observations from anglers and scientists suggest the decline could be due to recruitment failures (years when few eggs survived to become juveniles that will develop into sexually mature adults). Since 2009, the WGS was expanded to include brown trout. River conditions, including water temperature and discharge rates, have been monitored for the duration of the WGS.

We surveyed juvenile grayling and trout at six long-term 200 metre sites on the River Wylye each October from 2009 to 2016. During the survey, the sites were isolated by upstream and downstream nets, and juvenile fish were captured using between three and five electric fishing passes, until the number of grayling captured was less than half the number caught in the previous pass. All captured grayling and trout were lightly anaesthetised, measured, weighed, marked with a uniquely identifying tag and returned to their site of capture.

With financial support from the Grayling Research Trust, GWCT employed a post-doctoral research scientist to develop statistical models exploring associations between observations on grayling recruitment and river conditions. The models served to test the hypotheses that grayling recruitment was associated with temperatures during egg development and post-emergence, a measure of the intensity of drought post-emergence, the number of juvenile grayling sharing limited food and shelter, and the number of trout also sharing those limited resources. The statistical models assumed that the data from the six sites were representative of the whole river, and hence that the findings were relevant to the River Wylye fisheries managers.

Results and implications

Grayling recruitment was found to be negatively related to the number of other juvenile grayling during their development, suggesting that there was limited food or shelter to share among young juveniles. Recruitment was also positively associated with summer temperature, unless it exceeded 13.5°C, beyond which the association became negative. It was also positively associated with spring temperature, and negatively associated with low flows during the summer. The same conditions appeared to favour trout recruitment, despite long-standing speculation that the presence of one species would be detrimental to the other.

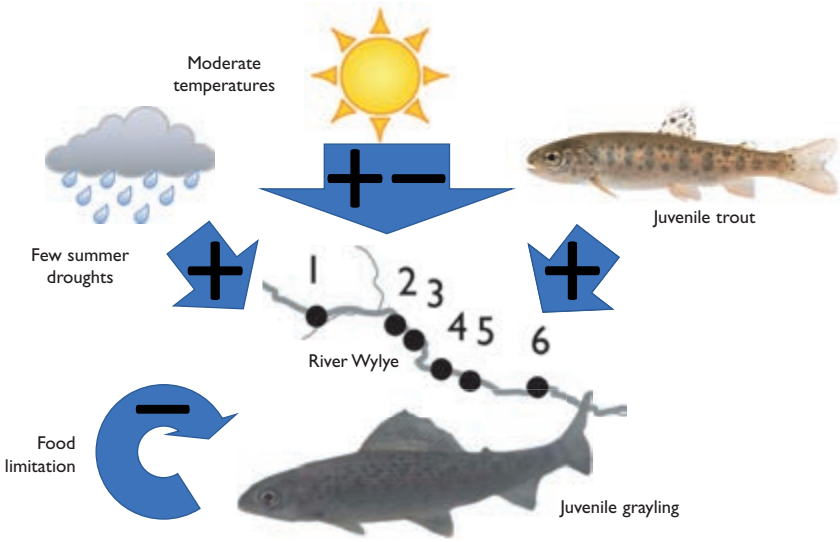

Figure 1

Effects of environmental variables and food limitation by juvenile trout and grayling on the recruitment of grayling measured at six sites on the River Wylye over eight years

Our findings suggest that grayling benefit from moderate river conditions during egg and early juvenile development, but are susceptible to high temperature and drought conditions during summer. Considered against the background of ongoing salmonid population declines, our findings emphasise the importance of management interventions that seek to increase population resilience via restoring natural discharge regimes. These would include sympathetic water use by people and their activities, and limiting future temperature increases, perhaps by protecting riverine habitats.

KEY FINDINGS

- Factors affecting juvenile grayling recruitment were explored, including river water temperature, discharge, and numbers of other juvenile salmonids sharing limited food.
- Juvenile grayling recruitment was positively associated with temperatures, until they exceeded 13.5°C, and negatively associated with drought (conditions that also favoured juvenile trout recruitment).
- Grayling, and perhaps trout, population persistence depends on maintaining natural discharge, requiring sympathetic water use by people and their activities, such as abstraction, particularly under worsening climate change and industrial and human development in the chalk stream catchments.

Stephen Gregory

Sites were isolated with nets upstream and downstream. © Dick Hawkes

Does capturing and tagging wild salmon smolts affect their survival at sea?

Rotary screw traps are commonly used to catch smolts and consist of a large conical chamber with a screw thread inside, which is rotated by the river flow. © Rasmus Lauridsen/GWCT

BACKGROUND

Marking or tagging individual animals is an important technique for studying many aspects of wildlife, including their migration, survival, population changes and behaviour. To give accurate information about natural behaviour, neither the tag nor the tagging process should affect the animal. For salmon, tagging involves catching the fish, giving it a light anaesthetic and inserting a small tag, before allowing it to recover prior to release. Passive Integrated Transponder (PIT) tags are used as an individual marker for young fish. They have been studied extensively and do not seem to have any adverse effect on fish.

The GWCT has, in collaboration with the Centre for Environment, Fisheries and Aquaculture Science (Cefas), tagged around 10,000 juvenile salmon with Passive Integrated Transponder (PIT) tags in the River Frome catchment every autumn since 2005. These PIT-tagged individuals are detected as the fish swim past monitoring stations, identifying the individual and informing us of when they are moving up and down the river. Coded wire tags (CWTs) are small pieces of magnetised steel with coded numbers engraved onto them and they are detected by a handheld detector that registers the presence of the tag. CWTs were used by the GWCT Fisheries team to mark seaward-migrating smolts between 2006 and 2012, in line with international standards.

What we did

All fish in this study were PIT-tagged in autumn. Some of these PIT-tagged individuals were then recaptured as seaward migrating smolts in spring using a rotary screw trap. Rotary screw traps are commonly used to catch smolts and consist of a large conical chamber with a screw thread inside, rotated by the river flow. The recaptured smolts were anaesthetised, had a CWT injected and allowed to recover before being released back into the river. For seven years, we collected data on PIT-tagged fish in two groups:

1. Those that were captured in a rotary screw trap and marked with a CWT when migrating to sea as smolts – the 'experimental' group.
2. Those that were detected migrating to sea as smolts via their PIT tag but were not captured and marked with a CWT – the 'control' group (see Figure 1).

We compared the adult return rates of experimental and control group smolts to measure any impact of the capture and CWT process on their return rate as adults. These analyses took into account environmental conditions before and during the tagging process. The effect of individual components of the tagging process cannot be separated out, so any differences between the groups could have been caused by capture, anaesthetic, or tagging, and we cannot determine which part of the process was responsible.

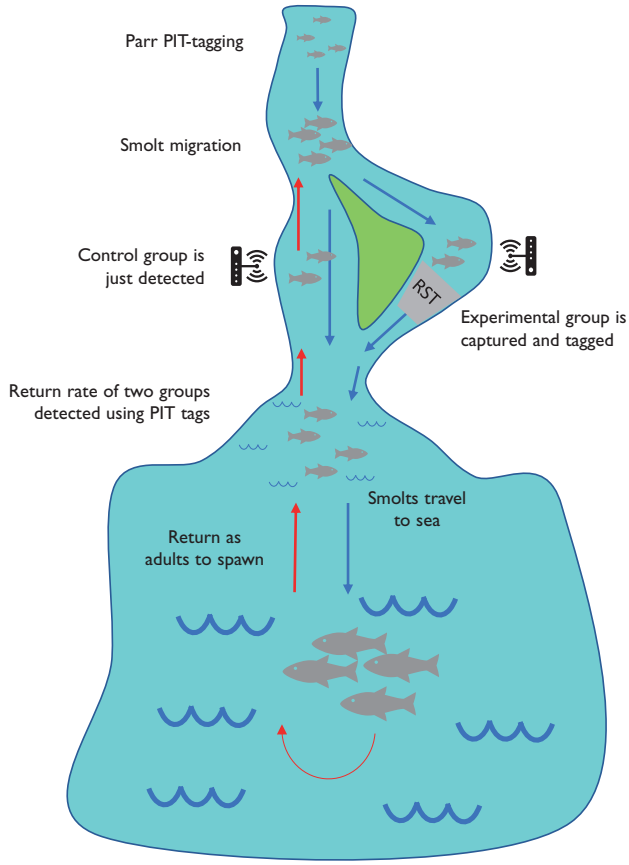

Figure 1

Schematic diagram of salmon migration to sea and back to the river and experimental design

Results and implications

Capture and tagging of smolts affected the rate at which adults returned only under certain conditions. In years that followed a mild winter and for fish that migrated at night, the experimental group had a lower return rate than the control group (see Figure 2). This means that fewer smolts from the experimental group returned to their home river as adults. In years with more normal weather conditions and river temperatures, the adult return rate was the same for both groups, suggesting that inserting the CWT, capture and handling did not affect the fish.

At East Stoke, we still capture a proportion of the spring smolts to collect samples, biometrics and to estimate the proportion of PIT-tagged fish, but we no longer mark them with CWTs. However, these results could help guide all users of CWTs on fish to minimise their potential impact by being cautious when tagging under these conditions.

KEY FINDINGS

- Tagging enables us to identify individual fish and is an important and widely used technique for studying wildlife. To ensure that findings from tagged individuals are not affected by the tagging process, we should monitor any effect that it has on the animal.
- We compared the adult return rate of two groups of juvenile salmon (smolts): an 'experimental' group of fish that were captured and tagged during their spring migration to sea, and a 'control' group that were not.
- Capture and tagging of smolts affected the rate at which adults returned only under certain conditions. Smolts that were caught and tagged during the night and after unusually mild winters, when river temperatures were higher, had a lower chance of returning as adults than uncaught smolts.
- The GWCT fisheries team still captures but no longer tags salmon smolts when they are migrating in spring.

Rasmus Lauridsen

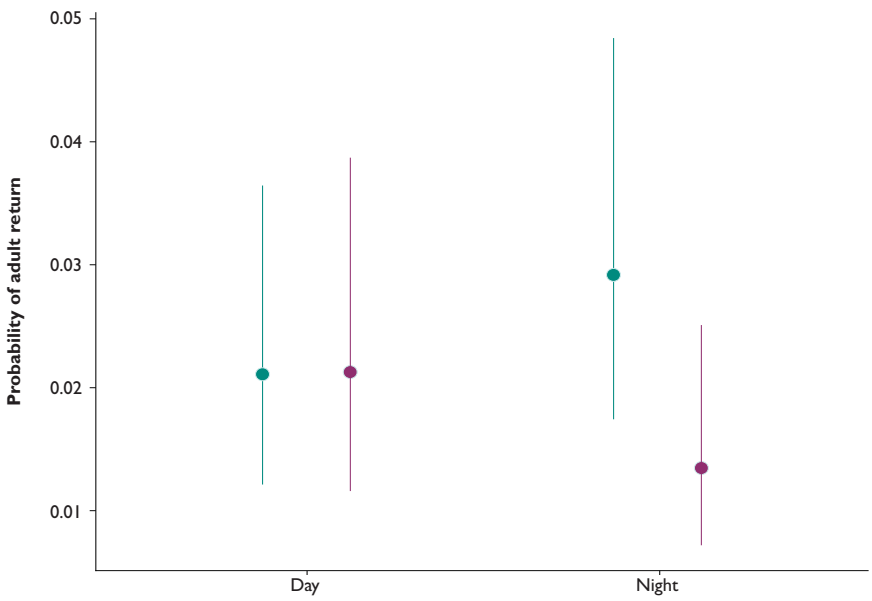

Figure 2

Probability of smolts returning depending on whether they migrated past East Stoke at day or night and whether they were captured and tagged 'Experimental group' as smolts or not 'Control group'

Control

Experimental

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Juvenile salmonid densities and habitat

Typical chalk stream habitat: mosaic of Ranunculus *beds on the River Frome. © Jessica Marsh/GWCT.*

BACKGROUND

This research forms part of Jessica Marsh's PhD project, which aims to understand the role of *Ranunculus* in chalk streams, its influence in shaping the physical environment of the river and subsequently the communities of macroinvertebrates and juvenile salmonids.

Understanding the habitat requirements of juvenile salmonids is vital if we are to better manage their freshwater environment. Although habitat variables influencing salmonid densities (water depth and velocity, river-bed substrate, in-stream cover) have previously been identified, their relative importance is poorly understood.

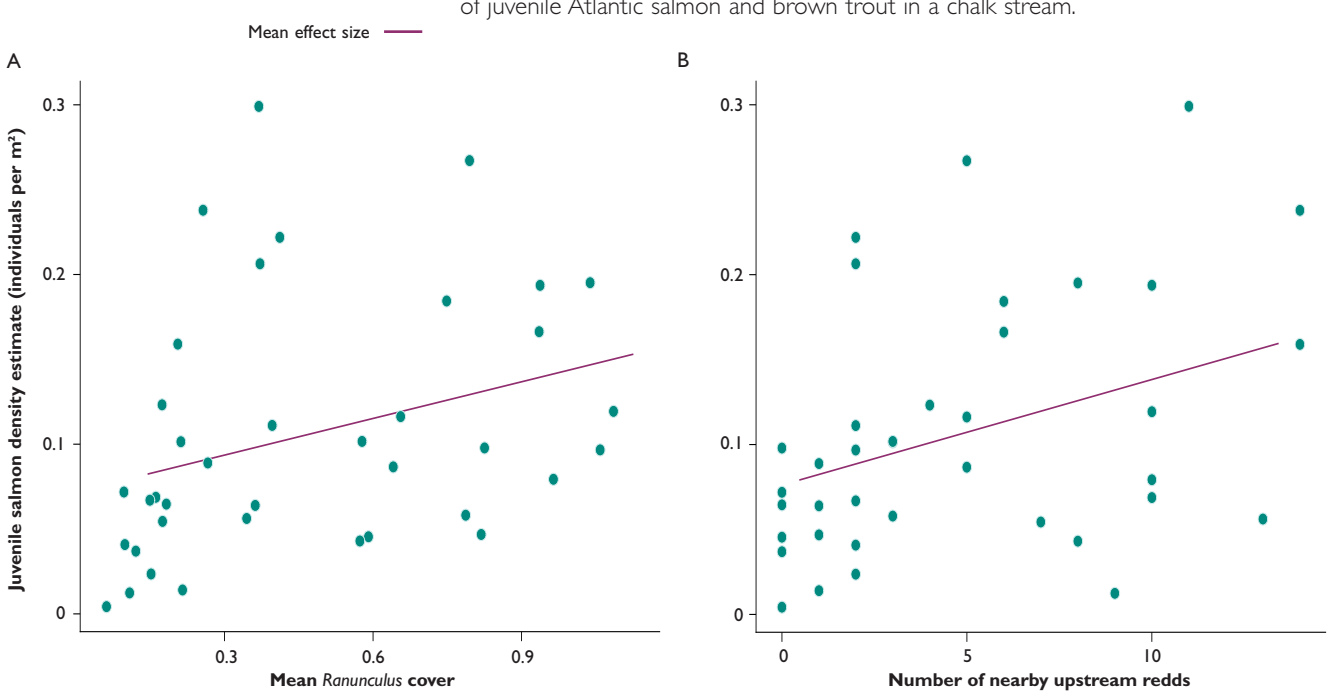
In place of large cobble and boulder substrates, which are favoured by juvenile salmonids in high-energy rivers, our low-energy chalk streams feature dominant *Ranunculus* (water crowfoot) beds, which may offer shelter from both predators and high water velocities. *Ranunculus* encourages complex habitats to develop with a mix of water velocities. This is beneficial to juvenile salmonids because they use both low and high velocity habitats for foraging: they maintain position in low velocity adjacent to a section of high velocity that brings their macroinvertebrate prey to them, so they can dart out to capture prey without expending too much energy. While this is well-documented foraging behaviour, previous studies have not attempted to record a measure of this variability in water velocity and relate that to salmonid densities.

An additional consideration, which has been overlooked in much of the literature, is the influence of the colonisation potential of a site. After emergence from spawning redds (nests), salmonid fry will disperse downstream until they reach suitable habitat to feed and grow before overwintering, therefore the proximity of redds to a site could influence the densities found there.

This study aimed to incorporate both the traditional habitat variables and novel considerations of mixed water velocity and redd proximity to best describe densities of juvenile Atlantic salmon and brown trout in a chalk stream.

Figure 1a & b

Juvenile salmon density increases with increasing (a) *Ranunculus* cover and (b) number of nearby upstream redds, after taking into account the effects of other variables



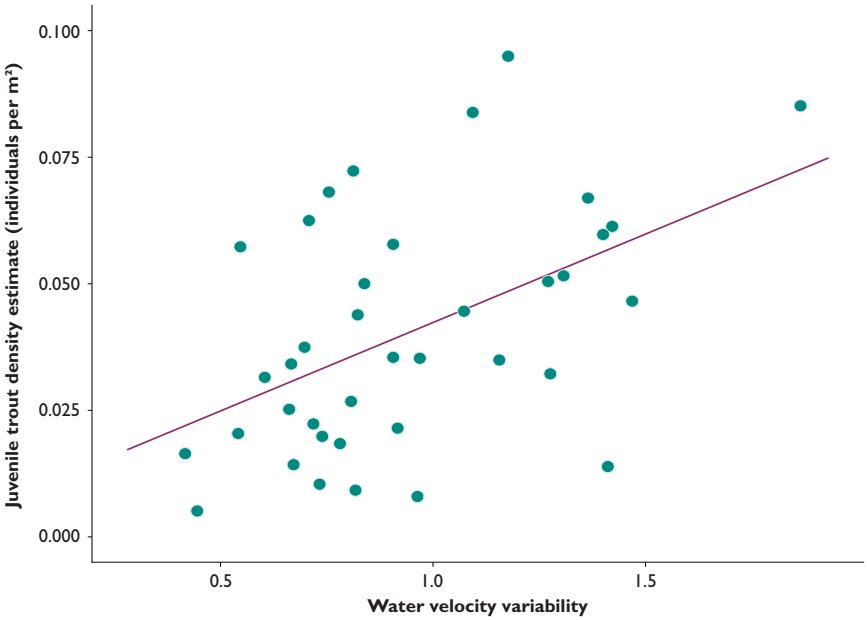


Figure 2

Juvenile trout density increases with increasing variability in water velocity, after taking into account the effects of other variables.
(x axis scale: 0 = low velocity variability
-2 = high velocity variability)

Observed trout density estimates

Mean effect size

Juvenile salmon (top) and trout (bottom) showing differences in morphology (notably the tail fork) and body colouration and patterns. © GWCT

For three years (2015-2017) in late summer, we sampled about 20 sites throughout the River Frome catchment, recording juvenile salmon and trout densities, habitat characteristics (observed in 50 quadrats per site: *Ranunculus* cover, water depth, proportion of fast and slow velocities, river substrate) and prey abundance (macroinvertebrates). To represent how mixed the water velocities were at a site, we aimed to capture the difference in velocity between neighbouring quadrats. We calculated the mean steepness of gradients in velocity between adjacent quadrats and averaged their absolute values to represent a site-level variable. We also used an annual salmon redd survey that is carried out on the Frome and its main tributaries, and determined site colonisation potential as the number of redds within one kilometre upstream of a study site.

In 2016, we unexpectedly observed a crash in recruitment of both salmon and trout: a trend that was later documented nationwide for salmon and thought to be caused by an especially warm and wet winter in 2015/16, which affected egg survival. Therefore, we decided to investigate fish density-habitat relationships both including and excluding this unusual year.

For both species, densities were reduced by at least 50% in the 'unusual' year relative to the two other years, driven by the dip in recruitment success in 2016. This highlights the overriding influence of recruitment success on the juveniles. In 'normal' years, juvenile salmon densities were best predicted by and positively associated with increasing *Ranunculus* cover, proportion of fast velocities and number of nearby upstream redds (see Figure 1a & b). These variables jointly explained 26% of the observed variance in salmon densities. In both 'normal' and 'unusual' years, water velocity variability was found to be an important predictor of trout densities, which were positively associated with more mixed velocities (see Figure 2). This could demonstrate an indirect influence of *Ranunculus* on trout densities, through its effect on water velocities.

Our study describes habitat characteristics that promote abundant juvenile salmon and trout in lowland chalk streams. Both an unexpected recruitment crash during this study and the importance of proximity to redds highlight the need to consider the influence of recruitment to habitat patches when exploring density-habitat associations. Additionally, knowledge of annual redd distributions would allow for more focused habitat conservation of sites with high colonisation potential, which our results suggest support higher juvenile densities. Our results suggest that salmon and trout have different habitat requirements and so ensuring in-stream habitat complexity could benefit both species. However, *Ranunculus* cover could be a key habitat characteristic for both species, either directly or by creating desirable habitat conditions. These findings are likely to be applicable to other lowland salmonid streams where *Ranunculus* plays a pivotal role in structuring the habitat.

KEY FINDINGS

- We found that juvenile salmon densities were positively associated with *Ranunculus* cover, fast velocities and proximity to spawning redds.
- Stretches of the river with a mix of fast and slow velocities were associated with the highest juvenile trout densities.
- The observed crash in recruitment in 2016 highlights the sensitivities of salmonid populations to larger themes, such as climate change.

Jessica Marsh

ACKNOWLEDGEMENTS

We acknowledge the generous funding provided by the G & K Boyes Charitable Trust. We are grateful for the help of GWCT staff and volunteers, Dave Cooling and James Pretty, in collecting and processing the data.

The use of enhanced released pheasants

A rearing pen with perching (above) provides a more interesting environment for young pheasants than a rearing pen without (see below right).
© Andy Hall/GWCT

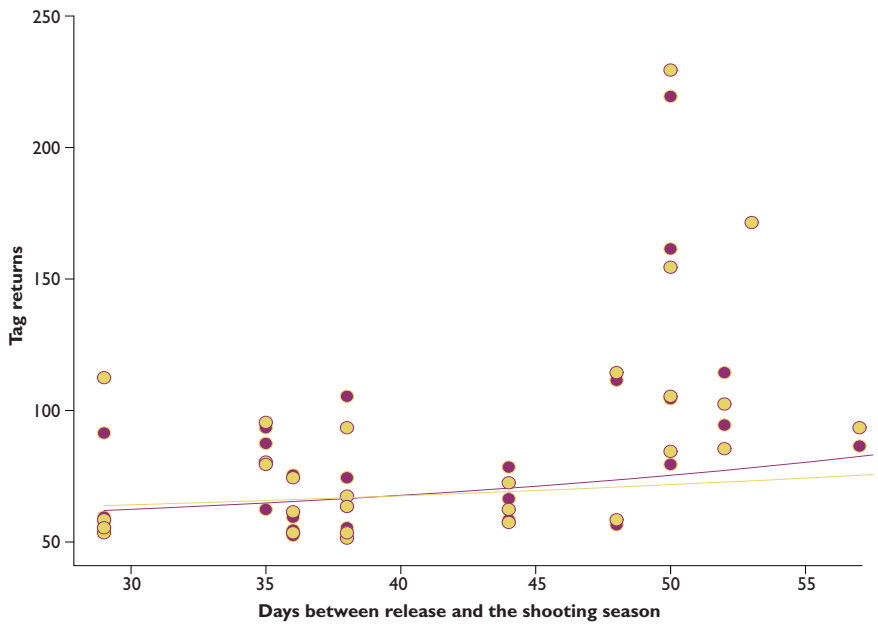
Rearing conditions involving dietary and physical enrichment are essential for improving post-release survival for captive-bred animals released for wildlife conservation, but for species released for other purposes, such as shooting, this is often not the case.

Typically only around 15% of the 65-70% of pheasants that are not shot remain after the shooting season, primarily due to an estimated 35% loss from predation. Survival rates after the shooting season are also very low, with birds released in previous years constituting <1% of the bag on large shoots. By contrast, pheasants bred and reared in the wild survive nearly seven times better than their pen reared cousins. Predator avoidance behaviours have been successfully taught to captive-bred gamebirds in the past, but integrating those fairly complex techniques into a commercial pheasant-rearing process would be neither viable nor cost-effective. It is often cheaper to simply release more pheasants, but increasingly this has ethical and environmental implications.

One behaviour key to avoiding predation is roosting at night. Reared pheasants rarely have opportunities to develop roosting behaviours or strengthen the appropriate muscles used in roosting prior to their release. In previous studies, the addition

Figure 1

Tag returns for enhanced rearing. For each datapoint the Y-axis is the total number of either Enhanced or Control birds shot from each individual release pen from the study (29 pens X 2 for each treatment = 58 data points). The X-axis is the number of days prior to the shooting season that the birds were placed into their release pens. The lowest at 29 = the latest release that we had on 2 September. The highest at 57 = the earliest release we had on 1 August



of perching material increased pheasant survival, as did providing a diet that more closely matches that of wild pheasants, but neither of these techniques have been tested within a commercial rearing environment. As such, the GWCT and the Pheasant Ecology and Cognition (PEC) team at the University of Exeter investigated if combining these methods within a commercial game farm could produce the same positive results in a cost-effective manner. We added perching material and an additional 1% feed weight of live mealworm and 5% wild bird seed mixes to a standard commercial pheasant rearing system, and after seven weeks of rearing, the birds were tagged and delivered to the shoots as normal. The aim of our enhanced pheasant project was to rear pheasants in a manner that increases their similarity to wild pheasants in the hope that their survival will also increase, allowing fewer birds to be released without reducing those available to be shot.

After the release of more than 10,000 tagged pheasants across eight shoots of differing sizes over two years, we found that enhanced pheasants were shot at a roughly 10% higher rate than standard birds. However, this increase was dependent on the time of release and scale of the shoot, with earlier releases and larger shoots having the greatest return rates of enhanced birds compared with standard birds. Late releases shot fewer enhanced birds than standard birds (see Figure 1). We also found that enhanced pheasants weighed less and had larger hearts, breast muscle, and tarsi relative to body weight than unenhanced individuals. One problem with the analysis was that enhanced rearing accounted only for a small amount of the variation in results between sites, with differences in land management, gamekeeping practices, and a plethora of other variables also impacting rates of return. Although these initial finding are positive, we believe that for greater accuracy this methodology needs to be applied to more shoots to collect a greater data sample. Furthermore, the studies that inspired this project showed that perching material alone increased release-to-shooting-season survival, while improved diet increased year-to-year survival. As such, rearing with perching material alone might offer greater efficiency to game rearers as the price of producing perching material was a fraction of the costs incurred from improving diet.

A rearing pen without perches. © Rufus Sage

BACKGROUND

We have been working with Exeter University on pheasants since 2010. Exeter have brought expertise in animal behaviour to our studies of how to improve rearing and releasing. An experimental study of enhanced rearing of pheasants (see *Reviews of 2013 and 2014*) showed that giving chicks early access to insects and wild seeds in their diet and to perches, improved aspects of their physiology, their ability to roost and their foraging and other behaviours during the post-release period. Here, the GWCT and Exeter University looked at how this enhanced rearing might benefit releasing for shooting in the real world.

KEY FINDINGS

- Reducing post-release losses to predation could lead to fewer birds being released while maintaining the same bag counts, making shooting both more environmentally sustainable and economically viable.
- A key factor that leads to higher predation in captive-reared pheasants is an absence of roosting behaviours. They also lack a natural diet that leads to poorer foraging efficiency. By providing pheasants with perching material and an improved diet for their first six to seven weeks of life, there was about a 10% increase in pheasants shot. This increase was also linked to earlier release dates and larger shoots, with fewer enhanced pheasants shot when releases were late. Enhanced pheasants also flew higher, weighed less, and had larger hearts, breast muscles and tarsi.

Andy Hall
Rufus Sage
Joah Madden

Breeding waders in the Avon Valley

Wet scrapes are important for wader foraging. Three four-week-old lapwing chicks, two adult lapwing and an adult redshank can be seen on this scrape.
© Lizzie Grayshon/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. 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.

The Avon Valley is typical of lowland river valleys where breeding waders were once numerous and are currently a conservation priority, but where reducing the impacts of predators is constrained by the landscape and multiple land ownership. The Waders for Real project comprises a local farmer-led initiative involving the private sector (farmers and landowners), conservation charities (GWCT, Hampshire & Isle of Wight Wildlife Trust), educational establishments (Sparsholt College) and the public sector (Natural England, Environment Agency) in an attempt to find workable options for wader recovery.

Our approach is to put into practice the three principles applied in wild game management, namely: (1) ensuring appropriate nesting habitat; (2) creating brood-rearing habitat; and (3) reducing predation pressure. Habitat assessments, monitoring data and tracking data from radio-tagged lapwing chicks have allowed us to plan habitat improvements more effectively.

Habitat work

We understand that low breeding success of lapwing is partially caused by unfavourable habitat. Our hotpot sites are focused on areas already holding important numbers of breeding waders and have each received habitat management improvements, monitoring and advice targeted at increasing productivity and breeding densities.

We have removed 1,260 metres of old fence lines and 6,015 metres of scrub along ditch lines to create groups of fields with more open boundaries. We have re-profiled 3,890 metres of ditches and added 1,690 metres of new ditches along with 10,540m² of scrapes. These shallow depressions of exposed soil retain water and provide a rich source of invertebrates on which wader chicks feed, along with soft mud to make feeding by probing easier (see *Review of 2016*, pp 22-23).

Working with land managers

Many of the farmers involved in the project have modified grazing and cutting regimes to help us maintain a short, damp sward perfect for lapwing, with scattered tussocks

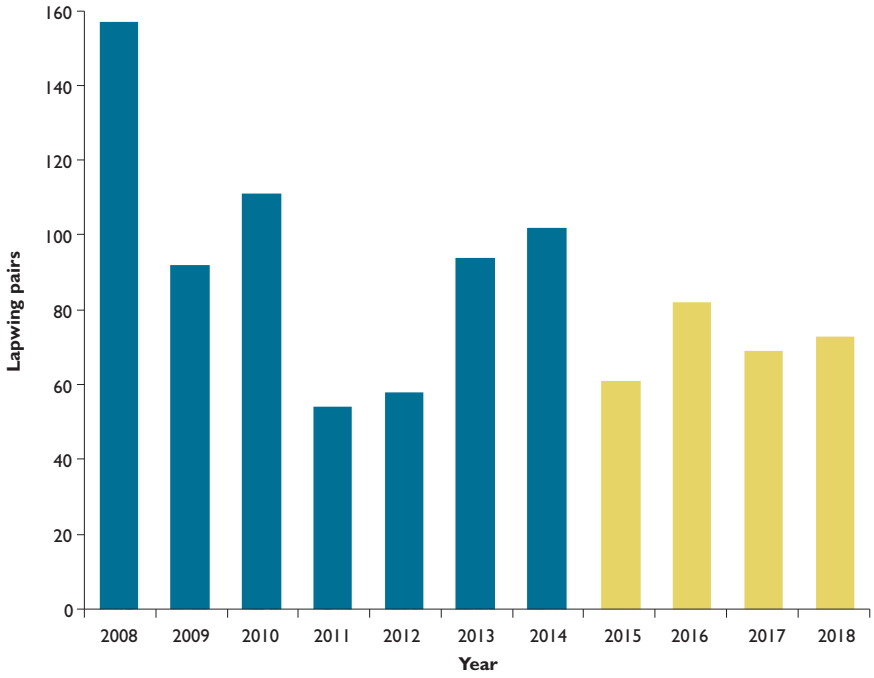


Figure 1

Trends in lapwing pairs in the Avon Valley since 2008. This work demonstrates what can be achieved when conservation organisations work closely with land managers: the combined knowledge and resources can halt decline, be that for breeding waders or any other farmland wildlife, with scope for recovery in the future

Before project

During recovery project

of soft rush, the favoured nesting habitat of redshank. To alleviate predation pressure from mammal predators and improve productivity, we have been trialling electric exclusion fencing to protect nests. Although we know they are not entirely fox-proof, we have records showing that they can improve nest survival rates. Local gamekeepers have received training in best-practice predation control methods, with some of them buying new equipment; two estates have invested in thermal imaging scopes. They have increased levels of legal, targeted predator control in spring to give wader nests and chicks better protection than previously.

Monitoring

We have documented a change in the trend of breeding lapwing since the start of the project and are starting to see numbers stabilise at close to 80 pairs (see Figure 1). We put this down to a combination of habitat restoration, increased predator management and engagement with the land managers involved. Despite exceptional, extensive flooding in April 2018, followed by a very dry summer, lapwing and redshank fledging rates were good, with broods making heavy use of in-field features that remained damp. Redshank have responded better than lapwing, increasing from 19 to 33 pairs and, for the first time for at least 10 years, two pairs of snipe were present at one hotspot site throughout the summer of 2018. There is still much more to be done to achieve a fully functional landscape for waders throughout the valley, but it is encouraging to see a halt in the downward trend recorded prior to 2015 and a collective desire among the farming community to see more birds on their farms again.

Electric fences are being used to exclude foxes and badgers to improve nest and chick survival.
© Lizzie Grayshon/GWCT

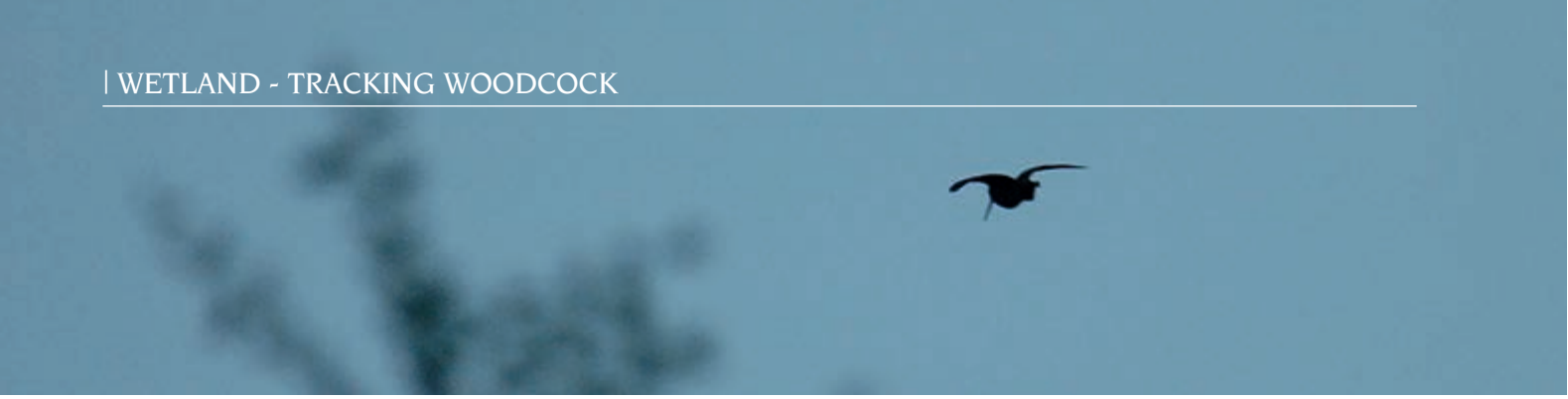
KEY FINDINGS

- Each of our four hotspot sites for breeding waders has seen habitat management improvements, targeted advice and detailed monitoring of outcomes.
- Working closely with farmers, keepers and land mangers has been essential to the project and its success.
- Since starting the project we have seen a stabilisation in numbers of breeding lapwing in the valley and an increase in numbers of breeding redshank.

Lizzie Grayshon
Ryan Burrell
Andrew Hoodless

ACKNOWLEDGEMENTS

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



The value of GPS tracking in woodcock studies

Our tracking work has revealed the astounding journeys made by migrant woodcock each spring. © Andrew Hoodless/GWCT

BACKGROUND

Britain and Ireland support a relatively small resident breeding population of woodcock estimated at 55,240 males in 2013, which has undergone a 56% decline in range since 1970. The woodcock was red-listed as a 'Bird of Conservation Concern' in December 2015 owing to the contraction in its UK breeding range. The European breeding population is estimated at seven to nine million males and shows a stable trend. In winter, we see an influx of 800,000-1.3 million migrant woodcock from Norway, Sweden, Finland, the Baltic states and Russia. Because woodcock are not easily observed, we are dependent on tagging individuals to learn about their habitat requirements, movements, breeding and survival. Tags using GPS technology are now available for smaller birds, such as the woodcock, enabling us to gain detailed insights into their movements and behaviour.

Our woodcock research has long depended on tracking individuals to study their behaviour and learn their fates. Various radio-tracking studies (employing a VHF transmitter on the bird and a hand-held receiver) since the late 1970s have uncovered the breeding system of the woodcock, details of habitat preferences during the breeding season and in winter, and survival rates. More recently, our satellite tracking (using tags transmitting to Argos satellites) has revealed the astounding journeys made by migrant woodcock each spring. Now, small GPS loggers, which passively record satellite signals to estimate location, are enabling us to collect many more locations (typically 400-700) of far greater accuracy (generally to within five to eight metres) within a 12-month period.

We urgently need to understand how best to manage habitat for breeding woodcock and the factors influencing breeding success. Since summer 2015, we have been using GPS tags to study woodcock during the breeding season. We have obtained data on the habitats used for feeding and roosting during the day, and the locations of foraging sites visited at night. For instance, male woodcock in Nottinghamshire left woodland, on average, on 19% of nights to visit arable fields, rough grassland and heathland that were typically within 400 metres of the woodland boundary. There was high variation between individuals, with just over half (53%) of tagged birds feeding entirely within woodland at night (at ride sides, clearings and clearfells). This work is ongoing, to build up a larger sample of birds in a wider variety of locations and to gather data from females as well as males. The eventual aim is to use the information to create management guidelines enabling managers to improve woodland for woodcock.

Because GPS tags can record movements at very short time intervals, they are useful for examining the roding display of male woodcock. GPS tags have allowed us to determine the frequency and timing of roding, plot display flights and estimate roding areas. Previously, the average roding area, crudely estimated by two or three observers simultaneously monitoring a radio-tagged bird, was 88 hectares (ha). Our data from 16 roding males with GPS tags suggests that roding areas may be larger than this. While there is reasonable consistency in the irregular loops comprising the display area used by the same bird on consecutive nights, the tracking has shown large variation in the display patterns of individuals (see Figure 1).

Figure 1

Tracking data from two male woodcock recorded during the dusk display period. Each bird was recorded for 90 minutes per evening for two days: 12/06/2016-13/06/16 (blue) and six days: 29/04/2016-04/05/2016 (pink). These birds were caught in clearings less than 200 metres apart but demonstrated different roding behaviour. (Landsat/Copernicus image © Google Earth)

Figure 2
Migration route of a woodcock tagged in Cornwall in February 2016, showing an autumn migration route more northerly than its spring route. This bird left its winter site on 23 March 2016 and arrived at its breeding area in Russia on 9 April 2016. It left its breeding site on 3 November and was back in Cornwall on 24 November. (Landsat/Copernicus image © Google Earth)

GPS technology is also helping us fill gaps in our understanding of woodcock migration and the behaviour of migrants on their breeding grounds. By deploying geolocators and satellite tags over the last seven years, we now have good knowledge on the timing of migration, origins of migrants wintering in Britain and Ireland, and spring migration routes. However, owing to the poor solar charging of satellite tags on woodcock between late summer and late winter, and the low positional accuracy of geolocators (typically 50-150 kilometres), we are lacking high-quality data on autumn migration routes and the behaviour of birds at breeding and wintering sites. GPS loggers are much cheaper than satellite tags (about a tenth of the cost) and can record at least two accurate locations a day for a year without relying on solar charging. Despite the need to recover the logger to download the data, we have been able to obtain data from 22% of the 68 deployed over the last two years.

GPS tags have revealed that woodcock generally migrate at heights of 500-1,000 metres (1,500-3,000 feet). We have recorded some discrepancy between spring and autumn migration routes, with woodcock typically making their way to Britain and Ireland in autumn via a more northerly route than that taken to the breeding site in spring (see Figure 2). Although we plan to collect more data and conduct a formal analysis of habitat selection, movement data obtained to date suggest regular use of woodland edges and relatively young woodland on the breeding grounds (see Figure 3).

KEY FINDINGS

- GPS technology provides data of appropriate resolution of both space and time to enable us to investigate woodcock roding behaviour.
- GPS tags are yielding accurate data on habitat use at British and foreign breeding sites, which will help us devise best practice management guidelines.
- We are now able to complete our work on woodcock migration, gaining a better insight into nocturnal flights and autumn migration routes.

Andrew Hoodless
Chris Heward

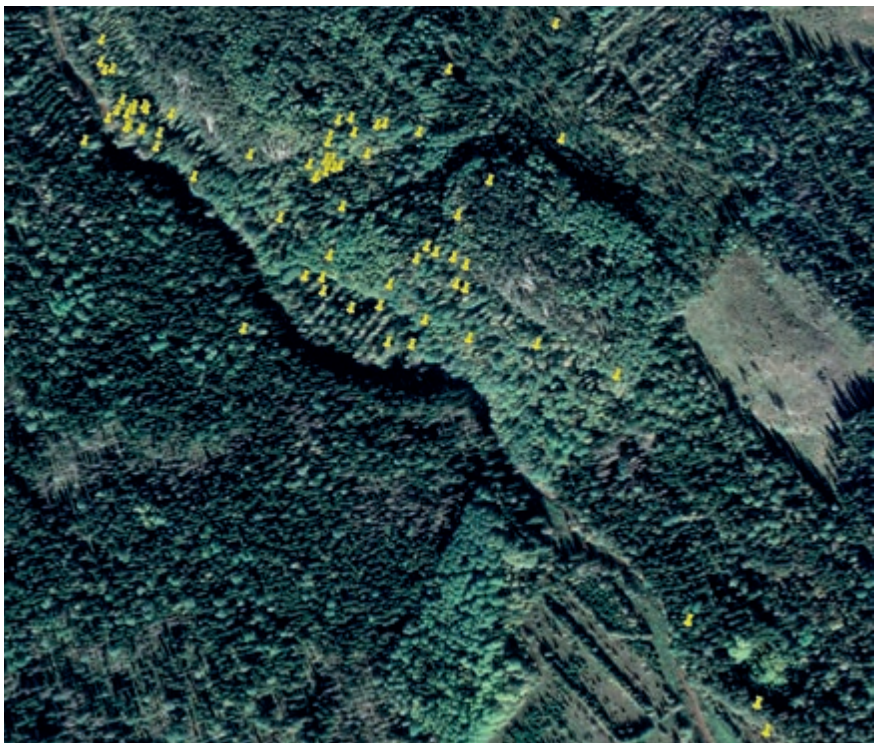


Figure 3
Daily breeding site locations (taken at 12.00 GMT) near Khiytola, Russia, between 31 May and 13 September, showing a preference by this bird for young woodland and edge habitat. This woodcock was probably a male and is the same bird as in Figure 2. (Landsat/Copernicus image © Google Earth)

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

National over-winter survival only dropped from 55% to 53% despite the cold weather in spring 2018. © Dave Kjaer

KEY FINDINGS

- National over-winter survival for 2017/18 was 53%.
- Productivity, recorded as Young-to-Old ratio, increased by an average 13% to 2.6 young birds per adult.
- Average autumn density across all PCS sites increased 8% to 21 birds per 100ha.

Neville Kingdon
Julie Ewald

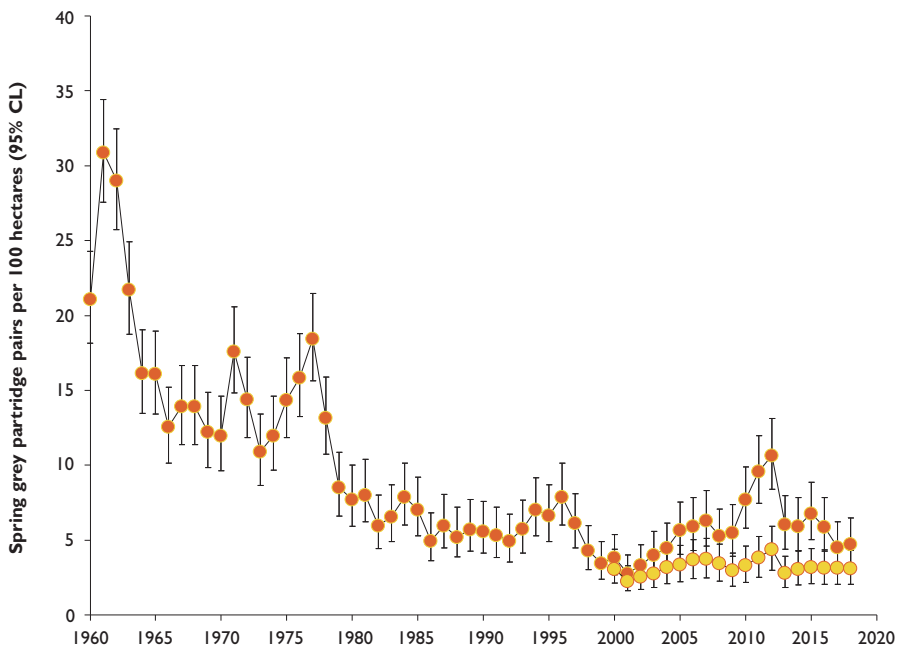
In spring 2018, Partridge Count Scheme (PCS) members submitted 470 spring counts, down from 527 the previous year. A total of 5,532 pairs of grey partridges were counted on 144,710 hectares (ha), down 274 pairs (-5%) on spring 2017 when a total of 171,350ha was counted. The grey partridge stronghold in eastern England continues to report nearly two-thirds of all the pairs recorded in the PCS, yet comprises only one third of participating sites. Nationally, spring pair density decreased by 10% to 3.8 birds/100 ha, although pair densities in southern England and the Midlands remained static. Pairs in eastern England and Scotland increased by around 5%, achieving averages of 2.2 to 5.1 pairs/100ha. Northern England recorded the largest decline (-29%) in pair density.

The national average over-winter survival (OWS) rate for 2017/18 was 53%, a small drop from the 55% of 2016/17. As a 'Barometer of the Countryside' this is good news for grey partridges regarding losses during the winter period. Many PCS members made particular comment about the cold and snowy weather at the beginning of spring 2018, and about the subsequent rain. Although PCS members in eastern England recorded the largest decline (-13%) in OWS to 53%, as compared with their 61% OWS in 2016/17, their OWS was at a high starting point compared with most other regions of the UK.

Summer 2018 stands out as one of the warmest and driest summers of the past 100+ years, with little appreciable rainfall for most areas (parts of southern England recorded less than 5% of the June average rainfall), until August when average temper-

Figure 1

Trends in the indices of grey partridge density, controlling for variation in the 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 2017 and 2018, 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	*2017*	**2018**	*2017*	**2018**	**Change (%)**	*2017*	**2018**	*2017*	**2018**	*2017*	**2018**	**Change (%)**
South	61	63	1.9	1.9	0	79	81	2.3	2.0	12.1	9.8	-19
East	141	141	4.8	5.1	6	133	143	2.3	2.7	21.7	22.3	3
Midlands	100	85	2.9	2.9	0	91	91	2.3	2.3	18.0	19.4	8
Wales	3	2	2.3	0	-100	3	2	1.8	-	4.4	0	-100*
North	134	109	6.8	4.8	-29	134	111	2.4	3.0	26.8	36.7	37
Scotland	87	69	2.1	2.2	5	73	69	2.3	2.5	11.1	11.3	2
N Ireland	1	1	9.9	7.9	-20	1	1	0.3	1.0	5.3	13.3	151*
Overall	**527**	**470**	**4.2**	**3.8**	**-10**	**514**	**498**	**2.3**	**2.6**	**19.3**	**20.8**	**8**

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

atures returned. While wildfires and flash floods made the news, it was brood-rearing habitats and sufficient chick-food insects for hatching broods that were of more concern to partridge managers.

The PCS received 498 autumn counts in 2018 (see Table 1). The total number (old and young) of grey partridges recorded nationally was 24,600. The total area counted covered 154,510ha. This was 5% less than the 161,750ha counted in autumn 2017 and the average area counted by PCS members remained stable at 321ha (down from 324ha in 2017).

Autumn density for the UK was 20.8 birds per 100ha, up 8% from 19.3 per 100ha in autumn 2017, but there was a wide variation between regions with the highest densities recorded in northern England (34.6 birds per 100ha) and, other than Wales, the lowest being southern England (10 birds per 100ha).

The Young-to-Old ratio (YtO), an easy measure for comparing breeding success, recorded a national increase of 13% from 2.3 to 2.6 young birds to every adult and remained well above the 1.6 threshold level necessary to cover adult losses into next year. The southern regions noted a decline in YtO (-13%).

Weather has certainly dominated the partridge counts of 2018. Both partridges and counters faced challenging conditions in the first few months of the year, only to be followed by a summer we have all wanted in a good while. But the many weeks of heat resulted in an advanced harvest. This was well underway by the time autumn counts began and, for PCS participants, it had an impact on access for counting to varying degrees. Regardless, overall 2018 has been a positive year for grey partridges and if winter survival for 2018/19 is as obliging then we hope to have good news to report in the spring counts.

An early harvest meant that autumn counts were easier to undertake. © 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 area of permanent habitat managed for partridges increased from 11% in 2010 to 15% by the end of 2018. © 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). In 2011, the estate entered a 10-year Higher Level agri-environment Scheme contract with Natural England, which allowed for additional partridge habitat to be established (mainly wild bird seed mixes, cultivated uncropped margins, beetle banks, overwintered and extended stubbles). Additionally, a long-term partridge-friendly hedgerow management plan was implemented. This resulted in a general increase of wildlife-friendly habitat measures established on formerly arable land, particularly in the core recovery project area, where most of the re-established partridges are found. There, the area of permanent habitat managed for partridges increased from 11% in 2010 to 15% by the end of 2018.

On the Trust side, we counted a minimum of 101 wild grey partridges in autumn 2018 (20 males, 16 females and 65 young from 11 broods). Spring 2018 was unusually wet and June-August exceptionally dry. This resulted in bigger brood sizes (5.9 young/brood) than in 2017 (4.5 young/brood). It was also higher than the average for southern England (5.4 young/brood), but the same as the national average which was 6.0 young/brood. Only 11 of 24 spring pairs (45.8%) produced a brood, with 16 hens (67%) surviving into autumn (see Figure 1). It remains unclear what caused the high rate of failed broods at Rotherfield in 2018. However, availability of suitable spring cover was exceptionally poor because of failures in the establishment of rotational wild bird seed mixes and cultivated uncropped margins, which may have allowed additional spring predation by raptors and resulted in insufficient amounts of suitable insect-rich

Figure 1

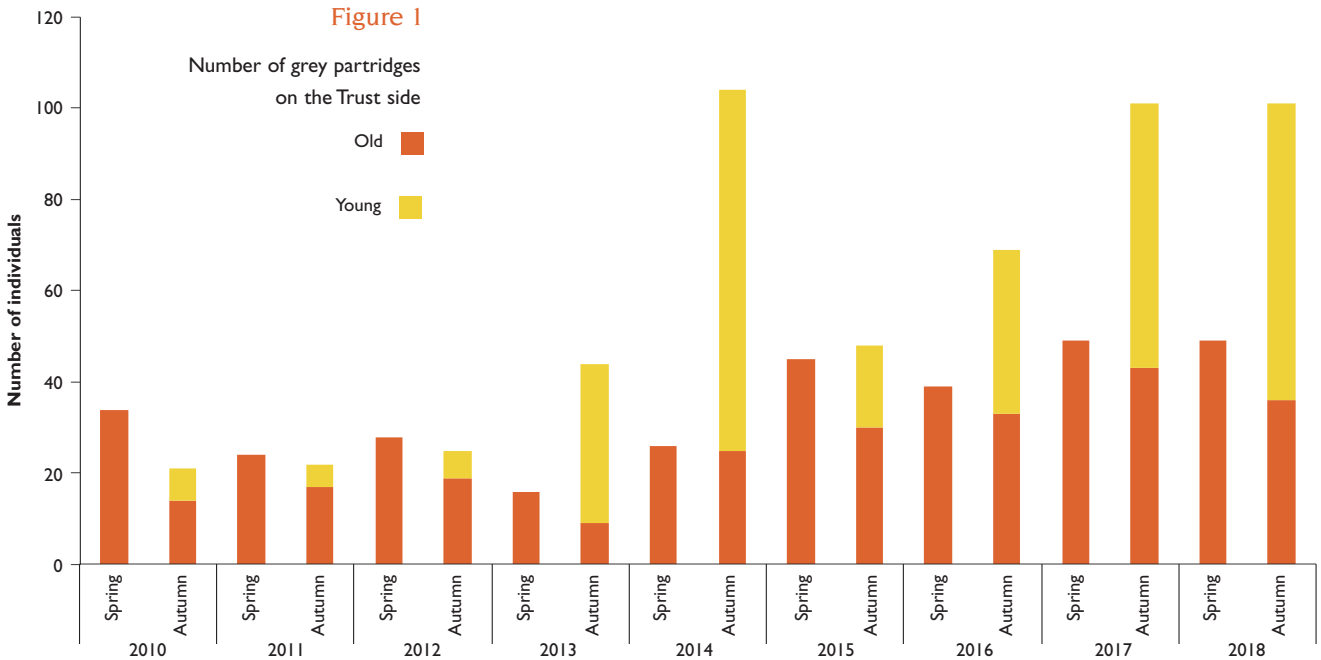


TABLE 1

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

Year		Spring pairs*			Autumn stock**		
		Trust	Estate	Total	Trust	Estate	Total
Grey partridge							
2018 (2017)		24 (23)	2 (1)	26 (24)	101 (101)	12 (2)	113 (103)
Red-legged partridge							
2018 (2017)		44 (44)	9 (18)	53 (62)	202 (138)	52 (35)	254 (173)
Pheasant							
2018 (2017)	Hens	207 (255)	96 (100)	303 (355)	347 (413)	145 (102)	492 (515)
	Cocks	170 (199)	92 (117)	262 (316)			

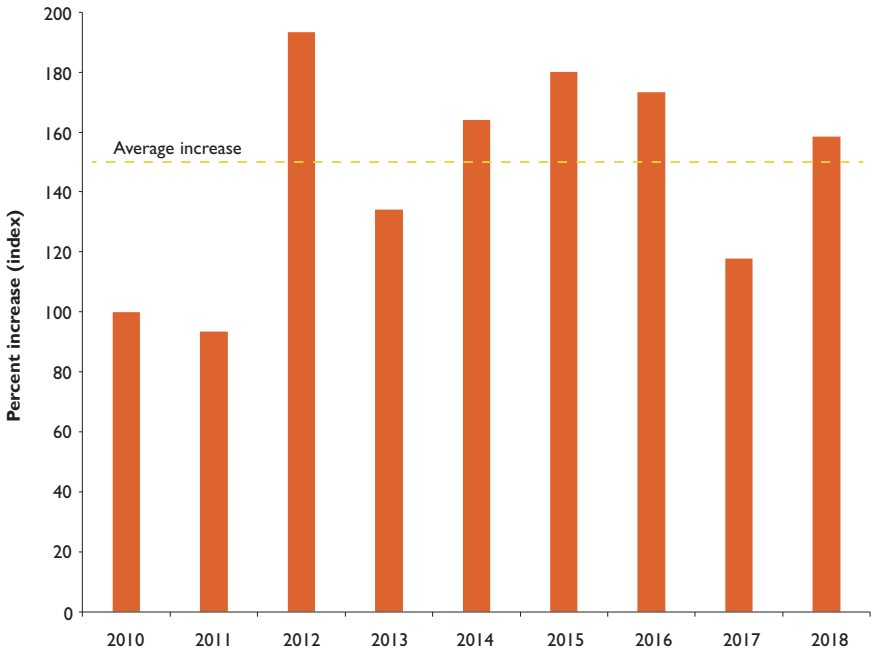
**For grey and red-legged partridges in spring, the numbers given are pairs; for pheasants, numbers of cocks (excluding released birds) and hens are tallied separately. ** Autumn stock is the number of cocks, hens and young combined. On the Trust side, 600 cock pheasants were released each year since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

foraging cover during the breeding season. On the Estate side, two spring pairs were counted, of which one produced a brood.

2018 was the third year since the project began in which autumn grey partridge numbers reached just over 100 birds. Given the still fragile size of the isolated re-introduced population, and a bag of 12 birds during the 2017/18 shooting season, the stable population size indicates that suitable management practices are in place to allow for further recovery, especially if habitat management practices continue to improve.

The dry summer conditions clearly suited the red-legged partridges at Rotherfield. The Trust side saw 24 broods producing 100 young (in 2017 14 broods produced 49 young), the highest number since the project began. The Estate side had seven broods producing 19 young (three broods with four young in 2017).

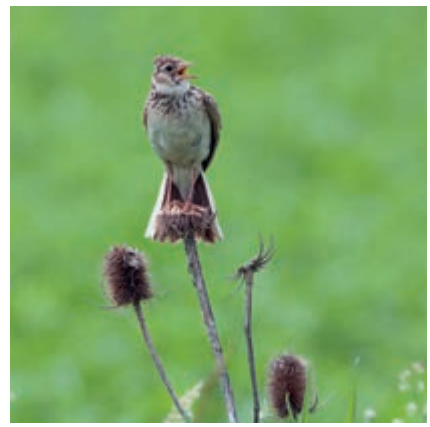
The habitat and predator management measures put in place for grey partridges since 2010 have also resulted in noticeable increases of farmland songbirds of conservation concern during the breeding season. On the Trust side, otherwise nationally declining farmland birds such as yellowhammer, skylark, linnet, dunnock, song thrush and whitethroat, have increased by an average of 52% over the past eight years (based on April, May and June counts along a 10 kilometre transect). In 2018, we recorded 59% more birds than at the start of the project, with the highest increase recorded in 2012 (93%).



KEY FINDINGS

- In 2018, the number of grey partridge spring pairs on the Trust's demonstration area was 24 pairs, one more than in 2017, the highest since the project began.
- On the Trust's area, the grey partridge autumn stock was 101 birds, the same as the year before.
- Since the project began in 2010, farmland birds of conservation concern have increased by an average of 52% in the project area, while national numbers keep declining.

Francis Buner
Malcolm Brockless
Nicholas Aebischer



Nationally declining birds such as the skylark have increased by an average of 52% over the past eight years. © 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 193 in 2012 for example, means that numbers have increased by 93% compared with the baseline year

Fifty years of the Sussex Study

Recent changes on the Sussex Study area include dividing fields and a return to patchwork cropping. © Jen Brewin/GWCT

BACKGROUND

In 2018, we celebrated 50 years of the Sussex Study. The study began in 1968, with Dick Potts employed to investigate the reasons behind the decline of grey partridges on the Sussex Downs. Dick began work on North Farm near Findon and over the next two years expanded the study area to cover an area from the River Arun in the west to the River Adur in the east (see Figure 1). Here we review some of the changes that have taken place on the study area and how results from the Sussex Study have informed both researchers and policy makers and will continue to do so.

The Sussex Study area encompasses 38km² (9,000 acres) of rolling farmland on the South Downs of west Sussex, comprising chalk soils and including small remnants of traditional chalk downland. Six farms make up most of the study area, with an additional six farms covering smaller areas. All the farmers currently practise some form of mixed farming, including both sheep and cattle. Although dairy farming was once common across the area, in 2018 there was only one dairy farm remaining. Three of the large farms have active shooting interests that range from wild grey partridge shoots to commercial enterprises with released pheasants and red-legged partridges. It is thanks to the generosity of the landowners, farmers, their families, farm staff and gamekeepers that the Sussex Study has continued through 50 years. They have allowed access for surveying, provided information and advice and, most importantly, friendship to those of us lucky enough to work on their ground. We are profoundly grateful to them all.

Changes in cropping across the study area reflect the pattern across the country over the last 50 years. Farming on the study area in the late 1960s and early 1970s followed a traditional rotation system. Grass crops or leys were followed by several years of cereal crops, culminating in a spring-sown cereal crop that was undersown with grass, resulting in a grass ley that was grazed and hayed over several years. Break crops of roots, fallow or fodder crops were interspersed in the rotation. This system supported the mixed farming practised on the area, providing fodder for livestock as well as grain. In the early years, the most commonly planted cereal crop was spring barley, and two farms have maintained a similar rotation throughout the 50 years. On the remainder of the area, the predominance of spring barley was replaced by winter-sown wheat through the 1980s and into the 1990s, with a loss of undersowing as a means of establishing grass leys in the 1980s. The end of the 1980s saw the beginning of the Environmentally Sensitive Area Scheme (ESA) on the study area, with many former arable fields reverted to closely-grazed permanent grass. By the mid-1990s fields of oilseed rape and occasionally linseed had replaced the earlier break crops. Set-aside began in the later 1990s, continuing until 2008 and provided some diversity in the habitat available on farms where winter wheat had come to dominate the rotation – often planted in large blocks. The expansion in field size, which had begun in the later 1970s when the UK joined the Common Agricultural Policy, reached its zenith in the late 1990s, with block cropping as well as field expansion across most of the study area resulting in big blocks of either winter wheat or grass leys. In the last decade and a half, several of the large farms have implemented new conservation management, with field sizes cut in half and a return to a more mixed rotation.

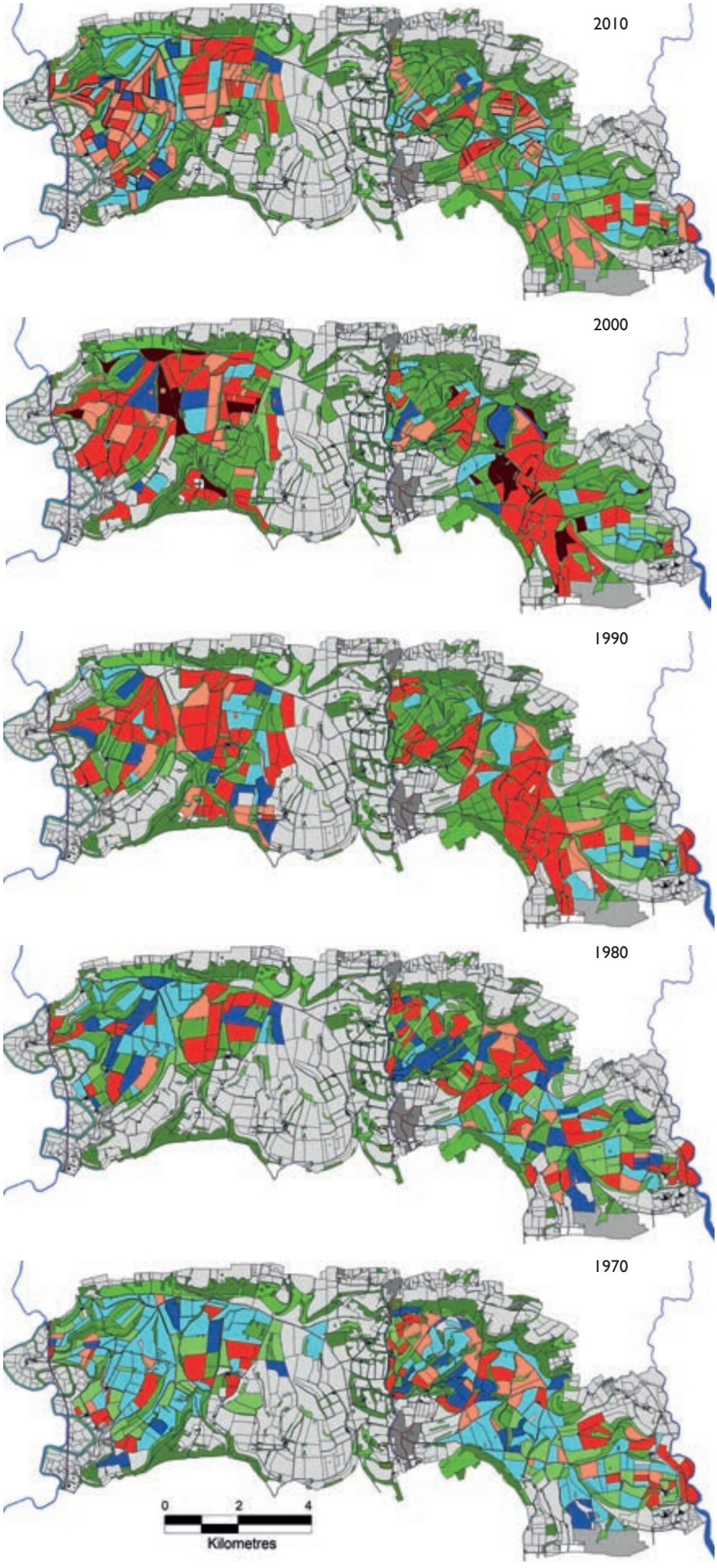


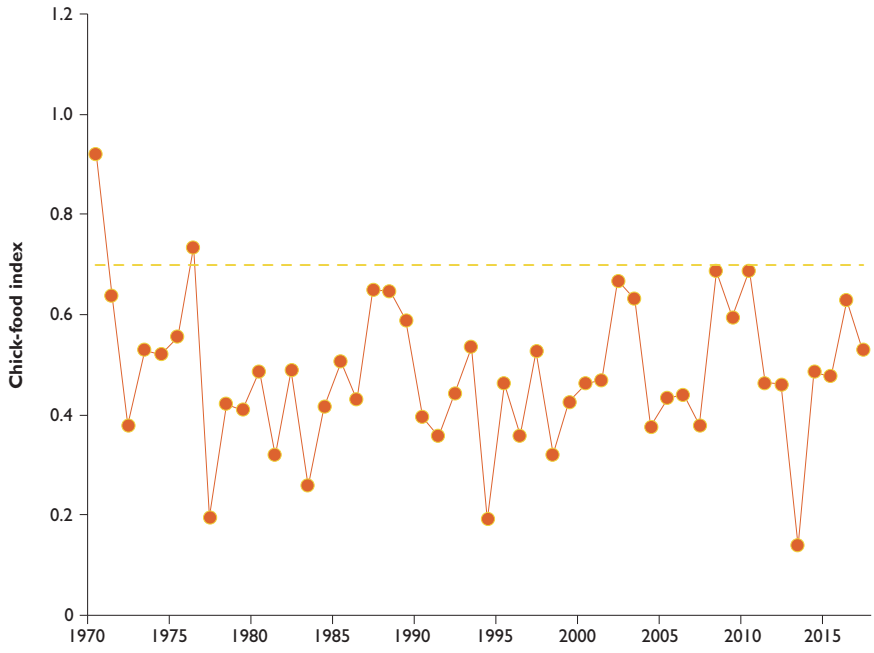
Figure 1

Changes in cropping over the five decades of the Sussex Study. Although mixed farming has remained the main land use on the study area, the detail of that management has changed, reflecting both agricultural policy and developments in agronomy over the time of the study

- Break crops
- Direct sown grass
- Undersown grass
- Set-aside
- Spring cereals
- Winter barley/oats
- Winter wheat

Figure 2

Changes in the average grey partridge chick-food index across the 50 years of the Sussex Study. The dotted line indicates the value needed to maintain numbers of grey partridges



KEY FINDINGS

- Mixed farming has been the predominant land use on 38km² of the Sussex Study but there have been changes in how this is done over the past 50 years. Recent years have seen an increase in agri-environment options on the area and a return to sowing spring cereals.
- The monitoring undertaken on the Sussex Study area has contributed to the design of agri-environment options, and informed agri-environmental policy, particularly Environmentally Sensitive Areas in the past and Farmer Clusters currently and in the future.
- Ten km² of the area has been managed as a wild grey partridge shoot since the mid-2000s, thereby restoring grey partridge numbers to 1960s levels.
- Monitoring will play an important part in informing researchers, farmers and policy-makers about agri-environment policies post-Brexit. Long-term trends of chick-food insects on the study area highlight the effects of weather and farming practice as well as the effort required to increase chick-food insects on farmland.

Julie Ewald
Nicholas Aebischer
Steve Moreby

This included a variety of cereal crops – leaning more towards spring-sown barley – and incorporated agri-environment options such as conservation headlands, beetle banks and wild bird covers as well as minimum tillage.

The wildlife monitoring centres around the life of the grey partridge – the reason the study began in the first place. In the third week of June (peak time for grey partridge chick hatching) we record arable flora and measure the abundance of invertebrates in cereal fields. In the autumn, following harvest, we map grey partridge family groups (coveys) recording their age and sex composition.

The Sussex Study team has, over the 50 years, investigated the effects of changes in arable management on the monitored flora and fauna of the cereal ecosystem. Early work by Dick Potts, Keith Sunderland and Paul Vickerman made the connection between the survival of grey partridge chicks and insects in cereal fields (see Figure 2). Declines in insect numbers reflected declines in arable flora in the fields caused by the widespread use and the increasing spectrum of activity of herbicides applied to crops. Widespread use of insecticides on the study area was first documented in 1975, becoming routine across the area by the late 1980s – reflecting crop management UK-wide. In the 1980s, the results from insect monitoring on the Sussex Study were one of the driving forces behind the GWCT's Cereal and Gamebirds Project, resulting in the development of conservation headlands and beetle banks. This illustrates how the monitoring on Sussex has come full circle, as GWCT's research into methods to

Research undertaken on the Sussex Study area helped to understand the importance of insects for partridge survival. © Peter Thompson/GWCT

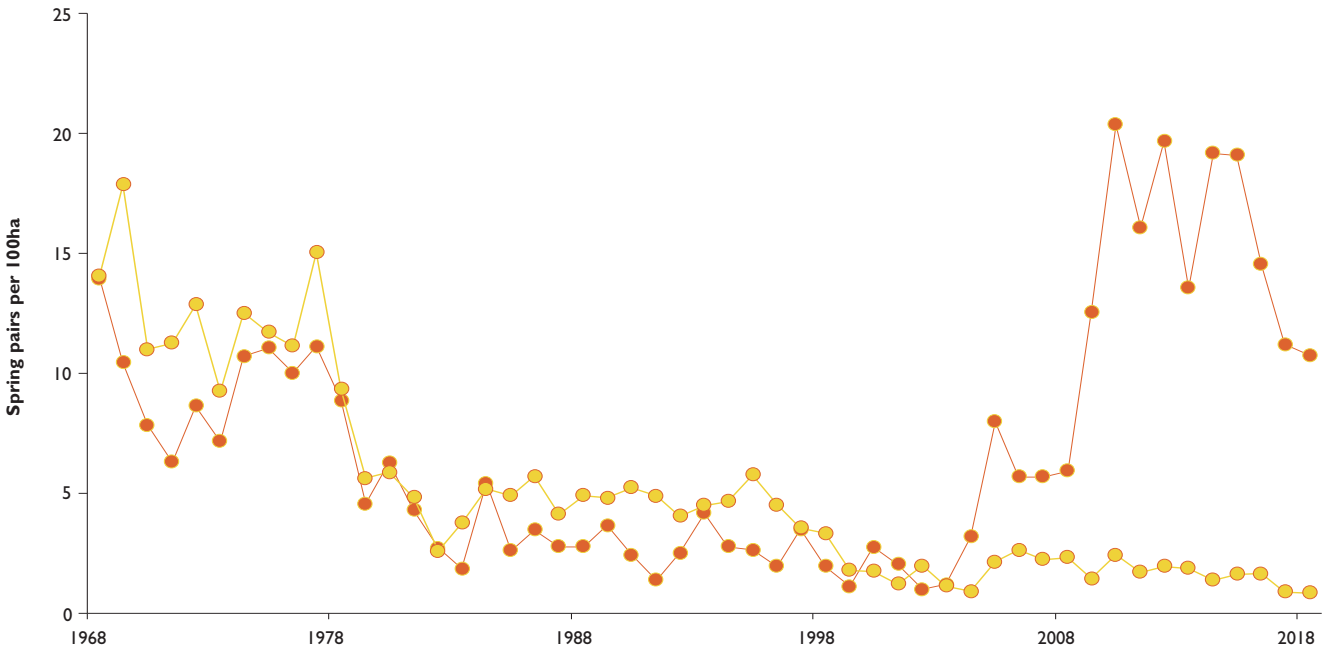
The Sussex Study began in 1968 to monitor the fortunes of grey partridges and changes in arable farmland. © Dave Kjaer

counteract the negative effects of agricultural intensification, informed by the Sussex Study, have been adopted into Government agri-environmental policy and are now being implemented on the study area. Similarly, monitoring within the Sussex Study fed into changes in policy for the ESA, with elements of low-input mixed farming, such as undersown leys, incorporated into this programme in the 1990s. In the last decade, it was the results from the Sussex Study that highlighted how one farmer restored grey partridge numbers to 1960s levels across 10km² of the study area (see Figure 3) that set the scene for Farmer Clusters. The Sussex Study area was incorporated into one of the first Farmer Clusters, the Arun to Adur Farmer's Group.

Looking to the future, the GWCT's Sussex Study will continue to provide a signpost to what is happening in the British countryside. The effect of Brexit on farm management and wildlife is likely to be substantial. It is important that we carry forward many of the successes that have arisen out of current policy – Farmer Clusters, agri-environment options – and that we continue to have farmers on the land. We need to bear in mind the advice from Chris Passmore, of Applesham Farm, who has been a part of the Sussex Study longer than any of us: "The best thing for a farm is the farmer's feet in the field". The farmers on the study area are committed to incorporating conservation in their management. It is important that farm policy provides them with the support to do this and farm profitably at the same time. The Sussex Study will continue to monitor the effects of that policy in the future.

Figure 3

Changes in grey partridge breeding density across the 50 years of the Sussex Study. The area managed as a wild grey partridge shoot from 2004 is in orange, the remainder of the study area is in yellow. Before the shoot management began this area held a lower breeding density of grey partridges than the remainder of the study area. Since 2004 the situation has reversed



Ground beetles on arable land

Field margins have increased on the farm and provide a range of overwintering habitat. © Peter Thompson

BACKGROUND

Between 1972 and 1974, Dick Potts and Paul Vickerman from The Game Conservancy Trust (now the GWCT) sampled ground beetles on a farm in Sussex. This was a time of great changes in farming and so this work intended to show how farmland beetles reacted to new farming methods. The samples were recovered in 2015 and Dick, who by this time had retired as director general, realised that this provided a unique opportunity to re-run the sampling and measure the changes more than 40 years later. Dick set the wheels in motion to gather a further three years' data between 2016 and 2018.

The apparent declines in insects have attracted much media attention over the last year with one controversial publication stating that insects had declined by 76%. Dick and Paul's early work (see background box) offers us the opportunity to measure differences in ground beetles *(Coleoptera: Carabidae)* between the early 1970s and today.

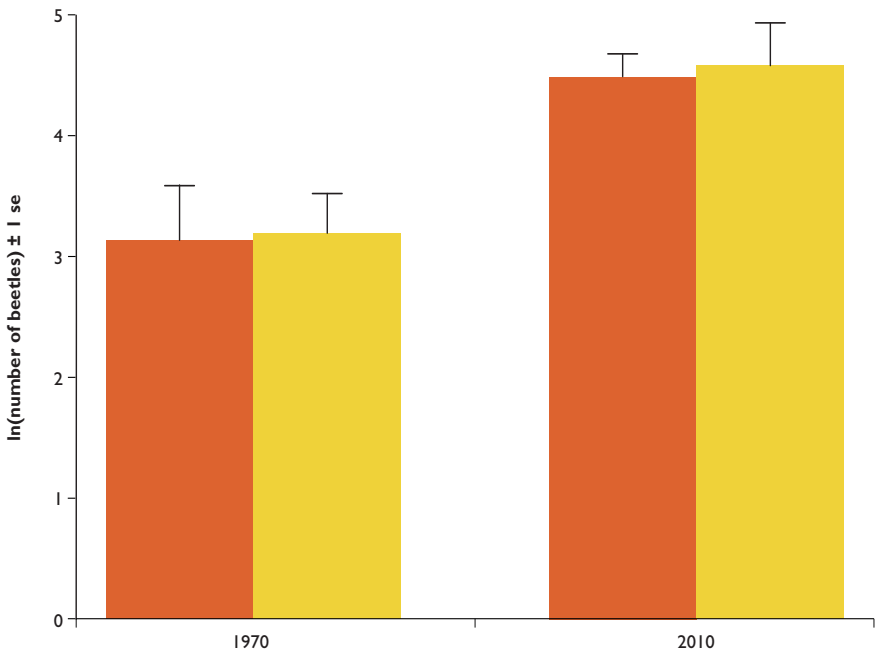
Ground beetles are a species-rich family with a range of feeding, dispersal and breeding strategies. Many species are agriculturally beneficial, eating insect pests or slugs, and in turn are prey items for many bird species including grey partridge chicks. The complexity of their life history and feeding strategies makes them an ideal group to help unravel the effects of farming practices.

The samples were taken in both time periods by setting pitfall traps (pots dug into the ground and filled with water – designed to capture beetles as they move across the ground and fall into the pot) in the same locations, fields and types of crops. They were collected weekly between late April and harvest at the end of July/early August in 1972-1974 and 2016-2018. The 2018 samples are still to be identified and analysed.

Rather than declining in numbers, as might be expected as a consequence of intensification of agriculture, numbers of beetles captured have increased four-fold (see Figure 1). Around half of all 46 species found were present during both time periods – of these, 14 species increased, eight decreased and two remained the same. Thirteen species present in the 1970s were not found in the 2010s, whereas nine new species were found in the 2010s. The most prevalent species in both decades was the large predator *Pterostichus melanarius*. While in the 1970s it accounted for 30% of all individu-

Figure 1

Mean number of ground beetles caught per pitfall trap in Sussex in 1972-74 and 2016-17



Pterostichus melanarius. © J. Walewski

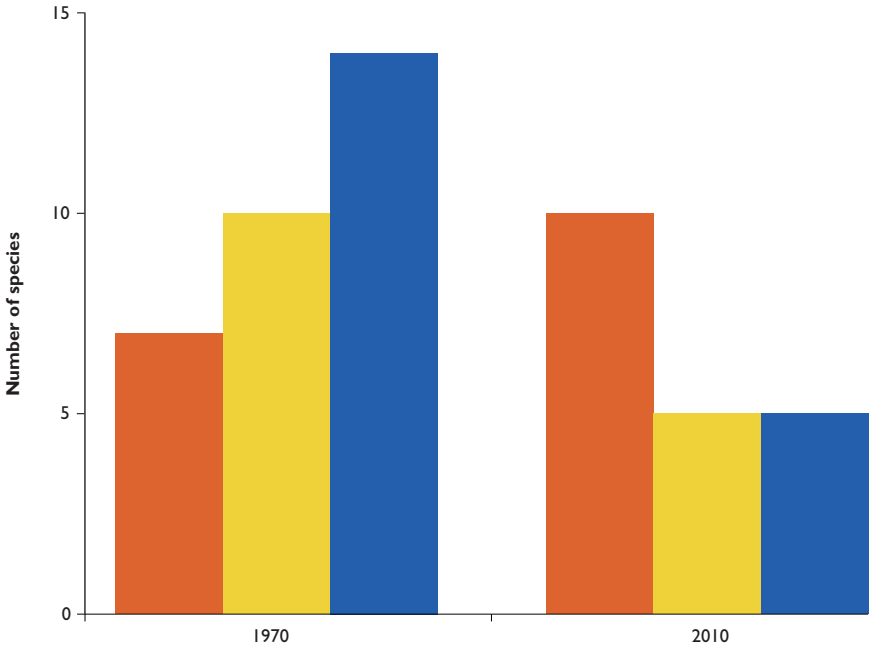


Figure 2
Number of large, medium and small species of ground beetles found in Sussex in 1972-74 and 2016-17

Large species
Medium species
Small species

als, its dominance increased significantly so that it now accounts for 75% of all beetles collected. The size of beetles collected also varied significantly: in the 1970s 80% of ground beetle species were small or medium sized, whereas now 50% of species are large (see Figure 2).

Ground beetles comprised species that live all year round in the field and ones that overwinter in the surrounding boundaries, migrating into crops in spring. Therefore, the main factors influencing their survival are foliar-applied insecticides, herbicides which affect cover and food, tillage type and quality of field boundaries for overwintering.

Since the 1970s, use of foliar-applied insecticide has decreased both in summer and in the autumn, replaced with neonicotinoid seed dressings. There are also many more field margins on the farm now, providing a wider range of overwintering habitats. The intensity of soil tillage has been reduced, which will particularly favour *Pterostichus melanarius* (the predominant species in the 2010s) because its larvae overwinter in the soil. The farm has also been applying more organic matter that can also encourage ground beetles.

This work shows that the community of ground beetles is quite plastic, adapting to changes in agricultural practices and perhaps too climate change. The loss of smaller beetles that are food for grey partridges is of concern, as is the dominance by a few larger species that may reduce the capability of the community to control insect pests.

KEY FINDINGS

- We repeated a three-year study of ground beetles within cereal crops in Sussex in the 1970s using pitfall traps in the same fields on the same farm in 2016-2018.
- Unexpectedly, beetle numbers increased four-fold between the two time periods. One species (*Pterostichus melanarius*) was predominant in both time periods but now accounts for 75% of all beetles sampled (up from 30% in the 1970s). Smaller species were most common in the 1970s, whereas now larger species are dominant.
- Changes in farming practices or climate may account for these differences.

Susan Hammond
John Holland
Julie Ewald

ACKNOWLEDGEMENTS

Dick Potts (1939-2017) was the director general of the GCT between 1993 and 2001. His research was instrumental in understanding the links between farmland bird survival and agricultural practices. The Dick Potts Legacy Fund was set up in his memory to support early career scientists to continue research in areas that Dick was passionate about. This work has been financially supported by the Dick Potts Legacy Fund. Thank you to the farmer for his ongoing support.

Beetles were caught in pitfall traps set in the crop.
© Susan Hammond/GWCT

Interreg North Sea project PARTRIDGE

New flower mixes have been developed for partridges and other farmland wildlife. © Rollin Verlinde

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 2020. Together with 10 other partner organisations from the Netherlands, Belgium, Germany, Scotland and England the project is showcasing how farmland wildlife can be restored by up to 30% at ten 500-hectare demonstration sites (two in each country). In the UK, the four PARTRIDGE demonstration sites (Rotherfield Park and the Allerton Project in England, and Whitburgh and Balgonie in Scotland) are all managed by GWCT staff together with their local partners.

PARTRIDGE is a cross-border Interreg project that demonstrates how to reverse the ongoing European-wide decline of farmland wildlife by using science-based management plans based on a bottom-up approach. The project is led by the GWCT in partnership with 10 partner organisations. These work with more than 100 farmers and hunters and several hundred volunteers in Farmer Clusters, supported by Government agencies, farming unions or collectives and conservation NGOs.

The project's locally adapted management plans are tailored to the grey partridge, an ideal farmland wildlife indicator. Where partridges thrive, farmland biodiversity is generally in a good state. Partridges are resident birds and, as such, need suitable habitat all year round to survive and breed successfully. Based on research and practical experience, the PARTRIDGE project focuses its habitat improvements at all its demonstration sites on wild bird seed mixes. From all the habitat options currently available in Agri-environment Schemes (AES), wild bird seed mixes have one of the highest potentials to achieve maximum benefits for partridges and other farmland wildlife, as they provide suitable habitat all year round when managed in a sympathetic way. PARTRIDGE has therefore developed new flower mixes, suited to each project country, planted ideally in plots of up to one hectare (ha) in size and managed in a rotation. This means that a maximum of half of each plot or strip is renewed each year. This provides suitable nesting cover and protection from raptors during the winter months in the year-old half, and foraging cover and insect food for broods in the

Farm walks at all 10 demonstration sites allow PARTRIDGE to showcase best management practice to recover farmland biodiversity at first hand. © Kevin Milner

newly-sown half of each plot every year. In England and Scotland, new PARTRIDGE seed mixes have been developed by Oakbank and Kings Crops. These are already sold widely on the UK and international markets.

Other wildlife habitats that PARTRIDGE promotes across its 10 demonstration sites are beetle banks, arable margins, floristically-enhanced margins, winter stubbles and extended overwinter stubbles. The latter are stubbles that are taken out of production for one season. At Rotherfield, thanks to a derogation from Natural England, we are trialling different cover crops sown into 20ha of extended stubbles to maximise their benefit for soil structure, weed suppression and wildlife. Overall, at least 7% of suitable partridge habitats, together with supplementary winter feeding, have been implemented at all 10 demonstration sites; legal predator management is carried out at six sites.

To highlight the urgency of reversing the continuing loss of farmland wildlife, PARTRIDGE puts a very strong emphasis on communication activities and in-depth advice. We estimate to have already informed between 3-4 million people via our online communications campaign, including radio broadcasts and TV shows.

Successes of PARTRIDGE so far

Two years into the project, PARTRIDGE has held more than 100 farm walks. In the UK alone, around 800 people have visited our four demonstration sites, ranging from local farmers, hunters, the general public, NFU and Scottish agronomy members, Natural England (NE) and Scottish Natural Heritage staff and UK Government agri-policy advisors. We have also welcomed visitors from Switzerland, the Republic of Ireland and Spain, as well as the Environment Minister of Denmark. Additionally, we held hedgerow management and partridge conservation workshops, gave AES habitat management advice to NE staff and participated in the Big Farmland Bird Count.

The experience of the new PARTRIDGE flower mixes has already been taken on board by Defra in developing the future Environmental Land Management Scheme (ELMS), that will come out after Brexit. As a result, their future management will become more flexible with increased wildlife benefits. In the Netherlands, beetle banks (developed by the GWCT) have been added as a new option to its new AES scheme, together with PARTRIDGE flower mixes; in Belgium, preparations are on the way to do the same.

In 2018 we undertook 15 in-depth key stakeholder interviews in each partner country (30 in the UK), to help us find answers that might improve the quality and uptake of national AES schemes targeting recovery of farmland wildlife across the North-Sea Region. This is because the current agri-environment schemes have not managed to halt the ongoing decline of farmland biodiversity across the EU, despite UK and EU Biodiversity 2020 targets.

Working across borders with a wide range of experts and stakeholders based on a bottom-up approach is proving to be a very successful strategy to demonstrate how to improve farmland biodiversity. There is no doubt that we are increasingly being heard by those at the highest political levels and numerous projects have already started copying our approach across the UK and the EU.

For more information, please visit **www.northsearegion.eu/partridge**.

Partridge-tailored wild bird seed mixes help to recover farmland wildlife generally, such as hares.
© PARTRIDGE NL

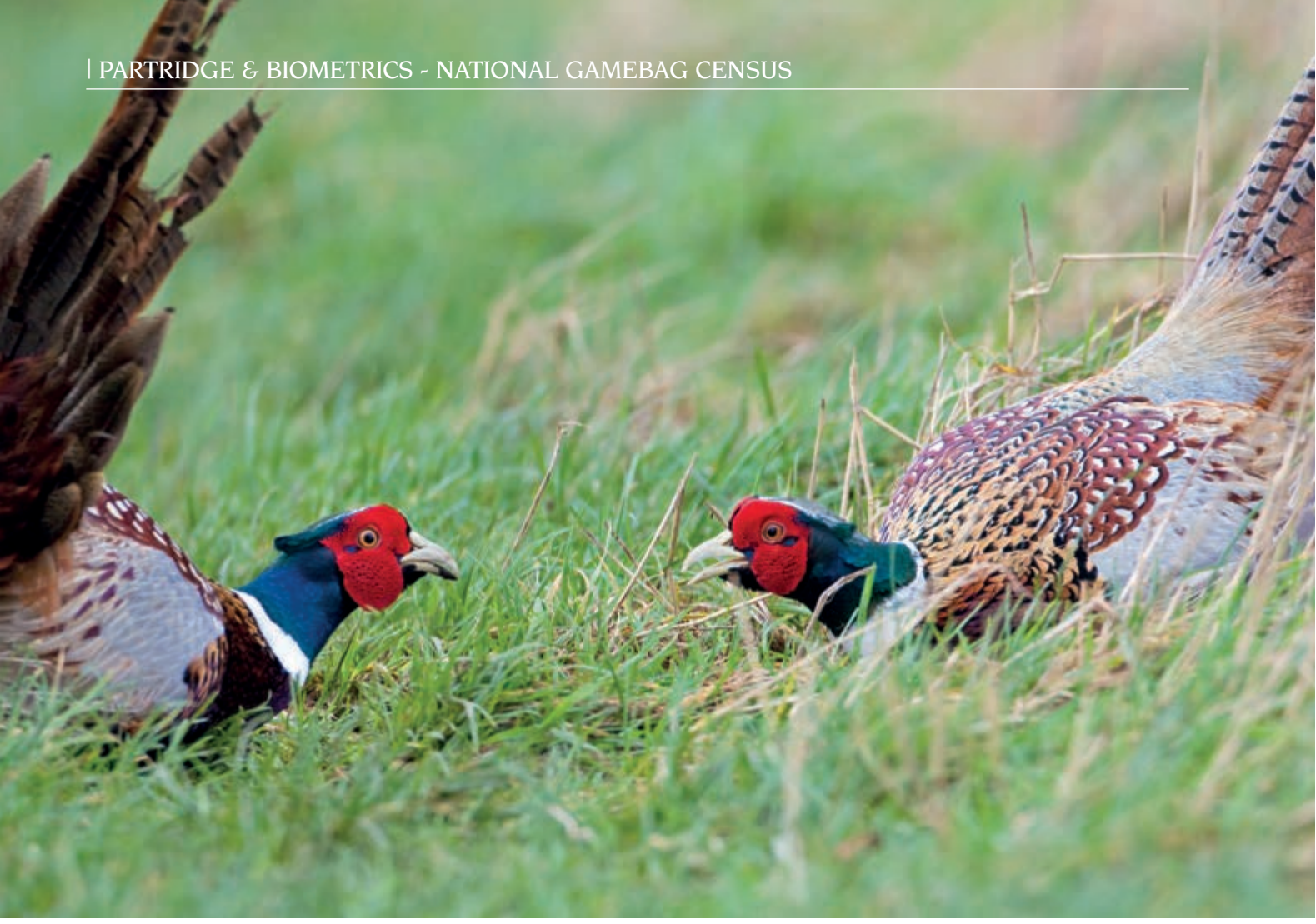
PROJECT AIMS

- GWCT-led North Sea Region (NSR) cross-border Interreg project involving England, Scotland, the Netherlands, Belgium and Germany.
- Demonstration of how to reverse farmland biodiversity loss at ten 500ha sites by 30% by 2020.
- Use the grey partridge as a flagship species for management plans at demonstration sites.
- Influence agri-environment policy and showcase how to enthuse local stakeholders to conserve farmland wildlife.

Francis Buner
Paul Stephens
Elouise Mayall

ACKNOWLEDGEMENTS

This project would not be possible without the help of hundreds of supporters. We thank all participating GWCT members of staff (in particular Dave Parish, Julie Ewald, Fiona Torrance, Chris Stoate, John Szczur and Austin Weldon), 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, and last but not least, the NSR Interreg Secretariat in Denmark.



Trends in commonly released gamebirds

Demand and economics have led to continued increases in the number of pheasants released for pheasant shooting. © Dave Kjaer

BACKGROUND

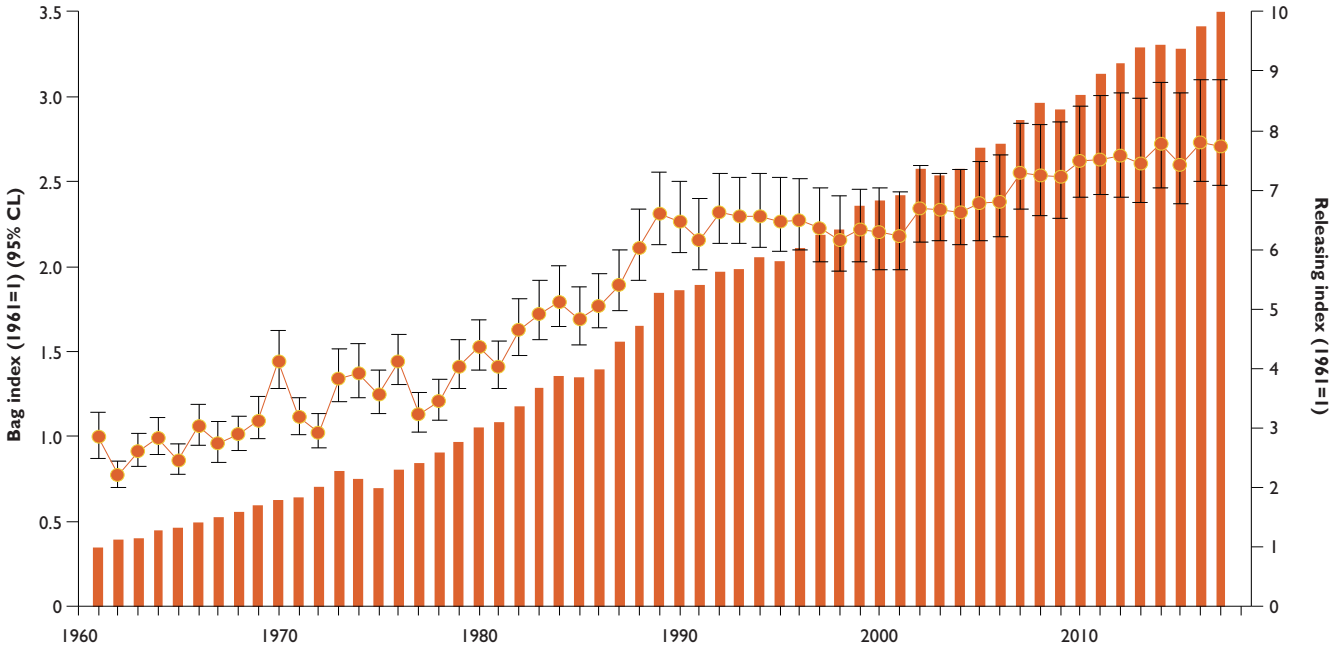
The National Gamebag Census (NGC) was established by the GWCT in 1961 to provide a central repository of records from shooting estates in England, Wales, Scotland and Northern Ireland. The records comprise information from shooting and gamekeeping activities on the numbers of each quarry species shot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

Since its inception in 1961, the most commonly recorded species in the National Gamebag Census (NGC) have been pheasant, red-legged partridge, grey partridge and mallard. Pre-shooting stocks of these four species are now frequently supplemented or even sustained by releases of reared birds, but that was not always the case. In this article, I illustrate how the numbers of birds released and shot of these species have changed over time. It would not be possible to produce such trends without the kind co-operation of NGC participants over more than 50 years, and we are most grateful to all of them for their contribution and support.

For each of the four species, the analysis is based on sites that have returned bag records for at least two years. It summarises the year-to-year change within sites as an index of change relative to the start year. In the graphs, this means that the 1961 value is set to 1, and subsequent index values represent the change since then. For instance, a value of 3 in 2011 indicates that numbers have tripled over the span of 50 years from 1961 to 2011.

Pheasant (Figure 1)

Pheasant releasing began in response to a decline in the traditional shooting of grey partridges as agricultural intensification in the 1950s and 1960s led to reduced wild stocks. Since then, demand and economics have led to continued increases in the numbers of pheasants released for shooting, which was estimated at 43 million in 2012 (*Review of 2017*, pp. 42-43). The NGC index of releasing has increased 10-fold since 1961, at an approximately constant rate of 2.4% per annum over the last 25 years. The bag index has increased more slowly, as it is now only 2.7 times as high as in 1961. Most noticeably, there was a complete lack of growth in bag size during the 1990s despite the increases in releasing, and it was only from 2000 that the index has resumed a slow increase. The reason why higher releases have not necessarily translated into higher bags is probably that many shoots now offer shoot days in January. Because of ongoing losses of released birds from August to December, disproportion-



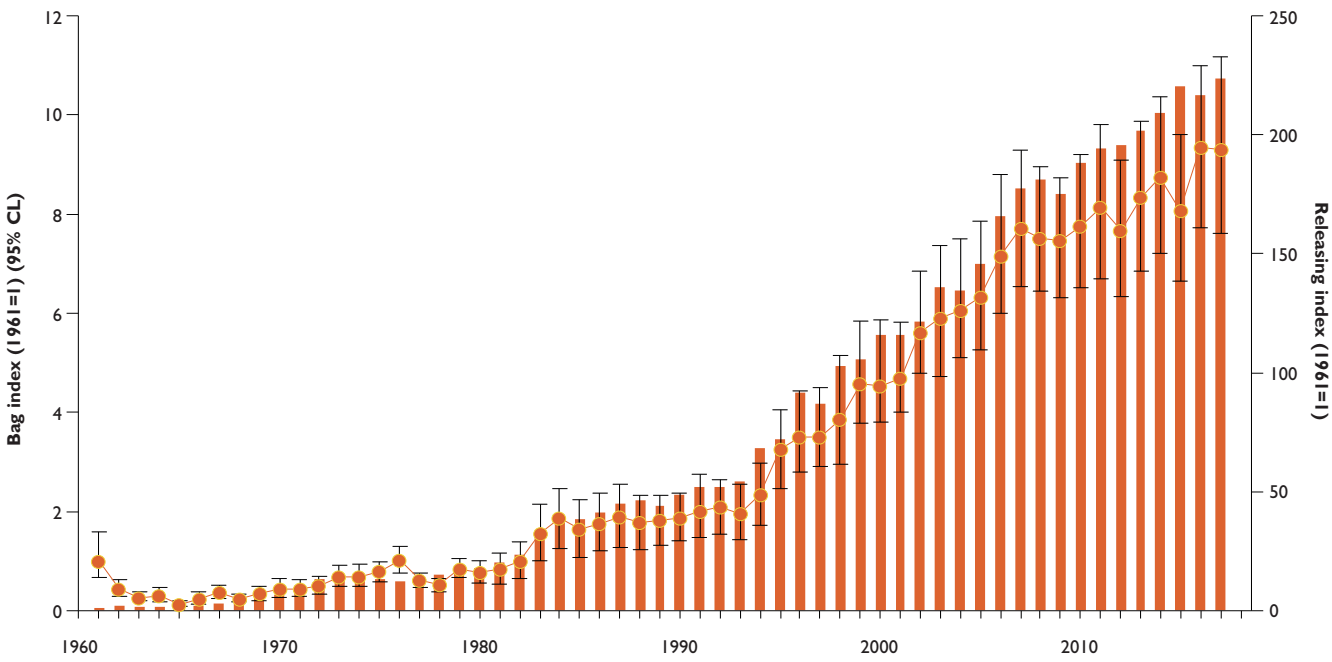
ately more pheasants must be released at the start of the season to achieve strong late-season bags.

Figure 1
Pheasant: UK bag index (left-hand scale) and releasing index (right-hand scale)

Red-legged partridge (Figure 2)

The releasing of red-legged partridges was uncommon practice in 1961. Only 19% of shoots in the NGC that reported bags of redlegs in that year also released them, and numbers released were tiny. Since then, there has been a near-exponential increase in the NGC releasing index, with some sign of slowing only in the last 10 years. The UK estimate in 2012 was of 8.9 million redlegs released (*Review of 2017*, pp. 42-43) and, overall, numbers released are now 220 times higher than in 1961. The bag originally relied on wild production, and so fell in the 1960s in the same way that the grey partridge bag fell, reflecting the impact of early agricultural intensification. Since then, the increase in releasing has fed through to the bag, which has increased nine-fold since 1961 but around 50-fold since the mid-1960s. The redleg bag index shows much less evidence of the stabilisation observed for pheasant over the last 20 years, probably because most redleg shoot days are still held in the early part of the season.

Figure 2
Red-legged partridge: UK bag index (left-hand scale) and releasing index (right-hand scale)



Red-legged partridge releases have increased 220 times since 1961. © David Mason

KEY FINDINGS

- Releases of pheasants have increased 10-fold since 1961. Pheasant bags increased correspondingly up to 1990, but have increased little since.
- Red-legged partridge releases have increased 220 times since 1961, and the changes in bags have largely followed them.
- Grey partridge releasing peaked in the 1990s, but the amount is now only twice as high as in 1961. Bags mainly reflect the productivity of wild birds.
- Releases of mallards increased eight-fold since 1961, with a temporary fall in the decade after 1999. Bags have broadly followed the same pattern.

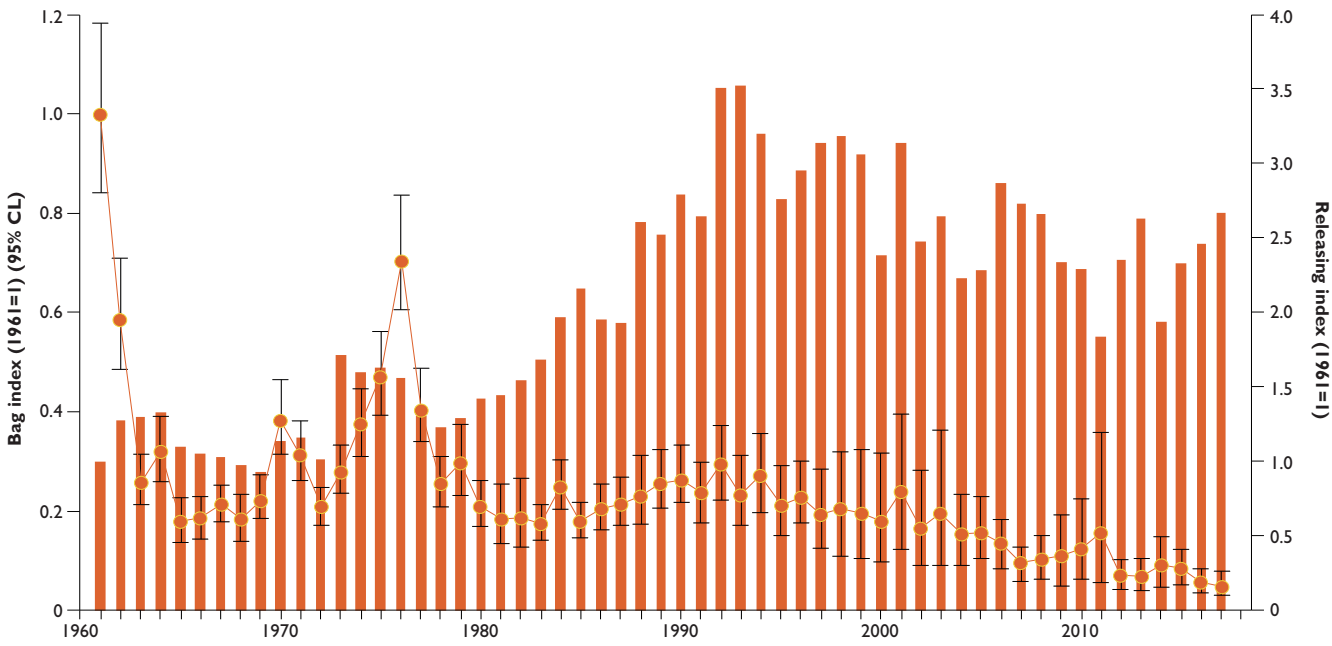
Nicholas Aebischer

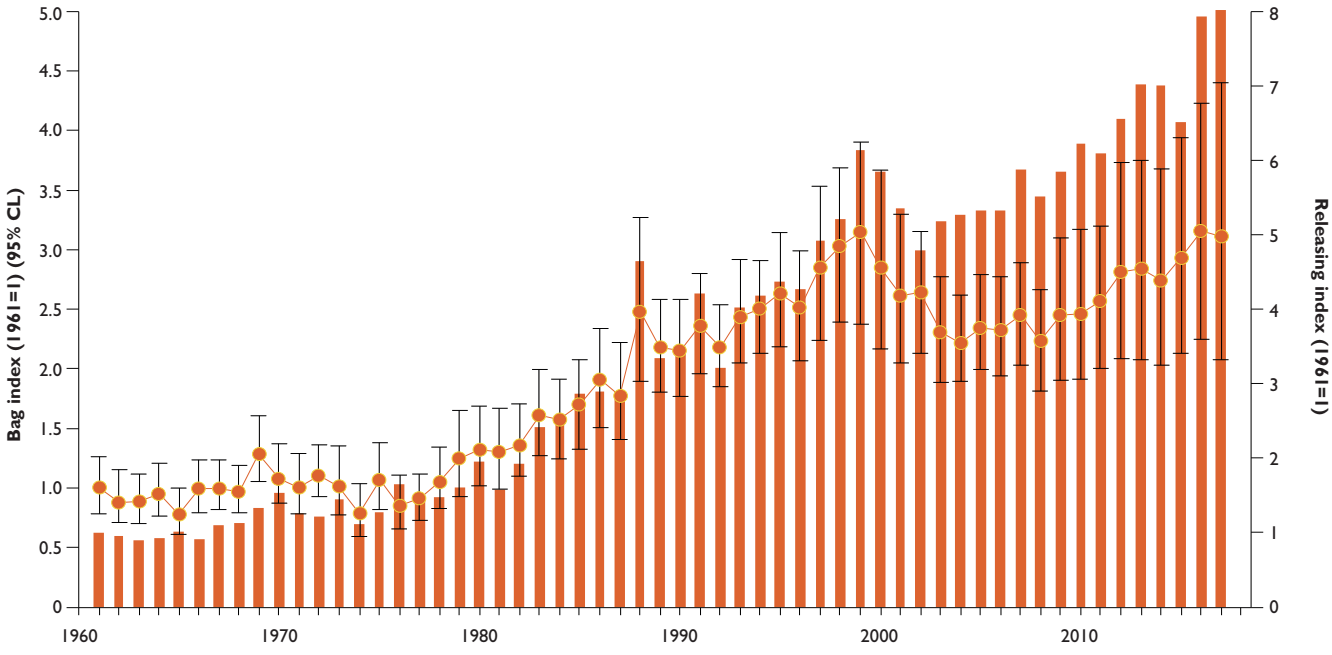
Grey partridge (Figure 3)

The grey partridge is the only one of the four species reviewed here whose bag index since 1961 is consistently below 1. Indeed, it reached an all-time low of 0.05 in 2016, indicating that bags had dropped by 95% since 1961. This is the species that is least suitable for mass rearing, and it is rare for it to be released in large numbers; the estimated number released in the UK in 2012 was 170,000 (*Review of 2017*, pp. 42-43). The peak of releasing was in the 1990s, when numbers were around three times higher than in the 1960s. Since then, releases have fallen back steadily to lie now at around twice the number released at the start of the series. These low levels of releasing mean that bags are dependent on wild production. This is most obvious in the 1975-76 spike in the bag index, but is also apparent in 2001 and 2011, as a combination of good summer weather and set-aside/Entry Level or Higher Level Stewardship habitat enhancement resulted in improved breeding success. Grey partridges continue to decline nationally, so it is important to count them in the autumn and avoid shooting them if there are fewer than 20 birds per 100 hectares (250 acres). Take particular care during driven redleg shooting not to shoot wild greys at the same time (see our guide *Conserving the grey partridge* at www.gwct.org.uk/advisory/guides/).

Figure 3

Grey partridge: bag index (left-hand scale) and releasing index (right-hand scale)



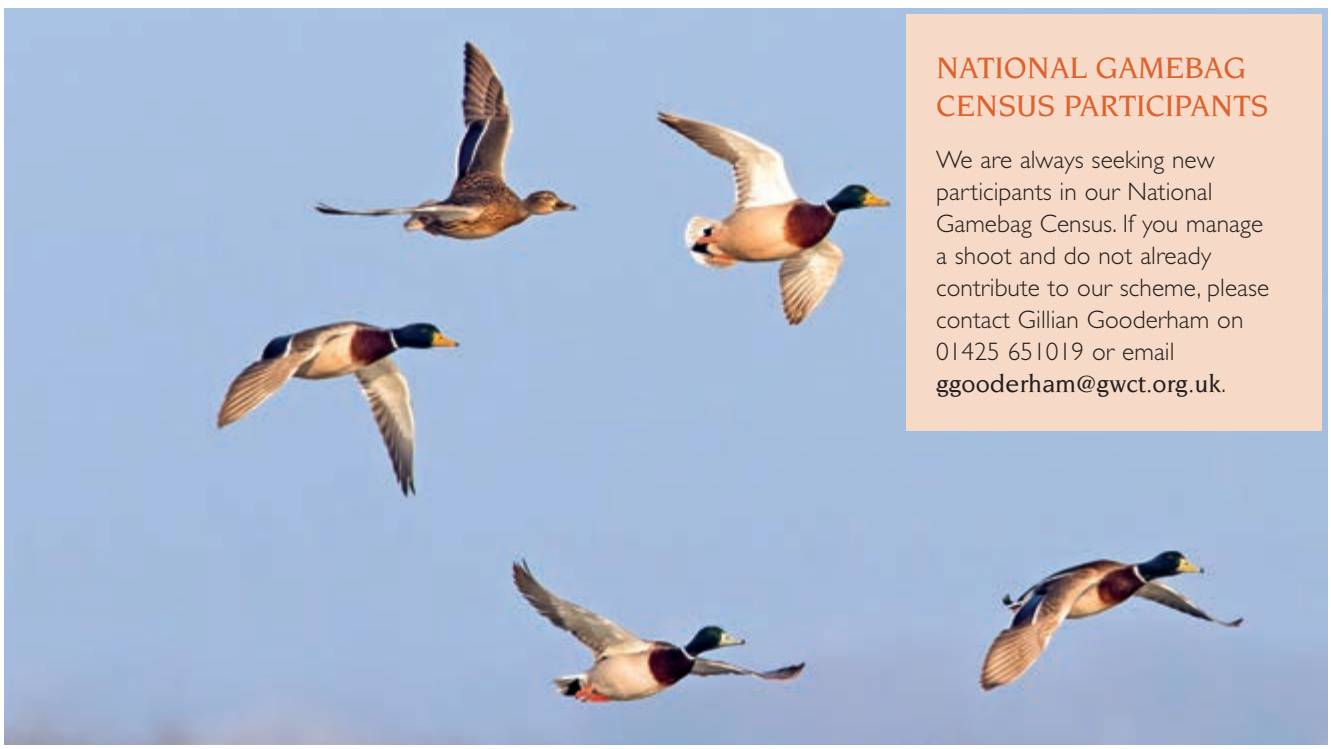


Mallard (Figure 4)

The mallard is another species that was released uncommonly in 1961, with just 17% of NGC returns involving shot mallards also reporting releases. The practice started to become more popular after 1980, although it never engaged more than just over a quarter of NGC participants. Releasing peaked in 1999 then fell back again, and it was not until 2012 onwards that numbers climbed consistently higher; in 2016 there were eight times as many mallards released as in 1961. The bag index, which has tripled since 1961, reflects a combination of numbers released and numbers available in the wild. It shows a pattern very similar to the pattern of releasing: stability until 1980, a peak in 1999, then a decline followed by a recovery. The decline is greater and subsequent recovery weaker than expected from the magnitude of the releases, probably because the wild overwinter population has declined by 38% over the last 25 years (WWT/BTO/RSPB surveys).

Figure 4

Mallard: bag index (left-hand scale) and releasing index (right-hand scale)



Mallard releases have increased eight-fold since 1961. © David Mason

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 Gillian Gooderham on 01425 651019 or email ggooderham@gwct.org.uk.

Uplands

Uplands monitoring in 2018

Red grouse counts have been conducted since 1980 in northern England and 1985 in Scotland. © Dave Kjaer

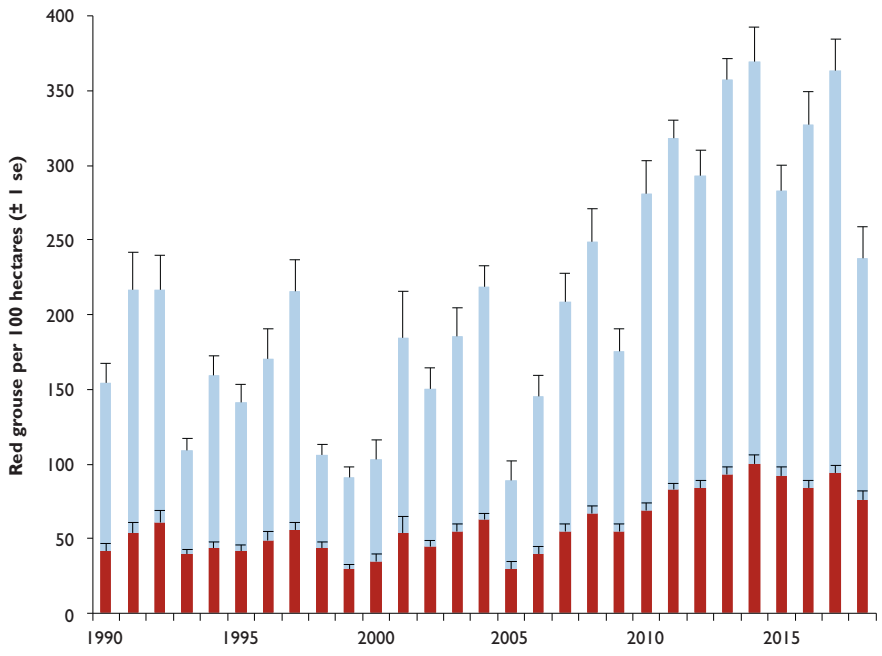
The core red grouse counts conducted in the spring and July are one of the main annual long-term monitoring undertakings by the Upland Research Group; the spring counts are pre-breeding estimates and July counts are post-breeding when numbers of both adults and young are recorded. The counts were first undertaken in 1980 in northern England and 1985 in Scotland and typically estimate grouse abundance using pointing dogs on 100 hectare (ha) blocks of predominantly heather-dominated moorland. Counts of strongyle worms, usually from shot grouse, are conducted on the same moors in August or September. Historically a sample of 10 adults and 10 juvenile birds were collected. Since 2010, owing to low worm burdens, samples are collected from 20 adults only.

Grouse counts - England

In 2018, spring densities were 5% lower than in spring 2017, with 114 birds per 100ha (120 in 2017). However, birds were seen in poor condition during spring counts and

Figure 1

Average density of young and adult red grouse in July from 25 moors in northern England 1990-2018



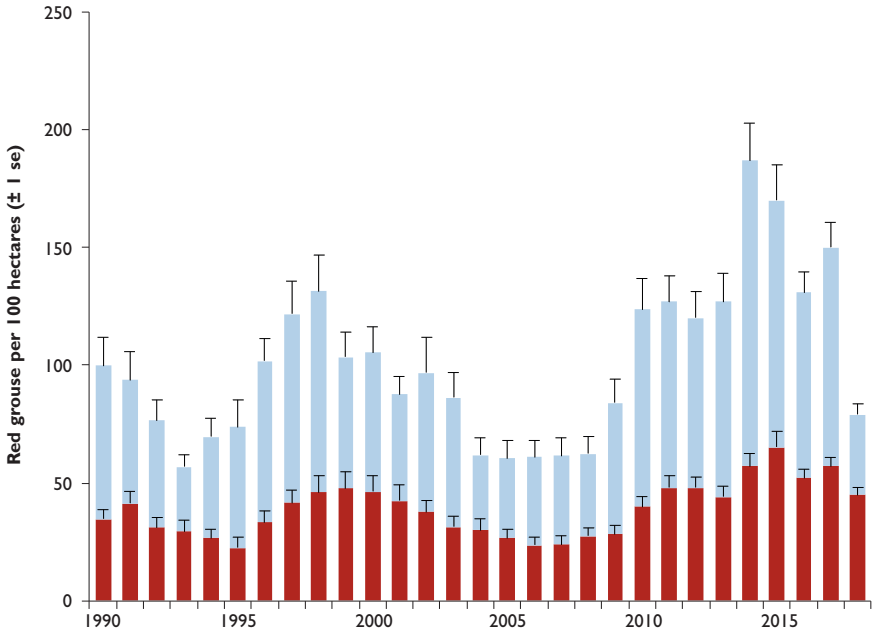


Figure 2

Average density of young and adult red grouse in July from 24 Scottish moors 1990-2018

Young grouse

Adult grouse

numbers of adult birds had subsequently fallen to 76 adult birds per 100ha by the time the July counts were conducted. This loss of adult birds between spring and July was attributed to increased levels of strongyle worms in the late winter/early spring, combined with adverse weather conditions. Breeding success was lower in 2018 with an average 2.1 chicks per adult (2.9 in 2017), giving a post-breeding density in July 2018 of 239 birds per 100ha, a reduction of 34% for the 25 counts which make up this data set (364 July density in 2017) (see Figure 1). This decrease in densities resulted in a much-reduced shooting programme on many estates. However, this reduction was not universal with some moors having densities very similar to 2017. The North York Moors was an area with particularly good densities of grouse in 2018. Grouse bags have reflected this, with reduced bags in many areas but not all. Good bags of grouse were shot on the North York Moors in 2018.

Scotland

Spring densities in 2018 averaged 60 birds per 100ha, a 23% decline from 2017 (78 in 2017). Breeding success in 2018 was only 0.75 chicks per adult compared with 1.5 chicks per adult in 2017. Post-breeding densities averaged 84 birds per 100ha in 2018, a decline of 44% from 2017 (150 in 2017). The reduction in spring densities together with the poor breeding success was the major cause of the decline in 2018 (see Figure 2). This reduction in grouse densities resulted in a reduced shooting programme in much of Scotland in the 2018 season.

BACKGROUND

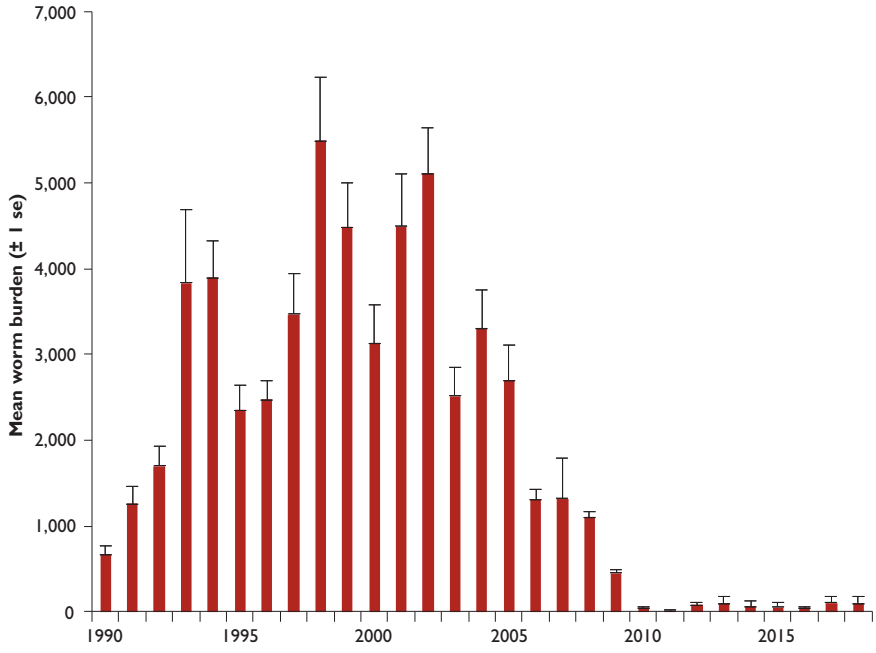
Each year our uplands research team conduct counts of red grouse in England and the Scottish Highlands to assess their indices of abundance, their breeding success and how survival may change relative to *Trichostrongylus tenuis* parasitic worm infestations. They also count black grouse at leks and estimate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

A reduction in spring densities together with poor breeding success resulted in a reduced shooting programme in much of Scotland. © Dave Kjaer

Figure 3

Average annual worm burden for autumn shot adult red grouse from 8-18 moors in northern England 1990-2018



KEY FINDINGS

- Spring stocks of red grouse in England were comparable to those in 2017 but breeding success was poor.
- In Scotland, in 2018, both measurements were lower than in 2017.
- Black grouse breeding success improved in 2018 but was still low despite the warm dry weather when chicks hatched.

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Kathy Fletcher
Nick Hesford
Michael Richardson
Phil Warren

Strongyle worms

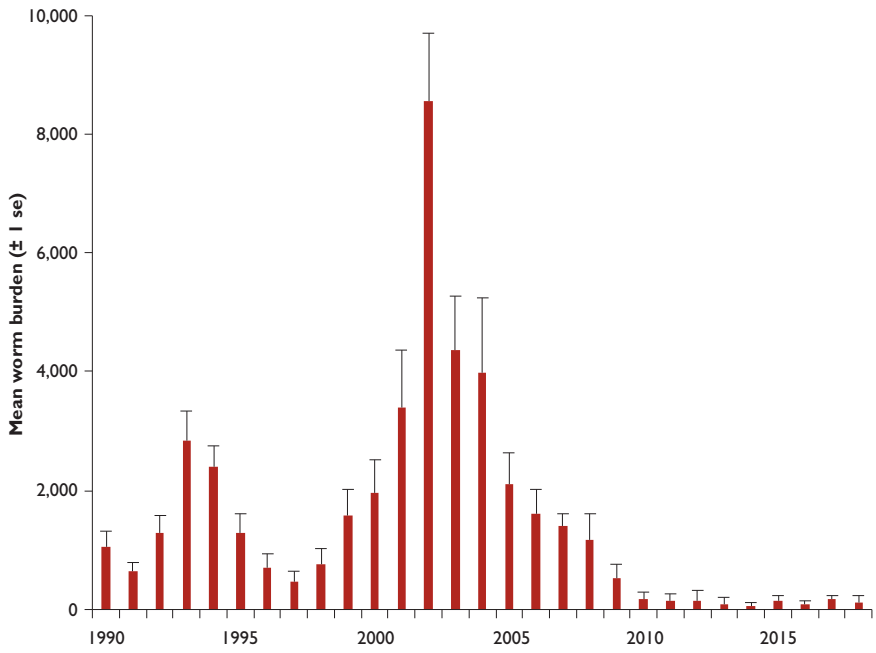
Several core sites in England and Scotland did not shoot in 2018 which has slightly reduced the sample size for 2018. Numbers of worms in both England and Scotland are very similar to 2017, but overall worm burdens have remained low on core moors using medicated grit (see Figure 3 England moors, see Figure 4 Scotland moors), despite some losses of adult grouse to strongyle worms in the spring. The average number of worms per adult has been in the low hundreds on moors in England and Scotland since 2010. Once again, this year zero worm counts were recorded in adult grouse, with 20% of adult grouse sampled from English moors and 14% from Scottish moors containing no worms. With the majority of moors in England and Scotland using medicated grit, strongyle worm burdens continue to be low.

Black grouse

We surveyed black grouse attending leks across northern England in spring 2018, which in the last national survey in 2014 supported 67% (958 males) of black grouse in England (1,437 males). We recorded a total of 682 males at these leks, a fall in

Figure 4

Average annual worm burden for autumn shot adult red grouse from 3-17 moors in Scotland 1990-2018



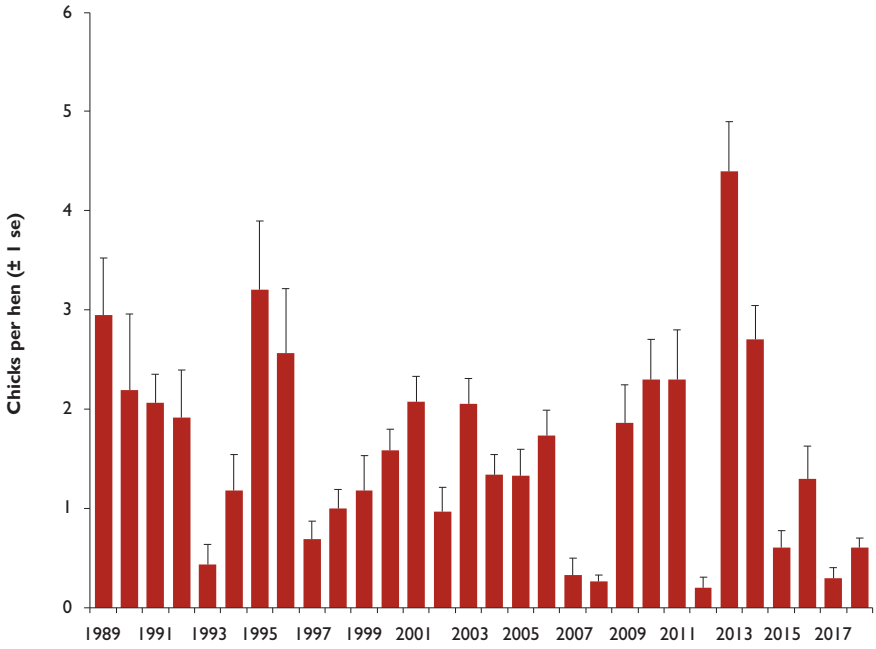


Figure 5
Black grouse breeding success in northern England between 1989 and 2018

numbers of 27% since last year, following poor breeding success in 2017. We now estimate the English population at c.1,000 males.

We carried out breeding surveys in northern England last summer using pointing dogs and found across our survey areas a total of 54 hens, 25% of which had broods totalling 33 chicks, giving an overall average of 0.6 chicks per hen (see Figure 5). Despite a warm dry June when chicks hatched, which is usually favourable for chick survival, this was a poor breeding year for black grouse.

Male black grouse numbers have fallen 27% since last year, following poor breeding success in 2017. © Dave Kjaer

Heather burning and blanket bog

Heather burning on grouse moors can be a contentious issue. © GWCT

BACKGROUND

Prescribed burning of heather is an integral aspect of grouse moor management. When done over blanket bog it can be ecologically damaging with claims that it leads to heather monocultures and a reduction in key peat-forming species. However, a long-term burning experiment at Moor House National Nature Reserve in the North Pennines, has shown that more frequent burning increased the cover of peat-building species such as *Sphagnum* mosses and cotton grass. We conducted a study to test the findings from that Moor House experiment on a site that is actively managed as a driven grouse moor.

ACKNOWLEDGEMENTS

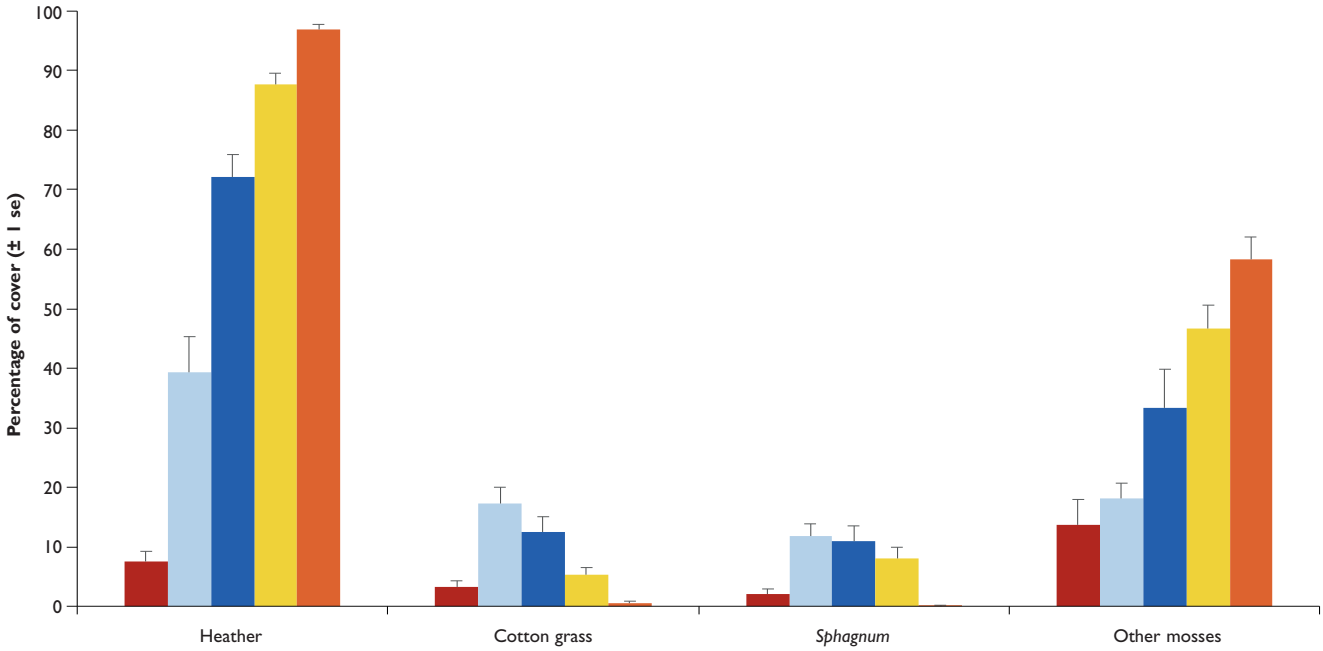
We would like to thank the landowner for permission to work on the study site, and the head keeper for his assistance with identification of sampling plots.

Blanket bog is an internationally significant habitat that fulfils vital roles in carbon storage and flood risk management. It also supports rare animal and plant species, including upland specialists such as golden plover and important peat-building *Sphagnum* mosses. Where blanket bog habitat occurs within managed grouse moors, it has traditionally been burnt over as part of the wider programme of habitat management. Such prescribed burning is a contentious issue and if conducted inappropriately, can damage the blanket bog through destruction of peat-forming plant species and drying out of the peat layers. Regular burning as part of grouse moor management is also considered by some to lead to an unfavourable change in plant species composition, with alleged development of monocultures of heather to the detriment of other peat-forming plant species such as *Sphagnum* mosses and cotton grass.

However, results from a long-term burning experiment at Moor House National Nature Reserve, a high-altitude deep-peat site in the North Pennines, have shown that 10-year burn intervals actually favour the main peat-building species of *Sphagnum* mosses and cotton grass. In contrast, longer burn intervals (20 years) or no burning resulted in increases in heather cover, but no such increases in *Sphagnum* or cotton grass.

We conducted a study to explore how the results from these experimental trials at Moor House compare with a site where different intervals of prescribed burning are being used as part of ongoing active grouse moor management. We selected a study site in the North Pennines that is managed for driven grouse shooting and which has significant areas of blanket bog (defined by Natural England as having peat depth >40cm). We used aerial images and knowledge of most recent burn dates to identify a series of burns of known age; these were grouped into five different age-categories of burn (1-2 years, 3-6 years, 7-10 years, 11-17 years and >17 years since burning). From 10 separate burns within each of those age-categories, we took a series of measurements of vegetation composition and abundance, recording overall vegetation height and percentage cover of each of the main plant taxa (heather, cotton grass, *Sphagnum* mosses and non-*Sphagnum* mosses).

Heather cover was lowest in plots that had been burned most recently and progressively increased in cover over time from under 10% to nearly 100% (see Figure 1). In contrast, *Sphagnum* cover initially increased five-fold, peaking in age-categories 3-6 and 7-10 years, before levelling and then declining in the older burns, a pattern that was also shown in cotton grass cover. The cover of non-*Sphagnum* mosses showed a similar pattern to that of heather, ie. increasing in time since burning.



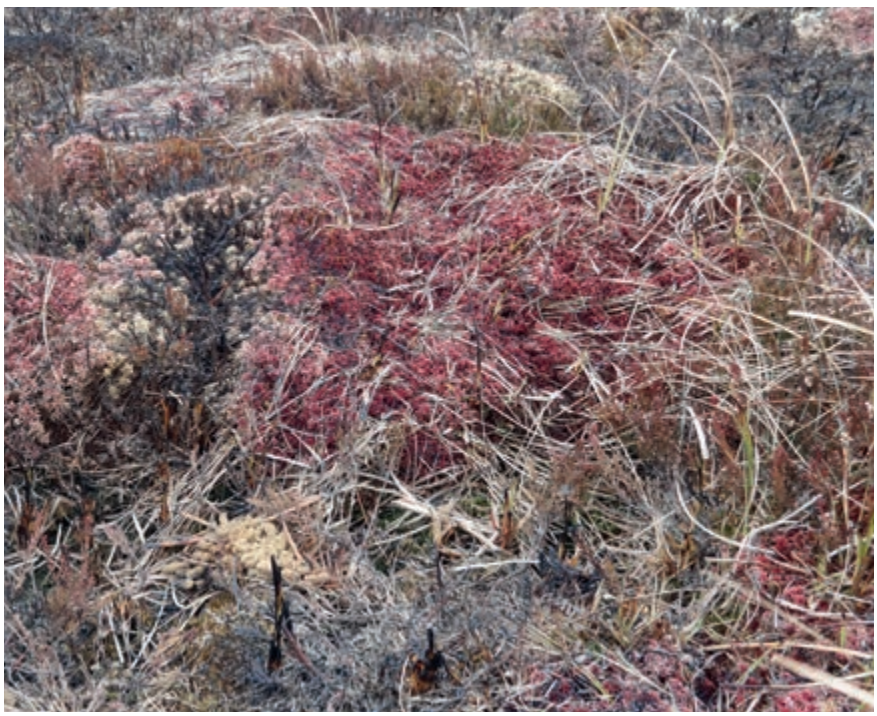
Vegetation height also increased with time since burning, a pattern that was explained by increased heather cover. In addition to these changes in vegetation height and cover, we also saw changes in the number of plant species, most notably an initial increase and then decline in the number of *Sphagnum* moss species. The oldest burns had the least amount of plant species variety, with plots dominated by heather and an understory of non-*Sphagnum* moss species.

Our study supports the earlier findings from the Moor House study which examined vegetation response within experimentally manipulated burn intervals. Here, we used data from an actively-managed grouse moor subject to prescribed burning to show that a longer time since burning can reduce the cover and species richness of important peat-forming species, particularly *Sphagnum* mosses. Our results suggest that in the shorter term after burning (less than 10 years in the case of this site), it is peat-forming species that benefit leading to a vegetation community structure that supports carbon capture.

Figure 1

Mean percentage cover (± 1 se) of each of heather, cotton grass, *Sphagnum* moss and other mosses in each burn age-category

- 1-2 years
- 3-6 years
- 7-10 years
- 11-17 years
- >17 years



Recently burnt blanket bog which supports important peat-building Sphagnum *mosses.*
© Sian Whitehead/GWCT

KEY FINDINGS

- We found highest levels of *Sphagnum* moss and cotton grass cover on moorland last burned within three to 10 years.
- Heather and non-*Sphagnum* moss cover, and vegetation height, were lowest in plots that had been burned most recently, and increased over time since burning.

Sian Whitehead

Mountain hare abundance

Mountain hare were more common on driven grouse moors. © Laurie Campbell

BACKGROUND

The mountain hare is a species of European importance, whose UK population is found almost entirely in Scotland. Concerns regarding the extent to which mountain hares are controlled on grouse moors, coupled with reported declines in their numbers, have been issues in a growing public debate about the alleged environmental impacts of driven grouse shooting in the UK.

KEY FINDINGS

- Mountain hare abundance indices were higher and relatively stable or increasing on driven grouse moors, compared with lower abundance indices and declines on moorland that was not managed for driven grouse shooting.
- On driven grouse moors, benefits to mountain hares from fewer predators and better foraging opportunities may outweigh dis-benefits from sporting harvests and tick-related culls.

Nicholas Hesford
Nicholas Aebischer
Dave Baines
Kathy Fletcher
David Howarth
Adam Smith

In Scotland, mountain hares are strongly associated with heather moorland managed for red grouse where they benefit from enhanced habitat management and control of generalist predators. However, potential benefits from grouse management may be offset by legal harvesting of hares for sport, forestry and crop protection. More recently, mountain hares have been identified as potentially important reservoirs for the tick-borne Louping ill virus, which can reduce grouse chick survival. Consequently, hares are culled in large numbers on some grouse moors. These large-scale culls, combined with recent reports of declines in mountain hare numbers, have been issues in a public debate about the alleged environmental impacts of driven grouse shooting and a UK public petition calling for stronger protection of mountain hares.

We surveyed mountain hares in early spring from 2001-2017 as part of our long-term red grouse monitoring scheme. Surveys were conducted using pointing dogs during 591 counts at 76 sites on 33 moors within the central and eastern Highlands of Scotland: Grampian (n=10 sites), Highland (n=31) and Tayside (n=35). We categorised sites according to grouse moor management intensity, defined as 'Driven' if the grouse shooting type was driven, 'Walked-up' if walked-up or 'Not shot' if not shot at all.

Our surveys showed that, overall, mountain hare abundance indices were higher on driven grouse moors than on moors managed for walked-up shooting or where there was no shooting interest. In Grampian, mountain hare abundance indices were 3.3 times higher on driven grouse moors than on walked-up moors, and in Highland, they were 2.3 times higher. In Highland, hare abundance indices on driven moors were 35 times higher than on moors that were not shot, while on walked-up moors they were 15 times higher than on moors where there was no grouse shooting interest. There was no significant effect of management intensity on mountain hare abundance indices in Tayside. Changes in mountain hare indices over time were more pronounced on driven moors, especially in Grampian and Highland where hare indices were highest. However, overall trends in mountain hare indices differed between regions and management intensity, remaining relatively stable on driven grouse moors but declining by 40.1% per annum on moors with no grouse shooting interest in Tayside. Whereas in Highland, trends in hare indices increased on driven grouse moors by 4.9% per annum, but declined by 6.6% per annum on walked-up moors and showed no significant change on sites that were not managed for grouse shooting. In Grampian, trends in mountain hare abundance indices increased on average by 5.2% per annum in Grampian regardless of management intensity (see Figure 1).

These results confirm previous reported positive associations between grouse moor management and mountain hares. It is likely that the reduction in the abundance of generalist predators such as foxes and stoats by gamekeepers on driven grouse moors, may improve mountain hare survival and reproductive success. Similarly, the routine strip burning of old heather on driven grouse moors may support higher indices of mountain hare abundance by promoting new heather growth, which is an important food resource for mountain hare. Furthermore, density-dependent processes such as infection by parasitic worms and competition for food, could explain the observed greater fluctuations in mountain hare abundance indices on driven grouse moors where hare indices are higher than on other moors.

Our data do not support recent reports that mountain hare culling on driven grouse moors is impacting the Scottish mountain hare population. Instead, we found that hare indices were higher and relatively stable on moors where driven grouse shooting was practised, compared with lower indices and declines on moors where grouse were walked-up or not shot at all. We conclude that benefits to hares from fewer predators and better foraging opportunities may outweigh dis-benefits from sporting harvests and tick-related culls.

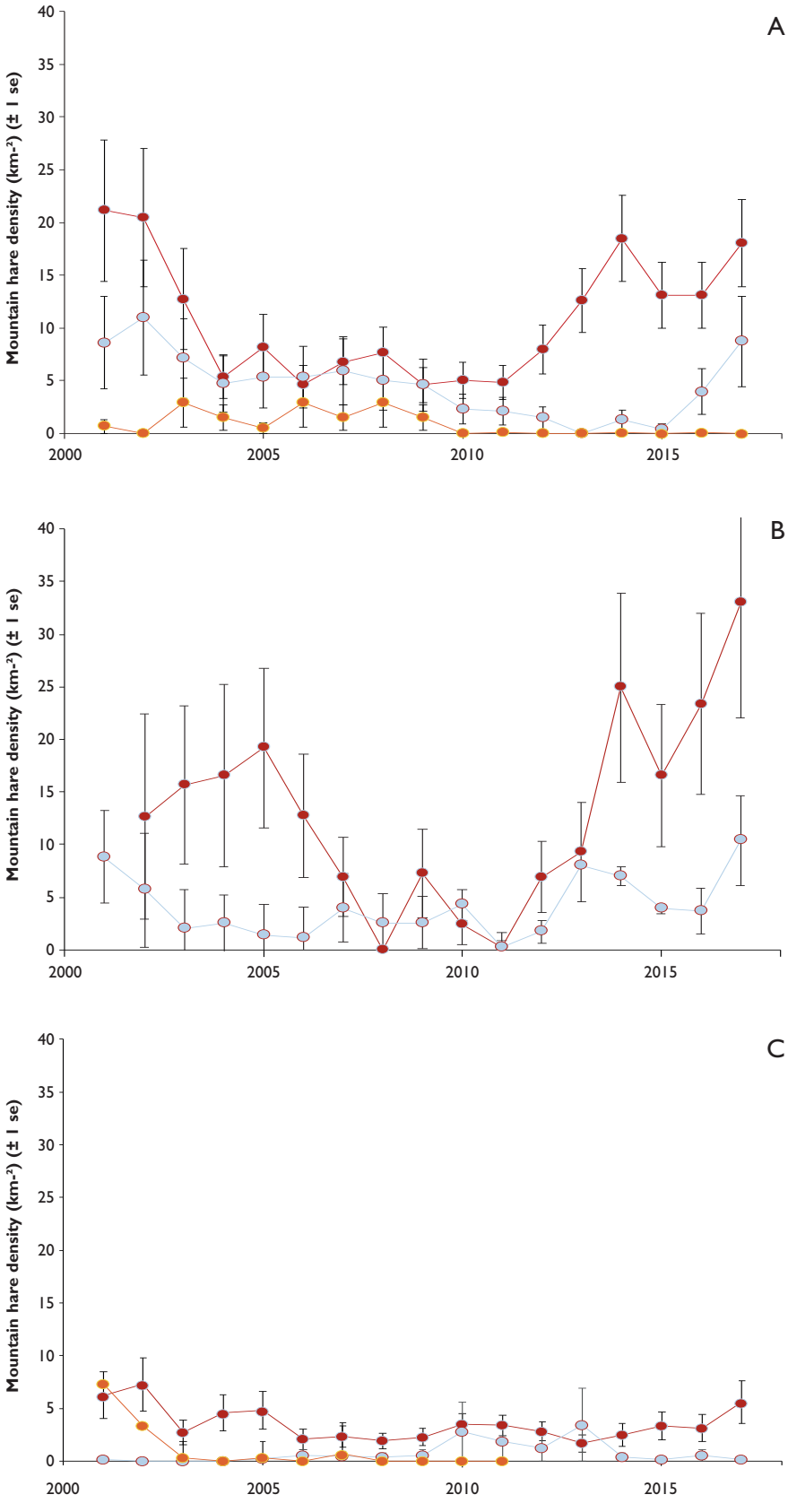


Figure 1a, b and c

Average annual mountain hare density (hares km^{-2}), ± 1 se, for driven grouse moors (Driven) walked-up moors (Walked-up) and moors with no grouse shooting interest (Not shot) in each of the three regions: a) Highland b) Grampian c) Tayside

ACKNOWLEDGEMENTS

We would like to thank all the owners and keepers who granted access to their moors and allowed us to collect the data for this study. This article is published in *European Journal of Wildlife Research* and is available at: http://dx.doi.org/10.1007/s10344-019-1273-7.

Respiratory cryptosporidiosis in red grouse

Infection is more prevalent in young red grouse.
© 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.

Respiratory cryptosporidiosis was first diagnosed in red grouse on a North Pennines moor in the autumn of 2010. In the next three years, respiratory infection by the protozoan parasite *Cryptosporidium baileyi*, which is confined to birds but includes several orders, had manifested itself in red grouse on half the moors in northern England and 80% of moors in the North Pennine Hills. *C. baileyi* is typically associated with high densities of birds, either released gamebirds or captive collections of birds in aviaries and zoos. Initially, we hypothesised that outbreaks in red grouse were also density related following the recent increases in both breeding and pre-shooting stocks across many moors in the English uplands.

In this account of the impact of respiratory cryptosporidiosis on grouse population dynamics, we fitted 111 diseased and 67 healthy grouse with radio-transmitters at two North Pennine moors where disease prevalence averaged 8.1% and monitored their survival and productivity between autumn 2013 and autumn 2015. Six-month natural survival rates (excluding birds that were shot) were 70% in healthy grouse, but only 44% in diseased females and 22% in diseased males. Some 39% of diseased birds died from their infection, whereas 28% of healthy birds were shot. A similar proportion of each group were killed by predators, either by stoats or raptors. On average, diseased

females bred eight days later than their healthy counterparts, but neither clutch size, egg volume or nesting success differed in relation to disease status. Productivity was 43% lower among pairs with a diseased member than in healthy pairs, but appeared impaired only if the female was diseased, not the male. Differences in productivity were related to chick survival rather than the proportion of pairs that reared broods, with chick survival being lower in the 10 days after hatching and again when chicks were 20-50 days old. This latter period was when respiratory infection among chicks was first noticed and the on-set of infection may have been a contributing factor to higher mortality during this period. Described levels of respiratory infection reduced the number of birds available to shoot in August by 6%, which represented a mean annual loss of £0.9 million in revenue across managed grouse moors. Likely reductions in shoot economics could escalate should prevalence increase.

We have continued monitoring disease prevalence involving screening in excess of 45,000 grouse shot at 10 North Pennine moors over the period 2013-18. Analysis of these data has shown that prevalence is twice as high in juveniles as in adults, it fluctuates across years in relation to annual breeding success and is highest in the years immediately following the first observations of disease on a given moor. There is no evidence for an escalation of prevalence over time, but we will continue limited annual monitoring at a smaller subset of moors in future years. Respiratory cryptosporidiosis has to-date largely been confined to the Pennines, especially the more northerly dales, and verified reports have been absent from the North York Moors, Trough of Bowland and all Scottish moors. These absences are despite similar densities of grouse to those in the Pennines on several moors in these UK regions, suggesting that outbreaks and subsequent prevalence may not be directly density-dependent.

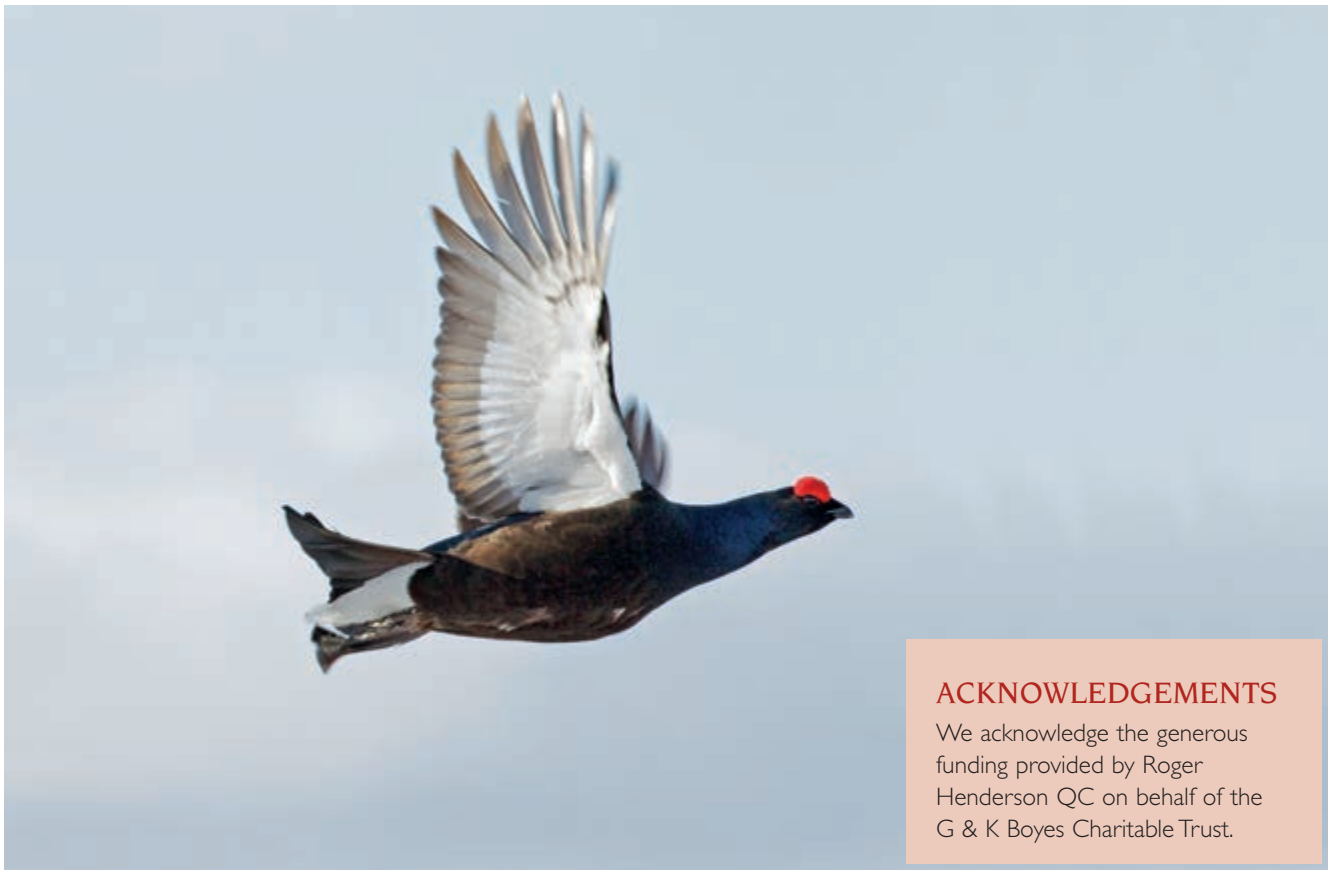
This disease is a welfare concern and potentially a conservation concern too should infection cross to other bird species occupying the same moors. A screening programme of black grouse occupying the fringes of moors where red grouse are infected has been conducted over the last three years. Despite in-hand examination of birds caught at night for research purposes, together with close-quarter visual examination of displaying males at leks and testing of droppings, we have found no sound evidence of respiratory cryptosporidiosis occurring in this species.

KEY FINDINGS

- Respiratory cryptosporidiosis was first diagnosed in red grouse as recently as 2010 and within three years was observed on half of driven grouse moors in northern England, most of those in the North Pennines.
- Infected female grouse bred a week later, produced only half the fledglings and survived only half as well as their healthy counterparts on the same moor.
- Impacts of disease on shooting have to date been slight due to low prevalence in the population, which currently shows no sign of increasing.
- Despite a programme of screening, the disease has not been found in black grouse.

David Baines
David Newborn
Mike Richardson
Philip Warren

The disease has not been found in black grouse.
© Dave Kjaer



ACKNOWLEDGEMENTS

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

The recovery of red grouse on Langholm Moor

Eighty two percent of predated red grouse carcasses were associated with signs of raptors.

BACKGROUND

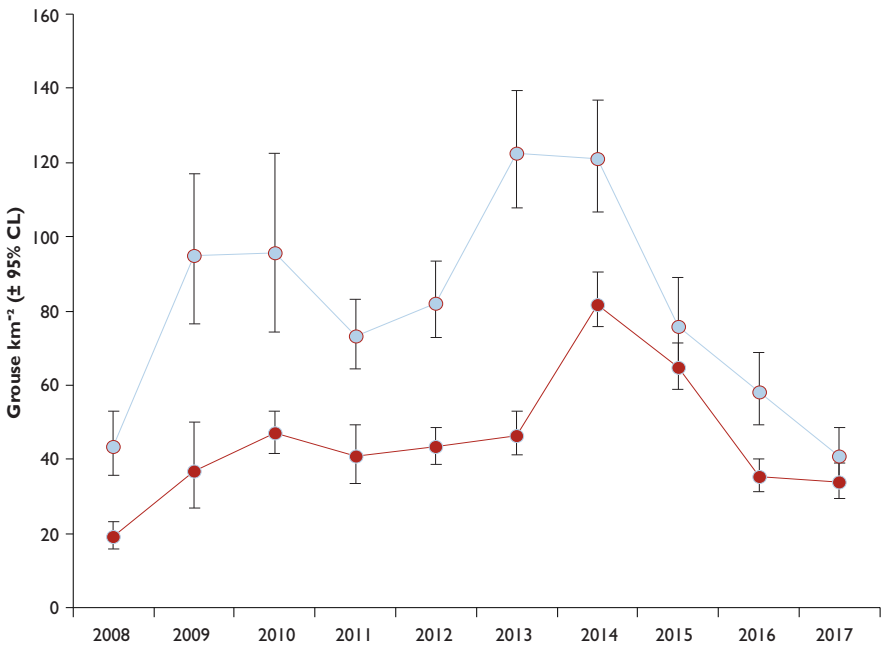
The Langholm Moor Demonstration Project (2008-2017) aimed to restore economically sustainable driven grouse shooting while maintaining a viable population of hen harriers, and to extend and improve the heather habitat. From 2008 until spring 2016, five gamekeepers controlled generalist predators and managed the heather habitat by rotational burning and cutting. To help restore heather cover, sheep grazing ceased on 39km² of moorland in 2011. All hen harrier broods were provided with diversionary food (see *Review of 2017*, p. 54-55).

Understanding the underlying causes of population change is key to managing animal populations in conservation and game management. Here, we consider which factors may have limited the recovery of red grouse on Langholm Moor. Grouse initially responded to the restoration of management in 2008 with a moderate population increase (see Figure 1), but this was not sustained, leading to the cessation of management in spring 2016.

First, we examined which grouse life stages were most important in explaining the observed changes in grouse numbers. Population changes are generally determined by birth and death rates (ie. breeding success and survival) as well as movement between populations, however, the latter was considered negligible because Langholm was isolated from other grouse moors. When estimates of breeding success and survival were based on annual grouse counts, a combination of adult summer and winter survival appeared to contribute most to population change; when based on radio-tagged individuals, it was adult summer survival and chick survival that contributed most. The contributions of clutch size, hatching success and nesting success were insignificant. Several factors may influence survival rates, but examination of grouse carcasses suggested that predation associated with raptor signs was the most important factor determining adult survival (see Figure 2) and was closely linked,

Figure 1

Mean spring and July densities of red grouse on Langholm Moor 2008-2017, derived from distance sampling. Gamekeepers were present until spring 2016, when management ceased



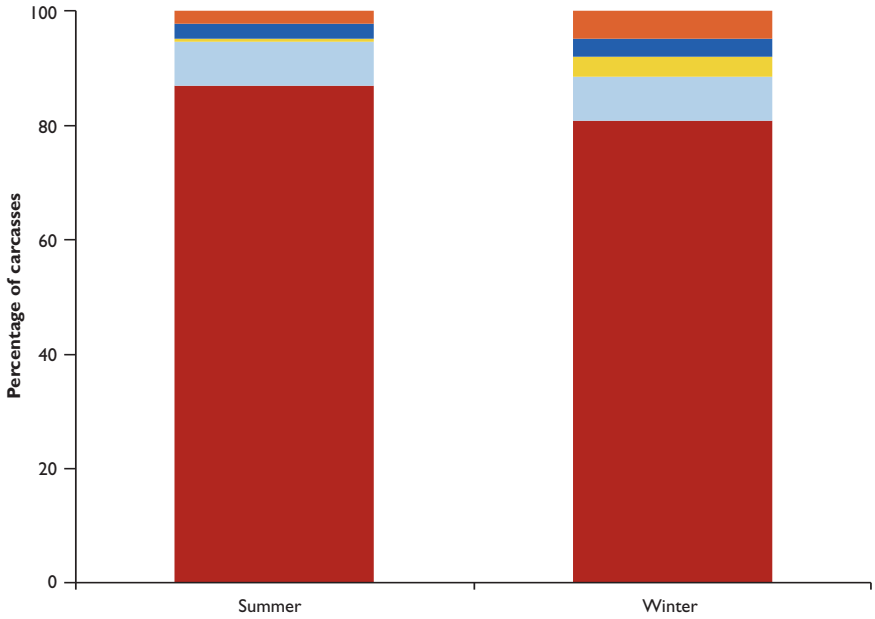


Figure 2
Frequency of red grouse carcasses associated with signs of predators (raptor, mammal or unknown predator), fence or road collisions, and unknown causes of mortality from examination of carcasses found between 2008 and 2016 on Langholm Moor during summer (April-July, N=350) and winter (August-March, N=1,092)

Raptor
Mammal
Unknown predator
Collision
Unknown

possibly alongside weather, to low rates of chick survival. However, it is possible that some grouse may have been scavenged by raptors rather than predated by them.

Second, we examined whether the restoration of heather habitat may help to mitigate the impact of predation by increasing grouse breeding success or survival. Reductions in sheep grazing from 2011 onwards increased the area of heather-dominated vegetation by 30%. We tested whether grouse densities, breeding success and survival based on counts were related to estimates of heather cover derived from ground vegetation surveys (2007, 2012 and 2015) and aerial photographs (2009 and 2015) in the count areas. Spring, and to a lesser extent also July, grouse densities were higher in areas with more heather. However, neither grouse breeding success nor summer and winter survival rates were related to heather cover. Survival of radio-tagged individuals also showed no relationship with any habitat measure, and there was no evidence that adult grouse moved into areas with increasing heather cover. During the early project years, grouse spring densities increased more where heather recovery was greatest. This can be explained by increased breeding success following the restoration of grouse moor management in 2008 and juveniles settling in areas with more heather. During the later years, when heather recovery accelerated after grazing reductions in 2011, we found that grouse spring densities did not respond to increases in heather cover. Overall, management for grouse had a larger effect on changes in grouse density and breeding success than reductions in grazing and the associated heather recovery.

Heather restoration has the potential to increase grouse carrying capacity in the long-term, eg. by restoring heather at low elevations from where it was previously lost. However, realising this potential first requires improving grouse breeding success and survival, which were suppressed by predation. Our results support other studies suggesting that habitat restoration alone may be insufficient to increase numbers in situations where predator pressure reduces productivity and survival.

Habitat restoration alone may be insufficient to increase numbers of red grouse. © Sonja Ludwig

KEY FINDINGS

- Survival of adult grouse and grouse chicks contributed most to annual population changes.
- Predation was the main cause of mortality and 82% of predated carcasses were associated with signs of raptor.
- Grouse breeding success and survival were not related to heather cover; hence, heather restoration alone is unlikely to mitigate against predation and increase grouse density.
- Our results suggest that grouse recovery at Langholm was not limited by habitat but by low survival rates, influenced by predation.

Sonja Ludwig

ACKNOWLEDGEMENTS

The Langholm Moor Demonstration Project was a partnership between the Game & Wildlife Conservation Trust, Scottish Natural Heritage, Buccleuch Estates, RSPB and Natural England. For more details see Ludwig et al. (2018) *Wildlife Biology 2018:* wlb.00430 and Ludwig et al. (2018) *Avian Conservation and Ecology* 13(2):14.

Cereal aphids and barley yellow dwarf virus

BACKGROUND

With the ban on the use of neonicotinoid insecticides on outdoor crops now in place, greater use is expected of pyrethroid insecticides applied as a foliar spray to prevent infection with viruses transmitted by aphids into crops such as cereals and sugar beet. These insecticides also pose a threat to the environment, including beneficial insects residing within crops and adjacent margins and for aquatic fly life if leaching into watercourses occurs. In cereal crops, spiders are the most valuable predators of cereal aphids, either creating an extensive coverage of webs or hunting out aphids on the ground. However, pyrethroid insecticides are especially toxic to them.

In anticipation of the neonicotinoid ban, we started investigating whether it would be possible to develop a within-field monitoring system for cereal aphids that would provide some indication of whether crops are at risk and therefore, help reduce the number of unnecessary prophylactic sprays. In the autumn, cereal aphids are notoriously difficult to count, and it is not known what densities pose a threat. Instead aphid forecasts are based upon a network of 12-metre-high suction traps that sample aphids daily. However, the network does not provide nationwide coverage and aphid levels can vary hugely even between fields on the same farm.

We chose to explore whether yellow sticky traps placed on the ground could be used as a within-field monitoring system and if the pattern of aphid immigration was affected by field boundaries. Sticky traps are cheap and, with training, relatively easy to assess and aphids have been shown to be attracted to them.

In southern England in the autumn, aphids normally arrive on a south-westerly wind. Therefore, 15 cereal fields were selected, of which eight were bounded by a hedgerow and seven woodland. For each boundary type, two transects of sticky traps, 10 metres (m) apart, were set up perpendicular to the boundary on either the south-west (upwind side) or north-east (downwind side), with transects at least 75m from the nearest field corner (only three fields were available for the upwind side of the woodland). Eight traps were used per transect, placed at 0.5m, 1.1m, 2.2m, 4.4m, 8.8m, 17.5m, 35m and 70m from the crop edge. Yellow 20-centimetre (cm) x 20cm wet sticky traps (Oecos Ltd) were fixed horizontally just off the ground, left for two weeks and collected in mid-November. Data were analysed using a generalised linear mixed

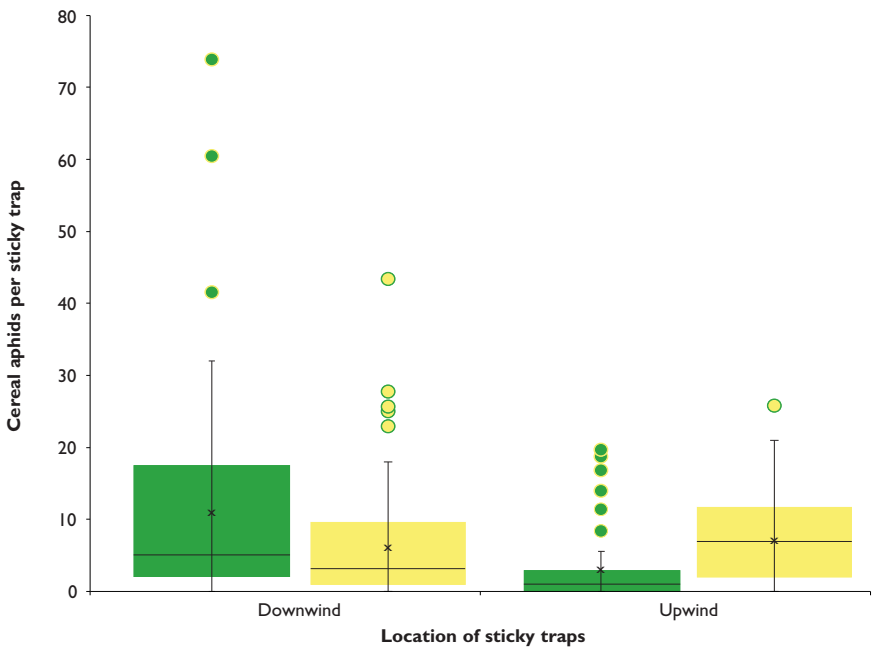


Figure 1

Effect of field boundary type on number of aphids captured on the sticky traps located either upwind or downwind of the boundaries. (Line in box shows the middle value (median); X is the mean)

Woodland

Hedgerow

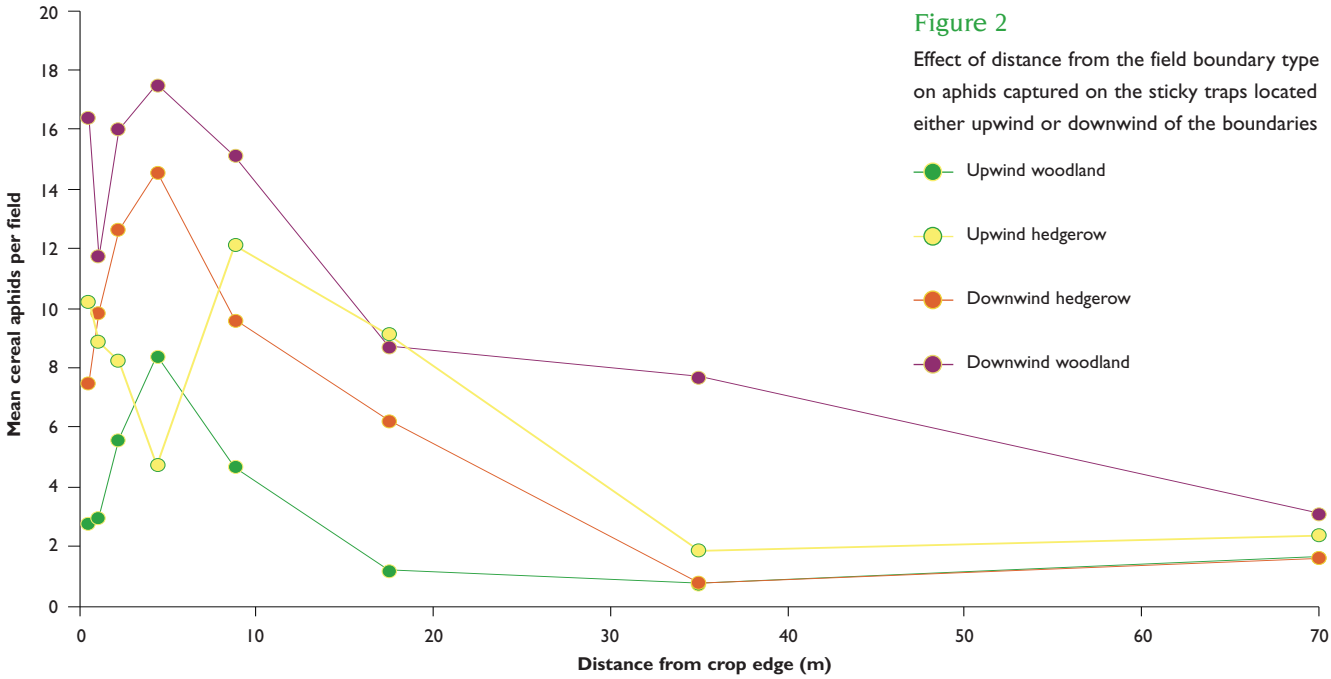


Figure 2
Effect of distance from the field boundary type on aphids captured on the sticky traps located either upwind or downwind of the boundaries

model with distance, type of boundary and location in relation to the wind direction as explanatory variables.

A total of 2,244 cereal aphids were captured, of which 59% were grain aphids *(Sitobion avenae)*, 30% bird cherry-oat aphid *(Rhopalosiphum padi)* and 11% rose-grain aphid *(Metopolophium dirhodum)*. Although three times as many winged cereal aphids were captured downwind of the woodland compared with upwind, the difference was not significant because some sites had many and some few aphids. Equal numbers were captured upwind and downwind of the hedgerows (see Figure 1). There was no detectable difference between woodland and hedgerow boundary types. The distance from the hedgerow had a significant effect on aphids ($P<0.001$); most were caught within 20m and on both upwind and downwind sides of the boundaries (see Figure 2).

The sticky traps showed promise as a within-field monitoring system as they were able to detect spatial variation in flying aphid immigration. The study showed that areas closer to boundaries are at higher risk of aphid infestation. Further studies have been conducted in autumn 2018 to confirm these findings, to determine whether sticky traps can predict subsequent aphid infestation and virus levels, and whether tillage affects aphid immigration.

KEY FINDINGS

- Yellow sticky traps were evaluated as a potential tool for monitoring when and how many cereal aphids fly into crops in the autumn.
- More aphids were trapped within 20 metres of woodland and hedgerow boundaries than at greater distances into the crop.
- Woodland boundaries may also increase aphid deposition downwind, but further studies are needed to confirm this finding.

John Holland
Belinda Bown
Jasmine Clark
Niamh McHugh

Yellow sticky traps were used to catch aphids flying in the crop. © John Holland/GWCT

Monitoring woodcock with acoustic recorders

Woodcock surveys are undertaken when the male woodcock are roding. © Laurie Campbell

BACKGROUND

As a British breeding species, the woodcock has experienced a 56% decline in site occupancy, at the 10x10-km-square scale, between 1970 and 2010 and a 29% decline in abundance between 2003 and 2013. Automated acoustic recorders offer a cost-effective way of increasing the reliability of current survey techniques by increasing survey coverage, especially in remote areas, and by providing data that can inform the interpretation of volunteer-led surveys like the GWCT/BTO Breeding Woodcock Survey.

The woodcock is 'red-listed' in the UK, owing to severe declines in its breeding range. The drivers of the decline are not fully understood, but GWCT research has shown that larger woods with a greater diversity of stands are more likely to support breeding woodcock. The male woodcock's conspicuous breeding display, known as 'roding', provides a practical means of surveying a species that is otherwise rarely seen. Roding surveys have formed the basis of national woodcock surveys in Britain since 2003, providing the most accurate indication of population size and trend to date.

Remote sound-recorders provide a new way to census a wide range of species, and a 2018 trial demonstrated the potential value of this technique for the study of woodcock. The recorders are stationed at fixed locations and record digital sound files according to a pre-programmed schedule. They are an efficient alternative to existing manual sampling as they can be used where regular access is difficult, reduce disturbance caused by human presence and maximise coverage over time through a long-term sampling regime. In this study we aim to examine the value of automated acoustic recorders and associated classification software as a way of surveying woodcock.

Surveys were conducted on fixed count points positioned along woodland rides or clearings within 16 individual woodland blocks (>10 hectares (ha) in size) in north Hampshire and took place between April and June 2018, using five SM3 acoustic detectors. At each wood, detectors were set to record over a seven-day period, twice a day: 1) 15 mins before, to 1.5 hours after sunset and 2) 1.5 hours before, to 15 minutes after sunrise. This system of monitoring has produced 784 hours of recordings representing 448 105-minute-long sessions. We have so far processed 12.5% of the total dataset, and already identified 500 woodcock recordings. The roding calls were displayed as spectrograms using Kelidoscope and SongScope, they consist of three to five low-frequency grunts followed by a high-pitched squeak, which is repeated at intervals of about three seconds (see Figure 1).

At two sites, manual roding surveys were conducted to assess the comparability of a human surveyor and an automated recorder. Initial results indicate high similarity between the two methods and in 2019 we plan to expand this comparison to encompass additional sites.

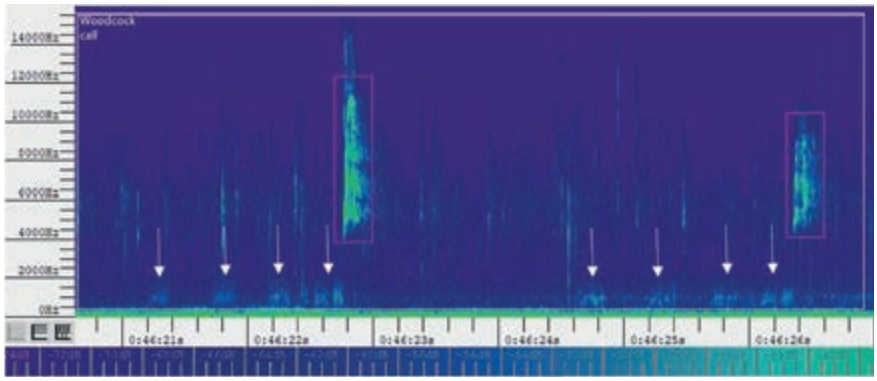


Figure 1
Woodcock spectrogram. The high 'squeak' and low 'grunt' phases are visible. The position of grunts have been marked with white arrows and squeaks are outlined using pink boxes

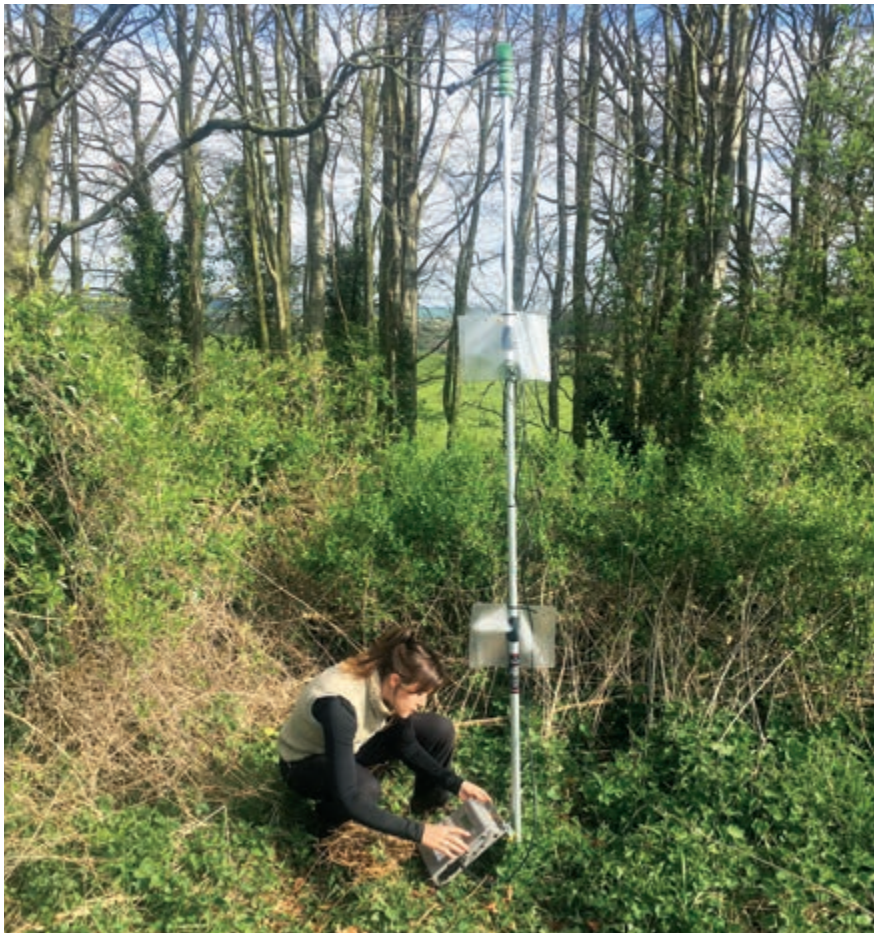
The data we have collected to date should provide us with comprehensive information regarding the variability in roding behaviour across different sites and survey periods. Existing interpretation of roding survey data relies upon a calibration equation that is used to convert woodcock 'registrations' (birds seen or heard displaying) into an estimate of the number of males present. This equation was devised using sonogram analysis that allows different individuals to be distinguished. In the future, remote sound-recorders could play a role in the refinement of these calibration equations by providing data from a wider range of woodland sites, and by monitoring change in the number of individuals detected at each site over time.

The national GWCT/BTO woodcock surveys, which have been used to estimate British breeding population size, rely on voluntary surveyors to conduct counts of roding woodcock. Generally, we recommend three visits to each survey site per year, but often this is difficult to achieve for remote sites. Demonstrating that automated sound recorders are able to detect woodcock as effectively as a human observer may mean that this technique can be used to increase survey coverage and improve its representativity.

KEY FINDINGS

- A 2018 trial demonstrated that acoustic recorders could be used to monitor woodcock remotely.
- Five hundred woodcock registrations have been identified from the 12.5% of recordings that have been examined so far.
- A total of 784 hours' of data has been collected.

Niamh McHugh
Chris Heward
Andrew Hoodless



Setting up an acoustic recorder in the field to record woodcock roding. © Niamh McHugh/GWCT

ACKNOWLEDGEMENTS

We would like to thank the landowners who allowed us access to their land to conduct acoustic surveys. We would also like to thank Nick Bailey who assisted in the field.

Research projects

by the Game & Wildlife Conservation Trust in 2018

ALLERTON PROJECT RESEARCH IN 2018

Project title	Description	Staff	Funding source	Date
Monitoring wildlife at Loddington (see p14)	*Annual monitoring of game species, songbirds, invertebrates, plants and habitat*	*Chris Stoate, John Szczur, Alastair Leake, Steve Moreby*	*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 SoilQuest*	*2012- ongoing*
Soil monitoring	*Survey of soil biological, physical and chemical properties*	*Chris Stoate, Felicity Crotty, Alastair Leake, Phil Jarvis*	*Allerton Project*	*2014- ongoing*
Soilquality.org	*Farmer engagement in mapping soil properties*	*Chris Stoate, Felicity Crotty*	*NERC SARIC*	*2016-2018*
SoilCare	*Soil management to meet economic and environmental objectives across Europe*	*Chris Stoate, Felicity Crotty, Gemma Fox*	*EU H2020*	*2016-2020*
Soil health and biology	*The role of soil biology in crop production systems*	*Chris Stoate, Felicity Crotty*	*AHDB*	*2016-2020*
Conservation Agriculture	*Economic and environmental impacts of three contrasting crop production approaches*	*Alastair Leake, Phil Jarvis, Chris Stoate, Felicity Crotty, 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*
RePhoKUs	*Understanding food system phosphorus balance at a range of scales*	*Chris Stoate with Paul Withers and partners*	*Research Councils*	*2018-2020*
Agroforestry	*Optimising tree densities to meet multiple objectives in grazed pasture*	*Chris Stoate, Felicity Crotty, Alastair Leake*	*Woodland Trust*	*2018- ongoing*
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*	*2014-2018*
PhD: Farmer and scientific knowledge of soils (see p20)	*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*	*2015-2018*
PhD: Multifunctional field margins	*An experimental comparison of plant species communities designed for pollinators, pest predators/parasitoids and water run-off management*	*Claire Blowers. Supervisors: Chris Stoate, Dr Heidi Cunningham, Dr Peter Sutton, Dr Nigel Boatman (Harper Adams University)*	*BBSRC Syngenta CASE*	*2015-2018*
PhD: P cycling in cover crops	*The role of cover crops in capturing and mobilising soil phosphorus*	*Sam Reynolds. Supervisors: Chris Stoate, Dr Karl Ritz (Nottingham University), Dr Andy Neal (Rothamsted Research)*	*NERC*	*2016-2020*
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 2018

Project title	Description	Staff	Funding source	Date
Core biodiversity monitoring (see p22)	*Monitoring of key groups to assess impacts of farming changes*	*Dave Parish, Marlies Nicolai, Minna Ots, Grace Edmondson, Beth Conway, Katherine Thorne*	*Core funds*	*2015- ongoing*
Wader population monitoring	*Surveying of wader numbers, distribution, productivity, radio-tagging lapwing chicks, GPS tagging curlew*	*Dave Parish, Marlies Nicolai, Grace Edmondson, Andrew Hoodless, Kirsty Maden*	*Core funds*	*2017- ongoing*
Rabbit population monitoring	*Assessing rabbit numbers in relation to control methods and impacts on grass and other species*	*Dave Parish, Marlies Nicolai, Minna Ots, Grace Edmondson*	*Core funds*	*2016- ongoing*
Thrush population monitoring	*Detailed investigation of thrush habitat use, distribution and productivity*	*Dave Parish, Marlies Nicolai, Minna Ots*	*Core funds, SongBird Survival*	*2017- 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, Minna Ots, Grace Edmondson, Beth Conway, Katherine Thorne, Adam Smith, Merlin Becker*	*LIFE+, Core funds*	*2016-2020*
Liming experiment	*Split-field experiment investigating impacts of liming on invertebrates, including mud snails*	*Dave Parish, Marlies Nicolai, Minna Ots, Grace Edmondson*	*James Hutton Institute, Core funds*	*2016-2020*
Mud snail and liver fluke interactions	*Investigating the importance of intermediate/ alternative fluke hosts and land-use*	*Dave Parish, Marlies Nicolai, Grace Edmondson*	*Core funds, Moredun Research Institute*	*2017- ongoing*

PREDATION RESEARCH IN 2018

Project title	Description	Staff	Funding source	Date
Pest control strategy	*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*	*2006-2018*
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, Anna Jones, Peter Wood, Jodie Case, Megan Baldissara, Alex Shishkin, Jonathan Reynolds*	*LIFE+ Waders for Real, Core funds*	*2015-2019*
Grey squirrel trapping strategy	*Evaluation of chew cards and track tunnels to determine presence/absence of grey squirrels*	*Megan Baldissara, Alex Shiskin, Jonathan Reynolds*	*Core funds*	*2018*
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*	*2018*

FISHERIES RESEARCH IN 2018

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*
Salmon life-history strategies in freshwater (see p28)	*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 (see p32)	*Long-term study of the ecology of River Wylye grayling*	*Stephen Gregory, Luke Scott, Tea Basic (now 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, Bill Riley*	*Cefas/Defra, Core funds*	*2015-2019*
Salmon smolt rotary screw trap assessment (see p34)	*Evaluating if capturing and tagging of emigrating salmon smolt affects their marine surval*	*Rasmus Lauridsen, William Beaumont, Stephen Gregory, Bill Riley, Ian Russell (Cefas)*	*CEFAS, EU Interreg, Core funds*	*2017-2018*
Impacts of hydro power on salmon and trout smolts	*Calculating the effects of a run of river archemedies hydro turbine on salmon and trout smolts*	*Rasmus Lauridsen, William Beaumont, Stephen Gregory, Bill Riley, Ian Russell (Cefas)*	*CEFAS, EU Interreg, Core funds*	*2017-2018*
Salmon and trout smolt tracking (see p30)	*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)*	*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 (Agrocampus Ouest)*	*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 at sea*	*Jamie Stevens, Andy King (Exeter University), Sophie Launey (INRA), Dylan Roberts, Rasmus Lauridsen*	*EU Interreg, Core funds*	*2017-2022*
New salmon stock assessment tools	*Providing new information for stock assessment models and new stock assessment tools in England and France as part of the SAMARCH project*	*Stephen Gregory, Marie Nevoux (INRA), Etienne Rivot (Agrocampus Ouest), Rasmus Lauridsen, William Beaumont, Luke Scott, Dylan Roberts*	*EU Interreg, Core funds*	*2017-2022*
New policies for salmon and sea trout in coastal and transitional waters	*Developing new policies for the better management of salmon and sea trout in coastal and transitional waters based on the outputs of SAMARCH*	*Dylan Roberts, Lawrence Talks and Simon Toms (EA), Laurent Beaulaton (Association of French Biodiversity), Gaelle Germis (Bretagne Grands Migrateurs), Paul Knight, Lauren Mattingley (S&TC, UK) and Jerremy Corr (Normandie Grands Migrateurs)*	*EU Interreg, Core funds*	*2017-2022*
MSc: Smolt migration speed	*Using the PIT tag infrastructure in the catchment to quantify the speed of in river salmon and trout smolt migration and investigate factors affecting this*	*Ali Harrison. Supervisors: Rasmus Lauridsen, Stephen Gregory, Guy Woodward (Imperial College London)*	*EU Interreg, Imperial College London*	*2017-2018*
PhD: Beavers and salmonids	*Impacts of beaver dams on salmonids*	*Robert Needham. Supervisors: Dylan Roberts, Paul Kemp (Southampton University)*	*Core funds, Southampton University, SNH, Salmon & Trout Conservation UK*	*2014-2019*
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 (QMUL), Bill Riley (Cefas), Sian Griffiths (Cardiff University)*	*QMUL, Cefas, Core funds*	*2015-2019*
PhD: Ranunculus as a bioengineer in chalkstreams (see p36)	*Investigate the role of Ranunculus as a bioengineer, driving the abundance and diversity of plants, invertebrates 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*

LOWLAND GAME RESEARCH IN 2018

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	*Study of factors affecting return rates of pheasant release pens*	*Rufus Sage, Maureen Woodburn*	*Core funds*	*2008- ongoing*
Consequences of releasing	*Review and synthesis of GWCT studies and other literature on ecological consequence of releasing for shooting*	*Rufus Sage*	*Core funds*	*2018-2019*
Pheasant survival and breeding success	*Radio-tracking pheasant populations at the Allerton Project Farm, Loddington, after the shooting-season*	*Rufus Sage, Austin Weldon, Matt Coupe, Charlotte Parker, Meg Speck*	*Core funds*	*2018-2020*
PhD: Improving released pheasants (see p38)	*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*	*2015-2018*

WETLAND RESEARCH IN 2018

Project title	Description	Staff	Funding source	Date
Woodcock monitoring	*Examination of annual variation in breeding woodcock abundance*	*Chris Heward, Andrew Hoodless, collaboration with BTO*	Shooting Times *Woodcock Club*	*2003- ongoing*
Woodcock survival and site fidelity	*Intensive ringing and recapture of woodcock at three winter sites*	*Andrew Hoodless, Chris Heward, collaboration with the Woodcock Network*	*Core funds*	*2012- ongoing*
Woodcock migration (see p42)	*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*
LIFE+ Waders for Real (see p40)	*Wader recovery project in the Avon Valley*	*Andrew Hoodless, Lizzie Grayshon, Ryan Burrell, Mike Short, Tom Porteus, Jonathan Reynolds, Clive Bealey, Paul Stephens*	*EU LIFE+ programme, Core funds*	*2014-2019*
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, private donors*	*2018-2022*
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*	*2013-2018*

PARTRIDGE AND BIOMETRICS RESEARCH IN 2018

Project title	Description	Staff	Funding source	Date
Partridge Count Scheme (see p44)	*Nationwide monitoring of grey and red-legged partridge abundance and breeding success*	*Neville Kingdon, Nicholas Aebischer, Julie Ewald, Kit Lawson, Samantha Skinner, Megan Baldissara, Alex Shishkin*	*Core funds, GCUSA*	*1933- ongoing*
National Gamebag Census (see p56)	*Monitoring game and predator numbers with annual bag records*	*Nicholas Aebischer, Gillian Gooderham, Ryan Burrell, Kit Lawson, Samantha Skinner, Sam Gibbs, Megan Baldissara, Katherine Harrap, Alex Shishkin*	*Core funds*	*1961- ongoing*
Sussex study (see p48)	*Long-term monitoring of partridges, weeds, invertebrates, pesticides and land use on the South Downs in Sussex*	*Julie Ewald, Nicholas Aebischer, Steve Moreby, Ryan Burrell, Sam Gibbs*	*Core funds*	*1968- ongoing*
Wildlife monitoring at Rotherfield Park (see p46)	*Monitoring of land use, game and songbirds for the Rotherfield demonstration project*	*Francis Buner, Malcolm Brockless, Julie Ewald Ryan Burrell, Holly Kembrey, Elouise Mayall*	*Core funds*	*2010-2018*
Grey partridge management (see p26)	*Researching and demonstrating grey partridge management at Whitburgh Farms*	*Dave Parish, Hugo Straker, Adam Smith, Merlin Becker, Fiona Torrance*	*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, Kit Lawson, Samantha Skinner, Megan Baldissara, Alex Shishkin*	*Core funds*	*2014- ongoing*
Developing novel game crops	*Developing perennial game cover mixes*	*Dave Parish, Fiona Torrance, Hugo Straker*	*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*	*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 Ryan Burrell, Katherine Harrap, Daniel Kosky*	*Core funds*	*2015-2018*
PARTRIDGE (see p54)	*Co-ordinated demonstration of management for partridge recovery and biodiversity in the UK, the Netherlands, Belgium and Germany*	*Francis Buner, Holly Kembrey, Elouise Mayall, Paul Stephens, Julie Ewald, Neville Kingdon, Ryan Burrell, Sam Gibbs Peter Thompson, Chris Stoate, Roger Draycott, John Szczur, Austin Weldon, Dave Parish, Fiona Torrance, Nicholas Aebischer, Francesca Pella*	*Interreg (EU North Sea Region) Core funds*	*2016-2020*
Recovery of grey partridge populations in Scotland	*Encouraging grey partridge management and monitoring across Scotland*	*Dave Parish*	*Core funds*	*2017- ongoing*

UPLANDS RESEARCH IN 2018

Project title	Description	Staff	Funding source	Date
Grouse Count Scheme (see p60)	*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,*	*SNH, Forest Enterprise Scotland*	*1991- ongoing*
Capercaillie: causes of poor breeding	*Radio-tracking females to ascertain habitat use and causes of low breeding success*	*Kathy Fletcher*	*SNH, Forest Enterprise Scotland, Cairngorms National Park Authority*	*2015-2018*
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*	*1995-2018*
Black grouse range expansion	*Black grouse range restoration in the Yorkshire Dales by translocating surplus wild males*	*Philip Warren*	*Biffa, Private funder, Yorkshire Water, Nidderdale AONB*	*1996-2018*
Langholm Moor Demonstration Project (see p70)	*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, Natural England, RSPB*	*2008-2018*
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*	*2016-2018*
Heather burning and moorland birds	*Does heather burning on high altitude blanket peat influence ground-nesting bird abundance?*	*David Baines, Mike Richardson*	*Core funds*	*2016-2018*
Post-burning vegetation recovery on blanket peat	*Using aerial images and field surveys to assess chrono-sequences of vegetation responses to heather burning*	*Sian Whitehead, David Baines*	*Core funds*	*2017-2018*
Declining waders in SW Scotland & north Wales	*Long-term declines of moorland ground-nesting birds in south-west Scotland and north Wales*	*Sian Whitehead, Nick Hesford, David Baines*	*Scottish Land & Estates, SGA*	*2017-2018*
Mountain hares (see p66)	*Are mountain hare abundance indices influenced by grouse moor management: an analysis of observations from grouse counts?*	*Nick Hesford, David Baines*	*Core funds*	*2017-2018*
Development of long-term heather burning experiments on blanket peat (see p64)	*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*	*2018*
Mountain hares	*10-yearly questionnaire on mountain hare abundance and distribution*	*Nick Hesford, Julie Ewald*	*Core funds*	*2018-2019*
Grey partridge	*Does supplementary feeding improve over-winter survival and local recruitment of breeding pairs*	*Nick Hesford, Julie Ewald, David Baines*	*Core funds, Philip Wayre Upland Trust*	*2018-2021*

FARMLAND RESEARCH IN 2018

Project title	Description	Staff	Funding source	Date
Insecticide effects on beneficial invertebrates	*Secondary feeding effects of insecticides on beetles*	*John Holland, Niamh McHugh, Belinda Bown, Chris Wyver*	*Core funds*	*2015- ongoing*
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, Chris Wyver*	*External funds*	*2015- ongoing*
Long-term trends in beetles (see p52)	*Beetle abundance and diversity in Sussex 40 years on*	*Susan Hammond, John Holland, Steve Moreby, Julie Ewald*	*Core funds*	*2016-2018*
Agribats	*Bat use of arable agri-environment scheme habitats*	*Niamh McHugh*	*Heritage Lottery Fund, The Mercer's Company, Wixamtree Trust, The Hamamelis Trust, Chapman Charitable Trust*	*2017-2018*
Long-term monitoring	*Monitoring of wildlife on BASF demonstration farms*	*John Holland, Belinda Bown, Chris Wyver, Roseanne Powell, Niamh McHugh*	*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, Chris Wyver, Roseanne Powell*	*Private funds*	*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, Belinda Bown, Roseanne Powell, John Szczur, Amy Corrin, Ellen Knight, Susan Hammond*	*Natural England*	*2018-2020*
Pilot within-field monitoring study to predict BYDV risk (see p72)	*Pilot study to evaluate sticky traps as a potential within-field monitoring and decision support system to predict the risk of BYDV*	*John Holland, Belinda Bown, Roseanne Powell, Ellen Knight, Amy Corrin*	*AHDB*	*2018-2020*
Detectors for monitoring woodcock (see p74)	*Evaluation of acoustic detectors for monitoring woodcock*	*Niamh McHugh, Belinda Bown, Chris Heward, Andy Hoodless*	*Core funds*	*2018- ongoing*
Invertebrate sampling methods	*Comparison of Dvac, sweep net and vortis suction sampling techniques*	*Steve Moreby, Belinda Bown, Chris Wyver*	*Core funds*	*2018- ongoing*
PhD: Solitary bees	*Seed mixes for solitary bees*	*Rachel Nichols. Supervisors: John Holland, Prof Dave Goulson (University of Sussex)*	*NERC/GWCT*	*2018- ongoing*

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; 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 2018

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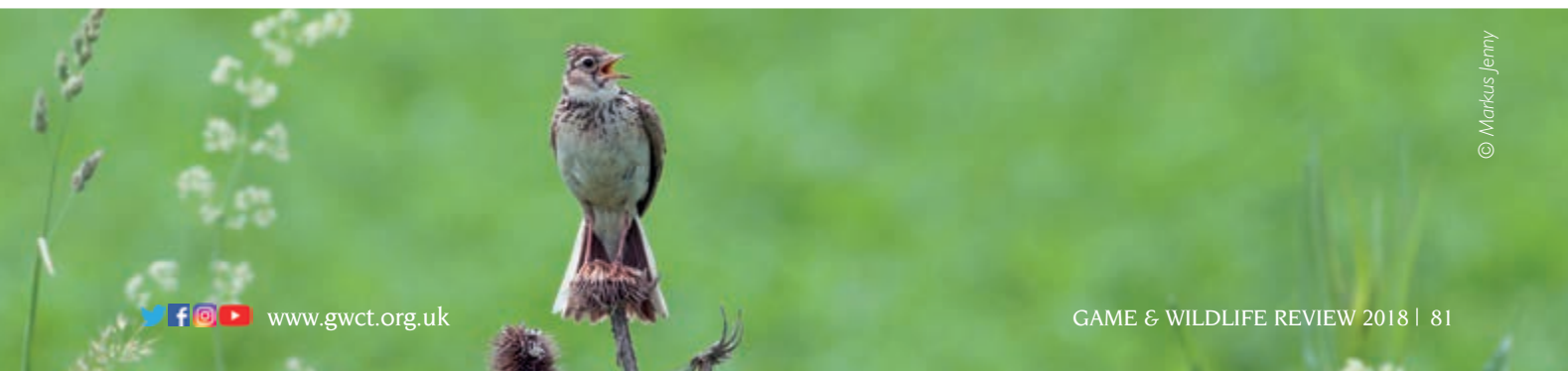
GWCT staff in bold.



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Financial report
for 2018

The summary report and financial statement for the year ended 31 December 2018, set out below and on pages 84 to 85, 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 1 May 2019 and which may be obtained from the Trust's Headquarters. The auditors have issued unqualified reports on the full annual accounts and on the consistency of the Trustees' report with those accounts, and their report on the full accounts contained no statement under sections 498(2) or 498(3) of the Companies Act 2006.

KEY POINTS

- Income was £8.46 million, a slight increase over 2017.
- Expenditure on charitable activities was £5.55 million (an increase of 8%).
- There was a surplus of £307,000 on unrestricted funds.
- The Trust's net assets were £8.6 million at the end of the year.

The Trust showed a surplus on unrestricted funds in 2018 due once again to the generosity of our supporters and effective cost management by our staff. The decrease in net assets was due to a combination of spending restricted donations which were received in the previous years and unrealised losses on the investments, reflecting the performance of the stock market in the final quarter of 2018.

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 2018 the Trust's reserves (according to this definition) were around £1.3 million, compared with £1.0 million at the end of 2017.

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

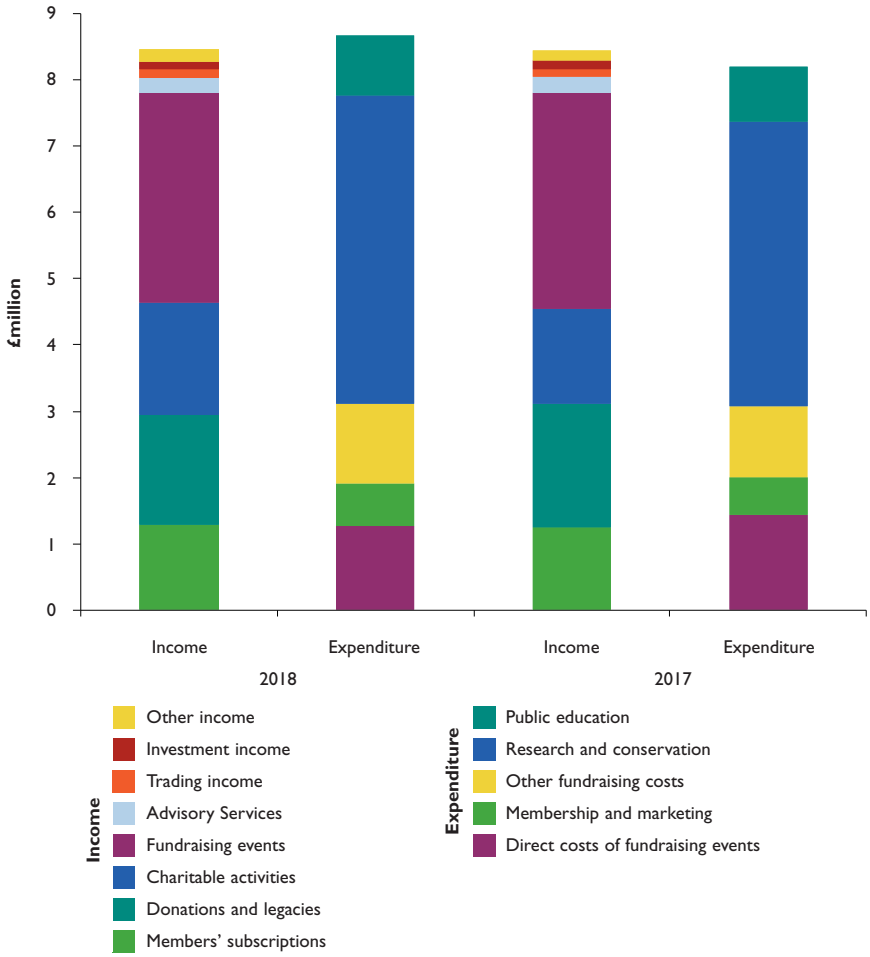

Figure 1

Total incoming and outgoing resources in 2018 (and 2017) 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 2018 which is set out on pages 84 and 85.

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 2018 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, 3 May 2019

Consolidated

Statement of financial activities

	General Fund £	Designated Funds £	Restricted Funds £	Endowed Funds £	**Total 2018 £**	Total 2017 £
INCOME AND ENDOWMENTS FROM:						
Donations and legacies						
Members' subscriptions	1,289,957	-	-	-	**1,289,957**	1,244,845
Donations and legacies	869,553	-	787,573	-	**1,657,126**	1,860,842
	2,159,510	-	787,573	-	**2,947,083**	3,105,687
Charitable activities	-	-	1,693,813	-	**1,693,813**	1,430,827
Other trading activities						
Fundraising events	3,093,592	-	59,923	-	**3,153,515**	3,273,019
Advisory Service	229,679	-	-	-	**229,679**	240,820
Trading income	127,266	-	-	-	**127,266**	106,206
Investment income	4,627	-	119,909	4,830	**129,366**	138,776
Other	110,247	-	60,670	-	**170,917**	137,301
TOTAL	5,724,921	-	2,721,888	4,830	**8,451,639**	8,432,636
EXPENDITURE ON:						
Raising funds						
Direct costs of fundraising events	1,267,053	-	-	-	**1,267,053**	1,447,028
Membership and marketing	638,639	-	-	-	**638,639**	549,406
Other fundraising costs	1,210,764	-	-	-	**1,210,764**	1,080,420
	3,116,456	-	-	-	**3,116,456**	3,076,854
Charitable activities						
Research and conservation						
Lowlands	1,305,148	-	626,065	-	**1,931,213**	1,799,284
Uplands	327,993	-	166,773	-	**494,766**	499,270
Demonstration	229,429	-	1,139,565	4,150	**1,373,144**	1,447,768
Fisheries	125,662	-	725,778	-	**851,440**	545,901
	1,988,232	-	2,658,181	4,150	**4,650,563**	4,292,223
Public education	313,542	75,000	459,266	50,000	**897,808**	827,717
	2,301,774	75,000	3,117,447	54,150	**5,548,371**	5,119,940
TOTAL	5,418,230	75,000	3,117,447	54,150	**8,664,827**	8,196,794
Income/(expenditure) before investment gains	306,691	(75,000)	(395,559)	(49,320)	**(213,188)**	235,842
Net gains/(losses) on investments:						
Realised	(12,882)	-	-	(7,124)	**(20,006)**	42,280
Unrealised	2,005	-	-	(237,412)	**(235,407)**	93,690
NET INCOME/(EXPENDITURE)	295,814	(75,000)	(395,559)	(293,856)	**(468,601)**	371,812
Transfers between funds	449,908	-	463,135	(913,043)	**-**	-
NET MOVEMENT IN FUNDS	745,722	(75,000)	67,576	(1,206,899)	**(468,601)**	371,812
RECONCILIATION OF FUNDS						
Total funds brought forward	2,407,544	86,492	811,045	5,798,986	**9,104,067**	8,732,255
TOTAL FUNDS CARRIED FORWARD	£3,153,266	£11,492	£878,621	£4,592,087	**£8,635,466**	£9,104,067

Consolidated

Balance sheet

as at 31 December 2018

	£	2018 £	£	2017 £
FIXED ASSETS				
Tangible assets		3,742,438		3,283,162
Investments		3,254,913		4,112,848
		6,997,351		7,396,010
CURRENT ASSETS				
Stock	401,697		356,835	
Debtors	1,481,921		1,373,622	
Cash at bank and in hand	1,024,917		1,002,516	
	2,908,535		2,732,973	
CREDITORS:				
Amounts falling due within one year	765,753		544,068	
NET CURRENT ASSETS		2,142,782		2,188,905
TOTAL ASSETS LESS CURRENT LIABILITIES		9,140,133		9,584,915
CREDITORS:				
Amounts falling due after more than one year		504,667		480,848
NET ASSETS		£8,635,466		£9,104,067
Representing:				
CAPITAL FUNDS				
Endowment funds		4,592,087		5,798,986
INCOME FUNDS				
Restricted funds		878,621		811,045
Unrestricted funds:				
Designated funds	11,492		86,492	
Revaluation reserve	205,216		296,065	
General fund	2,908,494		2,069,350	
Non-charitable trading fund	39,556		42,129	
		3,164,758		2,494,036
TOTAL FUNDS		£8,635,466		£9,104,067

Approved by the Trustees on 1 May 2019 and signed on their behalf

J PAICE

Chairman of the Trustees

Staff

of the Game & Wildlife Conservation Trust in 2018

CHIEF EXECUTIVE	Teresa Dent BSc, FRAgS, CBE
Personal Assistant	Laura Gell; Liz Scott *(from September)*
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
Head of Database	Corinne Duggins Lic ès Lettres
Head of Administration & Personnel	Alastair King Chartered MCIPD, MAHRM
Health & Safety Officer (p/t)	John Owen
Head Groundsman (p/t)	Craig Morris
Headquarters Site Maintenance	Steve Fish
Cleaner	Theresa Fish *(from March)*
Head of Information Technology	James Long BSc
IT Assistant	Charles Fisher *(until May);* Dean Jervis HNC, BA *(from October)*
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
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 *(from February)*
SAMARCH Research Assistant	Thomas Lecointre *(from December)*
SAMARCH Research Assistant	Jessica Picken BSc, MSc *(from October)*
PhD Student *(University of Southampton)* - beavers and salmonids	Robert Needham BSc
PhD Student *(University of Queen Mary London)* - *Ranunculus*	Jessica Marsh BSc, MSc
PhD Student *(University of Queen Mary London)* - low flows on salmonids and river ecosystems	Jessica Picken BSc, MSc
PhD Student *(Bournemouth University)* - smolt migration and survival	Olivia Simmons BSc, MSc *(from September)*
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
MSc student *(University of East Anglia)*	Charlotte Parker BSc *(March-July)*
Placement Student *(Manchester Metropolitan University)*	Meg Speck *(until June)*
Head of Wetland Research	Andrew Hoodless BSc, PhD
Research Ecologist	Kaat Brulez MSc, PhD *(until March)*
Research Ecologist	Lucy Capstick BSc, PhD
Research Assistant	Ryan Burrell BSc *(from April)*
Research Assistant	Jodie Case BSc *(from May)*
Ecologist – LIFE Waders for Real	Lizzie Grayshon BSc
Research Assistant/PhD Student *(p/t University of Nottingham)* - woodcock	Chris Heward BSc
MSc Student *(University of Reading)* - lapwing chick survival	Giselle Hynes BSc
MSc Student *(University of Newcastle)* - predator abundance	Heather Warrender BSc
MSc Student *(University of Reading)* - invertebrates in wet grasslands	Jessica Grimbley BSc
Placement Student *(University of Bath)*	Eleanor Ness *(until August)*
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
Research Assistant	Rosanne Powell *(April-December)*
PhD Student *(University of Sussex)* - solitary bees	Rachel Nichols BSc, MSc
MSc Student *(Harper Adams University)* - Sussex pitfalls	Susan Hammond *(April-December)*
Visiting PhD student *(Newcastle University)*	Nick Bailey BSc *(April-June)*
Placement Student *(Reading University)*	Chris Wyver *(until September)*
Placement Student *(Reading University)*	Ellen Knight *(from September)*
Placement Student *(University of Nottingham)*	Amy Corrin *(from September)*
Director of Upland Research	David Baines BSc, PhD
Office Manager, Uplands	Julia Hopkins *(until May);* Helen Allinson BSc *(Jan-March)*, Sarah Grondowski *(from Dec)*
Senior Scientist	Phil Warren BSc, PhD
Research Assistant	Michael Richardson BSc
Senior Scientist	Sian Whitehead BSc, DPhil
Research Ecologist Langholm	Sonja Ludwig MSc, PhD
Seasonal Field Assistant	Melissa Dawson BSc *(May-August)*
Placement Student *(York University)*	Beth Goodman *(until August)*
Placement Student *(Leeds University)*	Hannah Coyle *(until August)*
Placement Student *(University of West of England)*	Hannah Weald *(from September)*
Placement Student *(University of Nottingham)*	Megan Roberts *(from September)*
Senior Scientist - North of England Grouse Research	David Newborn HND
Senior Research Assistant - Scotland	Nick Hesford BSc, PhD
Senior Scientist - Scottish Upland Research	Kathy Fletcher BSc, MSc, PhD
Head of Advisory	Roger Draycott HND, MSc, PhD[2]
Co-ordinator Advisory Services (p/t)	Lynda Ferguson
Biodiversity Advisor – Farmland Ecology	Peter Thompson DipCM, MRPPA (Agric)
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)	Sofi Lloyd *(until March)*; Henrietta Appleton BA,MSc *(from April)*
Head of Research for the Allerton Project	Prof. Chris Stoate BA, PhD
Ecologist	John Szczur BSc
Soil Scientist	Felicity Crotty BSc, PhD *(until October)*
Research Assistant	Gemma Fox *(from October)*
Welland Project Officer	Geoff Gilfillan BSc, PhD *(until December)*; Chris French *(from December)*
PhD Student *(Harper Adams University)* - multifunctional field margins	Claire Blowers BSc, MSc
PhD Student *(Leicester University)* - soil biology	Falah Hamad BSc, MSc
PhD Student *(University of Nottingham)* - soil properties	Stephen Jones BSc, MSc
PhD student *(University of Nottingham)* - cover crops	Sam Reynolds
Head of Education and Development	Jim Egan
Project Development Officer	Amelia Woolford BSc
Farm Manager	Philip Jarvis MSc
Farm Assistant	Michael Berg
DEPUTY DIRECTOR OF RESEARCH	Nicholas Aebischer Lic ès Sc Math, PhD, DSc
Secretary, Librarian & National Gamebag Census Co-ordinator	Gillian Gooderham
Senior Conservation Scientist	Francis Buner Dipl Biol, PhD
Placement Student *(Nottingham Trent University)*	Holly Kembrey *(until September)*
Placement Student *(University of East Anglia)*	Elouise Mayall *(from September)*
Head of Geographical Information Systems	Julie Ewald BS, MS, PhD
Partridge Count Scheme Co-ordinator	Neville Kingdon BSc
Biometrics/GIS Assistant	Ryan Burrell BSc *(until April)*; Sam Gibbs BSc *(from June)*
Placement Student shared with Predation *(University of Plymouth)*	Megan Baldissara *(until September)*
Placement Student shared with Predation *(University of Plymouth)*	Alex Shishkin *(until September)*
Placement Student shared with Wetlands *(University of Southampton)*	Kit Lawson *(from September)*
Placement Student shared with Wetlands *(University of Sheffield)*	Samantha Skinner *(from September)*
Computer Science Placement Student *(University of Kent)*	Katherine Harrap *(until September)*
Computer Science Placement Student *(University of York)*	Daniel Kosky *(from September)*
DIRECTOR OF FUNDRAISING	Jeremy Payne MA, MInstF
Prospect Researcher	Tara Ghia *(from January)*
London Events Manager	Jo Langer
London Events Assistant	Molly Smith *(until July)*; Eleanor Usborne
Northern Regional Fundraiser (p/t)	Sophie Dingwall
Southern Regional Fundraiser	Max Kendry
Eastern Regional Fundraiser	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
Regional Organiser (p/t)	Anna Norris-Jones *(until May)*
National Development Manager (p/t)	Jennifer Thomas *(until July)*
Administration Assistant	Daniel O'Mahony
DIRECTOR OF COMMUNICATIONS, MARKETING & MEMBERSHIP	Andrew Gilruth BSc
Team Assistant	Teresa Jolly
Membership & Marketing Administrator (p/t)	Beverley Mansbridge
Membership Assistant	Heather Acors
Communications and Fundraising Manager	Gillian Kenny *(until January)*
Press & Publications Manager	James Swyer
Publications Officer (p/t)	Louise Shervington
Communications Officer	Joel Holt
Direct Mail Marketing Officer	Amber-Rose Rawlings *(from July)*
Online Marketing Manager	Rob Beeson
Website Editor	Oliver Dean
Online Marketing Officer	Danny Sheppard *(from July)*
National Recruitment Manager	Andy Harvey
Writer & Research Scientist (p/t)	Jen Brewin MSc, PhD
Specialist Writer	Joe Dimbleby *(from January)*
DIRECTOR SCOTLAND	Adam Smith BSc, MSc, DPhil
Scottish HQ Administrator (p/t)	Irene Johnston BA
Head of Policy (Scotland)	Ross Macleod MA, MBA *(from February)*
Head of Events (Scotland)	Sarah Ballantyne BSc
Regional Organiser (p/t)	Rory Donaldson
Events and Education Officer (p/t)	Iona Laing *(from February)*
Senior Scottish Advisor & Scottish Game Fair Chairman	Hugo Straker NDA[1]
Trainee Advisor (Scotland)	Merlin Becker BSc
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 *(University of Edinburgh Napier)* – breeding biology of waders	Kirsty Maden BSc
MSc Student *(University of Aberdeen)* – rabbits and laser deterrent	Andy Gibb BSc
Placement Student *(University of Keele)*	Grace Edmondson *(until September)*
Placement Student *(University of Southampton)*	Minna Ots *(until September)*
Placement Student *(University of Plymouth)*	Katherine Thorne *(from September)*
Placement Student *(University of Swansea)*	Bethany Conway *(from September)*
Shepherd Manager GWSDF Auchnerran	Allan Wright
DIRECTOR WALES	Sue Evans
Curlew Country Advisor	Amanda Perkins *(from April)* Matthew Goodall *(from July)*

[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 and Wales; [4] Austin Weldon also runs the Allerton Project shoot.

External committees with GWCT representation

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.	BASC Gamekeeping and Gameshooting	Mike Swan
6.	BASC UK Upland Policy Group	Adam Smith
7.	BBC Scottish Rural and Agricultural Advisory Committee	Adam Smith
8.	BBSRC Agriculture and Food Security Strategy Advisory Panel	Phil Jarvis
9.	Bird Expert Group of the England Biodiversity Strategy	Nicholas Aebischer
10.	British Ecological Society Scottish Policy Group	Adam Smith
11.	British Game Alliance Advisory Group	Roger Draycott
12.	Business in the Community (BiTC) Sustainable Soils Group	Alastair Leake
13.	CFE Hampshire Co-ordinator	Peter Thompson
14.	CFE National Delivery Group (Chair)	Jim Egan
15	CFE National Strategy Group	Jim Egan
16.	Capercaillie BAP Group	David Baines/ Adam Smith/ Kathy Fletcher
17.	Capercaillie Research Group	David Baines
18.	Code of Good Shooting Practice	Mike Swan
19.	Cold Weather Wildfowling Suspensions	Mike Swan/ Adam Smith
20.	Cornish Red Squirrel Project	Nick Sotherton
21.	Scientific Advisory Committee of the World Pheasant Association	Nick Sotherton
22.	Deer Initiative	Austin Weldon
23.	Deer Management Qualifications	Austin Weldon
24.	Defra AIHTS Technical Working Group	Jonathan Reynolds
25.	Defra Hen Harrier Action Plan Group	Adam Smith/ Teresa Dent
26.	Defra Natural Capital Committee - Major Landowners Group	Teresa Dent
27.	Defra Upland Stakeholder Forum and Upland Management sub-group	Adam Smith/ David Newborn/ Teresa Dent/ Sian Whitehead
28.	Ecosystems and Land Use Stakeholder Engagement Group (Scotland)	Ross Macleod
29.	English Black Grouse BAP Group	Phil Warren/ David Baines
30.	Environmental Land Management Scheme Practitioner Stakeholder Engagement Group	Jim Egan
31.	Executive Board of Agricology	Alastair Leake
32.	Farmer Cluster Steering Committees	Peter Thompson
33.	Fellow of the National Centre for Statistical Excellence	Nicholas Aebischer
34.	Fish Welfare Group	Dylan Roberts
35.	Freshwater Fisheries CEO Meetings	Nick Sotherton
36.	Freshwater Fisheries Defra Meetings	Rasmus Lauridsen
37.	Frome & Piddle Association	Rasmus Lauridsen
38.	Futurescapes Project: North Wales Moorlands	David Baines
39.	FWAG (Administration) Ltd	Alastair Leake
40.	Gamekeepers Welfare Trust	Mike Swan
41.	Gelli Aur Slurry Project Steering Group	Sue Evans
42.	Glamorgan Rivers Trust	Dylan Roberts
43.	Hampshire Ornithological Society, Scientific Committee	Ryan Burrell
44.	Honorary Scientific Advisory Panel of the Atlantic Salmon Trust	Rasmus Lauridsen
45.	Honorary Scientific Advisory Panel of the S&TC	Nick Sotherton
46.	International Association of Falconry Biodiversity Working Group	Julie Ewald/ Francis Buner
47.	ICES Working Group on North Atlantic Salmon	Stephen Gregory
48.	ICES Trout Working Group	Rasmus Lauridsen
49.	International Organisation for Biological and Integrated Control -WPRS Council	John Holland
50.	International Wader Study Group, scientific panel	Ryan Burrell
51.	Interreg PARTRIDGE Steering Group	Roger Draycott
52.	IUCN Species Survival Commission European Sustainable Use Group	Nicholas Aebischer/ Julie Ewald
53.	IUCN Species Survival Commission Galliformes Specialist Group	Francis Buner/ Nicholas Aebischer
54.	IUCN Species Survival Commission Grouse Specialist Group	David Baines
55.	IUCN Species Survival Commission Re-introduction Specialist Group	Francis Buner
56.	IUCN Species Survival Commission Woodcock & Snipe Specialist Group	Andrew Hoodless
57.	John Spedan Lewis Trust for Natural Sciences	Nick Sotherton
58.	Joint Hampshire Bird Group	Peter Thompson
59.	Langholm Moorland Demonstration Project	Teresa Dent/Adam Smith/Dave Baines/ Nick Sotherton
60.	LEAF Marque Technical Advisory Committee	Jim Egan
61.	LEAF Policy and Communications Advisory Committee	Alastair Leake
62.	Mammal Expert Group of the England Biodiversity Strategy	Jonathan Reynolds
63.	Marlborough Downs NEP Board	Teresa Dent
64.	Moorland Gamekeepers' Association	David Newborn
65.	Mountain Hare Monitoring Group	Ross Macleod
66.	National Species Reintroduction Forum	Adam Smith
67.	National Trust for Scotland, Natural Heritage Advisory Group	Adam Smith
68.	NE – Main Board	Teresa Dent
69.	NE National Agri-Environment Stakeholder Group	Jim Egan
70.	NFU East Midlands Combinable Crops Board	Phil Jarvis
71.	NFU National Crops Board	Phil Jarvis
72.	NFU National Environment Forum	Phil Jarvis
73.	NGO Committee	Mike Swan
74.	Norfolk CFE Local Liaison Group	Roger Draycott
75.	North Wales Moors Partnership	David Baines
76.	Northern Uplands Local Nature Partnership - Curlew Working Group	Sian Whitehead
77.	Oriental Bird Club, Conservation Committee	Francis Buner
78.	PAW Executive and Sub Groups	Adam Smith
79.	Perthshire Black Grouse Group	Kathy Fletcher
80.	Pesticides Forum Indicators Group of the Chemicals Regulation Directorate	Julie Ewald
81.	Poole Harbour Catchment Initiative	Stephen Gregory
82.	Powys Moorland Project	Sue Evans
83.	Principles of Moorland Management Steering Group	Adam Smith/ Ross Macleod
84.	Purdey Awards	Mike Swan
85.	RASE Awards Panel	Alastair Leake
86.	Resilient Dairy Landscapes Stakeholder Advisory Group	Alastair Leake
87.	River Deveron Fisheries Science	Dylan Roberts
88.	River Otter Beaver Trial	Dylan Roberts/ Mike Swan
89.	Rothamsted Research	Alastair Leake
90.	Rural Environment and Land Management Group	Adam Smith/ Ross Macleod
91.	Rutland Agricultural Society	Alastair Leake
92.	Scientific Advisory Committee of the Office National de la Chasse et de la Faune Sauvage	Nicholas Aebischer
93.	Scotland's Moorland Forum and sub-groups	Adam Smith/ Ross Macleod
94.	Scotland's Rural College Council	Adam Smith
95.	Scottish Black Grouse BAP Group	Phil Warren/ David Baines
96.	Scottish Farmed Environment Forum	Adam Smith/ Ross Macleod
97.	Scottish Government CAP Reform Stakeholder Group	Adam Smith
98.	Scottish Land & Estates Moorland Working Group	Adam Smith
99.	Scottish Moorland Groups (four regional groups)	Adam Smith/ Hugo Straker/ Merlin Becker
100.	Scottish Muirburn Code Review Group	Merlin Becker
101.	Scottish PAW Executive, Raptor and Science sub-groups	Adam Smith
102.	Scottish Principles of Moorland Management Group	Adam Smith/ Merlin Becker/ Ross Macleod
103.	SGR Monitoring Group	Alastair Leake
104.	SNH Deer Management Round Table	Merlin Becker
105.	SNH National Species Reintroduction Forum	Adam Smith
106.	SNH Scientific Advisory Committee, Raven Control & Wader Protection	Adam Smith Nicholas Aebischer
107.	SNH Scientific Advisory Committee Expert Panel	Nicholas Aebischer
108.	SNH South of Scotland Golden Eagle Reintroduction Project Scientific Steering Group	Adam Smith
109.	South Downs Farmland Bird Initiative	Julie Ewald
110.	Stiperstones and Cordon Hill Curlew Recovery Project	Roger Draycott/ Andrew Hoodless
111.	Strathbraan Wader Conservation Group	Adam Smith/ Ross Macleod/ Merlin Becker
112.	Strathspey Black Grouse Group	Kathy Fletcher
113.	Sustainable Intensification Research Platform	Chris Stoate
114.	The Bracken Control Group	Alastair Leake
115.	The CAAV Agriculture and Environment Group	Jim Egan
116.	The England Terrestrial Biodiversity Group	Jim Egan
117.	The FWAG Association Steering Committee	Jim Egan
118.	Tree Charter Steering Group	Austin Weldon
119.	Upland Hydrology Group	David Newborn
120.	UK & Ireland Curlew Action Group	Sian Whitehead
121.	UK Avian Population Estimates Panel (JNCC-led)	Nicholas Aebischer
122.	UK Birds of Conservation Concern Panel (RSPB-led)	Nicholas Aebischer
123.	Voluntary Initiative National Steering Group	Jim Egan
124.	Voluntary Initiative National Strategy Group	Jim Egan
125.	Voluntary Initiative Water sub-Group	Chris Stoate
126.	Waitrose Responsible Efficient Production Expert Panel	Alastair Leake
127.	Welland Rivers Trust	Chris Stoate
128.	Welland Valley Partnership	Chris Stoate
129.	Welsh Bird Conservation Forum	Sian Whitehead
130.	Welsh Curlew Forum	Amanda Perkins Sian Whitehead
131.	Welsh Government Fox Snaring Advisory Group	Mike Swan/ Matt Goodall
132.	Welsh Government Land Use group	Sue Evans
133.	Wildlife Estates England Steering Group	Roger Draycott
134.	Wildlife Estates, European Scientific Committee	Alastair Leake
135.	Wildlife Estates Scotland Board	Adam Smith
136.	Wildlife Estates Scotland Technical Committee	Ross Macleod
137.	World Pheasant Association Scientific Advisory Committee	David Baines
138.	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; 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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