Review

of 2017

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

www.gwct.org.uk

Game & Wildlife
CONSERVATION TRUST

Your gift to future generations

Remembering the Trust in your will could help to safeguard Britain's rich biodiversity, unique woodland, productive farmland 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.

In it for the long term

We were set up in the 1930s specifically to look at grey partridge numbers and we are still doing it today. Major Eley would have been delighted to know that what he started is continuing over 80 years later. The Sussex Study is the longest-running arable research project of its kind in the world, and even now we're looking at how we can achieve similar long-term results surveying grassland.

But we only do research to find answers to specific questions, so that we can improve things on the ground. That is why we have shown how game management helps not just pheasants and partridges, but also birds like finches, warblers, curlew and lapwing in the countryside.

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 or your family have any questions or wish to learn more about our work, we will always be happy to help. We will use your gift to support projects offering a brighter future for our countryside and the wildlife in it.

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

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

'As farmers, the research conducted by the Trust is central to understanding the environment in which we work and play. Solid information is important if we are to continue to preserve the wonderful countryside and wildlife abundant in this country, and therefore protect our surroundings and way of life.'

Robert & Claire Smith, GWCT Members

Game & Wildlife CONSERVATION TRUST

Review of 2017

Issue 49

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

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GAME & WILDLIFE CONSERVATION TRUST CHARITABLE OBJECTS

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

Game & Wildlife CONSERVATION TRUST

© Peter Thompson/GWCT

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as of 1 January 2018

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Berkshire	no chair
Bristol & North Somerset	Jerry Barnes
Buckinghamshire	Benedict Glazier
Cambridgeshire	Toby Angel
Cheshire	Anton Aspin
Cornwall	Gary Champion
Cumbria	William Johnson
Derbyshire & South Yorkshire	Jonathan Wildgoose
Devon	Christopher Bailey
Dorset	Oliver Chamberlain
Essex	Jeremy Finnis
Gloucestershire	Mark Ashbridge (Anthony Colburn)
Hampshire	James Bromhead
Herefordshire	Luke Freeman (James Spreckley)
Hertfordshire	Hugo Richardson (Jason Noy)
Isle of Wight	no chair
Kent	Paul Kelsey
Lancashire	Nicholas Mason
Leicestershire & Rutland	Thomas Cooper
Lincolnshire	George Playne
London	no chair
Norfolk	Justin Grady
North Wales	Will Richards (Richard Thomas)
Northamptonshire	Keith Smith (Richard Wright)
Northumberland & County Durham	James Jackson
Nottinghamshire	Richard G Thomas
Oxfordshire	Simon Scott-White
Shropshire	Timothy Main
Somerset	Nick Evelyn
South-East Wales	Roger Thomas
South-West Wales	no chair
Staffordshire	Brendan Kiely (Julian Mitchell)
Suffolk	Neil Graham
Surrey	no chair
Sussex	James Mulleneux
Warwickshire & West Midlands	Jonathan Bird
Wiltshire	Ian Bowler
Worcestershire	Mark Steele
East Yorkshire	no chair (Stephen Dales)
North Yorkshire	Toby Milbank
West Yorkshire	Adam Brown

Scotland

Highland	Chris Swift
Grampian	Ruairidh Cooper
Tayside	Mike Clarke
Fife & Kinross	Douglas Williams
Edinburgh & South-East	Tim Wishart
West of Scotland	David MacRobert
Scottish Auction	Bryan Johnston

Names in brackets were chairmen that stepped down during 2017.

Contents

Reflecting on eight successful years

by Ian Coghill, Chairman

© Hugh Nutt

Our Scottish demonstration farm at Auchnerran is a jewel in the crown of our achievements north of the border. © Marlies Nicolai/GWCT

- GWCT is blessed with excellent trustees, wonderful scientists and support staff and a loyal and committed membership.
- Partnerships continue to be forged with those who share our aims.
- Many achievements over the past eight years including a remarkable renaissance in Wales.

Time flies when you are enjoying yourself and it seems only moments ago that I was fortunate enough to become the chairman of the GWCT. In fact, eight years have passed and I am happy to say, not a minute has been wasted.

GWCT, blessed as it is with excellent trustees, wonderful scientists and support staff and a loyal and committed membership, has gone from strength to strength. It is, in my opinion, the best applied ecology research organisation that I've ever heard of. What is even more remarkable is that the GWCT achieves so much on such a small resource base, taking on things which look far too big to handle but, with skill and persistence, eventually succeeding.

One of the keys to this success is our enthusiasm for working in partnership with those who share our aims. This happily includes the majority of landowners and farmers, who are all too often forgotten by conservationists until the time comes to find someone to blame. The list of active partners is long and getting longer and reflects great credit on our frontline staff.

We have become much better at communicating with our supporters and the wider world. The website, the daily newsround, the weekly briefing, appearances on radio and TV, letters to the editor, and so on, any of which would have been a major event a decade ago, are now taken for granted but are a product of the dedication and skill of the staff involved, supported by the generosity of members.

GWCT has also risen to the challenges and opportunities presented by devolution. Scotland has, for some time, had its own director and chairman and has grown in stature under their skilful management. The jewel in the crown of their achievements is our demonstration farm at Auchnerran, a truly vital resource which, without Andrew Salvesen, would still be a distant dream.

Wales, once a virtual no go area for the GWCT, has had a remarkable renaissance, with successful county committees functioning again, its own excellent director

Ian Coghill has been a valued chairman for the GWCT over the last eight years. © Jon Farmer

and, in the person of Nick Williams, a fine and seriously committed chairman. All not a moment too soon, as we were in time to engage crucially in Natural Resources Wales (NRW) review of shooting on publicly-owned land. As ever, you can be proud of the GWCT's contribution. The consultation review stated that, 'Of all the submissions, that of the GWCT's, is in our opinion, the most sophisticated, and based on extensive empirical work and peer-reviewed research papers'. I couldn't have put it better myself.

It is impossible to list GWCT's achievements during the past eight years, they are simply too numerous, varied and multi-layered. What can be said is that while chairmen come and go, the heart of this wonderful organisation goes on beating. That heart is you, the members, people who believe that the countryside should be run by people who understand it and that policy should be based on sound science not on whim and prejudice.

Everyone needs some luck and I have been fortunate indeed to have Teresa Dent as CEO throughout my tenure. She is a remarkable person, with huge reserves of energy, integrity and common sense and without her far less would have been achieved. Helped by her management team, and trustees who freely give time and skill, which would cost a fortune in the market place, she has turned the GWCT into a modern, effective and efficient organisation, of which you can be justly proud. It's been a joy to watch.

Our contribution to the Natural Resources Wales review of shooting on publicly-owned land was praised for being sophisticated and based on extensive empirical work and peer-reviewed research papers. © Francis Buner/GWCT

Advising Governments for achievable solutions

by Alastair Leake, Director of Policy

© Hugh Nutt

Farmers will be supported for providing environmental benefits for wildlife. © Peter Thompson/GWCT

Secretary of state, Michael Gove MP, spoke about the value of shooting in the countryside at our All-Party Parliamentary Group meeting. © Joel Holt/GWCT

England

- Shaping the future of environmental schemes.
- Engaging with policymakers and politicians in Westminster.

Our work has very much focused on redesigning a post-Common Agricultural Policy (CAP) structure to ensure that money is available for farmers to access for environmental work on their farms. The Government has signalled that the hectarage-based Basic Payment Scheme will be phased out over time, but at present very many farms, including our own Allerton Project, would be loss making without this income. Keeping farmers on the land is important to the management of wildlife and the environment, and the Treasury has indicated a willingness to look at ways of supporting farmers for providing environmental services, so long as environment benefits result and there is some way a value can be placed on those outcomes. At present, we spend around £4bn on agricultural support and, in a post-CAP era, all political parties have indicated a desire to substantially reform the way the payments are made. If we want to use these reforms as an opportunity, then we need to ensure that payments continue to be made to the rural sector but deliver better public goods for the environment. One of the best ways to do this is through agri-environmental payments.

As we consider what a new agri-environment scheme might look like, we need to examine what worked in the previous schemes. Fundamentally, the options themselves, very many of them devised by our own scientists, are sound, but the rules around the management, the remuneration provided and the inspection regime all require modification. The new simplified scheme, introduced by Natural England, is to be welcomed – we want to make it easy for farmers and landowners to carry out conservation work and farmers are showing renewed interest in getting involved. By allowing farmers to choose their own options and to do as little or as much as they wish to do, and the more you do the more you get paid, should lead to better uptake.

During the year we continued to talk with officials within the Department for the Environment and Rural Affairs (Defra), meeting with Ministers, responding to consultations and holding debates in Westminster through our All Party Parliamentary Group (APPG). In April, Lord Curry presented his vision for a future agri-environment scheme, reflecting on his ground-breaking *Food and Farming* report, published over a decade ago, and looking at what might be achieved in a post-CAP structure. In June, just two weeks after the Queen's Speech, we held a debate on the proposed Agriculture Bill and were joined by the new secretary of state, Michael Gove MP, who spoke of the value of shooting in the countryside, and in November we debated the impact the Precautionary Principle has on innovation and considered this in relation to the registration of crop protection products.

by Adam Smith,
Director Scotland

Scotland

- GWSDF Auchnerran was used to highlight the need for support in maintaining good/enhanced condition of key environmental 'goods' such as wading birds and semi-natural habitats.
- The principles established in 'Understanding Predation' were developed for 'Working for Waders' and novel management licences.
- Best practice guidance on moorland management became increasingly linked to public policy.

The future of farming and its relationship with the environment took its own path in Scotland in 2017. We took part in two Scottish Government reviews, of Greening by Professor Russel Griggs and of the future for Scottish agriculture generally, by a panel of agriculture champions. We reinforced the need for a simple future for agri-environment, and one that recognised results, both in improving the condition of environmental assets such as soils and bird populations, and in maintaining better than average condition of these assets. Meetings with Fergus Ewing MSP, cabinet secretary responsible for farming and the NFUS Environment committee through the year were strong platforms for our post-Brexit/reformed CAP vision.

In 2016 'Understanding Predation' clarified that the practical day-to-day knowledge that farmers and keepers had of predation and habitat interactions was an asset when combined with research studies. Scottish Natural Heritage encouraged those interested in the plight of wading birds to use this approach, and we engaged with a project called 'Working for Waders' and developing ideas for novel approaches to wildlife management. Throughout 2017, 'Working for Waders' developed into a collaborative approach to raising the profile of waders and their conservation needs and identifying and supporting landscape scale management for waders. Such an approach is familiar from our Farmer Clusters method and will also need the land managers engagement to make it work. The need for honesty in tackling some of the challenges faced by wading birds, especially in terms of predation, will be part of this work, so we started developing ideas for how this can lead to testing novel approaches to wildlife management.

Away from new approaches, helping practitioners and policymakers maintain best current practice was a significant role for the policy and advisory teams in Scotland this year. The focal points were the Scottish 'Principles of Moorland Management' project and the new Scottish Muirburn Code. Pressure from environmental NGOs to constrain elements of contemporary moorland management in both England and Scotland, meant both pieces of work became more policy-oriented than the straightforward best practice guidance they could have been. These guides have become challenging work areas, where our knowledge has been critical in keeping tools available. Data from the National Gamebag Census, research into the range of mountain hares and the efficacy of medicated grit have all been essential as we inform what have been often polarised discussions about the future of moorland management.

As 2017 closed we learned about the Scottish Grouse Moor Management Group, a panel which will consider the sustainability of some moorland management, and whether further regulation is required to prevent damage to the environment. The review will be undertaken in 2018 and we are approaching it positively, ready to inform policy with evidence.

Muirburn and medicated grit are grouse moor management practices which we have co-produced best practice guidance for and are advising policymakers. © Adam Smith/GWCT

Professor Griggs visited the PARTRIDGE project site at Whitburgh in September 2017 to inform his review of greening in Scottish agriculture. © Adam Smith/GWCT

Wales gains political momentum

by Sue Evans, Director of Wales

The Sustainable Management Schemes aim to restore large areas of ground to boost wildlife corridors and help increase the number of skilled rural jobs in Wales. © Sue Evans/GWCT

(Far right) Kirsty Williams, cabinet secretary of education, visiting a moor. © Sue Evans/GWCT

Wales

- Our submission to the Natural Resources Wales Shooting Review was highly regarded.
- Ministers and Welsh Government officials visit grouse restoration projects.
- Our Brexit proposals received a favourable response from Welsh Government officials.

GWCT Cymru is pushing ahead with raising its profile in Wales and one of the first crucial tasks was to prepare for the call of evidence from Natural Resources Wales (NRW) over shooting on public land. The review was created due to implications from the new Environment (Wales) Act and following concerns raised by stakeholders.

Our response to the consultation was well received, with the official report noting that: 'Of all the submissions, the work of the GWCT is, in our opinion, the most sophisticated, and based on extensive empirical work and peer-reviewed research papers. Their work also underpins the *Code of Good Shooting Practice* which is universally supported by the shooting community. This portfolio of work should be granted greater significance'.

We believe that the conclusions made by NRW are well considered and should be adopted. NRW must be congratulated on its open and transparent approach to addressing concerns raised by those seeking to ban shooting. This detailed assessment shows that a firearm is not only a vital conservation tool, but a way of providing jobs and social cohesion in rural Wales.

The Big Farmland Bird Count was a great success and has helped us engage with some prominent landowners who admitted themselves that more can be done to encourage more birds on their farms. Thanks go to advisor Mike Swan.

The number of Sustainable Management Schemes (SMS) in Wales is increasing and the way forward is firmly set on landscape-scale projects to involve more farmers, graziers and communities by adopting a bottom-up approach to help restore large areas of ground to boost wildlife corridors and help increase the number of skilled rural jobs. All of these projects are strongly underpinned by the Well-being of Futures Generation Act and the Environment Act, which states that natural resources must be directly linked with the well-being of the nation. GWCT Cymru is now involved with a number of these projects with a view to developing part of a post-Brexit toolbox for farmers.

We have been looking at the seven proposed Area Statements in Wales and feeding into NRW to help shape them. This is all about how to integrate all schemes so that there are better collaborations with natural resources in the future.

GWCT Cymru is heavily involved with Welsh policy and viewed as an important contributor with regular meetings on the Land Use Steering Group of the Brexit Committees. We have met with Dr Tim Render, director of environment and rural affairs, for the Welsh Government and continue to lobby for a facilitation fund, among other things, to help collaboration scheme delivery.

We continue to engage with assembly members and MPs including cabinet secretary for education, Kirsty Williams, as connections with communities gain momentum and spread the good work of the GWCT. We are also in the process of setting up new committees across Wales and welcome anyone who would like to get involved.

25 years of the Allerton Project

- The Project has a reputation for looking at the wider aspects of wildlife and environmental management.
- Research carried out at the Project is now included in Government policy.

by Alastair Leake
Head of the Allerton Project

© Hugh Nutt

Kale, quinoa and a cereal such as triticale or millet provided the best sources of food for farmland birds such as yellowhammers. © Laurie Campbell

2017 marked 25 years since Lord and Lady Allerton left the Loddington Estate in Leicestershire to the GWCT. The first phase of the project, following a year long baseline survey, was to introduce a full-time keeper across the 800-acre mixed farm with the intention of establishing a wild bird shoot. The introduction of set-aside gave additional opportunities for habitat creation and the provision of food for insects and birds. Within three years songbird numbers had doubled and a modest, but sporting, wild bird shoot established. After the first decade of wild game management we began a second decade where we systematically deconstructed the game management system, at first ceasing to control predators and secondly ceasing winter feeding. The result was that our songbird and brown hare numbers plummeted; indeed, it exposed the limited results which habitat management alone can achieve. The final phase of the first 25 years saw the return of a gamekeeper, but on a part-time basis and across an expanded area, although with some releasing to augment the wild stock. Once again, songbirds responded to this management regime and increased by 92% (see page 60).

Although the use of game management has provided a long-term study of different practices on a single farm, the Allerton Project has gained a reputation for looking at the wider aspects of wildlife and environmental management, recognising how so many aspects of land management are inter-linked. To enable us to do that, we had to find other partners with expertise with whom we can collaborate with on research and demonstration projects on the site. To celebrate our 25th anniversary and in recognition of these valuable partnerships, we welcomed 270 guests to a series of farm walks to hear about the work from the researchers and practitioners.

Our Agroforestry project was planted in 2016 in partnership with The Woodland Trust. We have planted trees at different densities in a field of grass grazed by sheep and we will monitor the performance of both enterprises as well as recording environmental data. The project is important if we are to encourage the planting of more trees which are currently over 90% behind target.

The Water Friendly Farming project is the latest in a long series of studies looking at soil erosion, water quality and aquatic health, and is a partnership with Syngenta, the Environment Agency and the Freshwater Habitats Trust. Other studies have looked at the impact of compacted tramlines, cultivation techniques and the use of small on-farm water bodies to help reduce soil loss and water pollution. Our soils team showed visitors how soil structure is influenced heavily by different crop establishment techniques with the largest variation occurring between zero till and ploughing.

Wildlife seeds and pollen and nectar mixes were researched at Allerton and are now included in agri-environment schemes. They are considered to be key to the recovery of farmland wildlife. Visitors were also shown how the woodland is managed for wildlife and for game, but also to produce timber to be chipped for renewable energy.

The Community Orchard provided an excellent talking point with our partners LEAF (Linking Environment And Farming) about the importance of education and community engagement in the countryside, before returning to our award-winning eco-visitor centre which boasts straw bale wall insulation, woodchip heating and a rainwater reuse system.

The Agroforestry project is exploring the potential for introducing trees into pastures, while maintaining production of grass and lambs.

More than 300 people attended our Farmer Cluster conference in October. © Jon Farmer

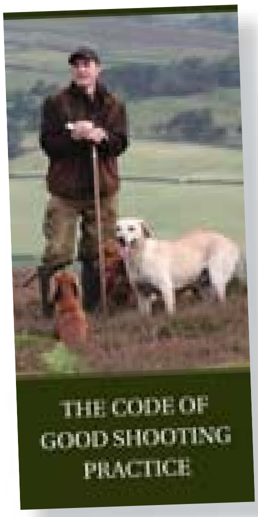
500,000 hectares and counting

by Roger Draycott,
Head of Advisory

- New *Code of Good Shooting Practice* launched.
- Farmer Clusters now covering around half a million hectares.
- New farmland conservation advisor Jessica Brooks joins the team.

Well-run shoots can deliver significant conservation benefits to the countryside and helping shoots achieve them is one of the key objectives of the advisory team. The foundation of running a good shoot is to follow the *Code of Good Shooting Practice*, which was updated in 2017 and re-launched at the Game Fair to a good reception from the shooting community. The Code draws significantly on GWCT research and advice and we provided talks about sustainable gamebird releasing and management at over 30 farm and shoot walks in the summer. We urge everyone involved in shooting, from shoot providers to guns and beaters, to read it and abide by it. That is the best way to ensure shoots and shooters are operating to high standards. A copy is available from the GWCT and all the other signatory rural organisations.

Ensuring high standards of animal welfare in game management is also vital. We made significant progress promoting the *Codes of best practice for fox snaring* in England and Wales. We ran 25 snare training courses which were led by Mike Swan and Austin Weldon, and much credit is due to them for all their hard work on this. Feedback from both upland and lowland keepers on course content and code-compliant hardware has been very positive, with sales of these products also increasing significantly.



The Code of Good Shooting Practice *was re-launched in 2017 and draws significantly on our research. © GWCT*

Demonstrating best practice on shoots is another important aspect of the work we do. As part of this, we welcomed more than 200 guns and accompanying guests to shoot days at Rotherfield Park and the Allerton Project at Loddington across the 2017/18 season. The aim of these days, in addition to providing a memorable day's shooting in the field, is to highlight the work of the GWCT and showcase how a well-run shoot can really deliver for wildlife conservation. Most shoot days are sold at auction with one or two raffled or sold privately, enabling a wide range of people to experience a day at Loddington or Rotherfield. A tremendous amount of time and effort goes in to making these days a success and we are indebted to Austin Weldon and Matt Coupe at the Allerton Project, and Francis Buner and Malcolm Brockless at Rotherfield for their hard work. Many people are needed to run a successful shoot day and several staff are involved in one way or another including beating, tractor driving, hosting the day and shoot administration. We are very grateful to everyone involved. In October we held a successful day for 11-18 year olds at the Allerton Project, at which three of the guns shot their first pheasants, and a wild partridge/pheasant day at Rotherfield (see page 36).

Mike and Luke Twigger, who enjoyed the young shots day at the Allerton Project, Loddington.
© Fieldsports Magazine

MORE INFORMATION

The latest *Code of Good Shooting Practice* can be found at **www.gwct.org.uk/codegood-shooting**. To book a training course go to **www.gwct.org.uk/courses** or contact the Advisory Service on 01425 651013.

2017 saw significant growth of the number of Farmer Clusters across the UK. Farmer Clusters are groups of farmers who work together to decide which species and habitats to conserve on their farms. Farmers are increasingly supportive of this approach as it is led by them. They are then supported by conservation experts who offer advice and guidance on how to achieve their conservation goals. The Farmer Cluster concept, designed and promoted by the GWCT with support from Natural England, is expanding rapidly. A further 37 Farmer Clusters were successful in the 2017 Countryside Stewardship Facilitation Fund round, bringing the total to 98 Clusters funded through Countryside Stewardship. These cover 450,000 hectares (ha), and the total area rises to around 500,000ha with the addition of several privately-funded Clusters. The GWCT advisory team has been actively supporting Farmer Clusters across the country, providing a range of advice and training days on topics like targeted predation control to protect nesting waders, grey partridge management, supplementary feeding farmland birds and soil management. We also held the inaugural Farmer Cluster conference in October, attracting more than 300 attendees to learn about the work this initiative is already achieving.

We are developing wildlife monitoring packages for farmers in clusters and to help deliver our Farmer Cluster work we were delighted to welcome Jessica Brooks, as farmland conservation advisor in the south of England in 2017.

(Below) Living Record's Adrian Bicker presents Jess Brooks with a trail camera prize for recording wildlife on Farmer Clusters.
© Peter Thompson/GWCT

Thank you for your support

© The Field, www.jamiesmith.photo

by Jeremy Payne
Director of Fundraising

(L-R) Pippa Matthews and Ted Innes Ker enjoying the Macnab ball, the inaugural Prestwold Hall clay shoot; Chef Colin McGurran serving up a masterpiece at the Nottinghamshire dinner.

- County committees raised over £1,000,000 of net income for the first time.
- Major donor income at more than £750,000.
- An estimated £330,000 from the New York auction (subject to exchange rate fluctuations).
- London events raised £220,000.

The fundraising team had a stellar year with income of £2.3 million in 2017. The county model continues to work well for GWCT, but only thanks to hundreds of people up and down the country giving freely of their time and arranging successful events ranging from pub quizzes which raise a few hundred or thousand pounds, all the way up to dinners with auctions raising in some cases more than £50,000. And don't forget ferret racing, hip flask challenges and dog days. All of these events, whatever their size, happen only because one person has an idea, then more people are prepared to keep picking the phone up or meeting people until they get the answer they need.

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

Our relatively few, but very generous, major donors were again a vital source of support whether their interest be in grouse, fishing, curlew or whether they simply wished to see us continue our robust science, highly-regarded advisory and increasingly influential policy and communications work.

GCUSA continued its record-breaking run raising an extraordinary £330,000, as ever only made possible by the hard work of our committee there and the generosity of our donors and bidders on both sides of the pond.

Tickets for GWCT events in London continue to be highly sought-after whether it be the stylish Macnab Ball, the exclusive Le Gavroche dinner hosted by Michel Roux Jr, the Christie's evening or the Harwood Arms event. At our Christie's event, Nicky Oppenheimer added another 'must visit' destination to many listeners' lists with his enthralling talk about Tswalu and we are grateful once again to the team at Christie's for making the event possible. Together all these events raised an impressive £220,000.

Nicky Oppenheimer gave an enthralling talk about Tswalu and helped our London events raise £220,000.

We do not lose sight of the fact that all of the auction lots we sell, whether in the US or London come from someone's 'patch', so the success we achieve here is only possible with the support and forbearance of our county committees who recognise that, most of the time, we can achieve prices in both places that would be unrealistic at many other events.

Nearly all our events are either only possible, or at the very least are made more profitable thanks to the support of numerous sponsors. Although sponsorship is a popular way to get a company's name in front of the right people, we also recognise that we are often only one of many charities seeking their support, so our sincere thanks to them all for underpinning much of our effort – listing them all would require much more space than we have available.

Finally, our job is to raise much of the money that makes the rest of the operation possible, but we pride ourselves on running events that people will speak well of and want to come back to. We also recognise that we are many people's first experience of the GWCT, so a by-product of all the successful fundraising is a new cohort of people all of whom, we hope, will want to know more.

Clay shoots are extremely popular and Cefntilla in south-east Wales raised more than £12,000.

Demonstrating the value of our work

by Nick Sotherton
Director of Research

© Hugh Nutt

The *Review* reports and showcases some of the research work undertaken by the research department over the last year. In recent *Reviews,* we have taken a wildlife group (eg. deer, corvids) and analysed trends over time using data from our National Gamebag Census (NGC). This year, Nicholas Aebischer has used the NGC, in combination with the national survey undertaken by the Public and Corporate Economic Consultants (PACEC), to calculate estimates of the numbers of birds and mammals shot in the UK (see page 42).

We report on the five long-term demonstration sites we are now running. Auchnerran in Aberdeenshire (see page 70) is in its opening years of demonstration, whereas our work at the Allerton Project at Loddington (see page 60) and the Sussex Study (see page 38) are now 25 and 50 years old, respectively. Long-term monitoring of sites is increasingly rare but the information they provide is invaluable. Once the domain of public-sector funded work, the Government is increasingly unable to fund long-term work. The fact that we commit large amounts of funding to such work is a credit to the private sector. This now includes salmon on the river Frome in Dorset, where the GWCT stepped in and saved the site and data collection that was more than 40 years old, and that would have ceased without our intervention (see page 18).

Our conservation work with declining species is a hallmark of our work. In this *Review* we report work on lapwing, woodcock, black grouse, Atlantic salmon and grey partridges in both the lowlands and uplands.

In 2017 one of our PhD students successfully defended their PhD and was awarded their doctorate. We also congratulate Dr Nicholas Aebischer who was awarded the degree of Doctor of Science (DSc) from Durham University. A DSc is awarded as a degree higher than a Doctorate (PhD) to somebody who has a proven record of internationally recognised scholarship, and in recognition of a substantial contribution to scientific knowledge well beyond that required for a PhD.

Lapwing breeding success continues to be high at our Scottish Demonstration Project at Auchnerran (see page 72). © Marlies Nicolai/GWCT

Our deputy director of research Nicholas Aebischer has been awarded the degree of Doctor of Science. © Hugh Nutt

Sheep ticks and the Louping ill virus they carry are known to have a serious effect on grouse chick survival. (see page 52). © Kathy Fletcher/GWCT

The ecology of foxes in the Avon Valley

The red fox features prominently in most detailed studies of predation on waders.
© Mike Short/GWCT

BACKGROUND

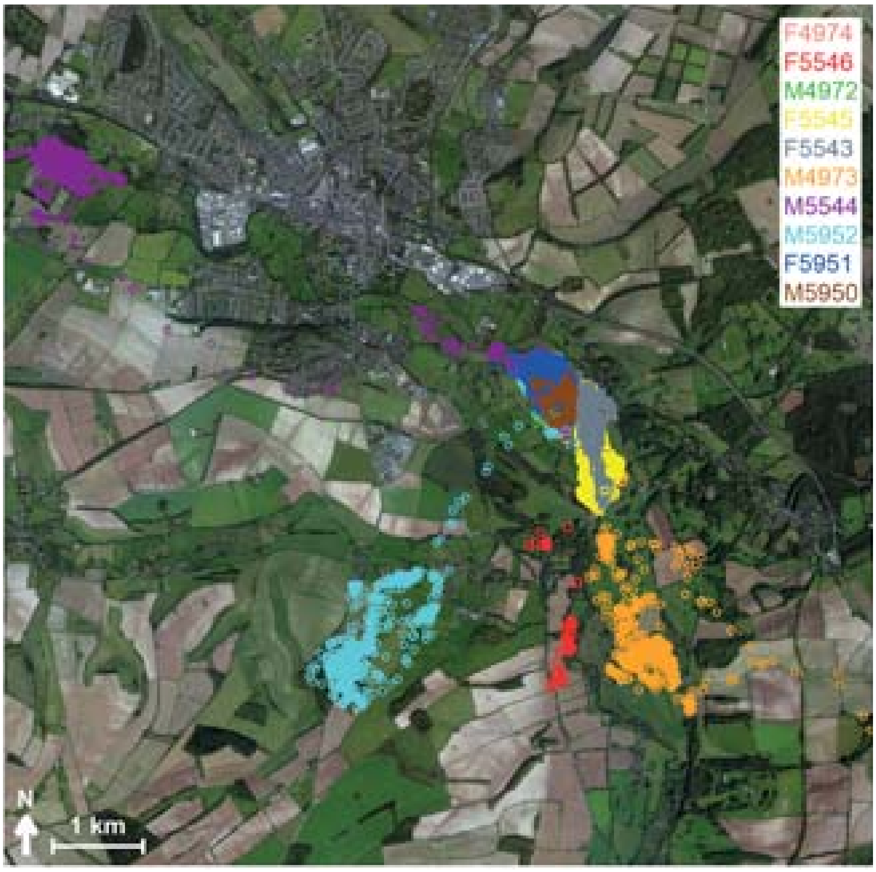
The Avon Valley in Hampshire is a river floodplain with outstanding biodiversity interest. In 1982, it constituted one of the top eight lowland wet grassland sites in England for breeding waders. Since then, our regular surveys have revealed dramatic declines in numbers of breeding lapwing, redshank and snipe, mirroring trends seen across Europe. Our data show that for lapwings, on average, 61% of nesting attempts fail and that 82% of nest failure is caused by predation. The EU LIFE+ 'Waders for Real' project was launched in 2014 with the aim of reversing these declines.

The red fox figures prominently in most detailed studies of predation on ground-nesting birds, especially lapwing. It is one of a number of generalist predators that are very successful in modern man-made landscapes, and whose densities are unlikely to be related to the abundance of breeding waders. The Avon Valley supports many small villages, several large towns, and a variety of rural enterprises like fish-farming, outdoor pig-rearing and released-game shooting, which generate food resources that might be exploited by foxes.

The fox is difficult to manage and a fundamental management decision is whether to (a) use lethal control measures to continually remove foxes that pose or might pose a threat, or alternatively (b) rely on physical barriers such as electrified fencing or watercourses to prevent foxes from reaching vulnerable birds. Both of these well-established predation control techniques have merits and shortfalls, but in this time of wildlife management austerity, which approach gives the best value for money in terms of delivering more waders, and what advice can we give to land managers to ensure that their efforts are effective?

At the present time, the simple answer is that we're working on it. The road to efficiently mitigating against fox predation hinges on a much clearer understanding of fox ecology and behaviour on river meadows. We're still seeking answers to lots of fundamental questions: How important are wader nesting habitats to foxes whose territories include them? How much time do foxes spend in them, and does this vary seasonally? How do foxes move around river valley habitats? What can we learn about their hunting patterns which might give clues as to how they could be disrupted? How much of a barrier are electrified fences, and how do water-filled channels and the main river itself influence fox movements and territories? What densities are foxes living at? How quickly are culled foxes replaced by others? How detectable are the foxes that use wader breeding habitats? What do river valley foxes eat? There are a lot of gaps in our knowledge.

Since 2015, we have used neck snares to catch adult foxes and fit them with GPS collars, to explore their use of river meadows during the nesting season. This research falls under The Animals (Scientific Procedures) Act 1986, and is strictly regulated by the Home Office. So far, we have tagged foxes on a single site in the upper Avon Valley just south of Salisbury. This site supported breeding waders in the recent past, but no longer. There has been no concerted fox culling effort here during the last decade. The



GPS tagging shows that foxes are living at very high densities in the upper Avon Valley, near Salisbury. The coloured dots indicate repeated locations of 10 adult foxes tagged on our study site in March-June 2017 (see key at top right; M = male, or F = female). The locations of some individuals are partially masked by the sheer density of overlaid data. The purple, light blue and orange circles show the movements of the males that dispersed in April; the red squares show the movements of a female that left the study site and shed her collar within 24 hours of being tagged. (Contains Bing imagery). © Microsoft Corporation 2017

area is bounded by a small village and the main river Avon, and includes small spinneys, cattle-grazed pastures, relict water-meadows, a network of carrier-channels and wet ditches. Hence the landscape is representative of wader-breeding areas lower down the valley.

To familiarise ourselves with the technology, we tagged two male foxes in July 2015. We tagged a further six males and three females in March-May 2016; and five males and five females in March-April 2017. We recovered our collars using a remote drop-off mechanism, so it's possible that some foxes were tagged in multiple years. All foxes were snared on a core 30 hectares (ha) area of river meadow.

The very active lives of captured foxes after release illustrates our long-held view that snares are not intrinsically injurious if used with care. This site also supports otter,

KEY FINDINGS

- Fitting foxes with GPS collars has revealed that they are capable of living at very high densities in the Avon Valley.
- In the upper Avon Valley, analysis of macroscopic prey remains suggests that small mammals are the most important food resource.

Mike Short
Tom Porteus

Analysis of macroscopic remains in fox scats suggests that field voles and water voles are important prey species for foxes in the upper Avon Valley. We have watched foxes successfully hunt water voles, found them outside active earths (see inset) and camera traps often record foxes carrying them. © Mike Short/GWCT

GPS tagging is revealing how foxes use river valley habitats. Wildlife managers use camera traps to assess predation risk. Tagging foxes will enable us to calculate their detectability using cameras and other survey methods. © Mike Short/GWCT

badger, roe deer and rabbit, but very careful selection of snare locations restricted non-target captures. Combining the 2016 and 2017 tagging seasons, fox capture rate and non-target capture rate was 15.3 and 3.3 captures per 1,000 snare/days, respectively. All non-targets (three roe deer, three rabbits) self-released from snares. This illustrates the value of modern-day neck snares for wildlife research and fox management purposes.

We are using remotely programmable GSM-type satellite collars set to take a fix every 10 minutes, or every hour, depending on our wider fieldwork objectives. Battery life is determined by the number of fix attempts; our current scheduling generates up to 6,000 fixes per collar. A web portal allows continual scrutiny of fox movements and it includes a battery-life indicator for each active collar. Once the drop-off is activated via the portal, the collar slips off the fox and emits a radio-beacon, enabling us to retrieve it. So far we have obtained 66,869 useable GPS locations for 19 adult foxes between March and June.

In 2016 and 2017, we maintained camera traps (one per 5ha) and conducted 140 point counts from high-seat positions, for 90 minutes around sunset and with a thermal-imager at night. This informed us about untagged foxes occupying the same area, and will enable us to calculate the detectability of tagged foxes. Camera traps

ACKNOWLEDGEMENTS

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

Waders for Real

Our experience proves that, when used carefully, modern-day snares (see inset) are an effective and selective way of live-catching foxes. Note that the fox caught here occupied good wader breeding habitat. © Mike Short/GWCT and high-seat watches are commonly used by wildlife managers to assess predator activity; shooting foxes from high-seats is a popular method of control in flat wetland landscapes. Thus, adequate detectability is fundamental both to the reliable assessment of predation risk and to the success of predation control measures.

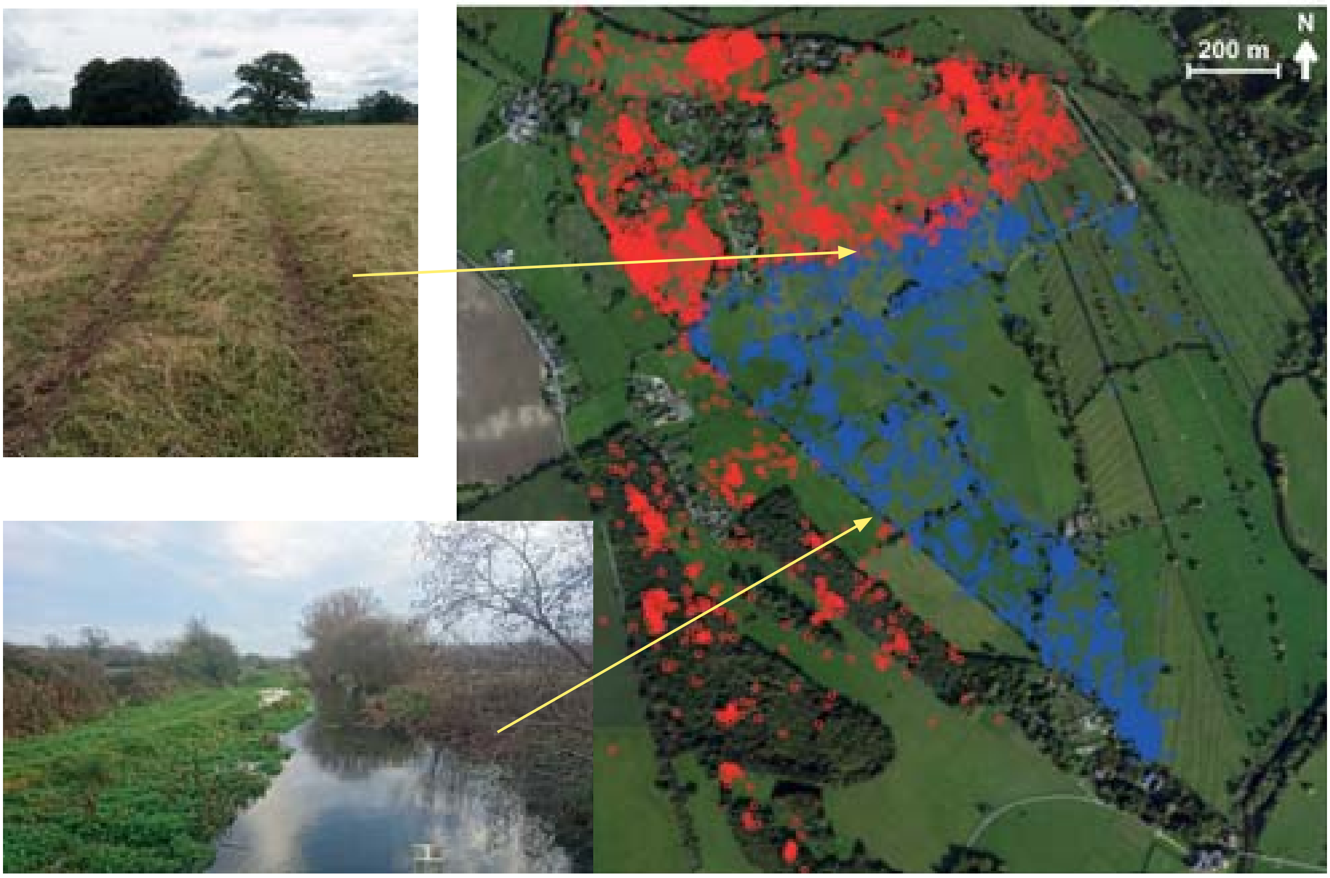
Analysing the huge volume of GPS material, and marrying it with camera trap and high-seat data to calculate detectability, is an enormous and currently incomplete task, but it is clear that foxes are capable of living at high densities in the Avon Valley. Combining these different data types suggested that during the period March and June 2016, a sample square kilometre of river valley was accessible to, and used by, 18 adult foxes (nine of which we had tagged). This is not a density estimate, rather it reflects the minimum number of adult foxes that would have to have been culled to keep this area fox-free during the wader-nesting season. It excludes cubs, and any adult foxes that might have moved in during this removal period. Importantly, the GPS data showed that many of these foxes lived and bred exclusively within the river meadow habitat during this crucial time of year.

In 2017, we again followed 10 tagged foxes; of these, three adult males dispersed in late April. All three re-settled within 10km, and were subsequently shot by gamekeepers. Judging by their age, build and submissiveness when handled, it is likely that two of these individuals were subordinate to other adult foxes occupying the study area, and that their simultaneous dispersal was driven by social pressures. This may reflect greater competition for food resources, compared with 2016.

All of this begs the question of what food resources sustain the foxes at such a density, since it clearly is not wading birds? In 2017, we collected fox scats along a four kilometre transect route through the study area, at two-week intervals, to investigate diet. Scats were also collected away from the transect, whenever they were found. Visual identification of prey remains from a random sample of scats suggested that field voles and water voles formed the bulk of fox diet. The remaining scats are destined for DNA analysis at a specialist laboratory, to check that we are not missing any important food types, and to check our inventory of the individual foxes present.

In 2018, we plan to repeat this work on a different site lower down the Avon Valley where lapwing and redshank still breed.

Shooting from high-seats is a popular method of fox control in wet grassland landscapes, which are typically flat and hard to access by vehicle. However, by May, visibility from high-seats is much reduced due to the rapid growth of vegetation. © Mike Short/GWCT



The red and blue dots represent the repeated locations of two territory-holding dog foxes. Note how distinctive their territory boundaries are. The western edge of the blue territory followed a water carrier channel, whereas the northern edge was defined by a discreet grass track, which split the two territories. Understanding how landscape features influence fox movements will help us understand how much of a physical barrier they are. (Contains Bing imagery.) © Microsoft Corporation 2017

River Frome salmon population

We tagged 10,000 salmon and 3,000 trout parr in 2017. © Rasmus Lauridsen/GWCT

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 the 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. This is a much more powerful analytical approach to help us better understand what is going on in the fish's life cycle. The PIT-tag installations 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 salmon populations to the International Council for the Exploration of the Sea (ICES) and the only one funded by the private sector.

Smolts

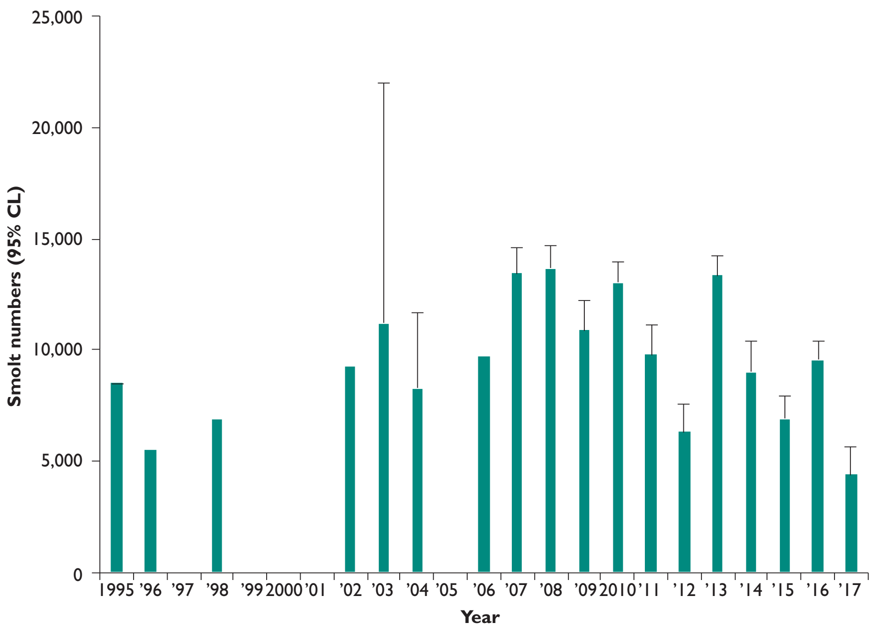
The number of smolts leaving the river Frome in the spring of 2017 was the lowest on record. The smolt run estimate for 2017 was 4,381, which is less than half of the 10-year average (9,689) and two thousand fewer than the second-worst year on record (see Figure 1).

As more than 97% of the Frome smolts are one year old, the poor 2017 smolt run was a result of poor recruitment from the adult fish that spawned in the winter of 2015/16. Low numbers of young salmon were already apparent during our annual parr tagging campaign in late summer of 2016, for which the catchment population was estimated to be 35,151 – substantially fewer than the 10-year average (91,353). Poor recruitment of salmon from the 2015/16 spawning season has been observed in many rivers across England and Wales, suggesting it is a national, rather than a local, phenomenon.

In 2015 we recorded 822 adults entering the river Frome for the 2015/16 spawning season, which was slightly more than the 10-year average of 746 (see Figure 2). This suggests that the problem affecting recruitment must have occurred sometime

Figure 1

Estimated spring smolt population 1995-2017



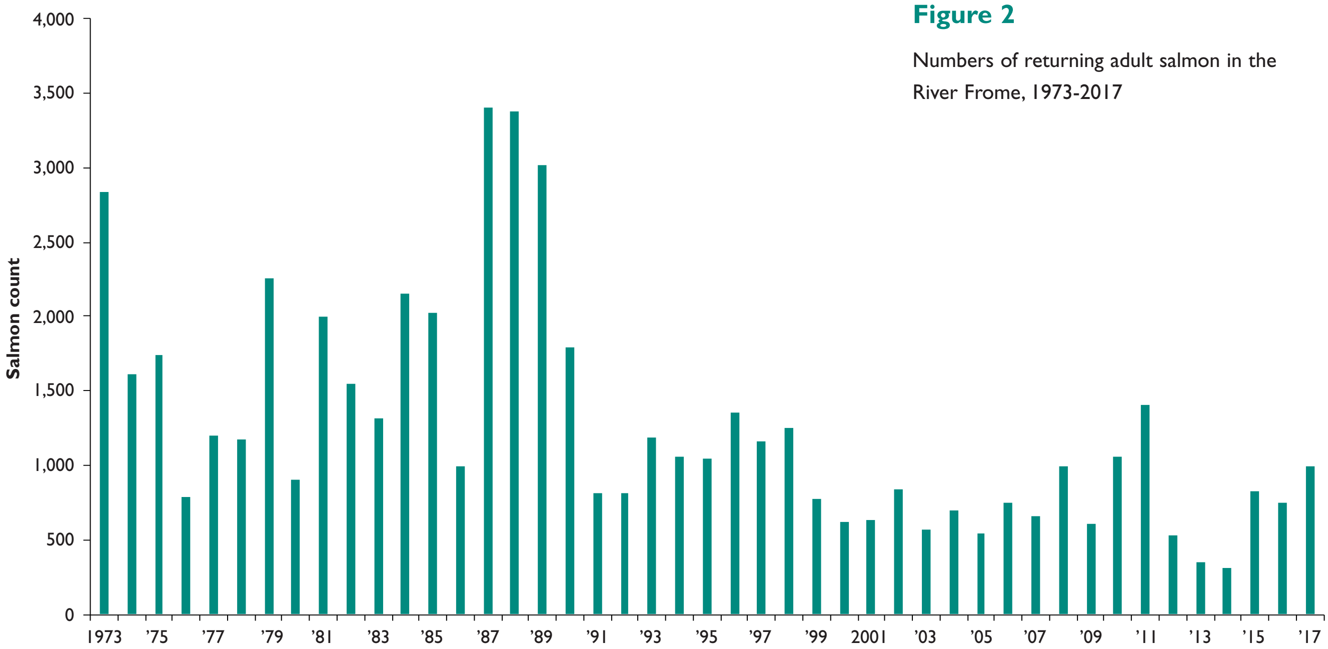


Figure 2

Numbers of returning adult salmon in the River Frome, 1973-2017

between spawning and the late summer of 2016, rather than having fewer than normal spawning fish present in the river.

During the early part of the winter in 2015/16, when the adult salmon were laying their eggs, unseasonably warm weather prevailed. The high air temperature resulted in an average water temperature in the river Frome for December 2015 of 11.2°C. This was the warmest December temperature recorded this millennium, 3.3°C warmer than the average December temperature and 2.0°C warmer than the second warmest in this millennium. We speculate that the high water temperature during spawning and early egg incubation had a negative impact on egg survival and subsequent juvenile recruitment.

Adults

After recording very poor runs of adults in 2013 and 2014, this year has continued the positive trend seen over the last couple of years with returns in excess of the conservation limit (see Figure 2). This is the result of a decent run of both one and two sea-winter fish.

In 2017 summer flows were low, but the water level was kept high owing to excellent in-river growth of water crowfoot (*Ranunculus spp.*) backing up the water level. Resulting conditions were favourable for parr habitat and due to the high-water level upstream, migration of adults was unhindered, but even so the majority of adult upstream movement during the summer occurred during flow events.

Parr

During the 2017 tagging campaign we encountered high densities of juveniles (parr) in large parts of the catchment. Indeed, the parr density was the highest encountered during the tagging campaign for a number of years. This made relatively light work of catching and tagging our target 10,000 salmon and 3,000 trout parr. Even so it took three weeks for 14 staff and volunteers each day to tag the target number of parr and to visit all our long-term sites.

The 2017 parr were recruited from a similar number of returning adults as the 2016 parr (see Figure 2). Such contrasting recruitment success again highlights the importance of the freshwater component of the salmon life cycle and its potential to affect stocks in years to come.

The low number of smolts that left the river Frome for their feeding grounds in the North Atlantic in 2017, is likely to result in a marked reduction in the number of adult salmon returning to the river in 2018 and 2019. Furthermore, we expect fewer than average adult returns in other affected rivers throughout the UK, albeit that the effects might be seen in later years depending on the age that their smolts go to sea.

KEY FINDINGS

- Poor recruitment from the spawning in 2015/16 resulted in the worst smolt run on record with less than half the smolts of the 10-year average leaving the river.
- The recruitment failure appears to be the result of processes happening in the river during the freshwater phase probably caused by high winter temperatures.
- High parr densities were recorded in 2017 as a result of excellent recruitment from the 2016/17 spawning.
- Data from the last few years highlights the importance of the freshwater component of the life cycle and its potential to affect stocks in years to come.

Rasmus Lauridsen

Interreg France (Channel Manche) England
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European Regional Development Fund

SAMARCH - salmonids in estuaries and coastal waters

Céline Artero range-testing acoustic receivers in the river Scorff estuary in France. *© Bill Beaumont/GWCT*

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

On the river Frome we have produced annual estimates of the number of juvenile salmon leaving the river and the subsequent number of adults that return for more than a decade. At the heart of this work is an intention to disentangle the reasons why some salmon survive to reproduce, and some do not.

On average 94% of the young salmon leaving the river Frome die at sea. This marine loss rate is similar to those reported from other wild salmon populations around the Atlantic ocean, but considerably higher than what was observed in the 1980s. Where do these fish die, in the estuaries or the open sea and why?

We are aware that lots of new data have been collected since the development of the models currently used to assess our salmon stocks. There is scope to use these new data to improve these assessment models. For the past two years we have worked with nine partners to submit a funding application to the EU that would enable us to address these questions.

In May, our application to the EU's Interreg Channel Programme, SAMARCH – SAlmonid MAnagement Round the CHannel project 2017-2022, was approved. The project will produce new scientific evidence to inform the management of salmon and sea trout (salmonids) in estuaries and coastal waters of both the French and English sides of the Channel. The work will focus on the five salmon and sea trout 'Index' rivers in the Channel area. These are the rivers Frome and Tamar in the south of England and the Scorff, Oir and Bresle in northern France.

The project involves 10 partners from France and England comprising regulatory and research organisations, and key stakeholders:

- Lead partner: Game & Wildlife Conservation Trust (UK).

ACKNOWLEDGEMENTS

The SAMARCH project is part-funded by the EU Interreg Channel VA Programme. We also gratefully acknowledge the financial support of the Atlantic Salmon Trust towards the fish tracking part of the project.

- University of Exeter (UK).
- Bournemouth University (UK).
- Environment Agency (UK).
- Salmon and Trout Conservation (UK).
- Institut National de la Recherche Agronomique (France).
- Agrocampus Ouest (France).
- Agence Française pour la Biodiversité (France).
- Normandie Grands Migrateurs (France).
- Bretagne Grands Migrateurs (France).

There are four main focus areas of the project:

- 1. **Tracking salmonid movements through estuaries and coastal waters.** We will use acoustic tracking technology to follow sea trout and salmon smolts through the estuaries of the rivers Frome, Tamar, Scorff and Bresle in the spring of 2018 and 2019 to apportion the mortality rate of smolts between the estuary and the sea. Using both acoustic and data storage tags in sea trout kelts on the Frome, Tamar and Bresle in the winters of 2018 and 2019, we will track their movements through the estuary and further to sea.
- 2. **Brown trout and sea trout genetics.** We will collect samples of juvenile brown trout from rivers in northern France and the south of England, and adult sea trout across the Channel, to build a common genetic database of brown trout and sea trout to identify the rivers of origin of sea trout caught at sea. We also aim to develop a transferable map based on seascape in the Channel area to predict which coastal areas are important for sea trout.
- 3. **Managing salmonid stocks.** We will collect data on the marine survival of salmonids and model this and other historic data from the five Index rivers to develop a predictive model for the abundance of returning salmonids. We will analyse large numbers of historical adult salmonid scales for changes in growth rate and sex ratio over time, and assess the fecundity of salmonids. These will all feed into the models used to manage salmonid stocks in England and France.
- 4. **Policy, stakeholder engagement and training.** This will ensure that the results produced by the project inform, improve and develop new policies for the management of salmonids in estuaries and coastal waters. It will engage with stakeholders in both England and France and further afield, to maximise the impact of the results generated by the project. It will provide training for students who are the next generation of environment managers.

BACKGROUND

Until recently salmonid research has focused on their freshwater stages, but now the technology exists to learn more about the time they spend in estuaries and coastal waters. The transition zone, where the smolts migrate from freshwater into saltwater is thought to be a critical phase in their migration. The use of acoustic technology will enable us to quantify the loss rate during this early part of their sea migration. If high loss rates occur in this transition zone, then we might be able to do something about it. We have employed Dr Céline Artero to lead the tracking element of SAMARCH in these transitional waters.

KEY FINDINGS

- SAMARCH is a five-year project with a budget of €7.8m which is part-funded (69%) by the EU's Interreg Channel Programme. The project has 10 partners.
- Only 6% of the salmon smolts that leave our rivers for their one to three year ocean migration, return to their native river to spawn.
- SAMARCH will analyse 15,000 sets of salmon scales spanning three decades to analyse changes in freshwater and marine growth of survivors.
- SAMARCH will use genetic techniques to sex 10,000 juvenile and adult salmon.

Dylan Roberts
Céline Artero

Bill Beaumont and Luke Scott electro-fishing for sea trout kelts on the river Tamar.
© Dylan Roberts/GWCT

Could bigger Atlantic salmon smolts be better?

A rotary screw trap is used to capture and measure a sample of emigrating juvenile Atlantic salmon smolts. © GWCT

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

KEY FINDINGS

- On the river Frome in Dorset, approximately 97% of smolts emigrate one year after emerging from their gravel nests, at about 14 centimetres in length.
- A smolt's chance of surviving at sea to return as an adult is related to length: longer smolts are between two and three times more likely to return as an adult than shorter smolts.
- Frome smolts appear to be shrinking (like Frome parr; see the *MorFish – protecting Atlantic salmon* article in the *Review of 2015*) but they also seem to be emigrating earlier.

Stephen Gregory

Atlantic salmon stocks (as indicated by catches) are declining (see Figure 1). For a long time, the finger of blame has been pointed at the marine environment, where climate change and the processes it influences, such as water temperature, sea-level and spatial and temporal variations in algal blooms, are thought to have rendered the environment hostile to migrating smolts. More recently, however, there has been a growing sense that factors affecting juveniles during their development, ie. in the freshwater environment, might play a larger role than previously judged.

Since 2006, the GWCT fisheries team has been capturing and measuring juvenile Atlantic salmon emigrating to sea, known as smolts. Each year, between 200 and 600 captured smolts are individually identifiable thanks to an electronic tag, known as a Passive Integrated Transponder (PIT) tag, implanted the previous September. These individuals are detected on our network of PIT antennae along the river Frome when they return to the river to spawn as adults. We have also measured the length of these individuals.

Among the long-standing but hitherto untested theories about smolt survival at sea is that size matters: the shorter or smaller you are, the less likely you are to survive. To date, however, the lack of individual data coupled with the low probability of adult return has prevented us from testing this theory with hard data. The GWCT smolt data fills that gap.

Using cutting-edge statistical techniques known as multi-state mark-recapture state-space models, we have results suggesting that smolt survival to adulthood, hereafter referred to as the 'probability of adult return' is a function of smolt length (see Figure 2). It seems that the larger you are, the higher your probability to return as an adult. Moreover, the effect is not small: a smolt of approximately 16 centimetres (cm) is between two and three times more likely to return as an adult compared with

ACKNOWLEDGEMENTS

The SAMARCH project is part-funded by the EU Interreg Channel VA Programme.

Figure 1

Catches of Atlantic salmon have been declining for decades. In part, this reflects reduced fishing effort but the declines are thought to represent declines in stocks, even after successive fishing quota restrictions

ICES Northeast Atlantic Commission countries Northern

ICES Northeast Atlantic Commission countries Southern

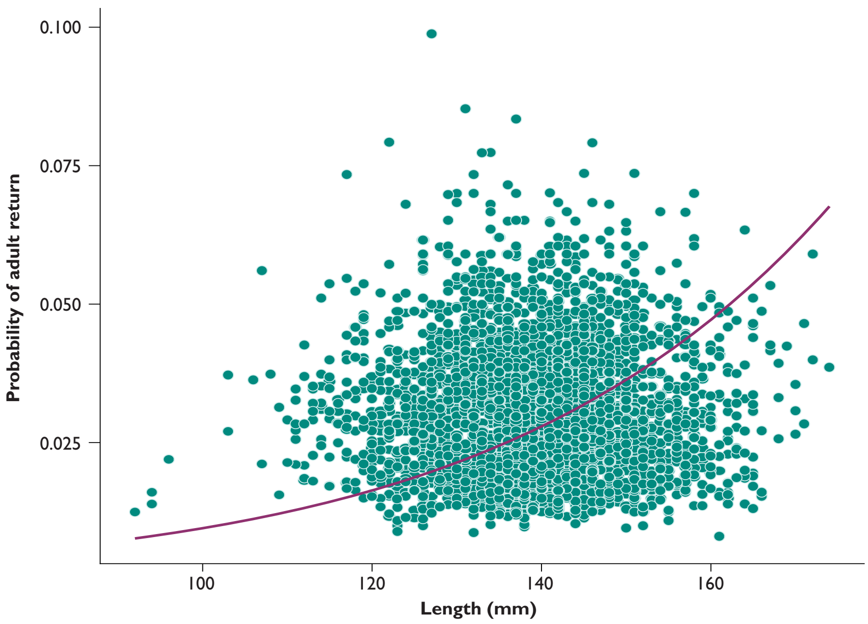


Figure 2

A plot showing that the probability of an individual age one smolt to return to its natal river as an adult (ie. potential spawner) is a function of its length at migration. It appears the effect of length is quite considerable: longer age one smolts are two-three times more likely to return as an adult compared with shorter age one smolts

Line of best fit

a 12cm smolt. To our knowledge, this is the first time that this result has been shown for a wild smolt population.

What does this mean? Taken in isolation, it suggests that juvenile development in the freshwater environment influences the number of returning adult salmon, ie. potential spawners. This is an important finding because it suggests that we could manage the freshwater environment to maximise the quality (ie. length and weight) of emigrating smolts and thereby the numbers of returning adults. This could be particularly important in light of the observation that Frome smolts and possibly smolts elsewhere, appear to be getting shorter (see Figure 3a). However, it is unlikely that their length at emigration is the only factor influencing their probability of adult return: marine conditions are undoubtedly deteriorating and the timing of salmon migrations are changing. For example, the median date of juvenile smolt migration seems to be getting earlier (see Figure 3b).

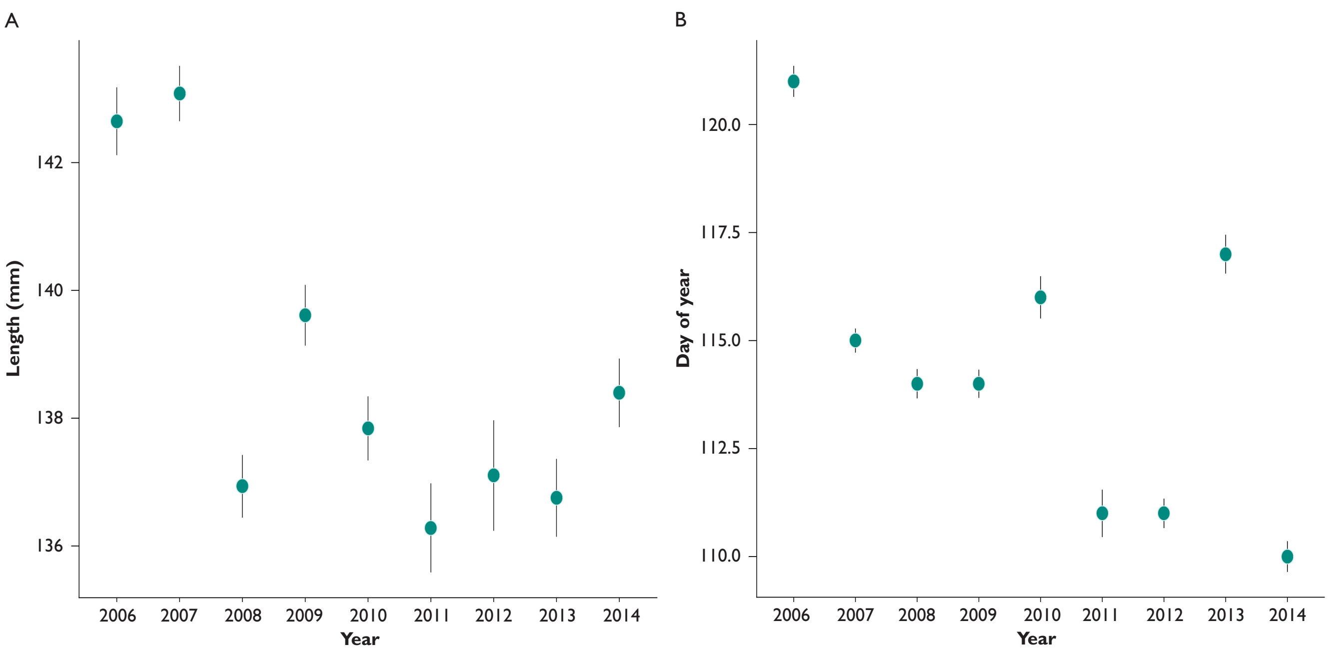
This study is under fast development. It is a GWCT fisheries SAMARCH project objective and will form part of a new three-year PhD project starting in 2018. Initial plans are that the project would seek to show similar results for other smolt populations and delve deeper into the possible mechanism(s). We believe it will reveal the importance of the GWCT salmon research programme and provide strong evidence that we can improve salmon stocks by improving our rivers.

BACKGROUND

Every year since 2006, the GWCT fisheries team has been using a rotary screw trap (pictured) to capture and measure a sample of emigrating juvenile Atlantic salmon smolts and monitor changes in their lengths and weights. After nine years, we are beginning to amass sufficient data to learn about how their condition affects their probability to survive to adulthood.

Figure 3 A & B

Plots showing (A) that age one smolt length appears to have declined since 2006 but also (B) that the median date of age one smolt migration to sea is becoming earlier. What are the implications of these patterns for smolt survival to adulthood?



The effect of releasing pheasants on Exmoor shoots

Our specialist lichen surveyor Aidan Hulyatt identifying a moss in an Exmoor woodland.
© Rufus Sage/GWCT

BACKGROUND

Releasing pheasants and associated management has a wide range of ecological impacts on woodlands and other habitats, some of which have been previously quantified by GWCT research while others remain speculative. In general the work so far suggests that the management for pheasants in and around release woodlands has a positive effect on habitat quality and other wildlife, whereas the presence of the pheasants themselves tend to have negative impacts.

The study has been designed to provide some quantification of the impact of releasing for shooting on habitat quality and wildlife in the Exmoor region. Given the scale of shooting activity on Exmoor, it had been expected that the releasing of pheasants and red-legged partridges and associated management would impact on the ecology of the area. We set out to assess some of the negative impacts but also to examine possible positive effects of management. The programme of work was outlined at a steering group meeting that included members of the Greater Exmoor Shoot Association (GESA) and other interested parties.

ACKNOWLEDGEMENTS

We would like to thank our field staff Aidan Hulyatt, Jenny Peach, Alice Deacon, Sam Gibbs, Greg Whall, the Exmoor estate owners and gamekeepers, Hugh Thomas, Exmoor National Park Authority and the National Trust.

We looked at a range of potential impacts of releasing pheasants on the environment at a sample of large shooting estates and non-shooting control sites on the southern Exmoor fringes. Estates had several release pens managed by professional gamekeepers.

Release pens and ground flora

Quadrat surveys at seven estates indicated that there was more bare ground inside release pens (40%) compared with the same woodland, but outside the pen (10%), fewer woodland herbs (15% compared with 30%) and a reduced fern community. There was no clear difference in overall plant diversity.

These impacts on ground floras are probably caused by a combination of trampling, soil enrichment and differences in the shrub and tree canopy. They are similar to those caused by pheasants in woodland release pens elsewhere in the country. To counter these effects, the 2017 *Code of Good Shooting Practice* recommends that pheasants be stocked in pens at below 1,000 birds per hectare of pen, and that pens occupy less than half of a wood.

Release woods and lower-order plants

At the same seven estates, moss and liverwort species diversity as measured using quadrats placed on tree trunks, was twice as high in non-release woods compared with release woods. Liverworts were also twice as abundant in non-release woods. These differences may relate to increased nitrogen in the air but other factors may be involved. This was the first time these woodland plant types have been investigated in relation to pheasant releasing.

Although the impact to ground floras was limited to within the release pen, the effects on lower order plants extended into woodland areas outside the pen but in the same wood.

Conifer woods

In a sample of 26 conifer woodlands on four shooting estates, we measured the structure of the woodland using vertical pole transects. This indicated the lower and upper tree canopy in woods managed for game was about 25% more open than in non-game ones. There was 30% more bracken in game woods and a tendency towards more bramble and grasses. Herb abundance was not different. We encountered 18 birds per survey in the game woods compared with 10 per survey in the non-game woods.

Conifer woods with the habitat differences identified are probably selected for game management purposes and then further improved through management for game. Previous GWCT research indicates broadleaf woods also benefit from this management.

Cropping and game crops

Mapping work at three large shooting estates that covered 5,885 hectares (ha) indicated 4.4%, or 256ha were game crops. The average size of these 143 game plots was just under 1.8ha, much larger than plots on other shoots. One quarter (65ha) were maize whereas three quarters contained 15 other crop types, the commonest being kale (28ha), miscanthus (24ha), root crops (20ha) and wild bird mix (18ha).

Cropping maps from 1967/8 were also digitised and showed that the game interest on the estates in 2017 contributed to a cropping pattern in the landscape that was more like that of the 1960s than of farmland without a game interest (see Figure 1).

Hedges and birds

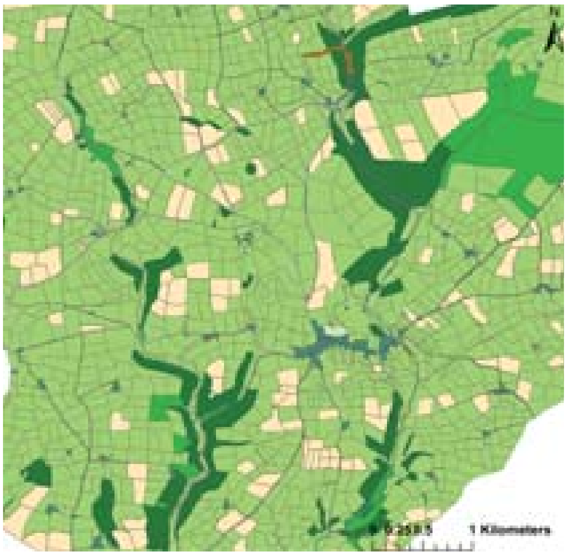
We walked along hedges and counted breeding birds using the hedgerows on the three game estates and compared these with three non-game farms. The number of breeding resident birds was twice as high in the game hedgerows while migrant birds, which arrive on the sites in spring, were not different. On game estates, hedges within 200 metres to game crops had more breeding resident songbirds in spring than the hedges further away.

Although we know game crops attract birds in winter, the scale of the difference in breeding birds was surprisingly large and requires further investigation. The large plots of seed-bearing game crops seemed to be making a significant contribution to the abundance and diversity of farmland birds.

KEY FINDINGS

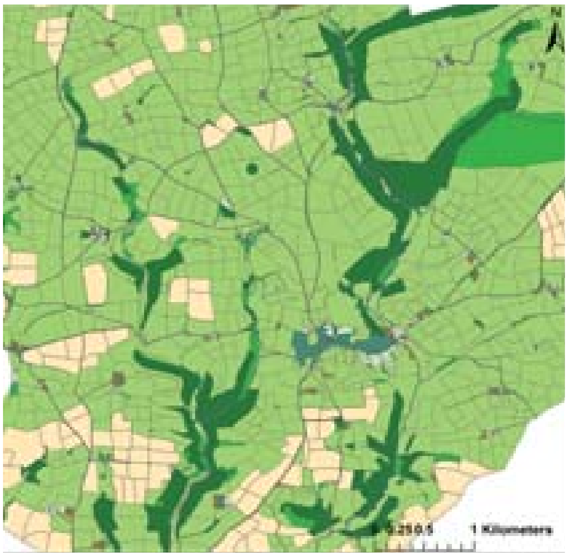
- Like other shooting areas in the UK, the release of pheasants into deciduous woods around Exmoor is usually detrimental to ground flora within pens but not elsewhere in the release wood.
- Mosses and lichens on trees were present but less common in and around release sites.
- Conifer woodland habitats are improved with game management.
- The shoots have exceptionally large game crop plots. This benefits overwintering birds and hedgerow breeding songbirds in summer.

Rufus Sage



1960s cropping map

Modern day without game crops



Modern day with cover crops

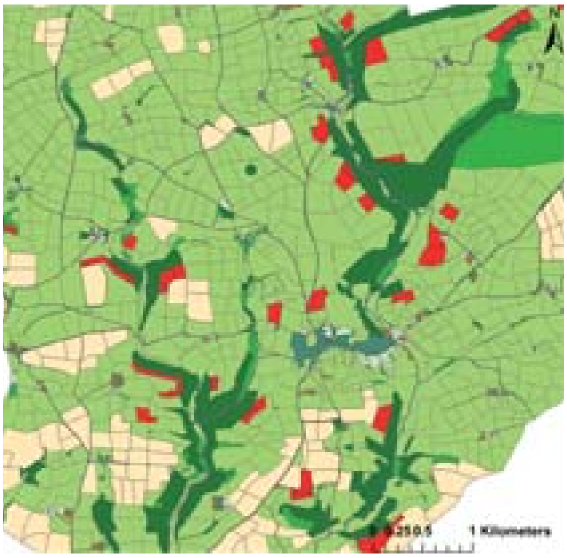


Figure 1

Past and present cropping in a typical area on the Exmoor fringes. The use of game crop plots today increases the spatial crop-type diversity of the otherwise grass dominated farmed landscape. The size and distribution of the game crop plots is more like a 1960s cropping pattern

Arable

Woodland

Cover crops

Grassland

Non-shooting losses of released pheasants

Radio-tracking pheasants in summer.
© Rufus Sage/GWCT

BACKGROUND

The economic activity associated with shooting provides the basis for funding research into gamebird conservation and like other organisations in Europe and the US, the GWCT has undertaken a variety of studies of gamebird populations over the past 30 years. In the last 20 years this support has funded a range of radio-tracking studies of pheasants from release-based and wild shoots, where individuals are caught, tagged and then followed. Although most of these studies did not focus on predation, it was always documented. This provides an opportunity to present data from many sites on predation rates of free-living adult reared pheasants in the months after release, through the shooting season and then following shooting, when the surviving birds attempt to breed.

About a third of pheasants released each year in the UK are shot. It varies between shoots, but the UK figure compares favourably with other release methods used elsewhere in the world. Nevertheless, it is useful to understand more about what happens to the other two-thirds of released pheasants that are not shot. Here we summarise data that we have collected over the last 25 years on the fate of radio-tagged released pheasants. Although radio tags are expensive and tracking is time consuming, the technology has allowed us to accumulate data from 13 different sites.

In studies of birds during the autumn/winter at six pheasant shoots managed by full-time gamekeepers between 2001-2003, we caught and tagged pheasants from one pen shortly after release in late summer. Predation of these birds by foxes before shooting began averaged 19.2±4.0%, but the range was very large (8.6% to 42.4%) with one study pen in particular contributing few birds each year to the shoot. During the shooting season (1 October-1 February) a further 15.9±1.9% of birds on average were predated (see Table 1). We did not see an effect of predator control effort on predation rates although effort did not vary substantially between sites. Taking account of accidents and other losses, overall 16.6% (one sixth) of the released birds at these six sites over three years survived beyond 1 February.

At seven different sites, between 1992 and 2013, we caught released (and some wild) hen pheasants in February or March and radio-tracked them during the spring and summer for one or more years each. Between 20 and 71% of these tagged

TABLE 1

Fate of 486 released pheasants during the pre-shooting period and shooting season in the three years 2001-2003 at six estates in southern England. SE is standard error

Site	Number of birds	Shot		Predated		Other	Alive
		On-site	Off-site	Pre-shoot	Shoot season	Accident/unknown	after shooting
1	75	0.144	0.012	0.424	0.170	0.160	0.090
2	74	0.258	0	0.239	0.179	0.158	0.166
3	87	0.380	0.069	0.135	0.158	0.064	0.194
4	86	0.371	0.047	0.182	0.142	0.142	0.116
5	87	0.381	0.082	0.087	0.136	0.087	0.227
6	77	0.258	0.092	0.086	0.169	0.190	0.205
Mean		**0.298**	**0.050**	**0.192**	**0.159**	**0.133**	**0.166**
SE		**±0.029**	**±0.014**	**±0.040**	**±0.019**	**±0.019**	**±0.020**

TABLE 2

Losses of hen pheasants and nest outcomes between mid-March and mid-July 1992 and 2013 between seven estates. Hens predated includes before, during and after nesting. Other outcomes include nest abandoned with hen dead or alive or nest destroyed (flood, tractor etc).

Site	Predator control	Number of hens	% Hens predated	Number of nests	% Nest success	% Eggs predated	% Other outcomes
7	Low	163	71	98	32	39	29
8	Low	78	60	50	22	52	26
9	Low	182	55	112	23	56	21
10	Low	45	49	31	48	33	19
11	High	89	38	70	34	40	26
12	High	104	32	83	45	36	19
13	High	150	20	90	36	25	39
Total	**-**	**811**	**46**	**534**	**34**	**40**	**26**

birds were predated, mainly by foxes, between mid-March and mid-July (see Table 2). Predation was significantly higher at sites with low-level predator control (59±4.7%) compared with those with high-level control (30±5.3%).

We also documented the fate of 534 nests produced by these 811 tagged birds at the seven sites. Nest success during incubation stage was on average 34% (see Table 2). The most common single outcome overall was for the eggs to be predated (40%), usually by corvids, but sometimes the nest remains suggested foxes or badgers. Nest survival was better on sites with high level predator control (48% compared with 27% with low level control).

Our data show how predation is the major non-shooting fate of released pheasants before, during and after the shooting season. Minimising these losses, supporting surviving released birds after shooting and encouraging an interest in wild birds are key elements of sustainable releasing for shooting. We can show that improved predator control on shoots interested in surviving released birds and wild birds can be effective. However, we need to understand more about how individual shoots can predict and reduce predation of releases before shooting begins. Although managing the predators themselves may seem to be the obvious approach, in our studies it has been difficult to show an effect of predator control. There are other approaches which we are exploring – for example, understanding more about how the release environment affects predation on individual shoots, or the development of rearing methods that produce pheasants that are better at avoiding predators.

KEY FINDINGS

- Using radio-tracking techniques at 13 sites since 1992, we know the fate of 1,300 released pheasants.
- At six release sites predation was the most common cause of non-shooting losses of 486 birds before and during shooting.
- One sixth of these released birds survived the shooting season.
- Approaching half of 811 pheasants that were tagged in March at seven sites, were predated by mid-July.
- One third of 534 nest attempts succeeded while 40% of nests were predated.

Rufus Sage

The fox is the main predator of pheasants in the UK. © David Mason

Lapwing nest predation in the Avon Valley

A fox entering a field containing breeding lapwings at 16:04 on 25 March 2017. (Below) A badger using the same bridge. © Lizzie Grayshon/GWCT

Low breeding success is the main limiting factor across many species of wader. In the *Review of 2016* (see pages 22-23) we outlined our approach and the habitat modification implemented in the Avon Valley, and here we provide an update on our predator and nest monitoring.

Since the start of the project in 2015, we monitored the success of 171 lapwing nests using field observations and temperature loggers (small devices the size of a 5p coin placed under the eggs, which record temperature every 15 minutes, pinpointing the time of predation events).

Hatching success over the three years 2015-2017 averaged 46% (SE ±3.9%). Out of the 53 nests known to be predated (other outcomes include unknown failure, trampled and abandoned) we have temperature logger data for 40 nests. Twenty-eight of these predation events took place after dark and 12 during daylight hours, indicating that 70% of nest predation was at night, probably by mammalian predators.

Although we can identify the timing of predation events using this method, we lack a good understanding of terrestrial predator abundance and how they behave in wet meadow landscapes, thereby making it difficult to mitigate their impact. We used motion-activated camera traps at our four hotspot sites to provide insight into

BACKGROUND

The number of lapwings breeding in the Avon Valley has fallen by 70% in the last 25 years, initially driven by changes in water meadow management leading to the loss of lapwing nesting habitat. Agri-environment schemes acted to support land managers to practise lower intensity farming to improve suitability for breeding waders on wet grassland. However, population recovery is not limited by habitat alone, with nest and chick predation by avian and mammalian predators playing a role. Our approach within the EU LIFE+ Waders for Real project is to create hotspot sites, with reduced predation pressure, to increase breeding success and future recruitment.

how we may reduce the impact of predators and on three of the sites improve the efficiency of fox control.

Each year we deployed 10 camera traps at each hotspot, alternating between 20 paired locations from mid-April to the end of June. Over 2016 and 2017, badgers were detected at 8% of camera sites with foxes present at 9%. Badgers and foxes were recorded on average 0.07 ± 0.01 and 0.17 ± 0.03 times per 24 hours per camera during the wader breeding season respectively.

In addition, camera traps tell us about the timing of predator activity on the water meadows. As expected, badgers are a crepuscular or nocturnal visitor with all detections between 6pm and 6am (n=510). Foxes also remain predominately active after dark, with the highest proportion of detections at 10pm (14% 168/1209). However, it is apparent from a small number of detections that foxes are accessing the water meadows during the day, with 6% (70/1209) of detections between 7am and 5pm (see main photo) and hence, foxes need to be considered among the range of predators potentially responsible for day-time predation events.

Our camera traps have also identified bottlenecks in the movement of predators with man-made bridges appearing significant to how they navigate this habitat.

Future analyses will use our camera trap and nest monitoring data to consider the relationship between fox and badger abundance and lapwing nest survival. This work, alongside other methods of predator monitoring and exclusion within the Waders for Real project, will help wildlife and land managers to develop more effective strategies for increasing lapwing productivity.

KEY FINDINGS

- Predator monitoring forms an important part of our LIFE+ Waders for Real project in the Avon Valley.
- Lapwing nest survival averaged 46% during 2015-2017. Two-thirds of clutch predation occurred at night, suggesting foxes and badgers as the likely culprits.
- Badgers and foxes frequented almost all the key wader nesting fields: badgers were detected at 8% of hotspot camera trap sites with foxes present at 9%.
- This project will help us devise more effective strategies for improving lapwing breeding success.

Lizzie Grayshon
Ryan Burrell
Rebecca Robinson
Thomas Oakley
Andrew Hoodless

A mink (top), fox (above) and otter (left) using the same bridge which leads to the water meadows.

ACKNOWLEDGEMENTS

We would like to thank all the landowners, farmers and keepers in the Avon Valley for their support of the Waders for Real project. The project is part-funded by the EU LIFE+ programme.

Waders for Real

The diet of lapwing chicks reared on farmland

Earthworms form a large part of a lapwing's diet.
© Laurie Campbell

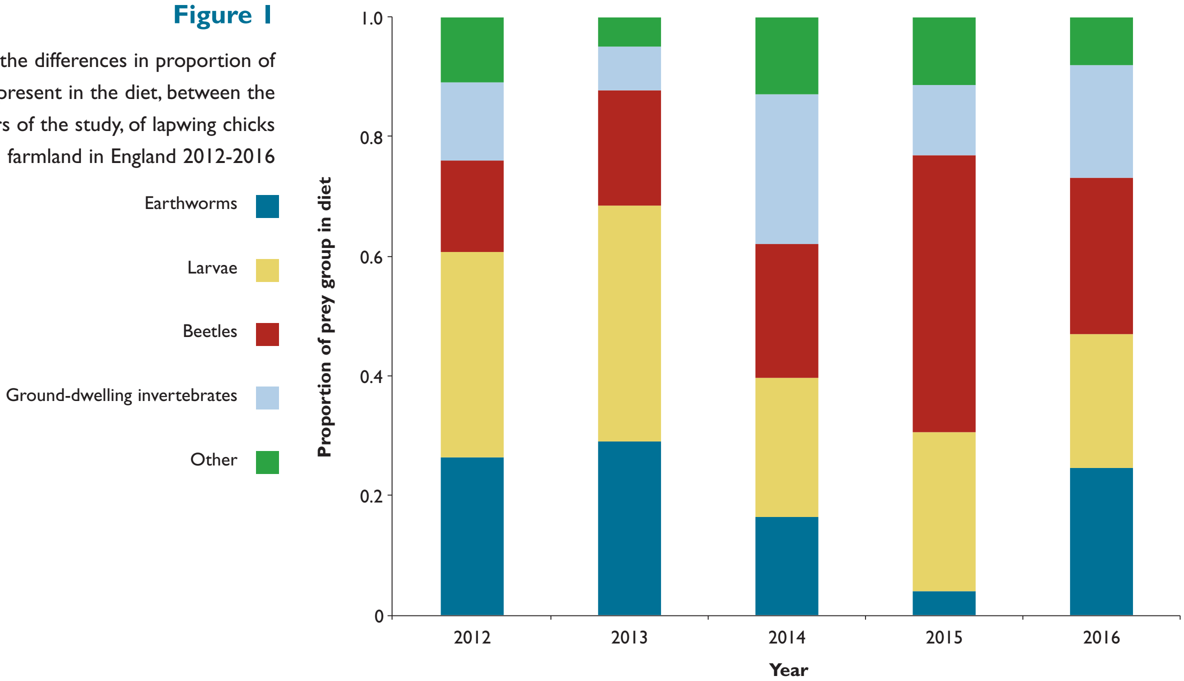
BACKGROUND

To help reverse the decline in the UK's lapwing population, an option in the agri-environment scheme (AES) was introduced, whereby farmers are financially encouraged to provide uncropped, roughly cultivated plots (referred to hereafter as fallow plots) of 1.0-2.5 hectares on arable land. Lapwing numbers are positively related to the area of fallow plots available and an estimated 40% of fallow plots are used by breeding lapwings in England. Lapwing nesting success is higher on fallow plots than in conventional crops, indicating that this AES option is successful in providing suitable nesting habitat for lapwings. However, little research has gone into whether they also provide good chick-rearing habitat. Fallow plots are expensive, so we need to know whether they are a cost-effective option for producing fledged lapwing chicks.

The lapwing, like many other farmland birds, has been severely affected by large-scale changes in agricultural practices, such as drainage of wet meadows and arable fields, intensification of crop-growing and the reduction of spring-sown cereals. As a consequence, the UK lapwing population has declined by 57% since 1990 and is listed as 'vulnerable' on the European Red List. Lapwings are ground-nesting waders and prefer nest sites that are flat, open and with little or no vegetation. These habitat require-

Figure 1

Plot showing the differences in proportion of prey items present in the diet, between the different years of the study, of lapwing chicks reared on farmland in England 2012-2016



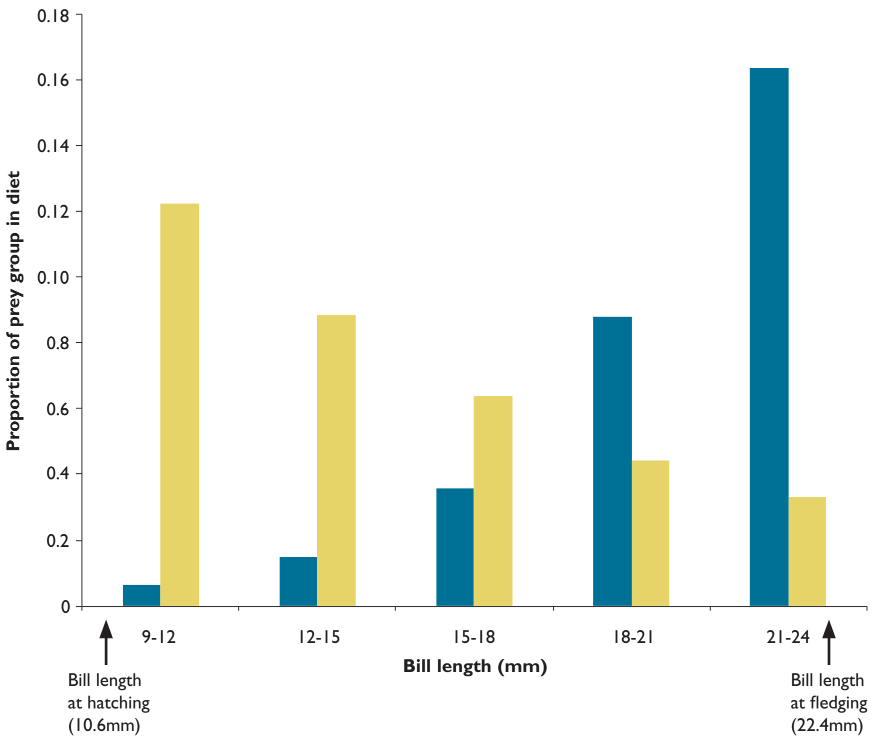


Figure 2

Changes in the proportion of earthworms and larvae present in the diet of lapwing chicks reared on farmland in England 2012-2016, in relation to bill length (used as a proxy for age)

ments are different from those required for chick-rearing, which include short vegetation for foraging and longer vegetation to provide cover from predators.

We examined the diet of lapwing chicks reared on farmland to evaluate whether the diet of chicks reared on fallow plots differed from that of chicks reared on conventional crop fields (mainly spring cereals and root crops) and dry grassland. We collected 256 faecal samples from 197 lapwing broods during the springs of 2012-2016 at 47 sites across Wessex (Hampshire, Wiltshire and Berkshire) and East Anglia (Norfolk and Suffolk). We rinsed the faecal samples in water using a sieve, allowing unnecessary small items (eg. sand) to pass through but retaining invertebrate fragments (eg. mandibles, tibia, fangs) required for prey identification. We then multiplied the number of unique body parts by published correction factors specific to the prey item, to give us total biomass for the whole sample. This allowed us to calculate proportions for each specific diet category.

We found no major differences in diet composition between chicks inhabiting fallow plots, conventional crop fields or grassland. Across all habitats, lapwing chick diet consisted of a variety of invertebrates but was dominated by five prey items: ground beetles, weevils, woodlice, earthworms and cranefly larvae (leatherjackets), constituting 54% of total biomass.

For all prey groups except larvae (including cranefly larvae, beetle larvae, sawfly larvae and caterpillars), there was a difference between the proportions of prey items consumed between years (see Figure 1). Weather variables such as rainfall, temperature and humidity have an effect on soil penetrability and invertebrate activity. In our study, rainfall varied between years, with considerably less rainfall in 2015 (receiving only 71% of the 1981-2010 average rainfall) than in other years. In 2015, chick diet comprised a significantly smaller proportion of earthworms but a larger proportion of beetles than in other years, indicating that earthworms may not have been accessible owing to the drier conditions and that chicks were compensating by consuming more beetles.

The proportion of earthworms and larvae in the diet were related to bill length, used as a proxy for chick age (see Figure 2): chicks with longer bills consumed a larger proportion of earthworms but a smaller proportion of larvae. As lapwing chicks grow larger, the energy required to maintain growth increases. Consequently, chicks switch to more profitable (more energy) prey items which may not have been available to them earlier owing to their shorter bills.

The next stage of this study is to examine how lapwing chick diet affects body condition, chick growth rates and fledging success, to better understand lapwing chick requirements and create habitat specifically designed for increasing both nest and chick survival.

KEY FINDINGS

- Lapwing chick diet consisted of a variety of invertebrates but was dominated by five prey items: ground beetles, weevils, woodlice, earthworms and cranefly larvae (leatherjackets), constituting 54% of total biomass.
- There was no difference in diet composition between chicks reared on fallow plots, conventional crop fields or grassland.
- Older chicks consumed a larger proportion of earthworms but a smaller proportion of larvae (including cranefly larvae, beetle larvae, sawfly larvae and caterpillars) than younger chicks.

Kaat Brulez
Andrew Hoodless

ACKNOWLEDGEMENTS

This work was funded by Defra (as part of projects BD5211 and LM0108) and The Dulverton Trust. We are grateful to all the farmers and landowners for site access. We thank Carlos Sánchez-García for fieldwork and helpful advice, and Michael MacDonald and the RSPB field team in East Anglia.

Managing resident and wintering woodcock

Our resident woodcock are declining in Britain and Ireland, but there is a stable trend across the main European breeding grounds. © Laurie Campbell

BACKGROUND

Britain and Ireland support a relatively small resident breeding population of woodcock, estimated at 55,240 males. This population has undergone a severe decline in size and range since 1970. The European breeding population is estimated at seven to nine million males and shows a stable trend. In winter we see a large influx of migrant woodcock from Norway, Sweden, Finland, the Baltic States and Russia. Migrants typically arrive from October to January, but the timing and numbers vary regionally within Britain and Ireland, as well as annually. We estimate that between 800,000 and 1.3 million migrant woodcock winter here.

KEY FINDINGS

- Landowners can help breeding woodcock by increasing structural diversity and open areas within their woods.
- Woodcock should not be shot before 1 December.
- Shooting of woodcock should stop after four days of continually frozen ground.
- Local knowledge is key to preventing overshooting of woodcock.

Chris Heward
Andrew Hoodless

In randomised surveys across Britain in 2003 and 2013, organised by the GWCT and the British Trust for Ornithology, occupancy of survey woods dropped from 35% to 22% and the estimated size of the British population of woodcock fell by 29%. The woodcock was moved to red status on the UK's Birds of Conservation Concern listing in December 2015, owing to an estimated 52% range contraction during the previous 25 years. Our research in recent years has comprised studies on specific aspects of woodcock ecology, with the overall objective of enabling us to provide better guidance on managing woodcock sustainably. Our use of satellite tags has provided a valuable insight into the timing of migration, the influence of weather and faithfulness of individual birds to particular breeding and wintering sites (see *Review of 2014*). An assessment of body reserves has helped us better understand the ability of woodcock to withstand cold weather (*Review of 2015*). Our national breeding woodcock surveys have enabled an evaluation of habitat preferences (*Review of 2016*).

Analysis of our breeding survey data with corresponding data on habitat, weather and mammal abundance indicates a strong positive association between woodcock abundance and large, continuous networks of woodland and with diversity of woodland stands. It also suggests greater woodcock declines in areas with higher fox abundance. Landowners can therefore help breeding woodcock by managing habitat and reducing predation. Maintaining a diversity of woodland structure and creating open space is likely to help. Where the canopy is dense and there is little undergrowth, thinning will create more ground cover. Making clearings to regenerate naturally, or for replanting, will create open space in the short term followed by thickets for foraging. We have been using GPS tags to assess fine-scale habitat use during the breeding season and from 2018 we will be tracking woodcock in actively-managed woods to better quantify management practices that are most beneficial.

At present, we cannot rule out shooting as a factor contributing to the decline of our resident woodcock. We have commenced work to examine the effect of shooting on woodcock numbers and produce guidance on sustainable harvest rates, but this is not yet complete. However, some of the results from our research to date are relevant to the shooting of woodcock. We know from ring recoveries and sightings at bird observatories that the first migrant woodcock typically only reach Scotland in mid-October, with the first migrants appearing in southern England about 10 days later. Data from geolocators and satellite tags fitted to woodcock during our migration study indicate that birds returned between 3 and 23 November. Our regular spot-lamp counts over the last 10 years in southern England indicate that woodcock numbers only usually increase appreciably in late November. Hence, to protect resident stock, it is important not to shoot woodcock early in the season and we advise no shooting before 1 December.

Our work on body reserves in winter showed that woodcock regulate their energy levels efficiently so long as the ground remains unfrozen for six to eight hours in a day,

Our woodcock tracking suggests that most migrant woodcock arrive in November and are largely faithful to the same wintering site between years. © Chris Heward/GWCT

but rapidly lose condition once the ground remains permanently frozen (typically when the minimum daily temperature is below -2°C and the maximum does not exceed 3°C). Consequently, it is important to stop shooting woodcock after four days of continually frozen ground. This is well before the current call for voluntary restraint after seven days of freezing weather and a statutory cold weather suspension comes into force after 15 days.

Our satellite-tracking of migrant woodcock showed birds to be faithful to their wintering sites, with 97% of birds that survived more than one year returning to the same location. Typically, birds used the same diurnal woodland roost and the same fields for night feeding each winter. Our annual ringing effort is telling a similar story, with a high level of recaptured individuals at the same sites between years. Hence, even where resident woodcock are absent, shoots should give careful consideration to numbers shot or the migratory link with the area will be broken and fewer woodcock may be seen in future years.

We advocate improving local knowledge about both the presence of resident breeders and the numbers of woodcock typically present at different times during the winter. Until we better understand the reasons for the decline in our breeding woodcock, shoots can help the bird through habitat management and adjusting their shooting policy.

ACKNOWLEDGEMENTS

We are grateful to the volunteer surveyors who participated in the breeding woodcock surveys and the BTO regional organisers. We thank the estates that collected birds for carcass analysis and the *Shooting Times* Woodcock Club and individual donors who funded our satellite-tracking. We thank the Forestry Commission and private landowners who have provided access to land as study sites, the estates that have hosted our ringing and Owen Williams of the Woodcock Network for sharing his ringing data.

Woodland management is likely to benefit breeding woodcock because open areas and patches with a developed shrub layer are heavily used. © Chris Heward/GWCT

Partridge Count Scheme

Help grey partridge numbers recover by joining the Partridge Count Scheme. © David Mason

KEY FINDINGS

- National over-winter survival for 2016/17 was 54%.
- The lack of recovery in the long-term pair density index remains a concern.
- First increase since 2013 in national young-to-old ratio to 2.4 young per adult.

Neville Kingdon
Julie Ewald

In 2017, the Partridge Count Scheme (PCS) received 527 spring counts (a 17% decline on counts returned in 2016) (see Table 1). We were able to calculate grey partridge over-winter survival (OWS) for 2016/2017 for sites returning both a 2016 autumn count and a 2017 spring count. The winter of 2016/2017 was rather dry and mild and the 54% OWS reflected this, compared with the 44% OWS in 2015/2016.

Mirroring this encouraging over-winter survival, PCS members recorded a 14% increase in average national spring pair density from 2016 (3.7 to 4.2 birds/100ha). There was a decline in the area counted from 190,000 hectares (469,000 acres) in 2016 to 172,000 hectares (426,000 acres) in spring 2017, resulting in fewer pairs recorded overall (5,806 grey partridge pairs in 2017 compared with 6,525 pairs in 2016). The stronghold of grey partridges in the UK continues to be East Anglia, with more than half of all spring pairs counted in 2017 (3,253) recorded in eastern England, while this region provides a quarter (26%) of all participating PCS sites.

The trend in the long-term grey partridge spring density index (see Figure 1) remains an ongoing concern. Long-term sites (those participating prior to 1999) recorded an average annual 21% decrease in the spring density index, falling to a level last seen in 2004. New sites (those joining since 1999) appear stable, although at low densities, with a 2% increase from 2016. It is extremely alarming that national grey partridge recovery in the PCS has stalled since 2012's abysmal summer, even for sites that have a track record of producing wild birds. This contrasts with previous decreases in the long-term spring density index where, after a small slump in 2007 and 2008, the index returned to its previous upward trend. That a similar upturn did not occur after the summer of 2012 needs further exploration, particularly as the index

JOIN THE PCS

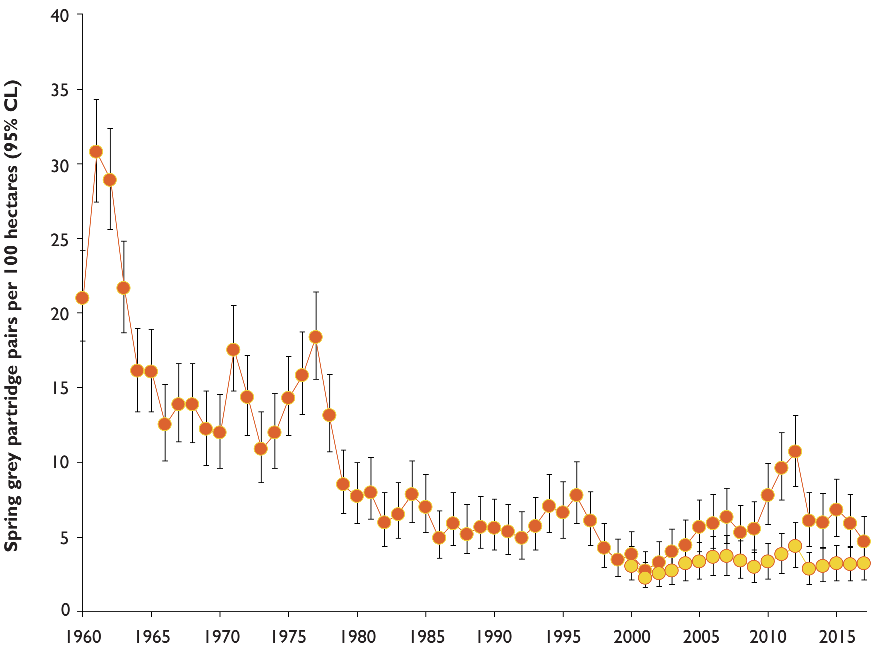
The country's wild grey partridges need more land managers, especially those with only a few grey partridges, to join the Partridge Count Scheme. Find out more at **www.gwct.org.uk/pcs**.

Figure 1

Trends in the indices of grey partridge density, controlling for variation in the different count areas

Long-term sites

New sites



ACKNOWLEDGEMENTS

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

was higher in spring 2012 than in 2007. Productivity in the previous year plays a big part in spring pair density and it is worth noting that the average young-to-old Y:O in 2009, 2010 and 2011 was 2.5, 2.7 and 2.9, respectively. We have not had a similar run of high productivity since 2012, with Y:O in 2013 and 2014 coming in at 2.5, but only 2.2 in 2015 and 2.1 in 2016. Locally spring pair numbers are closely related to the availability of good nesting cover, as well as the productivity in the previous year. We stress the need for all land managers (not only PCS members) to carefully evaluate whether their own conservation measures are delivering insect food resources for chicks, as well as nesting cover and what alterations could improve the breeding success of their partridges.

Although June 2017 (peak grey partridge hatching time) saw warmer than average temperatures across the country, overall the summer was ranked as one of the wettest in the UK since 1910. Cooler temperatures followed in late July, especially in the north, and across the country in August, leading to a rather unsettled autumn. September saw regular spells of rain; an inauspicious start to the PCS autumn covey counts.

The PCS received 494 autumn counts in 2017, 10% fewer than in autumn 2016 (see Table 1). Nonetheless, the total number of grey partridges recorded increased by 500 birds compared with 2016, with a total of 22,400 birds. As a result, the average national autumn grey partridge densities increased 22% from an average of 16.5 birds per 100 hectares in 2016 to 20.2 birds per 100 hectares in autumn 2017. One might argue that this higher density could be the result of losing sites that normally report zero birds, but it does not appear so. Sites recording no partridges in 2016 continued counting in autumn 2017 in similar proportions to those who had birds in 2016 (47% and 50% respectively). This same picture was seen when considering the spring pair counts; 47% of those that had no birds in the spring of 2016 counted in 2017, and 48% of those that had birds in 2016 counted in spring 2017. Although the overall number of counts received was down, it does not appear that this is due to PCS members without grey partridges failing to return counts.

PCS members recorded an increase in productivity; the average (Y:O) ratio across all sites rose 14% to 2.4 young per adult in 2017, compared to 2.1 in 2016. This is the first increase in Y:O seen at the national scale since 2013. It is also above the minimum 1.6 Y:O necessary for a stable population, although at the level of an individual site, productivity can vary considerably and poor survival during winter 2017/2018 could quickly reduce pair numbers in spring 2018. Better chick survival in 2017 does indicate that there is hope for those sites that have provided over-winter food, have practised legal predator control and ensured sufficient nesting cover.

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.

TABLE 1

Grey partridge counts

Densities of grey partridge pairs in spring and autumn 2016 and 2017, 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	*2016*	**2017**	*2016*	**2017**	**Change (%)**	*2016*	**2017**	*2016*	**2017**	*2016*	**2017**	**Change (%)**
South	86	61	1.8	1.9	5.6	69	75	1.6	2.3	12.2	13.0	6.6
East	178	141	5.1	4.8	-5.9	145	133	1.9	2.3	19.0	21.7	14.2
Midlands	123	100	3.2	2.9	-9.4	110	85	1.8	2.4	12.6	18.5	46.8
Wales	3	3	0.8	2.3	187.5	1	2	0	1.8	2.9	4.4	51.7*
North	143	134	4.4	6.8	54.5	135	131	2.2	2.4	25.0	23.2	-7.2
Scotland	93	87	2.5	2.1	-16.0	87	67	2.7	2.4	11.7	12.1	3.4
N Ireland	1	1	5.9	9.9	67.8	1	1	2.0	0.3	20.0	5.3	-73.5*
Overall	**627**	**527**	**3.7**	**4.2**	**13.5**	**548**	**494**	**2.1**	**2.4**	**16.5**	**20.2**	**22.4**

** 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.*

The Rotherfield Demonstration Project

Guns waiting in anticipation on Rotherfield's first partridge shoot day in more than 30 years.
© Francis Buner/GWCT

KEY FINDINGS

- In 2017, the number of grey partridge spring pairs on the Trust's demonstration area was 23 pairs, four more than in 2016 and the highest since the project began.
- On the Trust's area, grey partridge autumn stock was 101 birds, 32 more than in 2016 and the second highest since the project began.
- The first wild partridge shoot day since the early 1980s was held in October 2017. It resulted in a bag of 12 grey partridges, 20 red-legged partridges and 25 pheasants.

Francis Buner
Malcolm Brockless
Nicholas Aebischer

The Rotherfield Demonstration Project in east Hampshire aims to demonstrate how to recover grey partridges where they had gone extinct and to show how management tailored to grey partridge conservation benefits wildlife in general. The project began in 2010 when the Trust's gamekeeper was installed on c. 700 hectares (ha) (Trust side) and the Estate's gamekeeper was working on an adjacent c. 700ha (Estate side). In 2011, the Estate signed a 10-year Higher Level Agri-environment Scheme contract with Natural England, which allowed 240ha of high-quality partridge habitat to be established (mainly wild bird seed mixes, uncultivated uncropped margins, beetle banks, grass margins and overwintered and extended stubbles). Additionally, a long-term partridge-friendly hedgerow management plan was implemented. Because a wild bird partridge keeper is essential to recover grey partridges from zero successfully, the project also demonstrates how shooting interests can be met during the recovery phase when partridges cannot be shot (see *Review of 2013*). To achieve this, 600 wing-tagged cock pheasants have been released annually since 2011 while building up numbers of wild pheasants, with high-quality cock-only shoot days being held on an average of six driven days, three walked-up days and three spaniel trials per season.

On the Trust side we counted a minimum of 101 wild grey partridges in autumn 2017 (27 males, 16 females and 58 young from 13 broods, all but one from replacement clutches). Spring 2017 was unusually cold and August was exceptionally wet, with June and July suitably warm, but still with 60mm and 142mm of rain respectively. Hence, with the weather playing its part, the number of partridge juveniles per brood in autumn was disappointingly low in the project area (4.5 young per brood on average). Only 13 of 23 spring pairs (43.5%) produced a brood, with 16 hens (70%) surviving into autumn (see Figure 1). Average hen breeding mortality during the past five years was 29.9% (the release of reared partridges on the Trust side stopped in 2011 and since 2013 the stock is entirely wild, see *Review of 2013*). We are unsure as to what caused the high rate of replacement clutches. Low insect numbers in mid-June caused by the cold spring is one hypothesis, a high rate of chick mortality caused by other factors such

Figure 1

Number of grey partridges on the Trust side

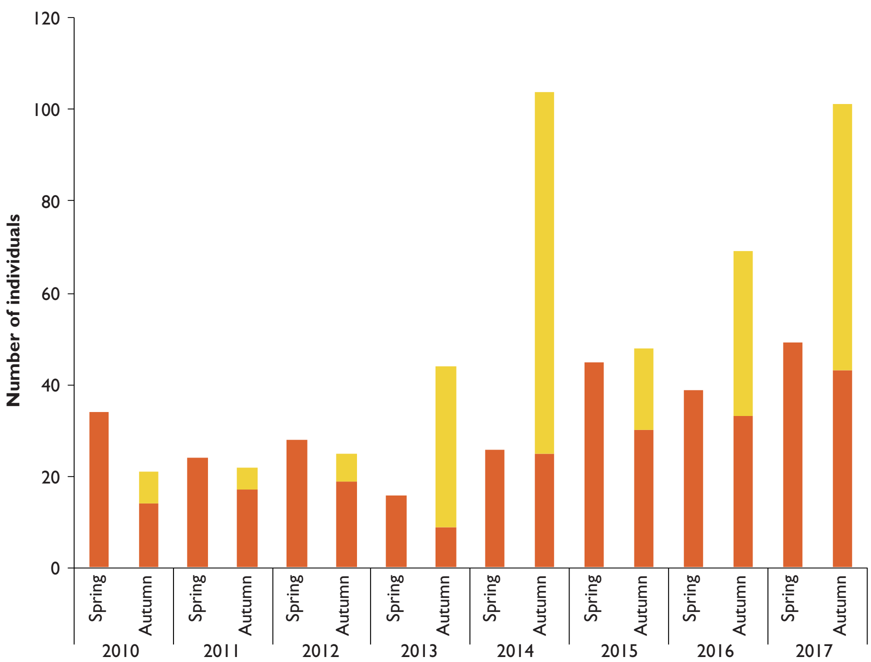


TABLE 1

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

Year		Spring pairs*			Autumn stock**		
		Trust	Estate	Total	Trust	Estate	Total
Grey partridge							
2017 (2016)		23 (19)	1 (3)	24 (22)	101 (69)	2 (3)	103 (72)
Red-legged partridge							
2017 (2016)		44 (38)	18 (24)	62 (62)	138 (76)	35 (74)	173 (150)
Pheasant							
2017 (2016)	Hens	255 (180)	100 (131)	355 (311)	413 (481)	98 (214)	511 (695)
	Cocks	199 (185)	117 (109)	316 (294)			

**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.*

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.

as predation, another. The low brood sizes associated with the replacement clutches, on the other hand, was almost certainly a consequence of the very wet August. On the Estate side, only one spring pair was counted, which failed to produce a brood.

After 2014, 2017 was the second year since the project began when autumn grey partridge numbers were above 100 birds. Given the difficult summer conditions during the past three years, this is a very encouraging result. The Rotherfield grey partridge re-introduction is the first project ever to document recovery of the species from extinction without the need for continuous releasing to sustain numbers.

The red-legged partridges at Rotherfield are neither specifically encouraged nor seen as a problem. Breeding birds are a welcome addition to the local game fauna and an 'add-on' quarry during the shooting season. No red-legged partridges have been released at Rotherfield since the late 1990s and their current breeding numbers are a result of wild breeding stock and immigrated released birds from neighbouring shoots. In 2017, the Trust side saw 14 broods producing 49 young (in 2016 six broods produced 15 young); the Estate side had three broods producing four young (one brood with six young in 2016).

The Rotherfield demonstration project is very much driven by the dedication of the landowners and their farm staff team. The long-term aim is to build a wild game shoot comprising moderate annual bags of grey partridges alongside the main quarry of wild pheasants. To showcase the feasibility of this goal, a wild partridge shoot day was held in October 2017 on the Trust side. The bag of the driven day organised for eight guns was 12 wild grey partridges, 20 wild red-legged partridges, 15 wild pheasants, 10 released wing-tagged cocks and two pigeons. This marked the first grey partridge shoot day since the early 1980s, when the last shot partridge was recorded in the Estate's gamebook (see *Review of 2010*).

Malcolm Brockless taking count of an historic gamebag. © Francis Buner/GWCT

A wild bird keeper legally managing predation during the breeding season is key to any successful grey partridge re-introduction project. © Markus Jenny

There are 240 hectares of high quality habitat to help grey partridge recovery. © Francis Buner/GWCT

Monitoring grey partridges on the Sussex Study

The main study area is made up of a patchwork of fields and partridge habitat. © Jen Brewin/GWCT

BACKGROUND

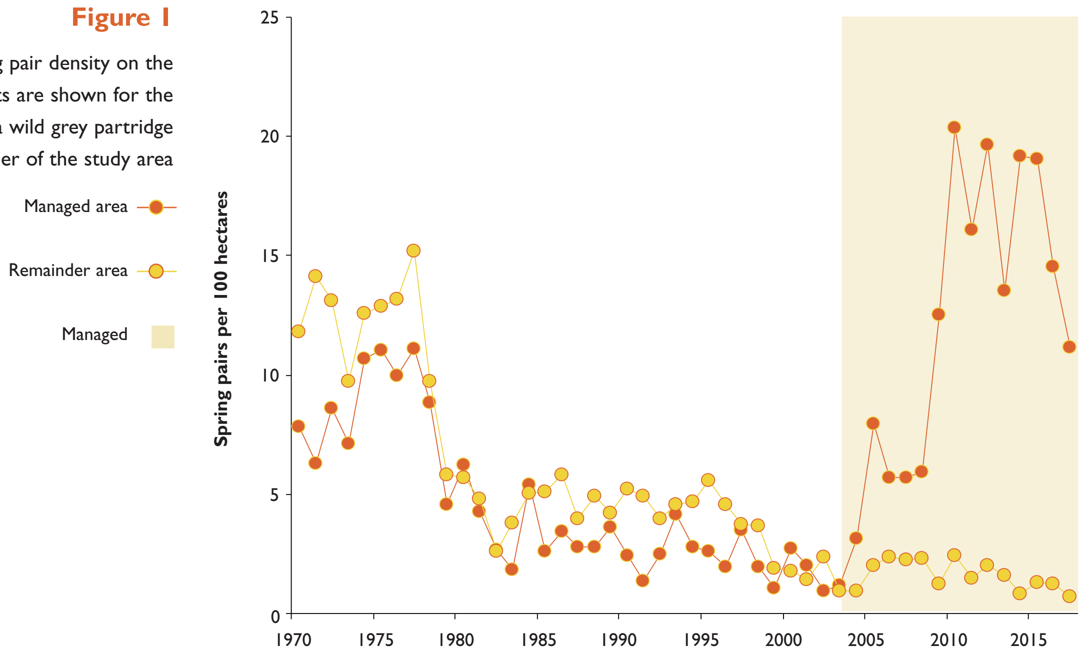
The GWCT's Sussex Study was initiated by Dr Dick Potts in 1968 to explain the decline of grey partridges on the South Downs. Dick monitored not only grey partridge numbers but also their environment, including cropping patterns, food and nesting resources. The monitoring has been ongoing since then and is now in its 49th year.

Between 2017 and 2018, several of the farms on the Sussex study area are modifying their agri-environment agreements, with changes to the configuration of both their chick-rearing habitat (conservation headlands) and over-winter cover (wild bird cover). It seems like an opportune moment to report on changes in grey partridge numbers on the Sussex Study area, before the effects of these changes on grey partridge numbers are felt.

As many of our readers will know, the Norfolk Estate, which covers roughly 1,000 hectares (ha) of the 32 km² of the Sussex Study area, embarked in 2004 on what has been a successful effort to restore a wild grey partridge shoot in southern England. The breeding density of grey partridges on the Norfolk Estate over these 14 years has been significantly higher than that on the remainder of the study area. The spring density on the Norfolk Estate averaged 12.5 pairs per 100ha, with the highest spring density seen in 2010, with slightly over 20 birds per 100ha (see Figure 1). Over the same period the average spring pair density on the remainder of the study area was 1.6 pairs per 100ha, with again the highest density (2.4 pairs per 100ha) seen in 2010. The Norfolk Estate was not the best place for grey partridges before it began its restoration work, with spring densities averaging 4.5 pairs per 100ha there before management, compared with 6.3 pairs per 100ha on the remainder of the study area.

Figure 1

Grey partridge spring pair density on the Sussex Study area. Results are shown for the area now managed as a wild grey partridge shoot and the remainder of the study area



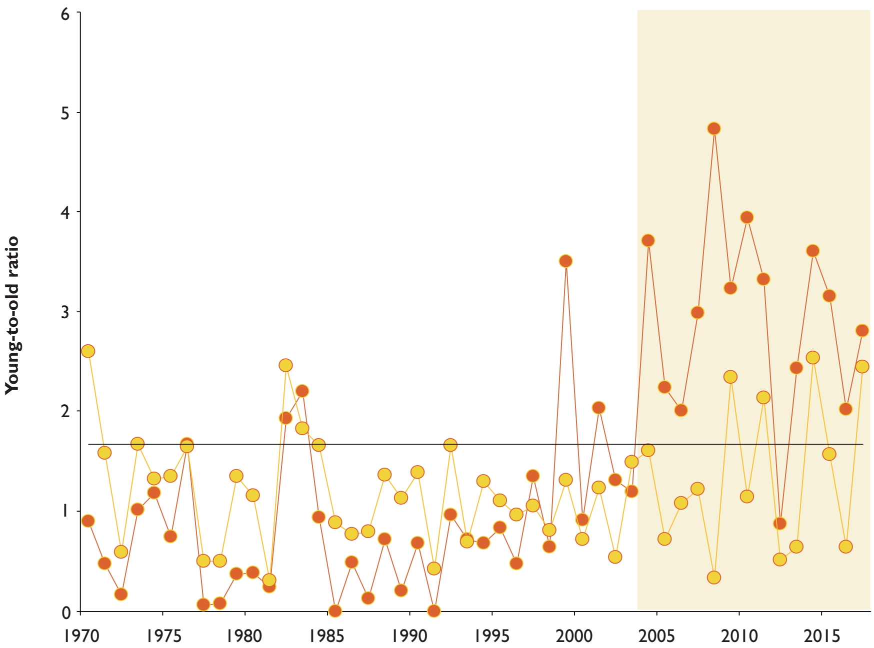


Figure 2

Young-to-old ratio on the Sussex Study area. Results are shown as per Figure 1. Line shows 1.67 young:old ratio needed to maintain numbers

Managed area

Remainder area

Managed

Production of partridges is measured from autumn counts by calculating the number of young birds produced for every adult bird – the young-to-old ratio. Over the past 14 years the Norfolk Estate has recorded an average of 2.9 chicks for every adult bird, significantly higher than the 1.4 chicks per adult bird on the remainder of the study area over the same period (see Figure 2). The highest grey partridge chick production on the Norfolk Estate was in 2008, when each adult bird produced 4.8 young, while on the remainder of the study area there were only 0.3 chicks per old bird. Since wild grey partridge management began on the Norfolk estate, it is only in 2012, when the spring rainfall exceeded any year since 1970, that the young-to-old ratio fell below the 1.67 level needed to maintain numbers. This has not been the case on the remainder of the study area, where the ratio exceeded 1.67 in only four years over the same time scale. Again, the Norfolk Estate historically underperformed relative to the remainder of the study area, with an average young-to-old ratio from 1970 to 2004 of 0.9 chicks per adult, compared with 1.2 on the remainder of the study area.

The provision of nesting cover, chick-food resources, legal predator control and over-winter feeding on the Norfolk Estate has resulted in the successful restoration of a wild grey partridge shoot. These results highlight the success that can be achieved with a concentrated effort to increase numbers of grey partridges. On the other farms across the remainder of the study area, where some components of this management have been applied, numbers of grey partridges have remained stable. We look forward to reporting on how changes in several of their agri-environmental scheme options will affect grey partridge numbers in the future.

KEY FINDINGS

- Since management to recover a wild grey partridge shoot began in 2004 on the Norfolk Estate, the breeding density of grey partridges has averaged 12.5 pairs per 100ha compared with 1.6 pairs per 100ha on the remainder of the study area.
- The production of young grey partridges on the Norfolk Estate, since 2004, averaged 2.9 chicks per adult bird versus 1.4 chicks per adult on the remainder of the study area.
- Changes to agri-environment agreements on several farms across the area over the next year raise the possibility of better provision of both chick-rearing habitat and over-winter cover.

Julie Ewald
Dick Potts
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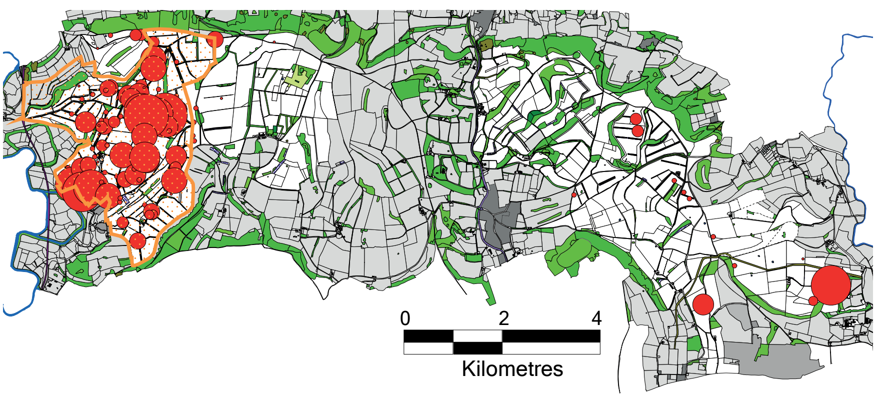


Figure 3

Results of the 2017 autumn grey partridge counts on the Sussex Study. The managed area is highlighted in orange. (The circles reflect the number of young per covey.)

17+
15-16
13-14
11-12
9-10
7-8
5-6
3-4
1-2
0

Interreg North Sea project PARTRIDGE

PARTRIDGE project lead co-ordinator Francis Buner welcoming Belgium's environment minister, Joke Schauvliege, during the Belgian project launch. © PARTRIDGE

PARTRIDGE is a cross-border Interreg project that demonstrates how to reverse the ongoing decline of farmland wildlife using science-based management plans (which include the establishment of 7% high-quality habitat, supplementary winter feeding during the winter hungry gap and legal predator management) and a bottom-up approach implemented by more than 100 local farmers, hunters, volunteer groups, other stakeholders and Government agencies. The local management packages are tailored to the needs of the project's farmland wildlife ambassador, the grey partridge.

The grey partridge is one of the best indicators of farmland ecosystem health; where partridges thrive, biodiversity is high and ecosystem services remain intact. In areas where few or no partridges exist, the farm environment is typically much degraded.

PARTRIDGE's most effective habitat measures are partridge-tailored flower mixes which provide suitable habitat all-year round, together with beetle banks, winter stubbles and arable margins. Each project has developed its own improved and locally adapted PARTRIDGE mixes, based on sharing knowledge. In the UK, the PARTRIDGE mixes have been designed together with Oakbank and Kings Seeds.

Farmland habitat measures supported by agri-environment schemes, which provide vital financial aid to farmers to help them manage their land in ways beneficial to wildlife and the broader ecosystem, are not new. They are a widespread strategy aimed at recovering farmland biodiversity across Europe under Pillar 2 of the Common Agricultural Policy (CAP).

However, despite their huge potential, in practice these schemes have not delivered on a large scale. There are several reasons for this: every member state has designed its own scheme (often without consulting each other's experiences) and most have ended up with schemes that are unable to reverse biodiversity loss, even on a local scale. Current measures are often developed on poor ground, are of insufficient quality and make up less than 2% of the farmed area. A further weakness is the lack of in-depth advice available to farmers and a failure to encourage other local stakeholders to take an active part in management plans.

In England, the Higher Level Stewardship (HLS) scheme, one of the most thought-through schemes available in the EU – which the GWCT helped to shape – has reversed biodiversity loss in many local cases (for example at the Allerton Project at Loddington, the Rotherfield Park Demonstration Project or the Arundel grey partridge recovery project to name just a few). Nevertheless, English farmland wildlife keeps declining on a national level and hence one could argue that even one of the best schemes in Europe has not managed to address the problem successfully.

PARTRIDGE also has the ambition to influence the post-Brexit agri-environment policy and the current CAP talks for the post-2020 period. Target 3a of the current EU Biodiversity Strategy to 2020 aims to: 'increase the contribution of agriculture to maintaining and enhancing biodiversity'. However, hardly a week goes by without reports of the continuing decline of farmland wildlife across Europe. This makes for

BACKGROUND

The GWCT is lead partner of a pioneering cross-border North Sea Region Interreg programme project called PARTRIDGE that will run to 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 (ha) 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 flower blocks are attracting hundreds of finches and other farmland wildlife in their first winter after establishment. © Jannie Timmer

depressing reading, especially considering that the factors responsible for farmland biodiversity loss are well understood: a combination of habitat loss, pesticides and predation.

To highlight the urgency of stopping the continuing loss of farmland wildlife, PARTRIDGE puts great emphasis on communication activities and in-depth advice. The demonstration sites are used to showcase best practise, not only to local farmland stakeholders, but also to local, regional and national decision-makers and agencies, especially those involved in agri-environmental schemes and agri-policy in general.

Early success of PARTRIDGE

Only one year into the project, PARTRIDGE has achieved considerable early successes, in particular an exceptional uptake of high-quality habitat measures on almost all 10 demonstration sites. This has resulted in the creation of habitat improvements that already exceed 7% of the farmed areas at most sites, which significantly exceed levels typical of current agri-environmental schemes across Europe. Across the partner countries new or much-improved PARTRIDGE flower mixes have been introduced and in the Netherlands and Belgium, beetle banks have been established for the first time.

To date, already more than 500 people have visited the PARTRIDGE demonstration sites, among them prominent visitors such as the Danish and Belgian Environment Ministers and the EU Commissioner for Agriculture and Rural Development.

Additionally, cross-border visits for all stakeholders including farmers and landowners are being organised, resulting in a flow of information exchange and enthusiasm among all involved. At most of the project sites PARTRIDGE has already managed to ignite a sense of 'pride' for partridge/wildlife-friendly farming. For more information, please visit www.northsearegion.eu/partridge.

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.

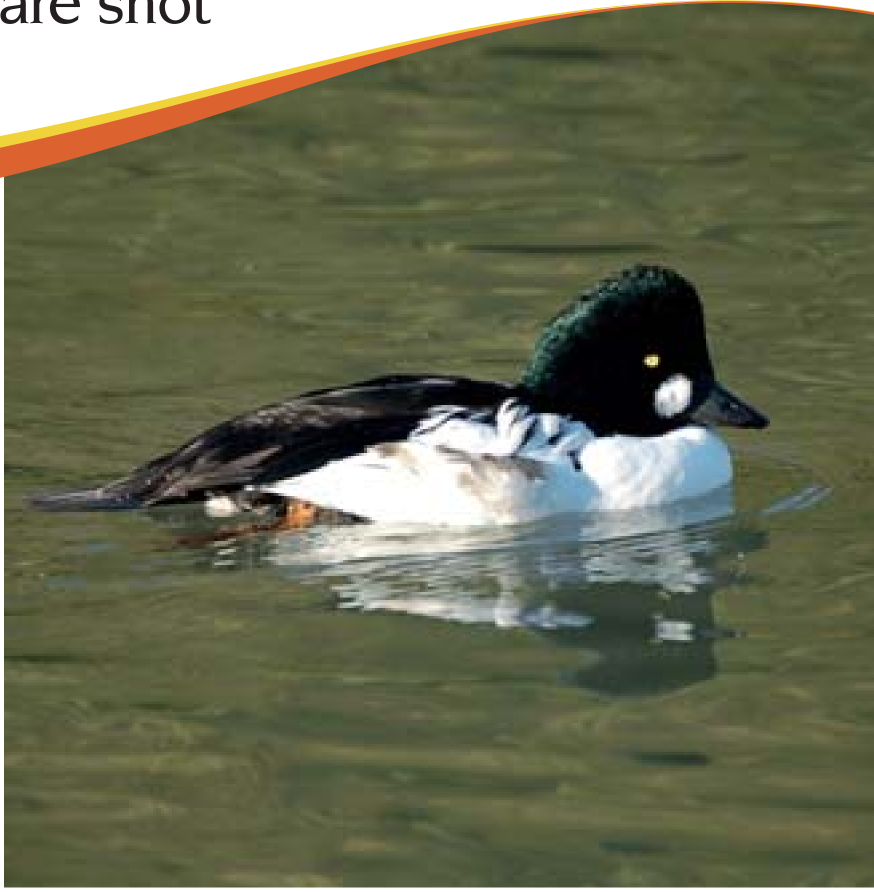
Francis Buner
Paul Stephens
Holly Kembrey

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.

The red-listed grey partridge is the key ambassador of PARTRIDGE. © Carlos Sánchez/GWCT

How many birds are shot in the UK?



Bird species with bags below 500 in 2012 are black grouse, ptarmigan, pochard, goldeneye (right), white-fronted goose and jack snipe (the latter legal quarry in Northern Ireland only).
© Peter Thompson/GWCT

BACKGROUND

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

KEY FINDINGS

- NGC data can be used to split up PACEC aggregate total bags to species.
- UK bags are highest for released pheasant (13-15 million) and red-legged partridge (2.5-4.4 million), but also for woodpigeon (1.1-3.6 million).
- UK bags are lowest for black grouse, ptarmigan, pochard, goldeneye, white-fronted goose and jack snipe (the latter is legal quarry in Northern Ireland only).

Nicholas Aebischer

The GWCT is often asked how many birds are shot annually in the UK. In itself, the National Gamebag Census (NGC) does not enable us to answer that question because, although we have over 800 participating shoots who return bags each year, we do not know what proportion this represents of the total number of shoots in the UK. This means that, even if we add up all the NGC records in a particular year for a particular species, we are unable to scale the total up to estimate the total UK bag.

The calibration that this requires would need to be based on a large-scale national survey that attempts to cover all shoots – a major and costly undertaking that is beyond our resources. An assessment of UK bags has, however, been part of two comprehensive surveys of the shooting industry done by the Public & Corporate Economic Consultants (PACEC): its report *The Value of Shooting* was published in 2014 (**www.shootingfacts.co.uk**), and follows on from *The Economic and Environmental Impact of Sporting Shooting,* published in 2006. These assessments were based on surveys of the 2012 and 2004 shooting seasons respectively. They cover gamebirds, wildfowl and avian pest species. The reports specify that the bags are of animals shot by unpaid shooting participants, so not as part of a job. The implication is that they will be underestimates for some pest species.

The difficulty is that, apart from a few species, the PACEC reports aggregate bags across groups of species. For example, all duck species are grouped together, so the reports tell us that 970,000 ducks were shot in 2004 and one million in 2012, but the number of, say, wigeon remains unknown. This is where the NGC comes to the rescue. Because NGC records are species-specific, they can be used to calculate the relative proportion of each species within a group and split up the aggregate PACEC group estimate accordingly, thereby deriving species-specific bag totals. By using the variation between returns in the NGC, and the stated accuracy of the PACEC estimates (±10%), it is also possible to generate 95% confidence intervals for the derived totals. Differences between the PACEC reports mean that numbers of partridges and pheasants released were available for 2004 but not for 2012. For these, 2012 totals were estimated by multiplying the 2004 values by the change calculated from NGC data between 2004 and 2012.

The estimated totals are presented in Table 1. At 13-15 million birds shot, the UK pheasant bag outstrips those of all other species because of the extent of releasing (35-43 million). Despite a 23% increase in numbers of released pheasants between

2004 and 2012, the pheasant bag seems to have dropped slightly, suggesting that return rates on releases have declined. Notable changes between 2004 and 2012 are increases in bags of red-legged partridge (76%) and red grouse (75%), the former in response to a 41% increase in estimated number of released birds. By contrast, the bag of grey partridge has fallen by two-thirds. Woodpigeon is another quarry species whose bag size exceeds one million, although the number shot has declined by two-thirds between 2004 and 2012. The mallard bag is close to a million, again sustained by releasing (although PACEC provides no data on number released). Many of the wildfowl species show a reduction in bags between 2004 and 2012, probably reflecting the tendency towards fewer cold winters pushing birds towards Britain, as well as a genuine population decline in some species such as pochard. More generally, species with bags below 500 in 2012 are black grouse, ptarmigan, pochard, goldeneye, white-fronted goose and jack snipe (the latter legal quarry in Northern Ireland only).

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.

TABLE 1

Estimated bags of gamebirds, wildfowl, waders, woodpigeons and corvids in the UK based on splitting the PACEC totals for 2004/05 and 2012/13 according to the frequencies in the NGC returns

	2004/05 season		2012/13 season	
Species	**Bag**	**95% Confidence interval**	**Bag**	**95% Confidence interval**
Pheasant	15,000,000	13,000,000-17,000,000	13,000,000	11,700,000-14,300,000
Pheasant released	35,000,000	31,000,000-39,000,000	43,000,000	38,000,000-47,000,000
Red-leg partridge	2,500,000	2,300,000-2,800,000	4,400,000	3,900,000-4,800,000
Red-leg partridge released	6,300,000	5,700,000-7,000,000	8,900,000	7,800,000-10,000,000
Grey partridge	77,000	40,000-120,000	27,000	14,000-44,000
Grey partridge released	180,000	97,000-290,000	170,000	80,000-270,000
Red grouse	400,000	360,000-440,000	700,000	630,000-770,000
Black grouse	70	30-140	75	30-150
Ptarmigan	260	50-710	110	20-260
Mallard	790,000	700,000-880,000	880,000	770,000-980,000
Teal	110,000	77,000-150,000	76,000	47,000-120,000
Wigeon	46,000	23,000-79,000	34,000	12,000-66,000
Tufted duck	5,500	3,600-8,300	4,600	2,500-7,800
Pochard	2,400	1,000-4,400	180	40-410
Goldeneye	680	150-1,500	200	60-420
Pintail	1,400	140-3,600	800	240-1,700
Shoveler	1,300	700-2,000	1,400	500-2,800
Gadwall	8,800	4,300-15,000	4,700	2,200-8,100
Canada goose	15,000	8,200-26,000	36,000	16,000-69,000
Greylag goose	28,000	16,000-37,000	66,000	29,000-90,000
Pink-footed goose	3,600	1,100-7,600	9,000	2,300-23,000
White-fronted goose	<100	0-100	<100	0-100
Woodcock	180,000	150,000-220,000	160,000	140,000-180,000
Common snipe	64,000	38,000-94,000	100,000	93,000-120,000
Jack snipe	<100	0-100	<100	0-100
Golden plover	1,300	100-3,400	5,100	600-13,000
Woodpigeon	3,600,000	3,200,000-4,000,000	1,100,000	990,000-1,200,000
Carrion crow	100,000	83,000-120,000	84,000	69,000-100,000
Hooded crow	13,000	7,000-21,000	9,300	6,200-14,000
Magpie	50,000	40,000-61,000	42,000	34,000-51,000
Rook	130,000	100,000-160,000	76,000	60,000-94,000
Jackdaw	75,000	56,000-95,000	75,000	59,000-93,000
Jay	10,000	7,500-14,000	13,000	10,000-17,000

Uplands monitoring in 2017

Spring densities of red grouse in 2017 were 10% higher in England and 12% higher in Scotland than 2016. We carry out the counts using pointer dogs. © *Dave Baines/GWCT*

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 cocks at their 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.

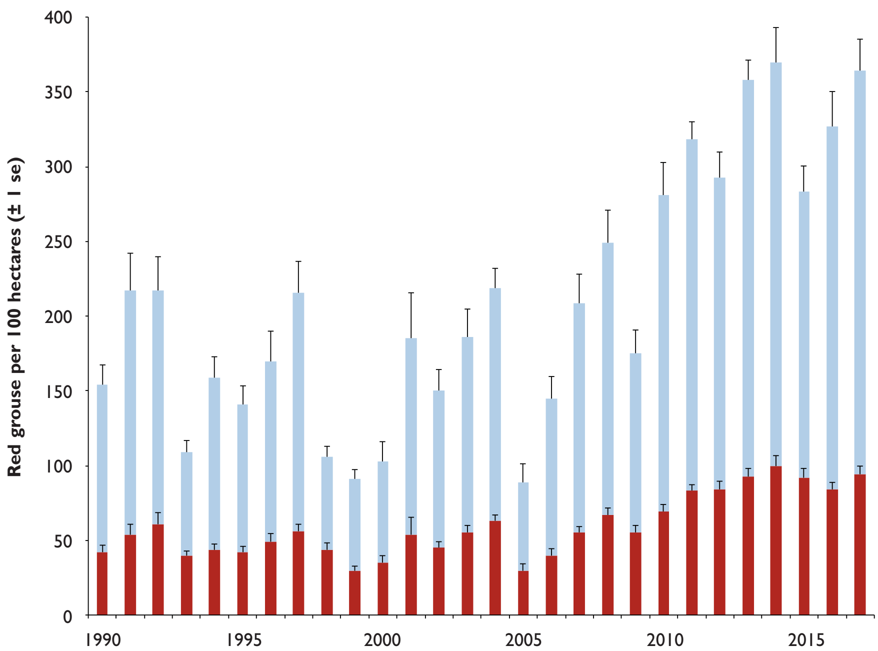
One of the main annual long-term monitoring undertakings by the upland research group are the red grouse counts; pre-breeding in the spring and post-breeding in July when numbers of adults and young are recorded. The red grouse counts first started in 1980 in northern England and 1985 in Scotland. Figure 1 represents eight to 25 core counts continuously counted in England and Figure 2 represents eight to 25 sites in Scotland since 1990. The counts typically estimate grouse abundance using pointer dogs on 100 hectare (ha) blocks of predominantly heather-dominated moorland. Counts of strongyle worms, usually from shot grouse, are conducted on the same core moors in August or September. Historically a sample of 10 adults and 10 juvenile birds were collected. Since 2010 due to low worm burdens, samples are collected from 20 adults only.

Grouse counts

England: In 2017, spring densities were almost 10% higher than in spring 2016, with 120 birds per 100ha (110 in 2016). Breeding success was the same as 2016 with an average 2.9 chicks per adult, giving a post-breeding density in July of 364 birds per 100ha for the 25 counts which make up this data set (327 July density in 2016) (see Figure 1).

Figure 1

Average density of young and adult red grouse in July from 8-25 moors in northern England 1990-2017



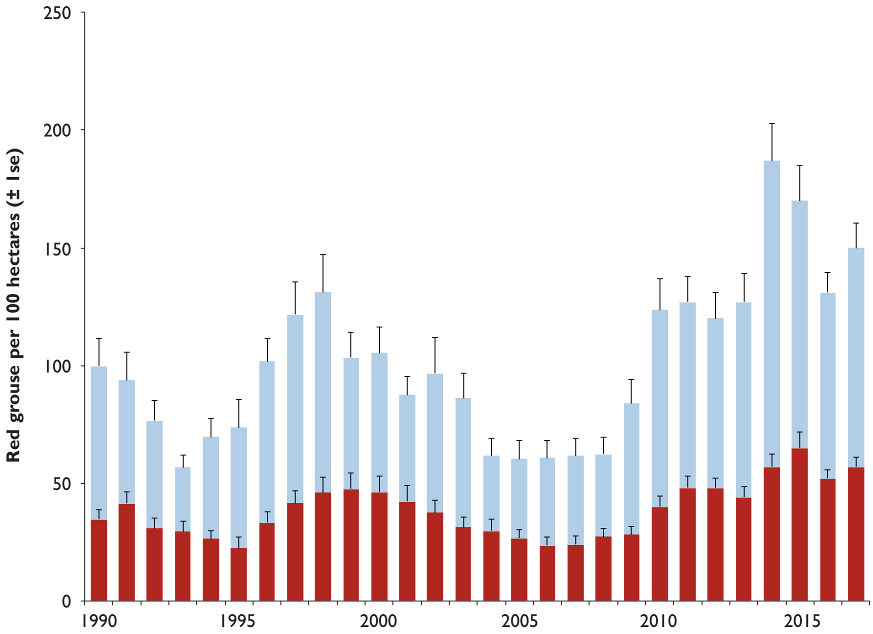


Figure 2

Average density of young and adult red grouse in July from 8-25 Scottish moors 1990-2017

Young grouse

Adult grouse

Scotland: Spring densities in 2017 averaged 78 birds per 100ha, a 12% increase from 2016 (69 in 2016). Breeding success was similar in 2016 and 2017 at about one and a half chicks per adult. Post-breeding densities averaged 150 birds per 100ha in 2017, a 13% increase from 2016 (131 in 2016) (see Figure 2).

In spring 2017 a new member of staff joined the upland research group (Nick Hesford), based in southern Scotland. As well as undertaking Scottish core red grouse counts, new counts were established in southern Scotland, seven counts were undertaken in spring 2017 with a red grouse density ranging from nine to 137 birds per 100ha. In July a further three counts were undertaken, giving a total of 10 new counts with a range of one to 445 birds per 100ha.

Strongyle worms

All samples have been collected, but processing of those samples is ongoing. To-date, samples have been analysed from 12 core moors in England and 10 core moors in Scotland. Numbers of worms in both England and Scotland are still low on all core moors using medicated grit (see Figure 3 English moors, Figure 4 Scottish moors). The average number of worms per adult grouse has been in the low hundreds on

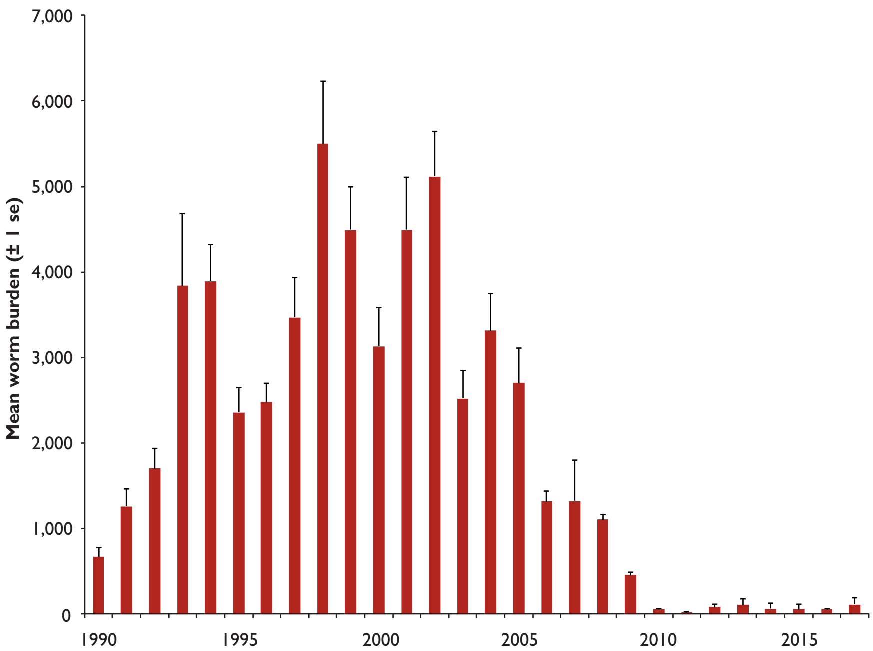
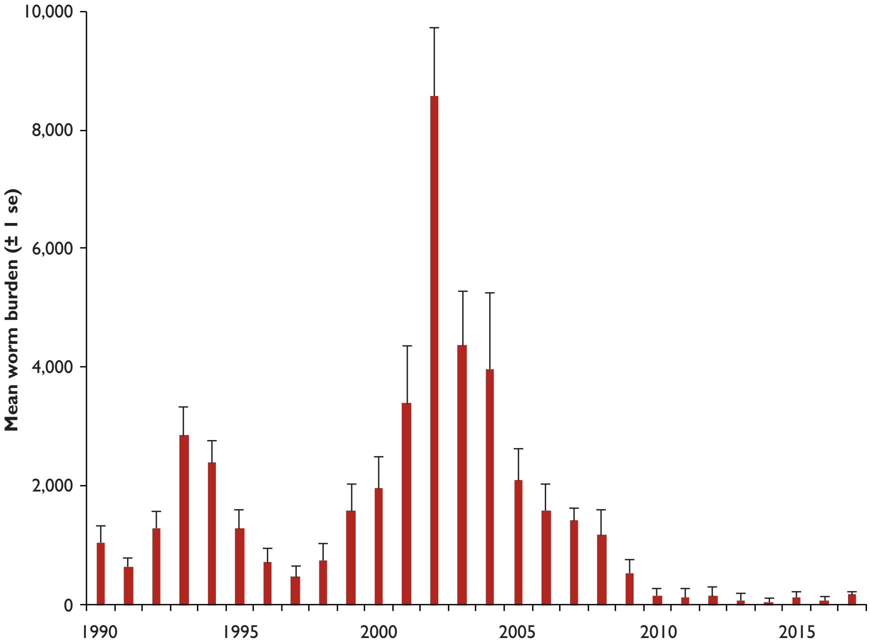


Figure 3

Average annual worm burden for autumn shot adult red grouse from 8-18 moors in northern England 1990-2017

Figure 4

Average annual worm burden for autumn shot adult red grouse from 3-17 moors in Scotland 1990-2017



KEY FINDINGS

- Red grouse numbers remain high and parasite levels low where medicated grit is used.
- Black grouse bred poorly in northern England, but capercaillie had a better year with sufficient chicks reared to offset the expected mortality of full-grown birds.

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

moors in England and Scotland since 2010. Last year, 28% of English moor and 16% of Scottish samples from adult grouse contained no worms.

Black grouse

In spring 2017, we sampled the numbers of males attending leks in northern England which in the last national survey in 2014 supported 67% (958 males) of the English black grouse population of 1,437 males. We counted 938 males at 138 leks, with overall numbers down 2% on the 2014 survey results.

Across our survey areas in northern England we found, in total, 46 hens, seven of which had broods, with 13 chicks, giving an overall average of 0.3 chicks per hen. Breeding productivity in 2017 was the second poorest since surveys commenced in 1989 (see Figure 5) and was attributed to the wet weather in June when chicks hatched, with June the sixth wettest since records commenced in 1910.

Capercaillie

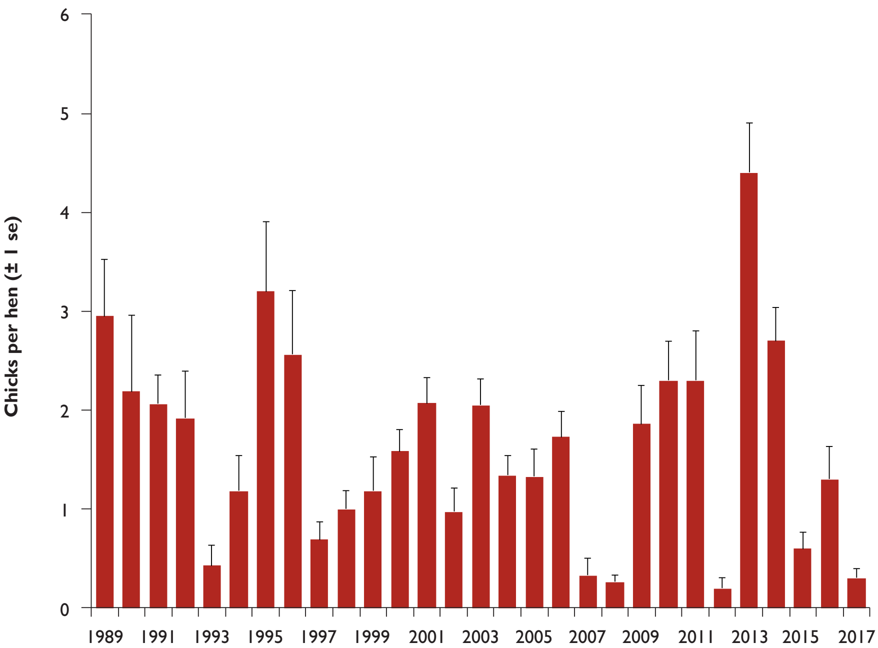
Counts of adults and broods were conducted in four forests in Strathspey, which now

Figure 5

Black grouse breeding success in northern England between 1989 and 2017

Black grouse productivity was poor and attributed to the wet weather in June when chicks hatched.

© Dave Kjaer



supports an estimated 83% of Scotland's remaining population. Across these sites, breeding success was higher than in the previous two years with an average 0.9 chicks per hen (see Figure 6), with 40% of hens found with a brood. To gain more information on the causes of mortality, breeding failure and habitat use we have tagged six females which we hope to continue monitoring in subsequent breeding seasons.

Capercaillie breeding success was higher in 2017 with an average 0.9 chicks per hen. We have now tagged six females and will monitor them in subsequent breeding seasons. © Dave Kjaer

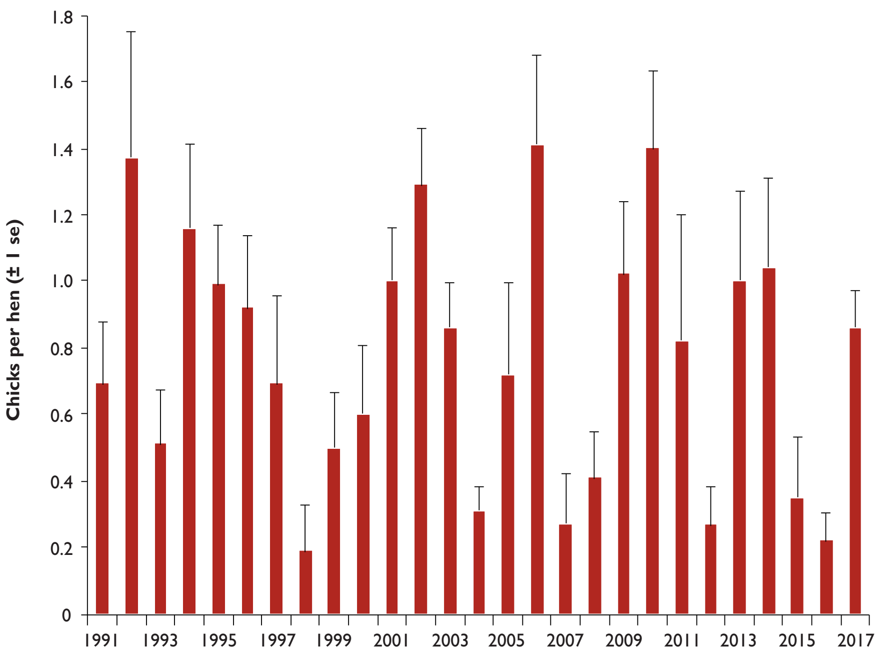


Figure 6

Capercaillie breeding success between 1991 and 2017 sampled from up to 20 forests per year in the Scottish Highlands. Capercaillie breeding success was derived from a different subset of forest areas each year before 2003, data for 2003 to 2009 are directly comparable, then since 2010 the number of forest areas surveyed has been reduced to between two and four per year, with the same four forests monitored since 2014

Respiratory cryptosporidiosis in red grouse

© Laurie Campbell

Cryptosporidiosis was first diagnosed in red grouse in 2010.

Infection by *Cryptosporidium baileyi,* a parasitic protozoan, causes respiratory cryptosporidiosis in red grouse. This is recognisable in the field and when handling grouse by swollen eye tissues, pale wattles, mucous nasal exudation, coughing and wheezing. It was first diagnosed in 2010, yet only three years later it had been detected across half of moors managed for grouse shooting in northern England, including 80% of driven moors in the North Pennines, the region where it was first diagnosed. Infection is most prevalent in young birds.

A radio-tracking study conducted by the GWCT showed that infected birds survived only half as long as healthy birds on the same moor. Those that survived long enough to breed, bred about a week later and reared only about half as many chicks as their healthy counterparts. The key period underpinning this difference in breeding success was when rearing chicks, when it was thought that a combination of poor mothering of young chicks by infected females and increased infection among chicks beyond three weeks old resulted in lower chick survival.

Despite significant impacts on grouse survival and productivity, the overall impact on autumn population size and hence potential and actual shooting bags has been low. This is due to the current low prevalence of infection among grouse, which averages 4% of birds. Should prevalence of this newly-emerging disease markedly increase, however, it has the future capacity to negatively affect grouse bags. We will carefully monitor disease levels through screening shot birds in game larders.

Understanding underlying causes of disease emergence and routes of infection transmission are fundamental to its subsequent control. To this end, we have been investigating whether contaminated grouse faeces within communal grit trays provided to grouse by grouse moor managers to help combat parasitic worms and associated grouse population crashes, may unwittingly form reservoirs of infection. We tested this by examining the contents of 23 grit trays from a grouse moor for *Cryptosporidium* reproductive stages or oocysts. Thirteen of the trays were known to be visited by

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 most prevalent in young birds. Understanding underlying causes of disease emergence and routes of infection transmission are fundamental to its subsequent control.

our radio-tagged infected grouse, while a further 10 randomly selected trays formed a background sample where we did not know whether or not they had been visited by infected grouse. Tray contents were subjected to oocyst concentration techniques prior to examination by microscopy, anti-body tests and finally genetic analysis to determine the *Cryptosporidium* species present. Seven of 13 (54%) grit trays known to be used by infected grouse were positive for *Cryptosporidium* by one method, compared with two of 10 (20%) random background trays. Using a more sensitive analytical method, 10 of the 13 (77%) trays used by infected birds amplified positive for *Cryptosporidium* and only three of the 10 (30%) random trays. All amplified products sequenced matched with *C. baileyi,* the commonest form infecting birds, apart from *C. parvum*, typically found in mammals, also being present in one grit tray.

These data suggest that communal grit trays used to 'worm' grouse and their immediate surroundings may act as reservoirs of *Cryptosporidium* infection. This, however, is far from proven and we have not considered other sources of infection on the moor such as communal drinking pools. It may, however, be prudent to attempt to improve tray hygiene by regularly cleaning trays of unused grit and faeces and moving their locations to avoid oocyst build-up. In future, revisions of tray design or size may need to be considered that minimise the opportunity for grouse to defecate within the tray and hence the risk of contamination. Realising the importance of sensible and sustained use of medicated grit, we will be looking to work with grouse moor mangers on improving tray design and identifying other potential reservoirs of infection.

KEY FINDINGS

- Respiratory cryptosporidiosis was associated with a halving of adult grouse survival and a halving of breeding success.
- The impact on breeding success occurred during brood rearing.
- Despite these impacts, the effect on pre-shooting autumn population size was generally slight due to a low disease prevalence averaging only 4%.
- Grit trays may be a reservoir of infection and care should be taken to improve hygiene.

Dave Baines
David Newborn
Mike Richardson

ACKNOWLEDGEMENTS

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

Hygiene can be improved by regularly cleaning trays of unused grit and faeces and moving their locations to avoid oocyst build-up.
© Henrietta Appleton/GWCT

Grey partridges on hill farms in north-east England

Grey partridges on hill farms preferred rough grazing habitats with rushes that provided cover. ©Tom Hornby/GWCT

BACKGROUND

In the uplands of northern England, grey partridges are found on hill farms. Little is known about their habitat requirements that may help inform future conservation management.

In north-east England, grey partridges are found on hill farms on the edges of heather moorland. Here, unimproved semi-natural grasslands dominate, which have been created by low-intensity traditional livestock farming and comprise a mix of grasses and herbaceous plants, along with sedges and rushes. Large tracts of these grassland habitats remain, with many now protected by statutory designations or managed through agri-environment schemes. This contrasts to the lowlands, where 97% of semi-natural grasslands were lost between 1930 and 1984 through agricultural improvement. Grey partridge numbers here appear stable, but little is known regarding their habitat requirements that may help inform future conservation management. In this study, we described habitat use, nest-site characteristics, chick diet and productivity on hill farms.

Between 2010 and 2012, 72 partridges (36 cocks and 36 hens) were caught and radio-tagged. During the breeding season, we checked birds weekly to investigate habitat use, find nests and monitor outcomes. After hatching, we collected droppings from night time roosts to investigate chick diet.

Home ranges of pairs during the breeding season (January to August) averaged 16 hectares (ha) (range three to 64ha) and they contained more rough grazing habitats than expected by chance. We located 29 nests, of which 69% were in rough grazings, 13% in rush pastures, 10% in roadside verges and 7% in meadows. Half of the nests were in rushes, which provided taller cover than the surrounding vegetation. Clutch size averaged 12 eggs (range six to 17) and hatched on average on 15 June (31 May to 23 June). Nest survival varied from 0.79 in 2010 to 0.37 in 2012. Of the failed nests, four were deserted and 11 predated (one by a corvid, eight by mammals, two unknown). In the first four weeks after hatching, brood home ranges averaged 2.5ha (range 0.3-11ha) and contained disproportionally large amounts of rough grazings. Breeding success varied between years from 3.8 chicks per pair in 2010 to none reared to fledging in 2012.

The diet of chicks varied with habitat and chick age. Young chicks (less than one week old) in rough grazing habitats ate mainly sawfly larvae (46%) and ants (34%). Older chicks in these habitats ate sawfly larvae (27%) and ants (23%), but also beetles (21%), parasitic wasps (6%) and other insects (sawfly adults, craneflies) (14%). This was different in enclosed fields (rush pasture, sparse rush pasture and meadow), where the

Grey partridges can be found on upland hill farms. © Dave Kjaer

main prey of young chicks were parasitic wasps (24%) and sawfly larvae (15%), with beetles (49%) the main prey of older chicks.

Grey partridge nesting habitats and the importance of sawfly larvae in chick diet were similar to those of black grouse, which share these rough grazing habitats in the uplands of northern England. Chick survival is a key driver of population change in grey partridges, so increasing the availability of sawfly larvae may help mitigate against the negative effect that poor weather can have. More knowledge of how to manage grass and rush swards to increase numbers of sawfly larvae is needed to help chick survival for both grey partridges and black grouse in these upland grasslands. To conserve grey partridges on these hill farms, it is important that rough grazings are retained and grazing regimes practised to provide suitable habitat for sawfly larvae to thrive.

KEY FINDINGS

- On hill farms, grey partridges preferred rough grazing habitats. Sixty-nine per cent of nests were found in rough grazing pastures with females preferring to nest in tall rushes that provided cover.
- Chick diet differed between habitats and in relation to brood age. In rough grazings, sawfly larvae were the most numerous item eaten by young (46%) and older broods (27%).
- It is important that rush-infested rough grazings are retained and grazing regimes that provide abundant sawfly larvae are practised.

Philip Warren
Tom Hornby
David Baines

A grey partridge nest hidden in rushes. © Tom Hornby/GWCT

Impact of ticks on red grouse breeding success

There were lower tick burdens on grouse at sites that treated their sheep with frequent applications of acaricide. © Dave Kjaer

KEY FINDINGS

- More frequent acaricide treatments of sheep were linked to lower tick burdens on grouse, even at higher deer densities.
- Sites with lower deer densities had greater grouse breeding success.
- Sites with higher mountain hare abundance indices were also those with higher grouse breeding success, which suggests that hares and grouse are both benefiting from grouse moor management, but does not provide evidence that hare culls are necessary to reduce ticks.

Kathy Fletcher
David Baines

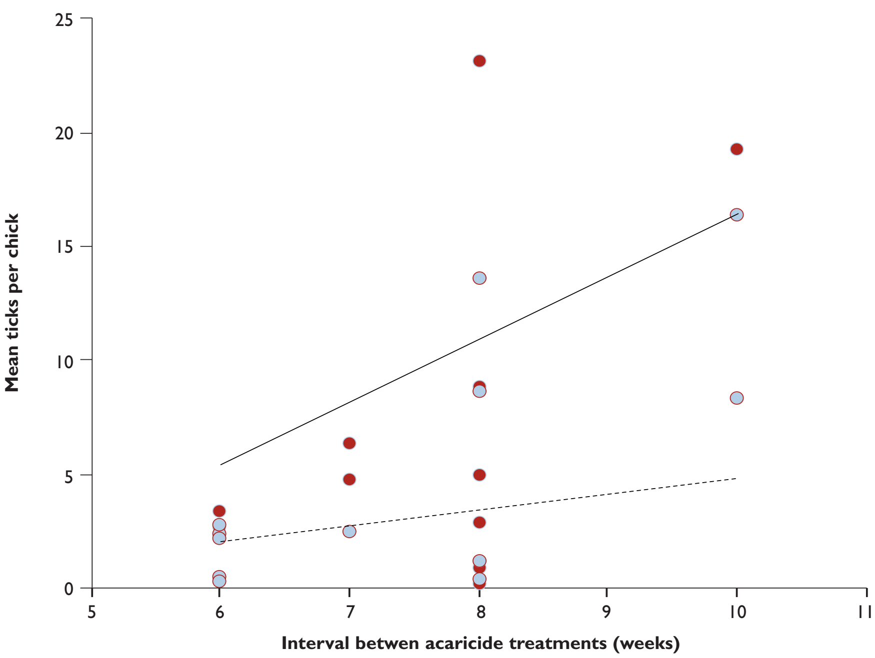
Sheep ticks and the Louping ill virus they carry are known to have a serious effect on grouse chick survival and are increasing in many parts of the Scottish Highlands. Our research in northern England has shown that regular treatment of sheep with acaricides can reduce tick numbers on grouse chicks, the prevalence of Louping Ill virus and improve shooting bags. In many parts of Scotland, tick management is complicated by the additional presence of red deer and mountain hares, and the effectiveness of using sheep as 'tick mops' is less certain.

The best way to assess the effect of alternative hosts on the efficacy of sheep tick mops would be through replicated field experiments. In the absence of such trials, we adopted a correlative approach. By comparing management levels (sheep density, sheep acaricide treatment frequency, mountain hare and deer abundance indices) with tick burdens on grouse chicks and grouse productivity on the same areas, we sought to determine if there was a level of these alternative tick hosts which rendered the

Figure 1

Relationship between tick burden and the interval between sheep treatments

(dash line = sites with low deer levels, solid line = sites with high deer levels)



ACKNOWLEDGEMENTS

We would like to thank all the owners and keepers who granted access to their moor for this study and provided financial contributions.

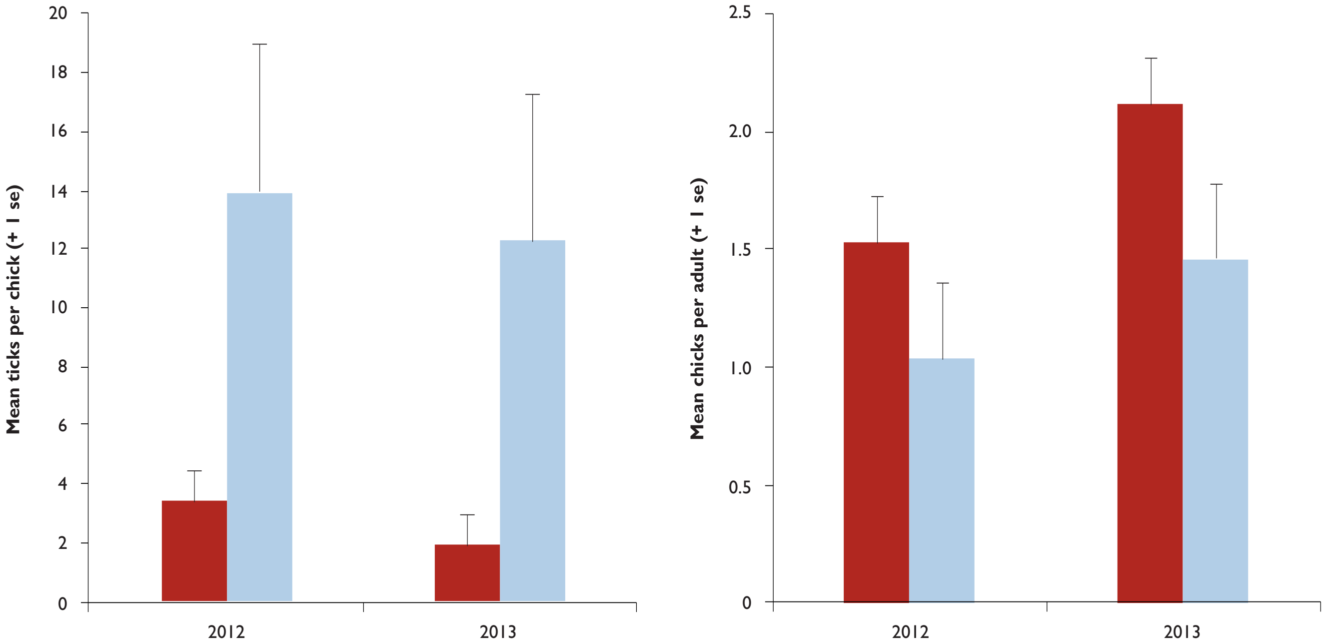


Figure 2

Tick burdens on young grouse chicks and productivity at fledging

Sites with low deer levels

Sites with high deer levels

sheep tick mops ineffective. The preliminary analyses of these data were presented in the *Review of 2013*, but the work has now been through the peer review process so we felt it would be useful to report the full findings.

We monitored 12 sites over two years where sheep management was being undertaken to reduce ticks, but with a range of hare and deer densities. Estate staff provided estimates of sheep numbers on the moor (range eight to 71 sheep per 100 hectares) and the interval between successive acaricide treatments (range six to 10 weeks). The density of deer recorded during counts in late-winter was used as a proxy for deer density during the summer, with sites grouped into those with low deer density (< 6 deer per km²) and those with high deer density (≥ 6 deer per km²). An abundance index for mountain hares was calculated as the number of hares seen during our grouse counts in July (range 0 to 3.6 hares per kilometre). We caught 10 or more grouse broods per site when chicks were approximately five to 25 days old to assess tick burdens per chick (range 0.3 to 23.2 ticks per chicks). Our July counts with dogs allowed us to measure grouse productivity (brood size, proportion of hens with broods and chicks per adult).

As expected from previous studies, there was an inverse relationship between average grouse productivity (brood size and chicks per adult) and chick tick burdens per site, but no correlation between the proportion of hens with broods and chick tick burdens.

From a management perspective, we found that sites with more frequent applications of acaricide on sheep had lower tick burdens on grouse chicks. Those sites applying acaricide at six week intervals had fewer ticks on grouse chicks (1.7 ± 1.0 SE) than those treating at 10 week intervals (14.6 ± 0.9 SE). This relationship was similar on sites with a range of deer densities (see Figure 1). This suggests that even when deer levels are ≥ 6 deer per km² regular acaricide treatment will reduce tick burdens on grouse, although no direct effect of acaricide treatment frequency was detected on grouse productivity. There was also no correlation detected between the density of treated sheep and the grouse tick burdens or breeding success. Sites with higher deer densities (> 6 deer per km²) had 368% higher grouse tick burdens and 33% lower productivity than sites with lower deer densities (see Figure 2).

Sites with higher grouse brood sizes and proportion of hens with broods were also those with higher mountain hare abundance indices, suggesting that both species are benefiting from the grouse moor management regimes. Our study did not find that hare abundance was lower on sites with lower tick burdens or higher grouse breeding success. Further experimental studies may be needed to demonstrate whether a hare cull would further reduce tick levels when used in conjunction with well-treated sheep and low deer levels.

BACKGROUND

Ticks are increasing in many parts of the UK, and tick activity overlaps with the chick-rearing periods of upland breeding birds. Adult ticks require a bloodmeal from a mammal host, but larva and nymph stages can feed on a wide range of hosts including red grouse chicks.

Hen harrier diet on Langholm Moor

Seventy six percent of the food provided was taken from feeding posts. © Laurie Campbell

BACKGROUND

The long-standing conflict between red grouse shooting and the conservation of raptors, particularly hen harriers, is well documented. Hen harriers are perceived as a risk to shooting interests as they can limit grouse at low densities and reduce shooting bags to the extent that driven shooting becomes economically unviable. Consequently, hen harriers are killed illegally, which limits their abundance and distribution and has contributed to their virtual disappearance as a breeding bird in England and on many grouse moors in Scotland.

KEY FINDINGS

- Diversionary food constituted almost half of hen harrier nestling diet, while grouse chicks formed only 0-4%, representing 0-6% of the annual grouse chick production.
- The number of grouse chicks delivered annually to harrier nests was 34-100% lower than predicted under unfed conditions.
- However, the combination of diversionary feeding and other management actions failed to provide sufficient grouse recovery to sustain economically viable driven shooting.

Sonja Ludwig
Dave Baines

Diversionary feeding of hen harrier broods has been suggested as a mitigation technique to reduce the impact of harrier predation on grouse. When tested experimentally, it reduced the number of grouse chicks provisioned to harrier broods by 64-94%, although no beneficial effect on post-breeding grouse density or productivity was found. However, only half of the broods were fed.

During the Langholm Moor Demonstration Project, diversionary feeding of harriers was introduced in 2008 simultaneously with the restoration of grouse moor management, ie. predator and grouse parasite control and heather habitat recovery, to test whether sustainable driven grouse shooting could be restored in the presence of harriers. Between 2008 and 2015, we provided day-old poultry chicks and rats to all 25 harrier broods for up to 60 days after hatching, and studied the diet of 15 broods using observations from hides, nest cameras and analysis of prey remains in regurgitated pellets. We considered the uptake of diversionary food by harriers, and compared the number of grouse chicks taken to that expected to be taken under unfed conditions.

The uptake of diversionary feeding by harriers was good; it took on average four days until the food was accepted and 76% of the food provided was taken from the feeding posts. Scavenging by other species, largely ravens, was infrequent and almost entirely after fledging. We identified a total of 2,318 prey items delivered to harrier broods (370 from hides, 1,392 from nest camera footage and 556 from pellets). Depending on the assessment method, diversionary food formed on average 44-53% of nestling diet (see Figure 1), 39-55% were natural prey (including 24-45% passerines, 4-15% small mammals, 0-4% grouse chicks) and 0-9% unknown items. The amount of diversionary food consumed was not influenced by the abundance of natural prey (ie. passerines, voles or grouse), harrier brood size, or whether the male tended to more

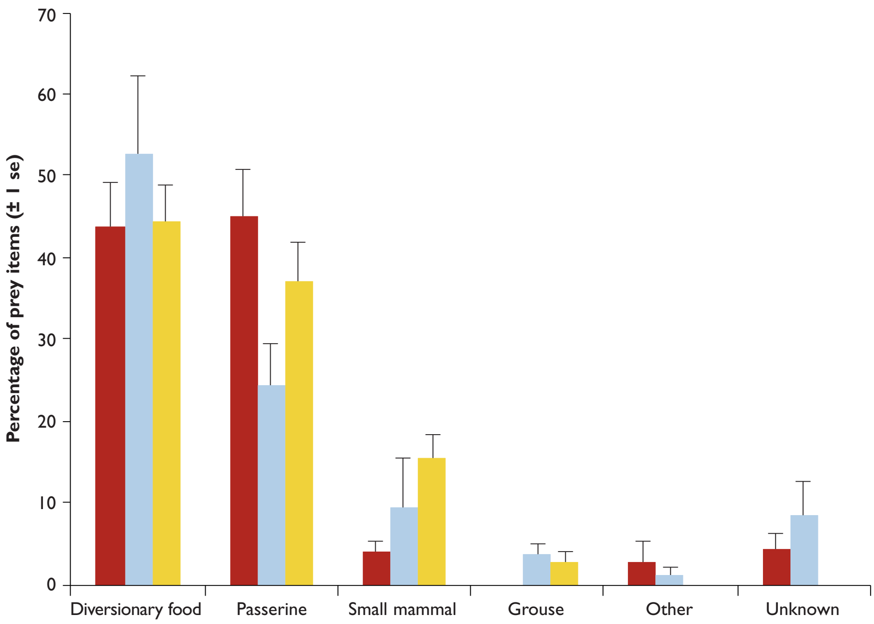


Figure 1

Mean proportion of prey items identified during hide watches (n=7 nests), nest cameras (n=8 nests) or in regurgitated pellets (n=10 nests)

Hide watch

Nest camera

Pellets

than one brood. The number of grouse chicks delivered annually to harrier broods represented 0-6% of the annual grouse chick production, and was 34-100% lower than expected from modelled predictions under unfed conditions.

However, the combination of diversionary feeding and other management actions did not provide a sufficient increase in grouse density to support economically viable driven shooting. Hence, diversionary feeding can be considered only partially successful. At Langholm, the recovery of grouse may have been constrained by multiple interacting factors, including other predators, the effect of inclement weather, especially on chicks, or insufficient progress with habitat recovery. Diversionary feeding of harriers may still help to restore or maintain driven shooting on other moors. However, stakeholders may be resistant to adopting this technique without better evidence that it can be an integrated component of grouse moor management that helps lead to sustained harvesting.

ACKNOWLEDGEMENTS

This study was part of the Langholm Moor Demonstration Project, a partnership between the Game & Wildlife Conservation Trust, Scottish Natural Heritage, Buccleuch Estates, RSPB and Natural England.

We studied the diet of 15 broods using observations from hides, nest cameras and analysis of prey remains in regurgitated pellets. © Laurie Campbell

Foraging bats and agri-environment schemes

Anna Forbes setting up an acoustic detectors microphone. © Niamh McHugh/GWCT

BACKGROUND

Bat populations declined significantly in Britain during the 20th century owing to a combination of factors including the loss of roost and feeding sites. Bats' roosts in Britain are protected under legislation, but foraging sites are unprotected making them susceptible to land use changes. In the UK, nine of our native bat species, including the lesser horseshoe and common pipistrelle, are known to navigate and forage using habitat edges such as field boundaries. It is therefore likely that their foraging activities are influenced by field margin management. A greater understanding of this relationship will allow the development of appropriate agri-environment scheme (AES) management options for these species.

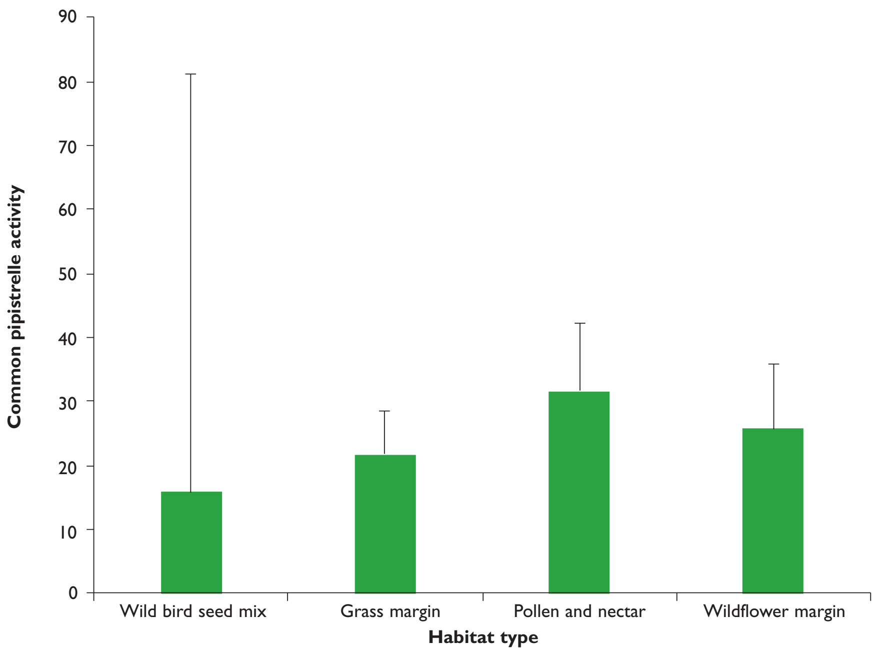
All 18 species of bat found in Britain feed on insects such as midges, beetles and moths and half of these species will routinely focus their foraging efforts along field edges. Therefore, agri-environment scheme (AES) habitats which support an abundance of insects and are planted along field edges, may present favourable foraging opportunities for these species.

Our project aims to investigate AES field boundary use by foraging bats on arable farmland in Hampshire and Dorset, through repeated acoustic surveys on a network of farms. Over the course of the project we hope to answer the following questions: Does bat activity vary between AES field boundary types? Does the use of AES field boundary types vary between bat species? Does general bat activity or foraging activity vary seasonally with flowering times of AES habitats?

Acoustic detectors were used to record echolocating bats as they navigated and foraged along field boundaries. Detectors were programmed to start recording when triggered by a high frequency call (8-192 kHz) and ended when no further trigger

Figure 1

Mean (±SE) common pipistrelle activity along boundaries with different types of habitat. Means (± SE) are back transformed following analysis



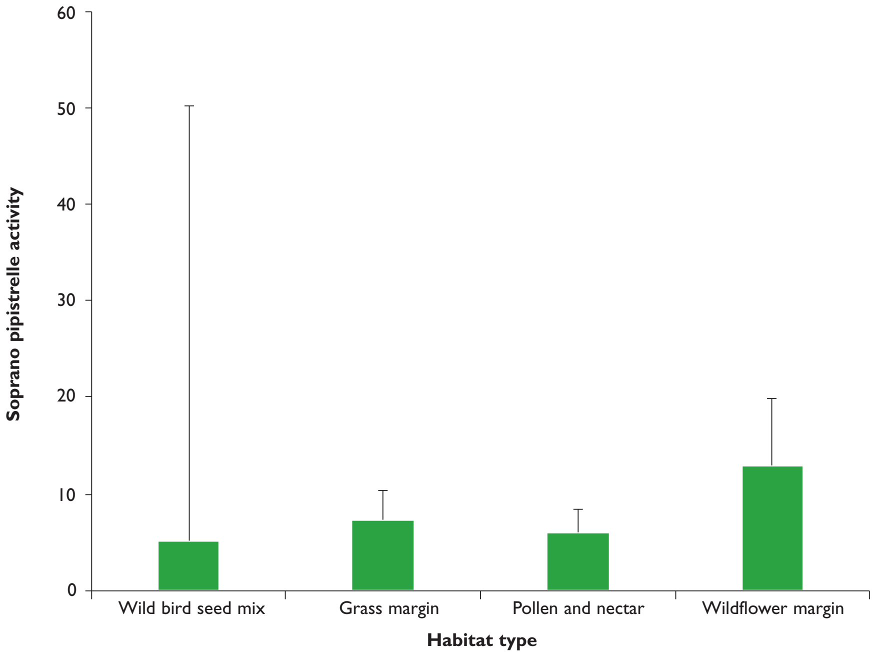


Figure 2

Mean (±SE) soprano pipistrelle activity along boundaries with different types of habitat. Means (± SE) are back transformed following analysis

was detected for 2.0 seconds. Recordings were then viewed as sonograms to allow different species of bat to be distinguished based on the frequencies and shape of their calls. Recorded calls give an indication of bat activity, which was defined as the sum of the individual bat recordings per night for each species.

In 2017, 432 nights of data collection took place on 15 farms which implemented at least three of the following AES habitat prescriptions: a) grass buffer strips (present on 14 farms), b) wildflower margins (eight farms), c) wild bird seed mixture plots (15 farms) and d) pollen and nectar plots (11 farms). We measured bat activity over all AES habitats on the same farm at the same time to allow robust comparisons of AES habitats to be made. Acoustic sampling took place at each location on three occasions between mid-April and early-September and detectors were set to record for three consecutive nights during each deployment. More than 10,000 bat recordings were collected during acoustic surveys, including several nationally uncommon species such as barbastelles, Nathusius' pipistrelles, lesser horseshoe and greater horseshoe bats.

A preliminary analysis has been conducted on our second survey recordings collected between mid-June and late-July, examining habitat use by our three species of pipistrelle bat (common, soprano and Nathusius' pipistrelles – 4,548 recordings). Common pipistrelle activity was predicted to be 98% higher along field boundaries that included a pollen and nectar plot than along ones sown with a wild bird seed mixture (see Figure 1). Similarly, soprano pipistrelle activity was predicted to be 153% higher where wildflower margins were present when compared with field boundaries sown with a wild bird seed mixture (see Figure 2). Previous studies have found that in agricultural areas general bat activity is highly correlated with foraging activity. This suggests that the recorded patterns of common and soprano pipistrelle activity along these habitats, which are designed to support invertebrates, may reflect the foraging patterns of these species, rather than movement associated with commuting. Nathusius' pipistrelles, however, showed an aversion to grass margins when compared with wild bird seed mixture plots and activity was six to 10 times lower along this habitat when compared with our other AES options under investigation. Grass margins are deployed to protect watercourses and hedgerows from agrochemicals, and their invertebrate community is known to be relatively impoverished when compared with alternative floristically and structurally diverse AES habitats.

These results provide an initial insight into bat movements on farmland and suggest that providing a diverse selection of foraging habitats within the landscape under future AES may benefit edge foraging bat species. The full dataset will be analysed in 2018 and from this guidelines on managing arable farmland for bats will be produced. For more information visit **www.agribats.com** or for regular project updates follow us on twitter **@agribats**.

KEY FINDINGS

- The activity of common and soprano pipistrelles increased along field boundaries that included an invertebrate-rich AES habitat.
- Nathusius' pipistrelle's activity was six to 10 times lower along grass margins than along wildflower margins, wild bird seed mixture and pollen and nectar plots.
- Providing AES habitats within the farmed landscape can benefit a range of foraging bat species.

Niamh McHugh
Belinda Bown
John Holland

ACKNOWLEDGEMENTS

We are grateful to the landowners who allowed us access to their land to conduct fieldwork and to Emily Brown, Anna Forbes, Jade Hemsley, Sophie Potter and Chris Wyver for their assistance in data collection. This work is supported by the Heritage Lottery Fund, Natural England, the Hamamelis Trust, the Chapman Charitable Trust, the Wixamtree Trust and the Worshipful Company of Mercers.

AgriBats
Learning about bats on arable farmland in Hampshire & Dorset

Insect sampling on the Sandringham Estate

In 2016 we collected insects from conservation headlands. © John Holland/GWCT

KEY FINDINGS

- Only beans had sufficient levels of grey partridge chick-food insects.
- Levels of chick-food insects in cereal crops were too low to support high levels of grey partridge chick survival.
- Newly-created conservation headlands showed promise, but failed to reach target levels of chick-food insect density.

John Holland
Steve Moreby
Roger Draycott

In 2015 and 2016 we sampled a range of crops across Sandringham Estate including cereals, peas and beans, some of which are grown organically, as well as some of the non-crop habitats and conservation headlands. In 2015 the aim was to investigate chick-food levels across a range of crops, whereas in 2016 we focused on the conservation headlands.

To assess whether sufficient insect food was available we calculated the grey partridge chick-food index (GP CFI) derived from the Sussex Study, which is based on the abundance of five groups of insects important to chick survival. A value of 0.7 or higher implies sufficient chick-food to yield a chick survival rate high enough to maintain or increase breeding stock.

In late June/early July 2015 there were significant differences in the grey partridge chick-food index between the crops/habitats (see Figure 1). The critical 0.7 level was reached in conventionally farmed and exceeded in the organic spring beans. The index in the non-crop habitats and organic spring barley was better than in the other conventionally farmed crops. The values for the conservation headlands, although higher than the standard headland, were still quite low, but this was not unexpected because the conservation headlands were only initiated in 2015, so we may not expect to see the full benefits for several years as the weed flora recovers.

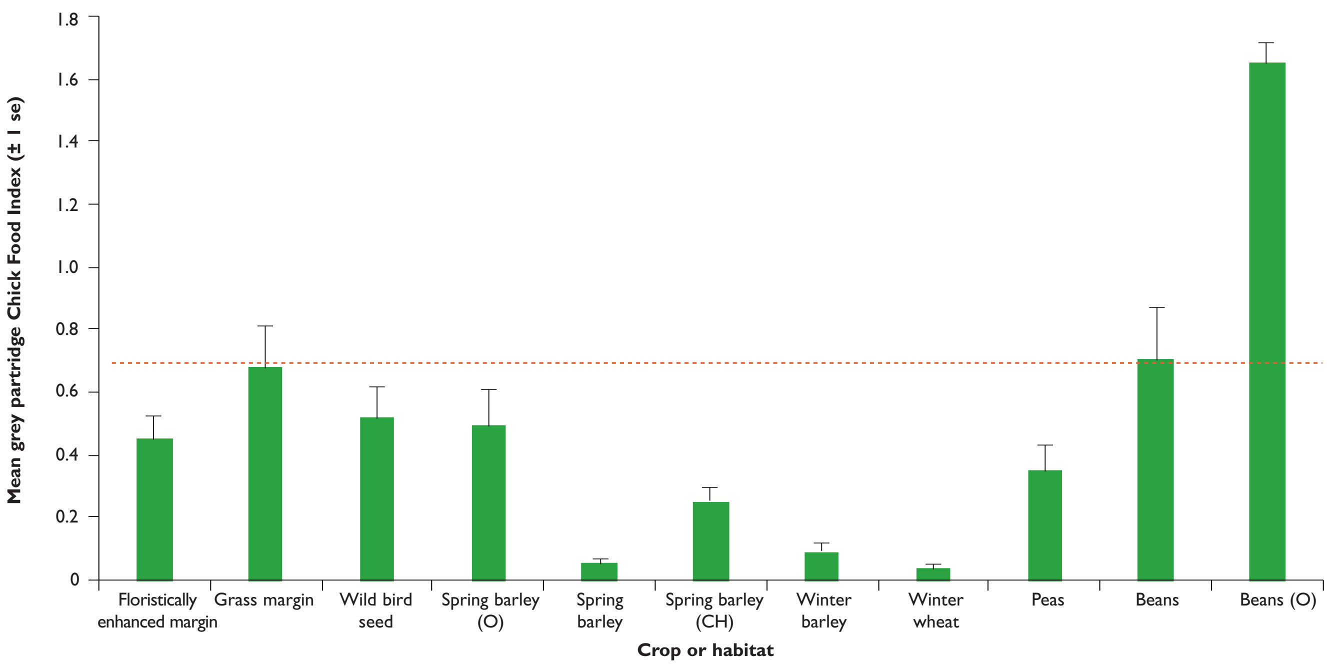
In 2016, the focus of the sampling was to evaluate the conservation headlands, so we also measured the abundance of weeds in them and compared these to the mid-field areas. All the conventionally managed (non-organic) cereal fields had much higher numbers of weed species (six to eight) as well as a higher percentage of

Figure 1

The average level of the grey partridge chick-food index in each crop/habitat in June/July 2015

Sufficient chick food - - -

(O= organic; CH = Conservation Headland; line is target level; values are raw means)



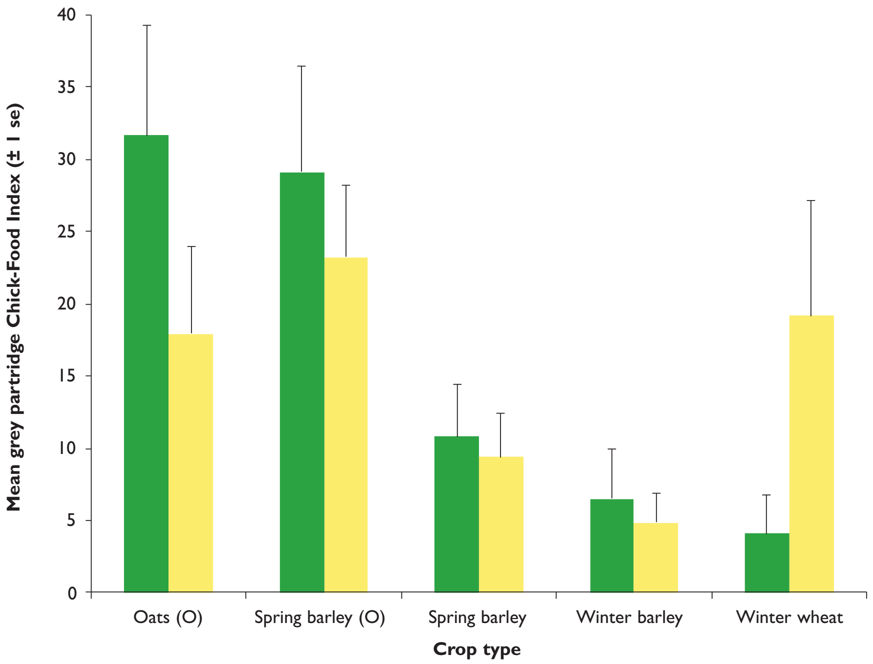


Figure 2

The average level of the grey partridge Chick-Food Index in the crop headlands and mid-field locations in each type of cereal in 2016

(O= organic; conservation headlands were present in the conventional crops; values are raw means)

Crop headland

Mid-field

ground cover in their headlands (up to 9%) compared with the mid-field sites, where there was usually only one species and the cover was less than 1%. At two of the sites which had been in conservation headlands for two years, weed cover was up to 16% and 17%, indicating that the weed flora is recovering quite rapidly. The organic oats and spring barley had on average three to six weed species, with levels of cover similar to the conservation headlands.

The GP CFI was highest in the headland area of the organic oats, but all the 2016 crops had less than the critical 0.7 level (see Figure 2). In conventional barley crops the GP CFI in the conservation headlands was only slightly higher than the mid-field locations. The reverse occurred in winter wheat, owing to the presence of larvae of *Oulema melanopa*, the cereal leaf beetle, which is a crop pest. Samples were also taken from the wildflower strips, which had a mean GP CFI of 0.25, and from the grass strips, which had a GP CFI of 0.54.

Overall, it appeared that the GP CFI levels were insufficient in most crops, but Sandringham is no different to what we find elsewhere across the country. Conservation headlands are one way of encouraging chick-food insects, providing there are still sufficient appropriate weeds left in the seedbank. If there are few arable plants to support the insects, then spreading mustard in May just before rain can help. Wild bird seed mixes can also provide high levels of chick-food; second-year kale especially is good and has the advantage of providing shelter from bad weather and avian predators.

BACKGROUND

The Sandringham Estate is home to some of the highest densities of wild grey partridges remaining in Britain today. Unfortunately, despite high nesting success, the chick survival rate is below what might be expected for a landscape that is so hospitable for partridges. Indeed, failure to produce sufficient young to replace adults has historically been the key factor in driving down the national population of grey partridges. To determine if a lack of chick-food insects was responsible for low chick survival at Sandringham, we started a programme of insect sampling in 2015 using our Dvac vacuum insect collectors and the same methodology we use in our long-term study area in Sussex and at the Allerton Project, Loddington.

ACKNOWLEDGEMENTS

We wish to thank the Sandringham Estate for supporting the project and Belinda Bown, Matthew Brown, Jasmine Clarke, Sophie Potter, Sarah Richardson and David Stevenson who helped with the sampling and invertebrate identification.

Dvac insect samples. © John Holland/GWCT

Allerton Project: game and songbirds

Brood-rearing cover is now sown in the autumn owing to the heavy soils to ensure provision of chick-friendly cover in time for hatching. © Kings

A small-scale, reared pheasant shoot is now well-established releasing 2,500 pheasant poults providing nine 100-150-bird driven days, three species days and two gundog trials each year. Habitat management continues, both in woodland, and through our Countryside Stewardship agreement on farmland. We are rejuvenating historic stewardship areas as many have been in place since the beginning of the project in the 1990s. Maize has been removed and the shoot's cover crops now comprise brassica and cereal mixes which are managed in rotation. Spring establishment of brood-rearing cover has been replaced with autumn-sowing owing to the heavy soils to ensure provision of chick-friendly cover in time for hatching. A total of 104 feed hoppers provide food for gamebirds throughout the winter and well into the spring, with a further 17 feeders provided for songbirds as part of our Stewardship agreement. Our part-time gamekeeper, Matthew Coupe, controls nest predators including foxes, corvids and small ground predators, especially during the breeding season when our previous research indicates some songbird species and gamebirds are most likely to benefit.

Our annual counts of wild gamebirds, hares and songbirds continue enabling us to document changes in their numbers in response to the changes in management. Since the re-establishment of the shoot in 2011, songbird numbers have increased gradually so that they are now 92% above the 1992 baseline, with Biodiversity Action Plan (BAP) species increasing by 56% over the same period. Of the BAP species, woodland birds such as song thrush and spotted flycatcher have increased whereas skylarks and yellow-hammers associated with farmland have not. The maximum increase in overall songbird numbers of 121% above the baseline was in 2001, following eight years of intensive management of wild gamebirds, but the latest results demonstrate that a reared pheasant shoot with some effective seasonal predator control can increase songbird numbers substantially above levels present in the absence of such management.

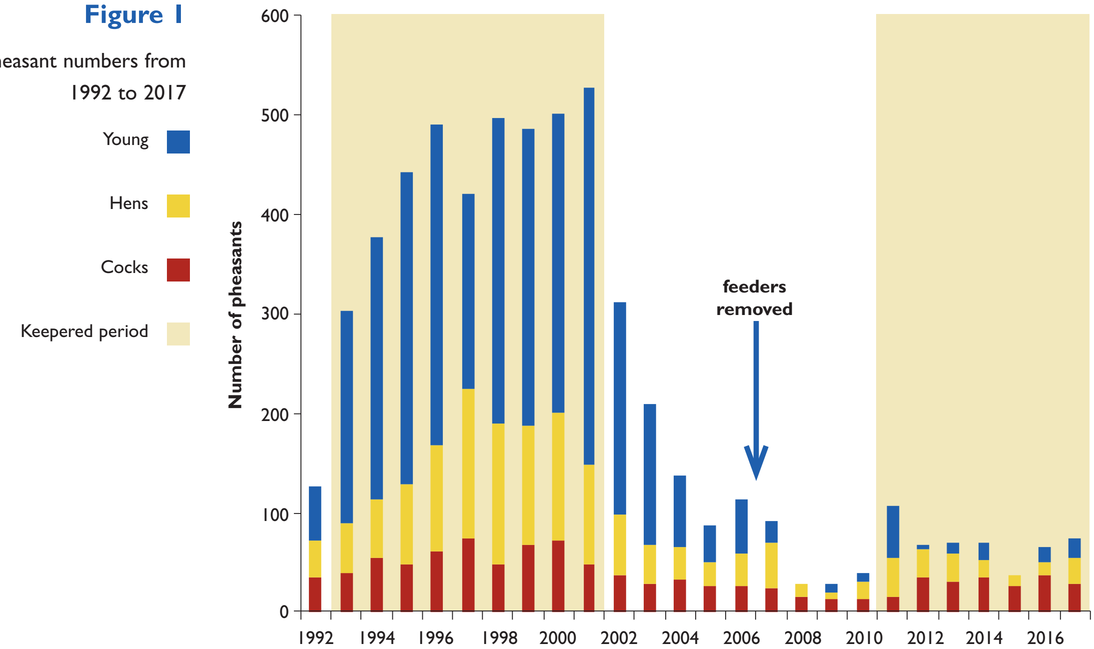
Hare numbers have also increased substantially and are now nine times higher than both the 1992 baseline, and the number present at our comparison monitoring

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.

Figure 1

Autumn wild pheasant numbers from 1992 to 2017



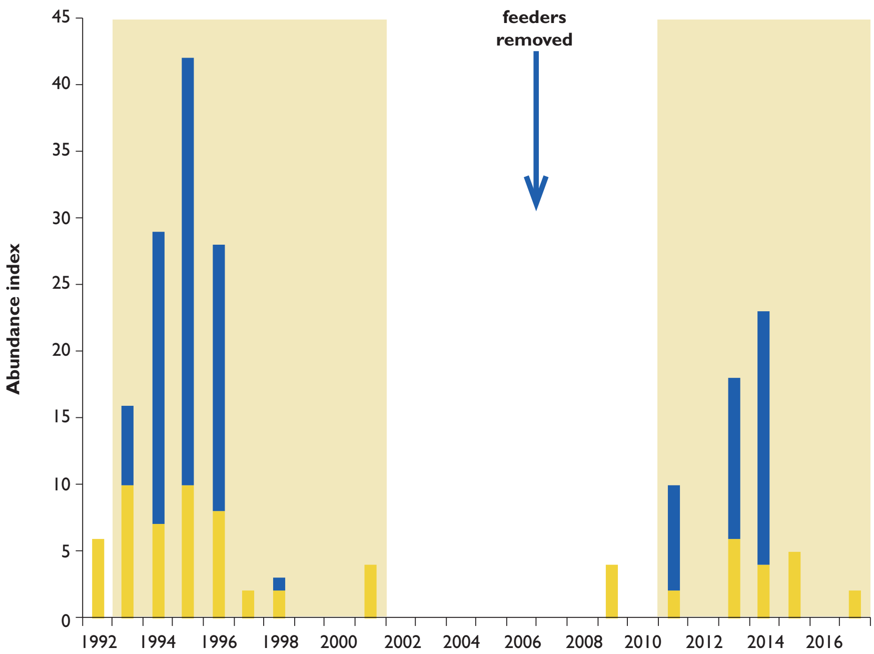


Figure 2

Autumn grey partridges

Young

Adults

Keepered period

site nearby. Wild gamebird numbers have not responded in the same way. Autumn pheasant numbers are lower than in 1992, with very low breeding success. Only 20 young birds were counted, compared with a maximum of 379 in the autumn of 2001. We are planning a radio-tracking study of hen pheasants in the late winter and spring period to investigate this issue. In particular, we need to assess to what extent the failure to breed can be attributed to the health of hen pheasants in this period, or to predation of hens on nests. The abundance of some predators has changed nationally since our original investigation at the Allerton Project in the 1990s so we are keen to see the results.

Grey partridges have shown signs of improved breeding success in recent years, with successful breeding in 2011, 2013 and 2014. Although adults have been observed each subsequent spring, none has nested successfully. The findings of the pheasant radio-tracking study may also have implications for our grey partridge management. In addition, we are now a study site for the EU Interreg-funded project, 'PARTRIDGE' (see page 40). Similar measures for grey partridge conservation are being implemented across all the European study sites, providing an opportunity to share knowledge to improve grey partridge numbers and other wildlife associated with their habitats.

KEY FINDINGS

- Songbird numbers are almost double the baseline while hare numbers are also increasing.
- Wild gamebirds are not responding to our management.

Chris Stoate
John Szczur
Austin Weldon

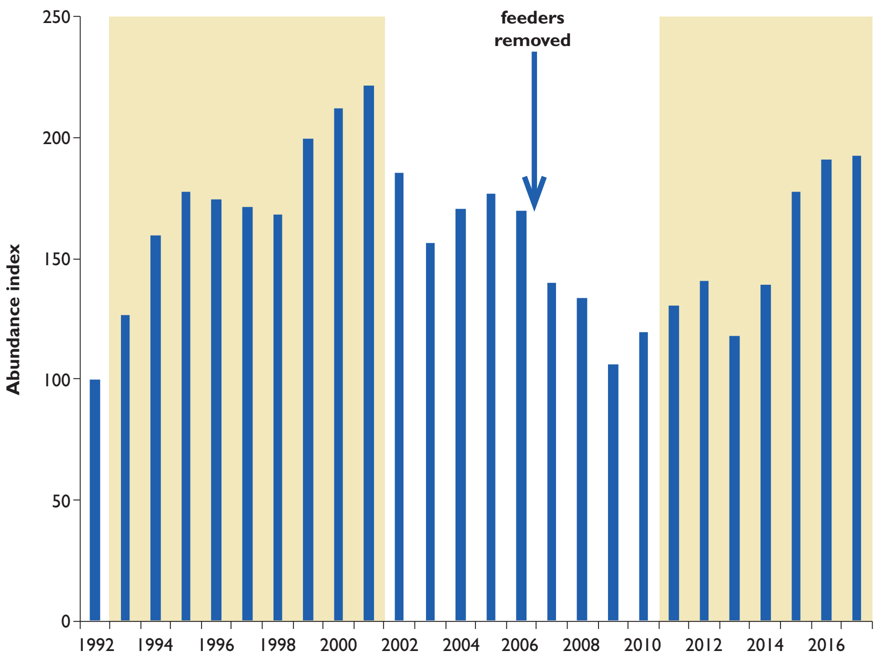


Figure 3

Songbird abundance

Keepered period

Yellowhammer. © Peter Thompson/GWCT

The farming year at the Allerton Project

Changes to landscape management will be on the horizon as a result of a new UK Agriculture Bill. © Syngenta UK

The pressure on UK farmers continues to build as the ramifications of a post-Brexit UK Agriculture Bill grows ever closer. The current thoughts from the Government are a move towards a more balanced model of food production, a focus on soil health, a watchdog to oversee the protection of the environment and a more targeted environmental support for farmers. These share some common ground with agro-ecological principles: the maintenance of a productive agriculture that sustains yields and optimises the use of local resources while minimising the negative environmental and socio-economic effects.

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.

TABLE 1

Arable gross margins (£/hectare) at the Allerton Project 2010-2017

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

No single/basic farm payment included

** winter beans, **spring oats*

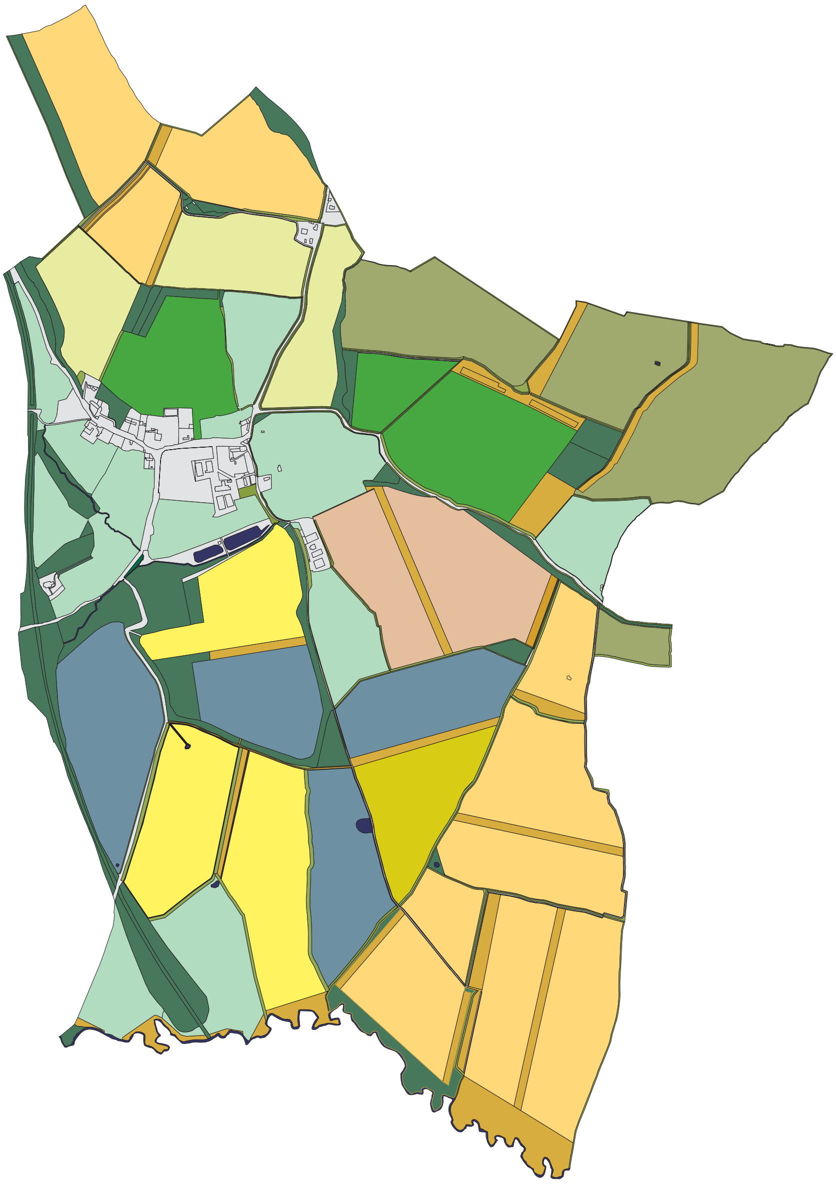


Figure 1

Allerton Project cropping 2016/17

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

KEY FINDINGS

- A new focus on soil health.
- Arable farming still has economic challenges ahead.
- An agroecological approach should evolve to combine smarter regulation and a coherent food policy.

Alastair Leake
Phil Jarvis

Soil health is high on the agenda.
© Felicity Crotty/GWCT

Our soil protection and enhancement start with the measures we can implement in the field such as cover crops. © Felicity Crotty/GWCT

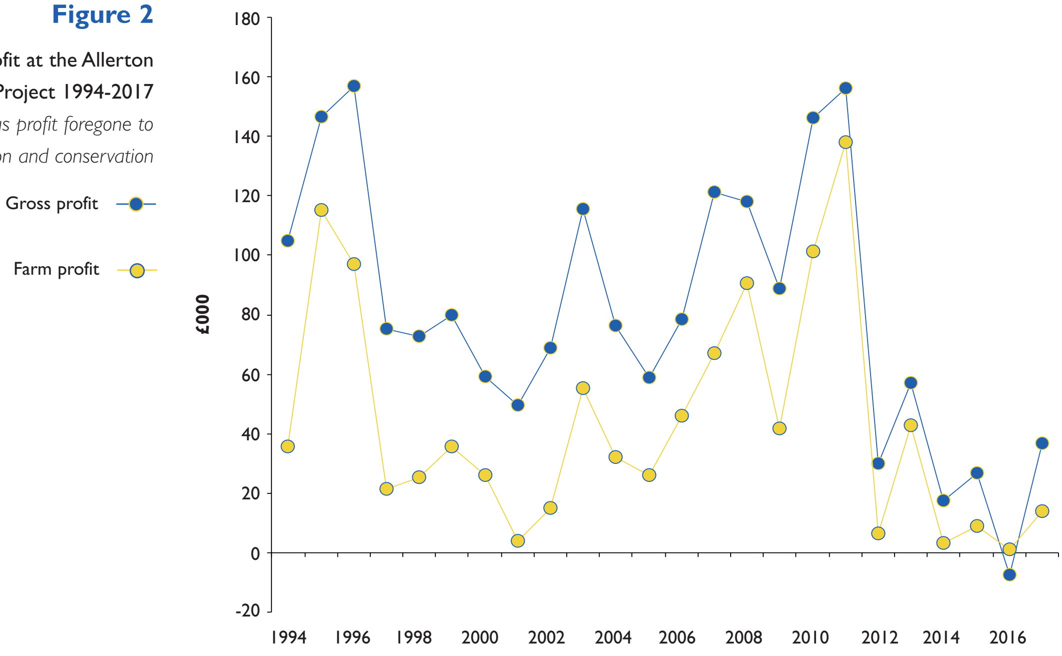
At the Allerton Project we are no strangers to such concepts and indeed in our 25th Anniversary year our approach has never been more relevant. Our staff have engaged with a multitude of farmers, students, schools, policymakers, academics and rural stakeholders. The minimum cultivation and physical, biological and chemical approaches to our soil management continue to gather momentum. Our soil protection and enhancement start with the measures we can implement in the field such as cover crops, reduced tillage, tramline direction and innovative machinery technology. Only then do we look at mitigation measures such as buffered margins, silt traps and infield grass strips. When these measures are implemented by several local farmers, the benefits for flooding and biodiversity in the wider landscape become much more tangible.

The way our production systems and agricultural support will unfold, needs to ensure that efficient, innovative and productive businesses have an economically promising future ahead of them. Although proper functioning markets, trade deals and labour availability are perhaps beyond our influence, investment in research in the

Figure 2

Gross profit* and farm profit at the Allerton Project 1994-2017

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



agricultural environment is very much on our agenda. Collaborations with academic institutions and commercial partners will provide us with some crucial production and environmental data required to help shape the future. The Allerton Project farm has certainly diversified into more research and demonstration work than in any time since the project's inception. Machinery compaction, greenhouse gas emissions, soil biological response to cultivation and economic returns are at the centre of our current farming activities.

With the backdrop of research and education, it is pertinent to remind ourselves that we are in the business of producing food. We continue to provide wheat, via the Kellogg's Origins programme, into the breakfast cereal market. Our extended rotation sees production of barley, oats, beans and oil seeds all entering the human food chain, and the temporary grass in our rotation provides forage for lambs at neighbouring Launde Farm Foods.

This year's harvest was the earliest start in the last decade and then it turned decidedly wet. It took us 23 days to harvest our oilseed rape and winter barley when we were expecting to complete it in nine days. This resulted in some lodged barley and ear losses. Wheat yields were promising, pushing 10 tonnes per hectare in some fields, but our average was nearer nine tonnes. The winter beans continued to yield well, but the late harvest of the spring crop saw ear losses. Late August and September saw rain on 26 of 36 days. Our future work will take a detailed look at the viability of cover crops and subsequent spring cash crops on heavy clay soils.

Despite the frustrating weather, autumn sowing conditions have allowed reasonable crop emergence and we are looking at alternative seed dressings to neonicotinoids, variable seed rate drilling, cover crops and a range of cultivation trials. The change in Ecological Focus Areas, within the Greening part of Single Farm payments, has led us to look at fallow, field margins and hedges as a way of meeting our requirements.

There seems to be a wind of change in regulatory developments, environmental enhancement and farming best practice, and the Allerton Project's farming activities will continue to feed into new policies and practices. The future will require positive assurance schemes and private sector partnerships that work alongside the Campaign for the Farmed Environment and the Voluntary Initiative. If we can avoid complicated and counterproductive regulation, the farming community will be much more engaged in the journey ahead. This is the aim of our Agricology Project, in partnership with the Organic Research Centre and the Daylesford Foundation, which brings together resources and information that champions good sustainable farming.

TABLE 2

Farm conservation costs at the Allerton Project 2017 (£ total)

Higher Level Stewardship costs (including crop income forgone)	-24,332
Higher Level Stewardship income	26,516
Woodland costs	-1,398
Woodland income	3,461
Farm Shoot expenses	-3,623
Farm Shoot income	3,263
Grass strips	-656
Total profit forgone	
- conservation	**4,903**
- research and education	**-27,516**
	-22,613

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

Technology and precision agriculture will help efficiency and the environment. © Phil Jarvis/GWCT

The Sustainable Intensification research Platform (SIP)

We have been looking at the potential economic and environmental benefits of cover crops. © Felicity Crotty/GWCT

The Sustainable Intensification research Platform (SIP) is a Defra initiative involving more than 30 partners from industry, NGOs and academia. The Allerton Project is one of three research and demonstration farms, linked to landscape-scale research projects, at the heart of the SIP. The landscape-scale research is integrated into our Water Friendly Farming project, while the plot and field-scale research is carried out on our own Allerton Project farm at Loddington. The main focus is on the potential economic and environmental benefits of cover crops, with a smaller study investigating the relationship between sward minerals and grazing sheep. Throughout, we are attempting to optimise the simultaneous benefits to food production, economic performance and the environment.

The benefits of cover crops, sown into the stubble immediately after harvest for reduced erosion and nitrate leaching, are well documented but we were interested to

BACKGROUND

The Allerton Project is one of five research and demonstration farms across the country which constitute the farm network for Defra's Sustainable Intensification research Platform (SIP). As part of our contribution to this initiative, we are working with farmers at the catchment scale, collaborating with Nottingham University on research into lamb performance and grass sward minerals, and investigating soil management in partnership with NIAB TAG. For the soil management work, our main focus is on the potential benefits of cover crops.

We are investigating the relationship between sward minerals and grazing sheep. © Chris Stoate/GWCT

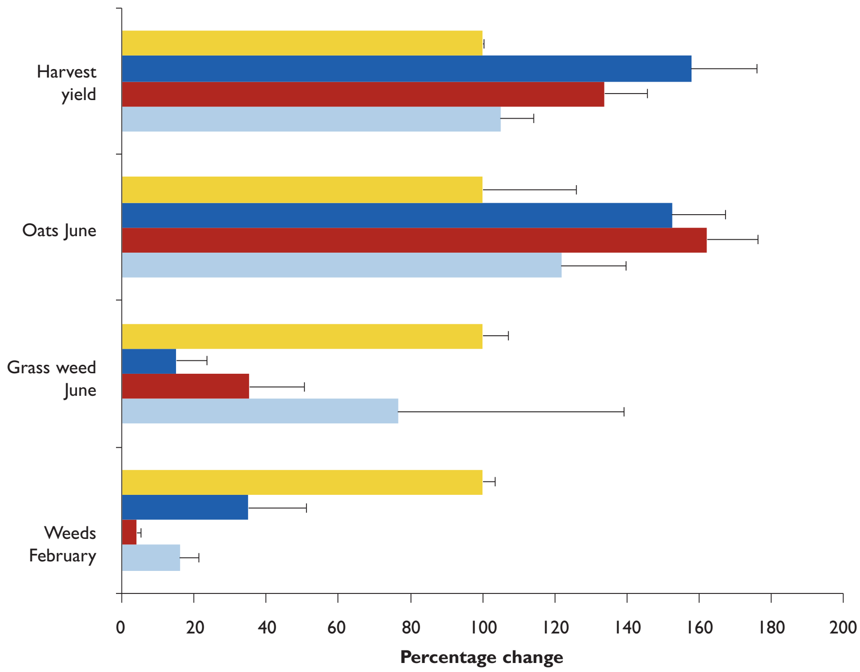


Figure 1

Percentage change highlighting effect of cover crop in relation to no cover (100%)

No cover

Cereal/Phacelia/Radish/Legumes

Cereal/Phacelia/Radish

Cereal/Phacelia

explore other potential effects, particularly on clay soils. In 2015/16, we tested three different cover crop mixtures against a control (no cover crop present), replicated across three fields. In 2016/17, we tested the individual component species in those mixtures, with three replicates in the same field in two replicated experiments. The first experiment adopted various mixtures of cereal, phacelia, radish and legumes, while the second experiment tested oats, phacelia, vetch, buckwheat and radish grown individually. In each case, we monitored a range of soil chemical, physical and biological properties, as well as cover crop and weed cover, and the yield and weed cover in the following spring-sown crop. In the second year, we also measured dead-leaf deposition from the cover crops onto the ground to document the amount of organic matter returning to the soil from above ground plant growth.

Cover crop mixtures containing radish generally supported four times higher numbers of surface-dwelling earthworms. Control plots had up to 23 times as much weed cover as cover crop plots (see Figure 1). In the following spring-sown oats, the yield, although low (3.5 t/ha), was 60% higher in plots which had contained these cover crop mixtures, and the amount of black-grass and other weeds was up to six times higher in the control plots than the plots which had contained cover crops.

KEY FINDINGS

- Some cover crops deliver benefits to the soil, including increases in surface-dwelling earthworms.
- These benefits follow through to enhanced yield and reduced weed cover in the following spring-sown cash crop.
- Understanding how sward minerals vary seasonally and across fields can help farmers optimise the use of grass.

Chris Stoate
Felicity Crotty
Nigel Kendall

Earthworm abundance was high in plots comprising radish and phacelia. © Phil Jarvis/GWCT

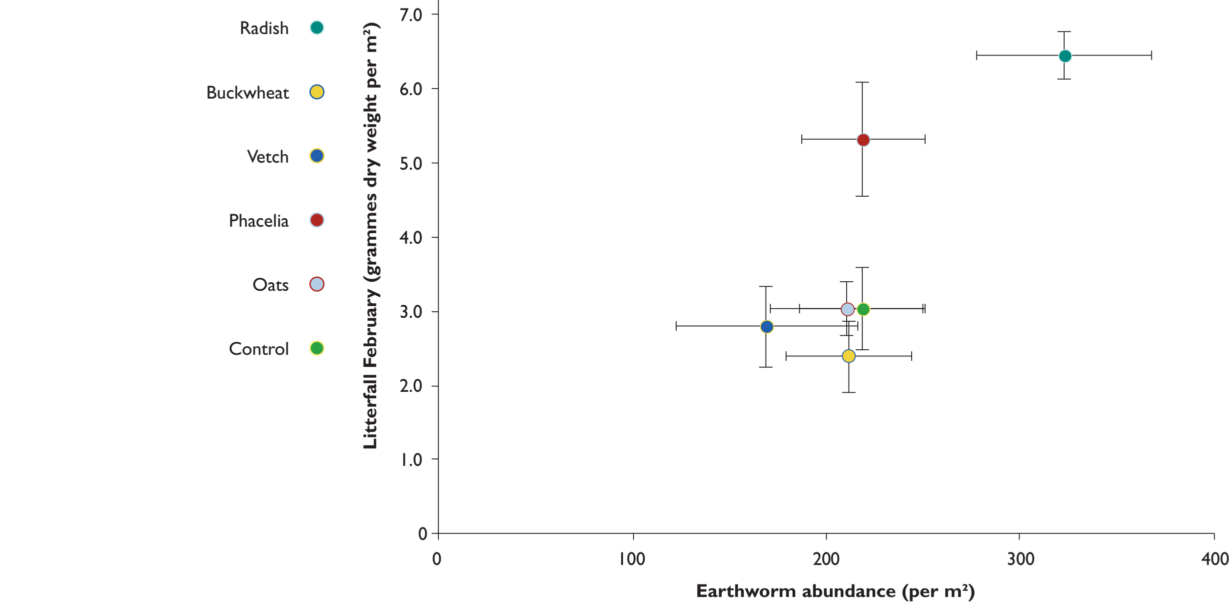
Evidence of deep burrowing earthworms on the soil surface. © Felicity Crotty/GWCT

In the single species cover crop experiment, by February, earthworm biomass was 3.5 times higher in the radish plots (36.6 ± 9.17 g per m^2) than in the control (9.8 ± 3.14) (see Figure 2). Leaf litter fall was highest from radish (11.7%) and phacelia (10.7%), and was positively correlated with overall earthworm abundance. As in the previous year, weed cover was over five times higher (116.6 ± 7.7 g per m^2) in the bare stubble control plots than in oats (25.2 ± 8.1) and radish plots (17.1 ± 3.5), which had good cover of the planted cover crops. This provides a clear indication of the ability of some cover crops to supress weeds. The yield of spring oats was 20% higher in plots which had previously contained radish compared with the bare stubble control plots, but overall yields were low 3.1 t/ha and the difference was not significant. The low weed burden is likely to be due to improved rooting conditions for the cash crop and associated crop vigour and competitive advantage.

Our cover crop research has identified some benefits in terms of yield, weed suppression and soil biology, with the yield difference being sufficient to cover the extra costs associated with establishing the crops, even on clay soils. However, clay soils continue to present challenges in terms of achieving timely drilling of the cover crop

Figure 2

Dry weight per m² – February 2016



We took sward samples from 15 fields for analysis of trace elements. © Chris Stoate/GWCT

and rapid germination and establishment. Although the costs remain constant from year to year, the benefits are likely to vary with weather, harvest and soil conditions.

The research into sward minerals was carried out by the University of Nottingham School of Veterinary Medicine and Science in collaboration with our neighbouring sheep farmer, Gareth Owen. This marks the first research at the Allerton Project into grass and livestock systems. The topic is important as availability of minerals to grazing livestock can limit lamb growth and impact health where other requirements such as forage quality and quantity and parasite control are already met. This is particularly relevant and topical now as many all-arable farmers are adopting or considering grass leys in their rotations to help control black-grass and improve soil structure, organic matter and function.

In 2015 and 2016, swards in 15 fields at the Allerton Project were sampled monthly through the March to November grazing period, as if grazed by sheep, and blood samples were taken under Home Office licence from grazing lambs and ewes. Sward and blood samples were analysed for a range of trace elements. Cobalt concentration in the sward varied both between fields and seasonally, and were above the 0.2 mg/kg of dry matter required by growing lambs only at each end of the grazing period. Rainfall affected concentrations so that sufficient cobalt (above 0.2 mg/kg dry matter) was available in April 2016 with higher than average rainfall, but only reached 0.1 mg/kg in the dry spring of 2015. In both years, the concentration was below 0.1 kg/kg from June to September, and cobalt concentrations in blood samples from grazing sheep reflected availability in the sward. There was a 10-fold increase in cobalt concentration in the sward between August and November.

Such knowledge of sward minerals can help in making decisions about the timing of grazing or provision of mineral supplements, or the use of fields for grazing or making silage to be fed to housed livestock along with concentrate feed or supplements. The potential consequences of this are improved economic return and animal health, and more effective use of arable leys.

Although the SIP ended in November 2016, our work on issues relating to Sustainable Intensification continues, as do some of the research partnerships established within the SIP.

The Scottish Demonstration Farm - Auchnerran

A combination of rabbit control, netting and soil improvement made the King's 'Highland Cereal' gamecrop mix a success this year. © Merlin Becker/GWCT

Auchnerran, the GWCT Scottish Demonstration Farm, had as challenging a year in 2017 as any farm, dealing both with the marginal weather and the need to deal with legacy issues of poor soil conditions, a huge rabbit population and sheep numbers, age, health, nutrition and quality. In many senses the integration with the wildlife (see page 72) was the easy bit, though the farm is yet to see any tangible financial benefit from growing lapwings as well as lambs.

Despite a wet winter, a very dry spring and a late summer and autumn that was persistently damp, final lambing was 120% (97% in 2016). Lamb sales comfortably exceeded budget for both numbers sold and quality, with Auchnerran Farm appearing in *The Scottish Farmer* gazette as top-selling farm at the local mart six times in the year. In 2017 1,020 ewes and gimmers went to the tup, with 657 ewe hogs being retained as replacements.

Next year's lamb production will be helped by this year's forage quality. We cut 1,100 bales of good silage at 23 bales per hectare (17 in 2016) and the kale crop is growing well thanks to timely erection of rabbit-proof fencing. Good forage will markedly reduce winter feed costs, and its production was explicitly managed to enhance wildlife. Damp parts of fields were left undrained and silaging and tillage was delayed until all the waders had fledged and moved off their nesting fields. This probably slightly compromised maximum forage production.

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.

Fergus Ewing MSP, cabinet secretary for rural affairs and connectivity visited the farm in September and met GWCT staff. (L-R) Sarah Ballantyne, Allan Wright, Merlin Becker, Fergus Ewing, Andrew Salveson and Dave Parish. © GWCT

Marlies Nicolai counts mud snails, a key vector of liver fluke in sheep and focus of a collaborative research project. © GWCT

But protecting and enhancing the wildlife and natural environment assets at Auchnerran is vital as we look forward to agricultural support systems which will increasingly only value environmental and social outcomes. These compromises mean the progress toward a balanced flock of 1,300 ewes and 550 hoggs in three years remains slow. So we have focused on ensuring that our tick counts indicated adequate levels of control to benefit both sheep and grouse.

The focus on flock quality and wildlife remains strategically important for the farm business and the research. It has also proved invaluable in enhancing our credibility as a forward-looking sheep farm. A measure of the interest in our 'active farm, abundant in wildlife' approach is that we have been involved in a raft of new activities on animal health, farm conservation, landscape-scale collaboration (Farmer Clusters) and game conservation. The farm has hosted 20 visiting groups in 2017 including the representatives of both Scottish Parliament Rural and Environment Committees, Scottish Natural Heritage, Soil Association, Royal Scottish Forestry Society, RSPB, the NFUS Environment Committee and Scottish Land & Estates.

KEY FINDINGS

- GWSDF Auchnerran farm seeks to integrate economic hill farming with wildlife conservation.
- 2017 was the first year when the farming was not constrained by recording ecological baseline data.
- This year's flock and forage performance suggests that Auchnerran can be an economic farm and retain its strong wildlife portfolio.
- Our objectives and approach were the subject of considerable public policy interest to visiting groups.

Adam Smith
Allan Wright
David Parish

Allan Wright the farm shepherd shows the NFUS Environment Committee the farm's single handed sheep handling race. © Adam Smith/GWCT

Auchnerran game and songbird counts

Song thrush nest with egg and chicks.
© Joe Bishop/GWCT

2017 was a good year for most of the wildlife at GWSDF Auchnerran. Despite the imperfect weather conditions early on, our surveys revealed increasing densities for many of our key species with, for example, wader numbers doubling since 2016 (see Table 1). Why this increase has occurred is unclear and is unlikely to reflect any activities on the farm itself.

We continued our intensive monitoring of wader breeding success in 2017 with the help of Ruth Highley, our placement student from Leeds University, and Lauren Fisher, an MSc student from Imperial College, University of London. With the help of Joe Bishop, also from Imperial College, we were able to start monitoring thrushes in a similar way, with regular visits to territories to try and record all breeding activities. These data are crucial for our long-term monitoring at GWSDF as they help illustrate how wildlife on the farm is responding to the agricultural improvements currently being made.

The lapwing is our most easily monitored wader species and so provides the most robust data, although this is still not easy. The very high density of over 40 birds per 100 hectares means that there are lots of birds in most of the occupied fields, so it is near impossible to follow individual pairs and record how many chicks each raises. So, we estimate productivity as the number of fledglings (mature chicks) per pair or per nest, based on average counts of adults and fledglings in each field, and the number of nests we find. Given that we have minimal access to, and restricted visibility of, fields at

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.

TABLE 1

Spring densities (individuals/100ha) of waders and thrushes at GWSDF Auchnerran. Data for woodcock are numbers of roding males

	2015	2016	2017
Lapwing	12.7	19.1	43.5
Oystercatcher	7.7	17.5	33.2
Curlew	2.5	3.7	7.1
Woodcock	-	4.3	6.2
Blackbird	7.3	4.0	18.0
Song thrush	7.5	14.1	24.4
Mistle thrush	5.0	1.0	7.8

TABLE 2

Pheasant densities (individuals/100ha) at GWSDF Auchnerran

		2015	2016	2017
Spring	Male	24.3	22.7	19.0
	Female	14.4	5.8	4.6
Autumn	Male	42.0	9.4	18.8
	Female	25.2	0.4	9.4

lambing time (most of May), the estimate of productivity per nest and per pair varies in relative accuracy from field-to-field, so we present a range of productivity estimates based on different approaches. This shows that somewhere between 0.9 and 1.3 fledglings were produced per pair/nest in 2017, which is a very high level of productivity and should be sufficient to maintain the population. We plan to expand our monitoring to include radio-tracking of chicks to better estimate and understand chick survival.

With the help of trail cameras, we were able to view 20 nests to try and identify any predators that may take lapwing eggs. All these 20 clutches hatched, some partially, and none were predated. Jackdaws and rooks were seen taking eggs, but only from nests that had already partially hatched and were no longer attended by adults.

The increase in breeding density and high productivity are obviously hugely encouraging, but there have been some changes that will need careful monitoring going forward. The distribution of lapwing nests was slightly different in 2017 with some previously occupied fields unused. These unused fields included those recently reseeded and others perhaps grazed more intensively, with increased densities of lapwing found in nearby fields.

A very similar story was found for the thrushes. Of a total of 30 thrush nests on the farm in 2017 (blackbird, song thrush and mistle thrush), 20 hatched and only three nests were predated, though we could not identify the culprits.

Our small shoot at GWSDF is developing well under the stewardship of Merlin Becker, and is based on small mixed bags with pheasants as a key staple. As previously reported, there used to be a large pheasant release at GWSDF before we took over and the birds we now have are naturalised individuals from that time. Our monitoring suggests that pheasant numbers have declined – not surprisingly as releasing has stopped – but that we have a reasonable population of birds that seems to be stabilising (see Table 2).

KEY FINDINGS

- For both waders and thrushes, abundance and productivity at GWSDF are high.
- Nest predation rates are very low.
- There is a suggestion that some early changes in field management have resulted in abandonment by breeding lapwing, but this needs further monitoring to confirm.
- Pheasant numbers appear to be stable.

Dave Parish
Marlies Nicolai

Lapwing are continuing to thrive. © Marlies Nicolai/GWCT

Trials of new Laser Fence technology

Introducing the Laser Fence project to the public at the Scottish Game Fair. © Marlies Nicolai/GWCT

BACKGROUND

Laser fencing is not really a fence at all, which implies a static line forming a barrier between two areas. Instead, the work we are describing here uses a more dynamic system with a moving laser beam projected onto the ground that we hope will scare animals away from designated areas. Rodenticide use across Europe is commonplace and often impacts non-target species through transmission via the food chain. This project hopes to develop Laser Fence technology as a viable alternative method of control, excluding rats from targeted areas in certain scenarios. We also hope to extend this principle to other mammalian species where some current control methods might not be applicable some of the time. It is unlikely to be a universal panacea for the control of mammal-pests but it could produce a useful tool for land managers in some situations.

The new LIFE-funded Laser Fence project is a collaboration led by Liverpool John Moores University with partners in Scotland, England, Spain and the Netherlands, to test whether laser technology might be an effective means of deterring mammalian pests from agricultural crops.

The lasers in question are commercially available as bird-scarers and are routinely used around the world in agricultural landscapes and at airports, among many others. In this context they are extremely successful, with users reporting that a large proportion of birds respond quickly to the presentation of the laser and leave the area. Our project aims to test whether the same impressive outcomes can be achieved with mammals.

We have two types of device at our disposal: an automated system that is capable of running alone once programmed and a smaller handheld device that you simply point in the vicinity of your trial subject and switch on. Both work by shining a bright green light on the ground close to the animals and it is the movement of this spot of light that scares them away (at least in birds). Our work to date has focused on the handheld unit. As this technology has been developed for use on birds, it may need some tweaking to make it equally effective on mammals. For example, it is coloured green because the manufacturer, Bird Control Group (BCG), discovered this was the colour best perceived by birds: is it the same for mammals? Liverpool John Moores University, along with BCG, are developing a new laser that will allow us to trial different colours in 2018 and beyond.

Across all the partners the prime species for trials is the brown rat, as it is hoped that the laser technology might provide an alternative to the use of rodenticides as a control method in certain scenarios. At GWSDF we will be looking at the rat in due course but to date our focus has been on the over-abundant rabbit as our monitoring suggests they are eating a considerable amount of grass that we would rather go to the sheep. As well as rabbits, we will also investigate the effectiveness of the lasers for deterring predatory species such as fox and stoat, but that is for the future.

Our trials on rabbits have focused on the handheld device, which gives us a greater degree of flexibility in how the laser is presented to the animals. We started by investigating how the movement of the laser itself might impact on the animals' response to see if there was an optimum presentation method that would maximise the likelihood of animals responding, and then we considered how this response differed among animals in different group sizes and of different ages. In due course we

Briefing GWSDF visitors on some of the laser technology for future use on the farm.
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hope to use the automated system to target designated areas within our test fields to see if the number of rabbits visiting these areas can be reduced and whether this results in increased growth of the grass here compared with control areas.

The early indications are that targeting individuals with the handheld device reveals a response rate of about 20%, irrespective of how the laser is moved around close to the animals. That is, only one in five rabbits show avoidance or alarm behaviour in response to the laser. This isn't great but is a significant difference and one that we may be able to increase if we can alter the design of the laser to make it more appropriate for use on mammals.

KEY FINDINGS

- This is the first deployment of laser technology as a mammalian deterrent.
- Trials to date have focused on the behavioural response of individual rabbits when the laser is projected onto the ground nearby.
- Early indications suggest that around 20% of rabbits were scared by the laser.

Dave Parish

Staff training with the handheld laser. Note the green spot (circled) just in front of the very relaxed rabbit.
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Research projects

by the Game & Wildlife Conservation Trust in 2017

PREDATION RESEARCH IN 2017

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*
Grey squirrel trapping strategy	*Exploratory research on optimal trapping strategy for grey squirrel control*	*Jonathan Reynolds, Mike Short*	*Core funds*	*2013-2018*
Foxes in the Avon Valley (see p14)	*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*	*2015-2018*
Diet of foxes in the Avon Valley	*Faecal analysis to determine main dietary components supporting foxes in the Avon Valley*	*Naomi Sadoff, Anna Jones, Peter Wood, Jodie Case, Megan Baldissara, Alex Shishkin, Jonathan Reynolds*	*LIFE+ Waders for Real, Core funds*	*2017*

FISHERIES RESEARCH IN 2017

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 p18)	*Understanding the population declines in salmon and sea trout*	*Rasmus Lauridsen, Dylan Roberts, William Beaumont, Luke Scott, Stephen Gregory*	*Core funds, EA, CEFAS, Mr A Daniell, Winton Capital*	*2009- ongoing*
Grayling ecology	*Long-term study of the ecology of River Wylye grayling*	*Stephen Gregory, Luke Scott, Tea Basic (now Cefas)*	*NRW, Core funds, Grayling Research Trust, Piscatorial Society*	*2009- ongoing*
Gyrodactylus salaris in salmon	*Modelling to predict the impact of Gyrodactylus salaris infection on UK salmon stocks*	*Rasmus Lauridsen, Alastair Cook, Nicola McPherson, Nick Taylor (Cefas)*	*Cefas/Defra, Core funds*	*2015-2019*
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 and trout smolt tracking (see p20)	*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 data base 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*
Salmon smolt rotary screw trap assessment	*Calculating the effects of rotary screw traps on salmon smolts for SAMARCH*	*Rasmus Lauridsen, William Beaumont, Stephen Gregory, Bill Riley, Ian Russell (Cefas)*	*CEFAS, EU Interreg, Core funds*	*2017-2018*
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*
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*	*2014-2017*
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*	*2015-2018*
PhD: Ranunculus as a bioengineer in chalkstreams	*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*

LOWLAND GAME RESEARCH IN 2017

Project title	Description	Staff	Funding source	Date
Pheasant population studies (see p26)	*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
Pheasant releasing on Exmoor (see p24)	Impacts of released pheasants and game management work on woodlands and farmland in Exmoor	Rufus Sage, Aidan Hulatt, Jenny Peach, Alice Deacon	Greater Exmoor Shoot Association	2015-2017
PhD: Gapeworm and pheasants	Gapeworm on shooting estates, spatial and temporal factors affecting infections in pheasants	Owen Gethings Supervisors: Rufus Sage, Prof Simon Leather (Harper Adams University)	BBSRC/CASE Studentship, Core funds	2014-2017
PhD: Corvids breeding on farmland	Breeding ecology of corvids, predatory behaviour and the effect of trapping on farmland	Lucy Capstick. Supervisors: Rufus Sage, Dr Joah Madden (Exeter University)	Songbird Survival	2014-2017
PhD: Improving released pheasants	Using improved hand-reared pheasants to increase survival and wild breeding post-release	Andy Hall. Supervisors: Rufus Sage, Dr Joah Madden (Exeter University)	Exeter University, Core funds	2015-2018

WETLAND RESEARCH IN 2017

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 migration (see p32)	Use of satellite tags and geolocators to examine woodcock migration strategies	Andrew Hoodless, Chris Heward, collaboration with ONCFS	Shooting Times Woodcock Club, Private donors, Woodcock Appeal	2010-2017
Strategies for coping with cold weather in woodcock	Examination of regulation of fat reserves, estimation of duration to starvation and behavioural responses	Carlos Sánchez, Andrew Hoodless	Private donors, Core funds	2014-2017
Effective options for lapwing recovery (see p30)	Quantification of predation of lapwing chicks and assessment of options for reducing losses	Andrew Hoodless, Sophie Brown, Kaat Brulez	The Dulverton Trust	2017-2018
LIFE+ Waders for Real (see p28)	Wader recovery project in the Avon Valley	Andrew Hoodless, Lizzie Grayshon, Mike Short, Tom Porteus, Jonathan Reynolds, Clive Bealey, Paul Stephens	EU LIFE+ programme, Core funds	2014-2019
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
PhD: Woodcock population status in Ireland	National breeding survey and investigation of the impact of habitat change and shooting	Jessica Perrott. Supervisors: Andrew Hoodless, Prof John Quinn and Prof John O'Halloran/University College Cork	Irish Research Council, NARGC, Core funds	2017-2020

PARTRIDGE AND BIOMETRICS RESEARCH IN 2017

Project title	Description	Staff	Funding source	Date
Partridge Count Scheme (see p34)	Nationwide monitoring of grey and red-legged partridge abundance and breeding success	Neville Kingdon, Nicholas Aebischer, Julie Ewald, Anna Jones, Peter Wood, Megan Baldissara, Alex Shishkin	Core funds, GCUSA	1933- ongoing
National Gamebag Census (see p42)	Monitoring game and predator numbers with annual bag records	Nicholas Aebischer, Gillian Gooderham, Ryan Burrell, Sean Elliott, Anna Jones, Peter Wood, Megan Baldissara, Katherine Harrap, Alex Shishkin	Core funds	1961- ongoing
Sussex study (see p38)	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, Dr Dick Potts (consultant)	Core funds	1968- ongoing
Wildlife monitoring at Rotherfield Park (see p36)	Monitoring of land use, game and songbirds for the Rotherfield demonstration project	Francis Buner, Malcolm Brockless, Peter Thompson, Roger Draycott, Julie Ewald, Holly Kembrey	Core funds	2010-2018
Grey partridge management	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, Anna Jones, Peter Wood, Megan Baldissara, Alex Shishkin	Core funds	2014- ongoing
Developing novel game crops	Developing perennial game cover mixes	Dave Parish, Holly Marshall, Louise Moore, 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, Sean Elliott, Ryan Burrell, Katherine Harrap	Core funds	2015-2018
British Deer Survey	Map the distribution of British deer species	Ryan Burrell, Anna Jones, Peter Wood, Julie Ewald	British Deer Society	2016-2017
PARTRIDGE (see p40)	Co-ordinated demonstration of management for partridge recovery and biodiversity in UK, the Netherlands, Belgium and Germany	Francis Buner, Holly Kembrey, Paul Stephens, Julie Ewald, Neville Kingdon, Ryan Burrell, Peter Thompson, Chris Stoate, Roger Draycott, John Szczur, Austin Weldon, Dave Parish, Fiona Torrance, Nicholas Aebischer	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 2017

Project title	Description	Staff	Funding source	Date
Grouse Count Scheme (see p44)	*Annual grouse and parasitic worm counts in relation to moorland management indices and biodiversity*	*David Baines, David Newborn, Mike Richardson, Kathy Fletcher, Nick Hesford, Phil Warren*	*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. Nick Hesford, 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 (see p52)	*Use of acaricide-treated sheep to suppress ticks in a multi-host system.*	*Kathy Fletcher*	*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 p54)	*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*
Respiratory cryptosporidiosis (see p48)	*Cryptosporidiosis in red grouse: study of spread of disease, prevalence and impacts on grouse survival and fecundity, is it present in black grouse?*	*David Baines, Mike Richardson, David Newborn, Phil Warren*	*Core funds, G and K Boyes Trust*	*2013-2017*
Grouse restoration in north Wales	*Interaction of habitat and predator management in determining numbers of red and black grouse*	*David Baines, Sian Whitehead*	*World Pheasant Association, Core funds*	*2014-2017*
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, Melissa Dawson, Mike Richardson*	*Core funds*	*2016-2018*
Capercaillie genetics	*How accurate are non-invasive genetical techniques in estimating population size and survival rates*	*Kathy Fletcher, David Baines, Royal Zoological Society Scotland*	*World Pheasant Association*	*2017*
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*
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*
Mountain hares	*Are mountain hare abundance indices influenced by grouse moor management: an analysis of observations from grouse counts?*	*Nick Hesford, David Baines*	*Core funds*	*2017*

FARMLAND RESEARCH IN 2017

Project title	Description	Staff	Funding source	Date
QuESSA	*Quantification of Ecological Services for Sustainable Agriculture*	*John Holland, Niamh McHugh, Steve Moreby*	*EU FP7*	*2013-2017*
Insecticide effects on beneficial invertebrates	*Secondary feeding effects of insecticides on beetles*	*John Holland, Niamh McHugh, Belinda Bown, Sophie Potter*	*Core funds*	*2015- ongoing*
Chick-food and farming systems (see 58)	*A comparison of grey partridge chick-food in conventional and organically farmed crops and habitats*	*John Holland, Steve Moreby, Niamh McHugh, Sophie Potter, Belinda Bown*	*External funds*	*2015- ongoing*
Long-term trends in beetles	*Beetle abundance and diversity in Sussex 40 years on*	*Dick Potts, Steve Moreby, Belinda Bown*	*Core funds*	*2016-2018*
Wild bird seed mixtures	*Extending the life of wild bird seed mixes using a sticking agent*	*John Holland, Niamh McHugh, Belinda Bown, Lizzie Grayshon*	*External funds*	*2016-17*
Agribats (see p56)	*Bat use of arable agri-environment scheme habitats*	*Niamh McHugh, Sophie Potter, Belinda Bown, Anna Forbes, Jade Hemsley, Emily Brown, Chris Wyver*	*Heritage Lottery Fund, The Mercer's Company, Wixamtree Trust, The Hamamelis Trust, Chapman Charitable Trust*	*2017-2018*
Tillage and invertebrates	*Effects of different tillage systems on beneficial invertebrates*	*John Holland, Belinda Bown, Chris Wyver*	*BASF*	*2017- ongoing*

ALLERTON PROJECT RESEARCH IN 2017

Project title	Description	Staff	Funding source	Date
Monitoring wildlife at Loddington (see p60)	*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*	*Chris Stoate, John Szczur, Jeremy Briggs, Penny Williams, (Freshwater*	*EA, Regional Flood and Coastal Committee*	*2011- ongoing*

	with farming in the upper Welland	*Habitats Trust), Professor Colin Brown (University of York)*		
School farm catchment	*Practical demonstration of ecosystem services*	*Chris Stoate, John Szczur*	*Allerton Project, EA, Anglian Water, Agrii SoilQuest*	*2012- ongoing*
Remote sensing data applications	*An investigation into the potential uses of remote sensing and ground sourced data for catchment management*	*Chris Stoate, Antony Williamson (EA), Crispin Hambidge (Geomatics), Georgina Wallis (CSF)*	*EA/CSF*	*2016-2017*
Sustainable Intensification Platform Project 1 (see p66)	*Farm-scale assessment of soil properties in relation to crop establishment and cover crops, and sheep performance in relation to sward minerals*	*Chris Stoate, Felicity Crotty, Phil Jarvis, Alastair Leake, Jim Egan, Ron Stobart (NIAB), Nigel Kendall (Nottingham University)*	*Defra*	*2014-2017*
Sustainable Intensification Platform Project 2	*Landscape scale assessment of potential for collaborative interventions to meet sustainable intensification objectives*	*Chris Stoate, Exeter and Nottingham Universities and other partners*	*Defra*	*2014-2017*
Soil monitoring	*Survey of soil biological, physical and chemical properties*	*Chris Stoate, Felicity Crotty, Alastair Leake, Phil Jarvis*	*Allerton Project*	*2014- ongoing*
VALERIE	*Project to improve the accessibility and availability of new knowledge for innovation in agriculture and forestry*	*Chris Stoate, Jim Egan*	*EU*	*2015-2017*
SoilCare	*Soil management to meet economic and environmental objectives across Europe*	*Chris Stoate, Felicity Crotty*	*EU H2020*	*2016-2020*
Soil health and biology	*The role of soil biology in crop production systems*	*Chris Stoate, Felicity Crotty*	*AHDB*	*2016-2020*
Soilquality.org	*Farmer engagement in mapping soil properties*	*Chris Stoate, Felicity Crotty*	*NERC SARIC*	*2016-2018*
Conservation Agriculture	*Economic and environmental impacts of three contrasting crop production approaches*	*Alastair Leake, Phil Jarvis, Chris Stoate, Felicity Crotty*	*Syngenta*	*2017-2021*
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*	*2014-2017*
PhD: Farmer and scientific knowledge of soils	*A comparison of farmers' perceptions of soils and researchers' assessment of soil properties*	*Stephen Jones. Supervisors: Chris Stoate, Dr Carol Morris, Dr Sacha Mooney (Nottingham University)*	*ESRC*	*2015-2018*
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*	*BBSRC Syngenta CASE*	*2015-2018*
PhD: Dietary choice	*Influences on water quality of food choice in the context of broader ethical considerations for individual diet.*	*Karoline Pöggel. Supervisors: Chris Stoate, Dr Carol Morris, Dr Susanne Seymour (Nottingham University)*	*ESRC*	*2016-2020*
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 2017

Project title	Description	Staff	Funding source	Date
Core biodiversity monitoring (see p72)	*Monitoring of key groups to assess impacts of farming changes*	*Dave Parish, Marlies Nicolai, Ruth Highley*	*Core funds*	*2017- ongoing*
Wader population monitoring	*Surveying of wader numbers, distribution and productivity*	*Dave Parish, Marlies Nicolai, Ruth Highley, Lauren Fisher*	*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, Ruth Highley*	*Core funds*	*2016- ongoing*
Thrush population monitoring	*Detailed investigation of thrush habitat use, distribution and productivity*	*Dave Parish, Marlies Nicolai, Joe Bishop*	*Core funds*	*2017- ongoing*
GWSDF Tarland farmer cluster	*Establishing the first farmer cluster in Scotland*	*Dave Parish, Marlies Nicolai*	*Core funds*	*2016-2018*
LIFE Laser Fence (see p74)	*Experimental trials of laser technology as a deterrent for various mammals*	*Dave Parish, Marlies Nicolai, Ruth Highley, 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 Ruth Highley*	*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*

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; 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; 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 2017

Aebischer, NJ (2017) *Contributions to the understanding of wildlife population dynamics.* DSc thesis. University of Durham, Durham.

Aebischer, NJ (2017) Obituary – George Richard (Dick) Potts (1939-2017). *Ibis,* 159: 937-939.

Baines, D, Giles, M & **Richardson, M** (2017) Microscopic and molecular tracing of *Cryptosporidium* oocysts: identifying a possible reservoir of infection in red grouse. *Pathogens*, 6, 57: 1-5. DOI: 10.3390/pathogens6040057.

Baines, D, Richardson, M & **Warren, P** (2017) The invertebrate diet of black grouse *Tetrao tetrix* chicks: a comparison between northern England and the Scottish Highlands. *Bird Study*, 64: 117-124.

Beaumont, WRC (2017) Comment: rates and effects of branding due to electroshock: some additional perspectives. *North American Journal of Fisheries Management,* 37: 429-430.

Begg, G, Bianchi, F, Birch, N, Gerowitt, B, **Holland, JM**, Lupi, D, Moonen, C, Ramsden, M & van Rijn, P (eds) (2017) *Landscape Management for Functional Biodiversity.* IOBC/WPRS Bulletin, 122. Proceedings of the 7th meeting at Dundee. IOBC-WPRS (International Organization for Biological and Integrated Control of Noxious Animals and Plants – West Palearctic Regional Section), Darmstadt, Germany.

Crotty, FV (2017) Slug invasions: cover crops, establishment methods or environmental conditions? *Aspects of Applied Biology*, 136: 299-306.

Crotty, FV & **Stoate, C** (2017) Understanding cover crops at the farm-scale – a method of sustainable intensification? *Aspects of Applied Biology*, 136: 79-86.

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Financial report
for 2017

KEY POINTS

- Overall funds increased by £371,812, including an increase of £94,515 on unrestricted funds.
- Income was £8.43 million, an increase of 10% from 2016.
- Expenditure on research was £4.3 million (an increase of 10%).
- The Trust's net assets were £9.1 million at the end of the year.

The summary report and financial statement for the year ended 31 December 2017, 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 12 April 2018 and which may be obtained from the Trust's Headquarters. The auditors have issued unqualified reports on the full annual accounts and on the consistency of the Trustees' report with those accounts, and their report on the full accounts contained no statement under sections 498(2) or 498(3) of the Companies Act 2006.

The Trust showed a surplus in 2017 due once again to the generosity of our supporters and effective cost management by our staff. We have seen a welcome increase in income, and a commensurate increase in our expenditure on our charitable objects with very little increase in fundraising costs. Public sector income has also increased mainly due to the starting of our SAMARCH Project (SAmonid MAnagament Round the CHannel).

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 2017 the Trust's reserves (according to this definition) were around £1 million.

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.

I Coghill
Chairman of the Trustees

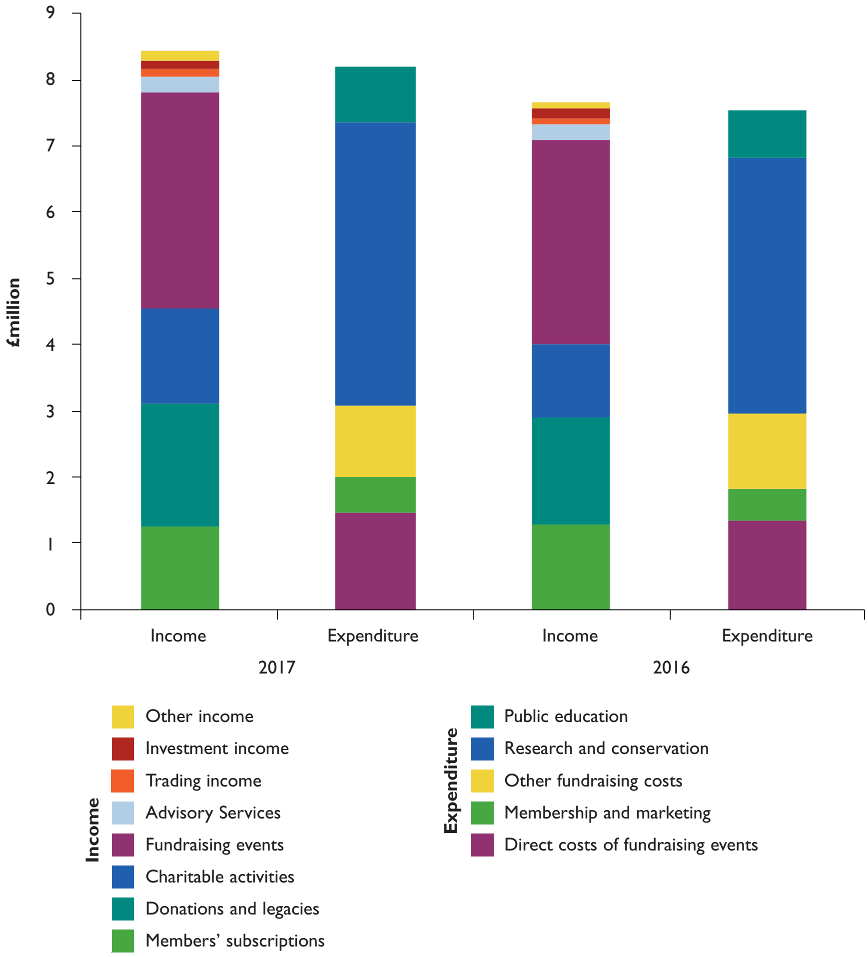

Figure 1

Total incoming and outgoing resources in 2017 (and 2016) 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 2017 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 2017 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, 25 April 2018

Consolidated

Statement of financial activities

	General Fund £	Designated Funds £	Restricted Funds £	Endowed Funds £	**Total 2017 £**	Total 2016 £
INCOME AND ENDOWMENTS FROM:						
Donations and legacies						
Members' subscriptions	1,244,845	-	-	-	**1,244,845**	1,270,855
Donations and legacies	784,885	-	1,075,957	-	**1,860,842**	1,632,219
	2,029,730	-	1,075,957	-	**3,105,687**	2,903,074
Charitable activities	-	-	1,430,827	-	**1,430,827**	1,115,354
Other trading activities						
Fundraising events	3,270,139	-	2,880	-	**3,273,019**	3,087,049
Advisory Service	240,820	-	-	-	**240,820**	217,436
Trading income	106,206	-	-	-	**106,206**	95,325
Investment income	12,030	-	118,825	7,921	**138,776**	143,889
Other	75,446	-	61,855	-	**137,301**	100,671
TOTAL	5,734,371	-	2,690,344	7,921	**8,432,636**	7,662,798
EXPENDITURE ON:						
Raising funds						
Direct costs of fundraising events	1,447,028	-	-	-	**1,447,028**	1,345,699
Membership and marketing	549,406	-	-	-	**549,406**	467,128
Other fundraising costs	1,030,420	50,000	-	-	**1,080,420**	1,130,344
	3,026,854	50,000	-	-	**3,076,854**	2,943,171
Charitable activities						
Research and conservation						
Lowlands	1,265,616	-	533,668	-	**1,799,284**	1,578,031
Uplands	343,034	-	156,236	-	**499,270**	524,516
Demonstration	240,270	-	1,203,348	4,150	**1,447,768**	1,386,095
Fisheries	161,692	-	384,209	-	**545,901**	397,703
	2,010,612	-	2,277,461	4,150	**4,292,223**	3,886,345
Public education	550,224	-	227,493	50,000	**827,717**	699,990
	2,560,836	-	2,504,954	54,150	**5,119,940**	4,586,335
TOTAL	5,587,690	50,000	2,504,954	54,150	**8,196,794**	7,529,506
Net gains/(losses) on investments:						
Realised	8,122	-	-	34,158	**42,280**	(144,662)
Unrealised	(10,288)	-	-	103,978	**93,690**	415,291
NET INCOME/(EXPENDITURE)	144,515	(50,000)	185,390	91,907	**371,812**	403,921
Transfers between funds	(50,000)	-	150,000	(100,000)	**-**	-
NET MOVEMENT IN FUNDS	94,515	(50,000)	335,390	(8,093)	**371,812**	403,921
RECONCILIATION OF FUNDS						
Total funds brought forward	2,313,029	136,492	475,655	5,807,079	**8,732,255**	8,328,334
TOTAL FUNDS CARRIED FORWARD	£2,407,544	£86,492	£811,045	£5,798,986	**£9,104,067**	£8,732,255

Consolidated

Balance sheet

as at 31 December 2017

		2017		2016
	£	£	£	£
FIXED ASSETS				
Tangible assets		3,283,162		3,340,057
Investments		4,112,848		4,070,486
		7,396,010		7,410,543
CURRENT ASSETS				
Stock	356,835		374,921	
Debtors	1,373,622		967,475	
Cash at bank and in hand	1,002,516		1,075,188	
	2,732,973		2,417,584	
CREDITORS:				
Amounts falling due within one year	544,068		549,253	
NET CURRENT ASSETS		2,188,905		1,868,331
TOTAL ASSETS LESS CURRENT LIABILITIES		9,584,915		9,278,874
CREDITORS:				
Amounts falling due after more than one year		480,848		546,619
NET ASSETS		£9,104,067		£8,732,255
Representing:				
CAPITAL FUNDS				
Endowment funds		5,798,986		5,807,079
INCOME FUNDS				
Restricted funds		811,045		475,655
Unrestricted funds:				
Designated funds	86,492		136,492	
Revaluation reserve	296,065		375,723	
General fund	2,069,350		1,893,468	
Non-charitable trading fund	42,129		43,838	
		2,494,036		2,449,521
TOTAL FUNDS		£9,104,067		£8,732,255

Approved by the Trustees on 12 April 2018 and signed on their behalf

I COGHILL

Chairman of the Trustees

Staff

of the Game & Wildlife Conservation Trust
in 2017

CHIEF EXECUTIVE	Teresa Dent BSc, FRAgS, CBE
Personal Assistant	Laura Gell
Chief Finance Officer	Nick Sheeran BSc, ACMA, CGMA
Accountant	Leigh Goodger
Senior Accounts Assistant	Hilary Clewer
Finance Assistant	Lindsey Chappe De Leonval *(from January)*
Accounts Assistant (p/t)	Helen Aebischer
Head of Database	Corinne Duggins Lic ès Lettres
Head of Administration & Personnel	Jayne Cheney Assoc CIPD *(until July)*
	Alastair King Chartered MCIPD, MAHRM *(from July)*
Health & Safety Officer (p/t)	John Owen *(from June)*
Head Groundsman (p/t)	Craig Morris
Headquarters Janitor/Handyperson	Steve Fish
Head of Information Technology	James Long BSc
IT Assistant	Charles Fisher *(from February)*
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 *(from June)*
Head of Fisheries	Dylan Roberts BSc
Head of Fisheries – Research	Rasmus Lauridsen BSc, MSc, PhD
Senior Fisheries Scientist	William Beaumont MIFM
Fisheries Scientist	Stephen Gregory BSc, MPhil, PhD
Research Assistant	Luke Scott
SAMARCH Project Scientist	Céline Artero BSc, MSc, PhD *(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
Head of Lowland Gamebird Research	Rufus Sage BSc, MSc, PhD
Ecologist - Pheasants, Wildlife (p/t)	Maureen Woodburn BSc, MSc, PhD
PhD Student *(Exeter University)* - corvids and songbirds	Lucy Capstick MSc *(until May)*
PhD Student *(Exeter University)* - pheasant release pens	Andy Hall MSc
Placement Student *(University of Plymouth)*	Sam Gibbs *(until July)*
Placement Student *(University of Plymouth)*	Greg Whall *(until September)*
Placement Student *(Manchester Metropolitan University)*	Meg Speck *(from July)*
Head of Wetland Research	Andrew Hoodless BSc, PhD
Research Ecologist	Kaat Brulez MSc, PhD
Research Ecologist	Carlos Sánchez Garcia Abad PhD, BVSc *(until April)*
Research Ecologist	Lucy Capstick BSc *(from August)*
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)* - lapwings on wet grassland	Geraldine Pearson BA, FdSc
MSc Student *(University of Reading)* - predator abundance on wet grassland	Rebecca Robinson BSc
Placement Student *(University of Plymouth)*	Sophie Brown *(until August)*
Placement Student *(University of Bath)*	Eleanor Ness *(from September)*
Head of Predation Control Studies	Jonathan Reynolds BSc, PhD
Senior Field Ecologist	Mike Short HND
Research Ecologist	Tom Porteus BSc, MSc, PhD
Volunteer *(University Centre Sparsholt)* – fox diet on wet grassland	Jodie Case
MSc Student *(University of Leeds)* – fox diet on wet grassland	Naomi Sadoff
Head of Farmland Ecology	Prof. John Holland BSc, MSc, PhD
Senior Entomologist	Steve Moreby BSc, MPhil
Post Doctorial Scientist	Niamh McHugh BSc, MSc, PhD
Research Assistant	Sophie Potter BSc, MSc *(until June)*
Research Assistant	Belinda Bown *(from July)*
Placement Student *(Reading University)*	Jade Hemsley *(until September)*
Placement Student *(University of York)*	Anna Forbes *(until September)*
Placement Student *(Reading University)*	Chris Wyver *(from September)*
Placement Student *(Nottingham University)*	Emily Brown *(from September)*
Director of Upland Research	David Baines BSc, PhD
Office Manager, Uplands	Julia Hopkins
Senior Scientist	Phil Warren BSc, PhD
Research Assistant	Michael Richardson BSc
Senior Scientist	Sian Whitehead BSc DPhil *(from January)*
Research Ecologist Langholm	Sonja Ludwig MSc, PhD
Seasonal Field Assistant	Melissa Dawson BSc *(May-August)*
Placement Student *(Nottingham Trent University)*	Hollie Fisher *(until August)*
Placement Student *(Harper Adams)*	Natalie Elms *(until August)*
Placement Student *(York University)*	Beth Goodman *(from August)*
Placement Student *(Leeds University)*	Hannah Coyle *(from August)*
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 & THE ALLERTON PROJECT	Alastair Leake BSc (Hons), MBPR (Agric), PhD, FRAgS, MIAgM, CEnv
Secretary (p/t)	Katy Machin MA, Sarah Large
Policy Officer (England)	Sofi Lloyd
Head of Research for the Allerton Project	Prof. Chris Stoate BA, PhD
Ecologist	John Szczur BSc
Soil Scientist	Felicity Crotty BSc, PhD
Welland Project Officer	Geoff Gilfillan BSc PhD *(from September)*
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)* - dietary choice	Karoline Pöggel
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
Farm Assistant	Ben Jarvis *(until April)*
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 *(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
Placement Student shared with Predation *(University of Cardiff)*	Anna Jones *(until September)*
Placement Student shared with Predation *(University of the West of England)*	Peter Wood *(until September)*
IT Placement Student *(Nottingham Trent University)*	Sean Elliott *(until September)*
Placement Student shared with Predation *(University of Plymouth)*	Megan Baldissara *(from September)*
Placement Student shared with Predation *(University of Plymouth)*	Alex Shishkin *(from September)*
IT Placement Student *(University of Kent)*	Katherine Harrap *(from September)*
DIRECTOR OF FUNDRAISING	Jeremy Payne MA, MInstF
London Events Manager	Jo Langer
London Events Assistant	Molly Smith; Eleanor Usborne *(from September)*
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)	Louise Jones *(until December)*
Regional Organiser (p/t)	Jill Scorer *(until April)*
Regional Organiser (p/t)	Pippa Hackett
Regional Organiser (p/t)	Fleur Fillingham *(from November)*
National Development Manager (p/t)	Jennifer Thomas
Administration Assistant	Daniel O'Mahony
DIRECTOR OF COMMUNICATIONS, MARKETING & MEMBERSHIP	Andrew Gilruth BSc
Team Assistant	Teresa Jolly *(from October)*
Membership & Marketing Administrator (p/t)	Beverley Mansbridge
Membership Assistant	Heather Acors
Communications and Fundraising Manager	Gillian Kenny *(from May)*
Communications Officer	Holly Howe *(until March);* Joel Holt *(from April)*
Direct Mail Fundraising & Marketing Officer	James Swyer
Publications Officer (p/t)	Louise Shervington
Digital Fundraising & Marketing Officer	Rob Beeson
Website Editor	Oliver Dean
National Recruitment Manager	Andy Harvey *(from October)*
Writer & Research Scientist (p/t)	Jen Brewin MSc, PhD
DIRECTOR SCOTLAND	Adam Smith BSc, MSc, DPhil
Scottish HQ Administrator (p/t)	Irene Johnston BA
Head of Events (Scotland)	Sarah Ballantyne BSc
Regional Organiser (p/t)	Rory Donaldson *(from October)*
Policy & Advisory Officer (Scotland)	Merlin Becker BSc
Senior Scottish Advisor & Scottish Game Fair Chairman	Hugo Straker NDA[1]
Head of Scottish Lowland Research	David Parish BSc, PhD
Research Assistant - GWSDF Auchnerran	Marlies Nicolai
Research Assistant - Scottish Grey Partridge Recovery Project	Fiona Torrance *(from February)*
MSc student *(University of Reading)* - use of novel cover crops by birds	Louise Moore
MSc student *(University of Stirling)* - invertebrates in novel cover crops	Holly Marshall
MSc student *(University of Aberdeen)* - rabbit responses to LaserFence	Andrew Taylor
MSc student *(Imperial College London)* - breeding biology of thrushes	Joe Bishop
MSc student *(Imperial College London)* - breeding biology of lapwing	Lauren Fisher
MSc student *(Imperial College London)* - habitat use of bats	Alicia Logan
Placement student *(University of Keele)*	Grace Edmondson *(from September)*
Placement student *(University of Southampton)*	Minna Ots *(from November)*
Placement Student *(University of Leeds)*	Ruth Highley *(until September)*
Shepherd Manager GWSDF Auchnerran	Allan Wright
DIRECTOR WALES	Sue Evans *(from May)*

[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. BASC Gamekeeping and Gameshooting	Mike Swan
3. BBC Scottish Rural and Agricultural Advisory Committee	Adam Smith
4. Biodiversity Strategy Group	Jim Egan
5. Bird Expert Group of the England Biodiversity Strategy	Nicholas Aebischer
6. British Ecological Society Scottish Policy Group	Adam Smith
7. Business in the Community (BiTC) Sustainable Soils Group	Alastair Leake
8. CFE Hampshire Co-ordinator	Peter Thompson
9. CFE National Delivery Group	Jim Egan
10. CFE National Strategy Group	Jim Egan
11. Capercaillie BAP Group	David Baines/ Adam Smith/ Kathy Fletcher
12. Capercaillie Research Group	David Baines
13. Code of Good Shooting Practice	Mike Swan
14. Cold Weather Wildfowl Suspensions	Mike Swan/ Adam Smith
15. Cornish Red Squirrel Project	Nick Sotherton
16. Council of the World Pheasant Association	Nick Sotherton
17. Deer Initiative	Austin Weldon
18. Deer Management Qualifications	Austin Weldon
19. Defra AIHTS Technical Working Group	Jonathan Reynolds
20. Defra Hen Harrier Action Plan Group	Adam Smith/ Teresa Dent
21. Defra Natural Capital Committee - Major Landowners Group	Teresa Dent
22. Defra Upland Stakeholder Forum and Upland Management sub-group	Adam Smith/ David Newborn/ Teresa Dent
23. Ecosystems and Land Use Stakeholder Engagement Group (Scotland)	Adam Smith
24. English Black Grouse BAP Group	Phil Warren/ David Baines
25. Executive Board of Agricology	Alastair Leake
26. Farmer Cluster Steering Committees (x5)	Peter Thompson
27. Fellow of the National Centre for Statistical Excellence	Nicholas Aebischer
28. Fish Welfare Group	Dylan Roberts
29. Freshwater Fisheries CEO Meetings	Nick Sotherton
30. Freshwater Fisheries Defra Meetings	Rasmus Lauridsen
31. Futurescapes Project: North Wales Moorlands	David Baines
32. FWAG (Administration) Ltd	Alastair Leake
33. Gamekeepers Welfare Trust	Mike Swan
34. Glamorgan Rivers Trust	Dylan Roberts
35. Hares Best Practice Group	Mike Swan
36. Heather Trust Board	Adam Smith
37. Honorary Scientific Advisory Panel of the Atlantic Salmon Trust	Rasmus Lauridsen
38. Honorary Scientific Advisory Panel of the S&TC	Nick Sotherton
39. IAF Biodiversity Working Group	Julie Ewald/ Francis Buner
40. IOBC-WPRS Council	John Holland
41. IUCN/SSC European Sustainable Use Specialist Group	Nicholas Aebischer/ Julie Ewald
42. IUCN/SSC Galliformes Specialist Group	Francis Buner/ Nicholas Aebischer
43. IUCN/SSC Grouse Specialist Group	David Baines
44. IUCN/SSC Re-introduction Specialist Group	Francis Buner
45. IUCN/SSC Woodcock & Snipe Specialist Group	Andrew Hoodless
46. John Spedan Lewis Trust for Natural Sciences	Nick Sotherton
47. Joint Hampshire Bird Group	Peter Thompson
48. Langholm Moorland Demonstration Project	Teresa Dent/Nick Sotherton/Adam Smith/Dave Baines
49. LEAF Marque Technical Advisory Committe	Jim Egan
50. LEAF Policy and Communications Advisory Committee	Alastair Leake
51. Mammal Expert Group of the England Biodiversity Strategy	Jonathan Reynolds
52. Marlborough Downs NEP Board	Teresa Dent
53. Moorland Gamekeepers' Association	David Newborn
54. Natural England – Main Board	Teresa Dent
55. Natural England National Agri-Environment Stakeholder Group	Jim Egan
56. NFU East Midlands Combinable Crops Board	Phil Jarvis
57. NFU National Crops Board	Phil Jarvis
58. NFU National Environment Forum	Phil Jarvis
59. NGO Committee	Mike Swan
60. Norfolk CFE Local Liaison Group	Roger Draycott
61. North Wales Moors Partnership	David Baines
62. Northern Uplands Local Nature Partnership - Curlew Working Group	Sian Whitehead
63. Perthshire Black Grouse Group	Kathy Fletcher
64. Operation Turtle Dove, Suffolk and Essex Steering Committee	Roger Draycott
65. Oriental Bird Club, Conservation Committee	Francis Buner
66. Pesticides Forum Indicators Group of the Chemicals Regulation Directorate	Julie Ewald
67. Poole Harbour Catchment Initiative	Stephen Gregory
68. Purdey Awards	Mike Swan
69. RASE Awards Panel	Alastair Leake
70. Resilient Dairy Landscapes Stakeholder Advisory Group	Alastair Leake
71. River Deveron Fisheries Science	Dylan Roberts
72. River Otter Beaver Trial	Dylan Roberts
73. Rivers and Lochs Institute Advisory Group	Adam Smith
74. Rothamsted Research	Alastair Leake
75. Rural Environment and Land Management Group	Adam Smith/ Merlin Becker
76. Rutland Agricultural Society	Alastair Leake
77. Scientific Advisory Committee of the Office National de la Chasse et de la Faune Sauvage	Nicholas Aebischer
78. Scotland's Moorland Forum and sub-groups	Adam Smith/ Merlin Becker
79. Scotland's Rural College Council	Adam Smith
80. Scottish Black Grouse BAP Group	Phil Warren/ David Baines
81. Scottish Farmed Environment Forum	Adam Smith
82. Scottish Government CAP Reform Stakeholder Group	Adam Smith
83. Scottish Land & Estates Moorland Working Group	Adam Smith
84. Scottish Moorland Groups (four regional groups)	Adam Smith/ Hugo Straker/ Merlin Becker
85. Scottish Muirburn Code Review Group	Merlin Becker
86. Scottish PAW Executive, Raptor and Science sub-groups	Adam Smith
87. Scottish Principles of Moorland Management Group	Adam Smith/ Merlin Becker
88. SGR Monitoring Group	Alastair Leake
89. SNH Deer Management Round Table	Merlin Becker
90. SNH National Species Reintroduction Forum	Adam Smith
91. SNH Scientific Advisory Committee Expert Panel	Nicholas Aebischer
92. South Downs Farmland Bird Initiative	Julie Ewald
93. Stiperstones and Cordon Hill Curlew Recovery Project	Roger Draycott Andrew Hoodless
94. Strathspey Black Grouse Group	Kathy Fletcher
95. Sustainable Intensification Research Platform	Chris Stoate
96. Technical Assessment Group (Scotland)	Hugo Straker/ Mike Short/ Jonathan Reynolds
97. The Bracken Control Group	Alastair Leake
98. The CAAV Agriculture and Environment Group	Jim Egan
99. The England Terrestrial Biodiversity Group	Jim Egan
100. The FWAG Association Steering Committee	Jim Egan
101. Tree Charter Steering Group	Austin Weldon
102. Upland Hydrology Group	David Newborn
103. UK & Ireland Curlew Action Group	Sian Whitehead
104. UK Avian Population Estimates Panel (JNCC-led)	Nicholas Aebischer
105. UK Birds of Conservation Concern Panel (RSPB-led)	Nicholas Aebischer
106. Voluntary Initiative National Steering Group	Jim Egan
107. Voluntary Initiative National Strategy Group	Jim Egan
108. Voluntary Initiative Water sub-Group	Chris Stoate
109. Waitrose Responsible Efficient Production Expert Panel	Alastair Leake
110. Welland Rivers Trust	Chris Stoate
111. Welland Valley Partnership	Chris Stoate
112. Welsh Bird Conservation Forum	David Baines
113. Wildlife Estates England Steering Group	Roger Draycott
114. Wildlife Estates, European Scientific Committee	Alastair Leake
115. Wildlife Estates Scotland Expert Panel	Adam Smith
116. World Pheasant Association Scientific Advisory Committee	David Baines
117. Working for Waders	Adam Smith/ Merlin Becker

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; 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; 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