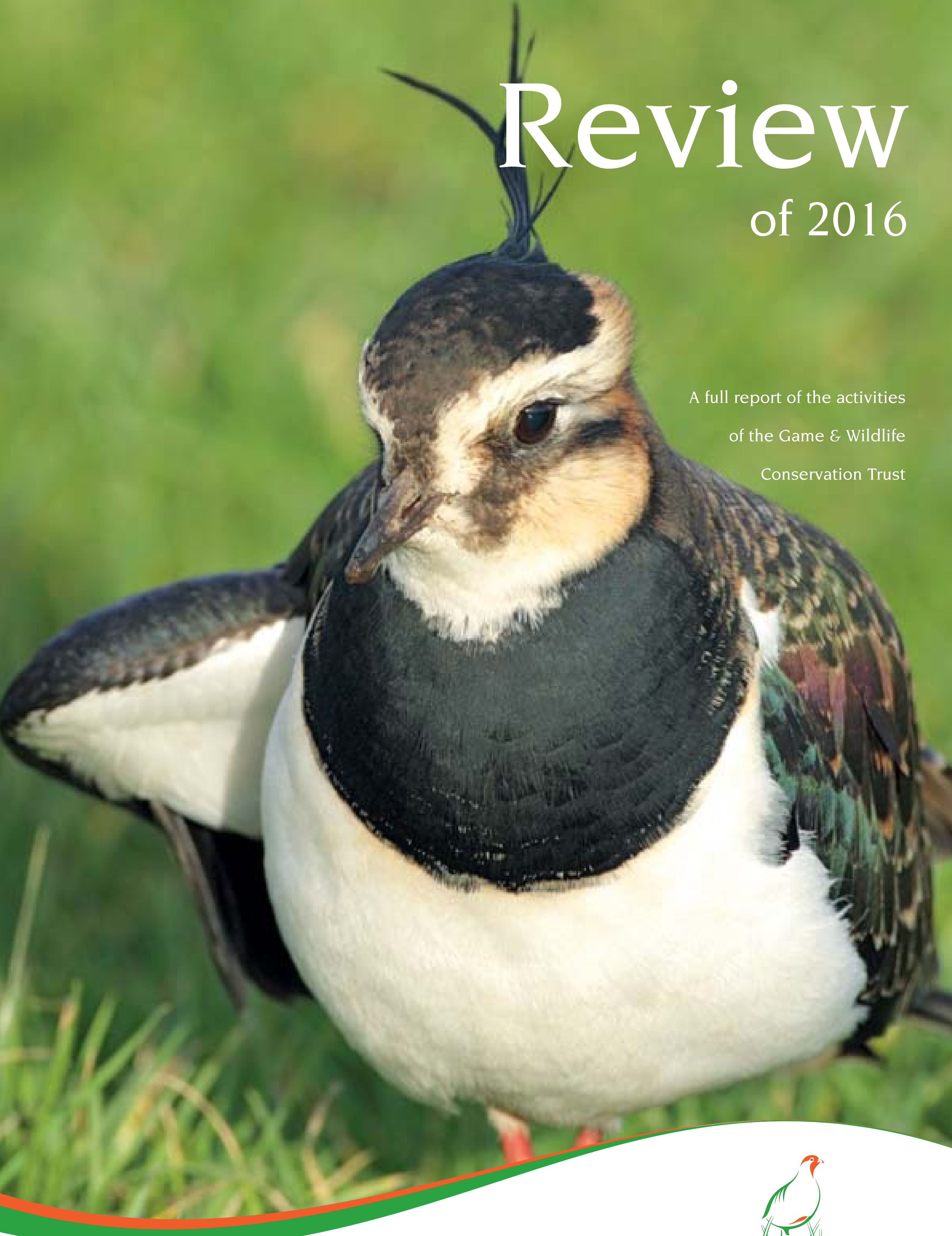
Review of 2016

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



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Game & Wildlife
CONSERVATION TRUST

Review of 2016

Issue 48

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

Produced by: Game & Wildlife Conservation Trust
Fordingbridge, Hampshire, SP6 1EF
Tel: 01425 652381 Fax: 01425 655848
info@gwct.org.uk

Editing, design, layout: Louise Shervington/James Swyer

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GAME & WILDLIFE CONSERVATION TRUST OBJECTS

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

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Game & Wildlife CONSERVATION TRUST

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Council
as of 1 January 2017

President and Vice-Presidents

Chairmen of GWCT county committees in 2016

Names in brackets were chairmen that stepped down during 2016

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George Richard (Dick) Potts 1939-2017

Dick Potts, who was director general of the GCT until 2001, had a passion for partridges and conservation – his ideas were considered pioneering and even before their time. © Charlie Pye-Smith

by Nicholas Aebischer, Deputy Director of Research and Nick Sotherton, Director of Research

Dick was born in 1939 to a farming family in north Yorkshire. From an early age, he took a keen interest in the wildlife on the family farm, particularly on how the severe winter weather of 1948 impacted on the birds.

He studied zoology at Durham University, where he specialised in ecology and entomology, as well as taking part two years running in a Durham University expedition to the Faeroes to study seabirds. After graduation, he undertook a PhD on the breeding ecology of the shag on the Farne Islands, Northumberland. He was lucky to have witnessed at first hand the devastating impact of a toxic algal bloom on seabirds. This reinforced his interest in environmental poisons, initially sparked from observations as a boy on the farm and pursued with the examination of organochlorine residues in shag eggs. Dick was always fascinated by the intrinsic and extrinsic processes that regulated bird populations. He wanted to understand why a species was in decline so that he could devise ways of reversing that decline. He brought this philosophy to his next post, a move to the chalklands of southern England, where he was tasked by The Game Conservancy Trust to unravel why the grey partridge was in decline and what could be done to turn this decline around.

The Partridge Survival Project started in 1968 in a Portakabin on North Farm, South Downs, West Sussex. With his farming background and ecological insight, he realised that to understand changes in partridge abundance, he needed to understand changes in the partridge environment. So began one of the most important, longest running and inspirational research projects on the ecology of partridges and arable farmland. From the Sussex work, Dick identified three main causes of the partridge decline: reduced chick survival through herbicide-induced reduction in chick-food invertebrates, lack of suitable nesting habitat reducing settling density, and poor nesting success arising from increased predation pressure. He brought them together in a computer simulation model to predict their relative importance and synergistic interaction, dubbing the trio the 'three-legged stool' on the grounds that if one leg failed, the partridge 'stool' would collapse.

At the same time, with his team of Drs Stephen Tapper, Paul Vickerman and Keith Sunderland, Dick initiated a detailed study of cereal ecosystems that became known as 'The Sussex Study'. Such work on farmland ecosystems was truly ground-breaking and controversial at the time, given that previous thinking on conservation concentrated on pristine habitats, not those worked by man to produce food, fuel or fibre. In 1974, he and Paul co-authored a seminal paper entitled *Studies on the Cereal Ecosystem* in the scientific journal

Advances in Ecological Research. It became the inspiration for a generation of ecologists who went on to amass a huge body of research. In partnership with Southampton University alone, at least 20 doctoral theses were written based on the cereal ecosystem and inspired by Dick's pioneering work.

In 1976 the Sussex team moved to The Game Conservancy Trust's headquarters in Fordingbridge, where Dick became the director of research in 1977. Through experimental work, he sought to verify the conclusions from the Sussex modelling and develop practical solutions that could co-exist with modern farming. This led first to the Cereal and Gamebirds Project, which developed selectively sprayed field margins known as 'conservation headlands', and mid-field tussocky grass strips known as 'beetle banks'. Farm-scale experimentation demonstrated the efficacy of such management in restoring invertebrate abundance and improving partridge chick survival, while agronomic studies evaluated practical farming issues. Second, the Salisbury Plain Experiment demonstrated conclusively that generalist predators affected not just partridge breeding success but also their breeding abundance, contradicting accepted ecological wisdom but in line with traditional gamekeeper lore. Meanwhile, the Sussex Study did not stop and annual monitoring continues to the present day, making it the longest-running study of farmland ecosystems in Europe, if not the world.

His passion for partridges continued unabated throughout his life. Most authors aspire to write one monologue on their chosen species. Dick wrote two, the first one in 1986 covering the Sussex story of partridges, pesticides, predation and farming, and the second one in 2012 ranging more widely across partridge species and their biology, published in the prestigious Collins New Naturalist series.

Dick was, however, by no means a single-species biologist. He turned his skills to conservation issues concerning other species including brown hare, red grouse, woodcock and lapwing. Research on these species has been taken up by GWCT staff and so our knowledge of game and associated species improves, thanks to Dick's original inspiration.

Dick's ideas were often viewed as pioneering, or even 'before their time', so it often took a while for the scientific community to catch up with them. Dick was talking about the pressures of modern farming affecting the survival of farmland birds 20 years before the Government or its agencies also reached this conclusion. But Dick never criticised farmers for their action. He did not play the 'blame game', he was more interested in what could be done to improve the situation. Dick always thought positively.

"For all of his working life Dick was told that thriving farmland wildlife could not co-exist with modern farming. Dick proved the doubters wrong – he was good at that"

Among Dick's original thoughts were:

- That pesticides operating via the disruption of the food chains of farmland birds could remove the insects eaten by chicks and also remove the host plants of these insects, thus causing a decline.
- That farmers and farming held the key to reversing the declines of farmland birds, and it was possible to devise management solutions compatible with modern agriculture.
- That the removal of common predators, seasonally and legally, could improve the breeding success and breeding abundance of ground-nesting birds both in lowlands and uplands.
- That raptor predation could put a stop to driven red grouse shooting and its associated benefits to upland breeding waders, so that a managed solution was needed to resolve the grouse-raptor conflict.

Dick became director general of The Game Conservancy Trust in 1993 until he retired in 2001. During that period, he oversaw the transformation of Lord and Lady Allerton's gift of Loddington Farm into an influential demonstration farm, where the Trust turned 'words into birds'. He was also the driving force behind the Joint Raptor Project, which quantified the impact of hen harrier predation on red grouse demography at Langholm Moor, in southern Scotland. He coined the phrase 'conservation through wise use', which became a byword for sustainable harvesting of game species. In retirement Dick remained active, continuing to work on his beloved Sussex study area and helping to bring about the remarkable recovery of the grey partridge on the Norfolk Estate there, after the estate set about implementing all of Dick's knowledge about grey partridges. For all of his working life, Dick was told that thriving farmland wildlife could not co-exist with modern farming. Dick proved the doubters wrong – he was good at that.

Also, in retirement, Dick worked with the World Pheasant Association (WPA), the Cranborne Chase Area of Outstanding Natural Beauty and the International Council for Game and Wildlife Conservation (CIC).

Almost up to his death, you could hear Dick's laughter and enthusiastic bubbly personality filling the corridors at the Fordingbridge HQ of the Game & Wildlife Conservation Trust, as he discussed the latest analysis of the long-term data from Sussex or how the lapwing were improving on the Norfolk Estate or how ground beetle assemblages were changing in the cereal fields of west Sussex.

Dick's drive, enthusiasm, vision and 'can do' attitude inspired several generations of scientists and his legacy will continue in the GWCT. He will be sorely missed.

2016 highlights

by Ian Coghill, Chairman and Teresa Dent CBE, Chief Executive

© Hugh Nutt

(Top) The hen harrier action plan includes a trial Brood Management Scheme. © Laurie Campbell

- The 49 Farmer Clusters in England now cover over 200,000 hectares between them.
- The Westminster debate on driven grouse shooting demonstrated the contribution fieldsports can make in the uplands.
- Brexit provides an opportunity for Britain to identify the ways it can change conservation policy for the better.

It is easy to look back on 2016 and see the big external milestones: first, at the end of January, the launch of the Hen Harrier Joint Action Plan; then the vote to Brexit in June; third, September's announcement that there were now 49 Farmer Clusters in England, and finally the debate on driven grouse shooting in Westminster Hall.

GWCT had worked for a Hen Harrier Joint Action Plan for many years. Dick Potts (our previous director general) advocated hen harrier quotas in 1998, and the Action Plan includes a trial Hen Harrier Brood Management Scheme – essentially the same thing. All credit to Dick for a solution that eventually everyone returned to. Equally, all credit to Defra for understanding that if a genuine problem is causing wildlife conflict, first one needs a remedy to the problem before one can resolve the conflict.

We all remember how we felt the morning after the Brexit referendum. For both of us the prevailing thought was 'my goodness, there is going to be an awful lot to do'. Defra estimates 80% of its business is framed by EU legislation, most of it relevant to how the countryside is farmed, the environment managed, how farmers, gamekeepers and land managers are regulated, and whether or not sensible wildlife management is permitted – so all relevant to the GWCT. Everything will be transferred lock, stock and barrel into UK law, plus the Government has pledged to honour subsidies and grants until 2020. Thereafter we face uncertainty. However, there will also be opportunity: no one is suggesting that EU regulation is perfect; the trick is to identify both the areas to change and the areas that will be better left.

The debate resulted from a petition calling for a ban on driven grouse shooting, which this year got the required hundred thousand signatures (the third year of trying).

The Westminster Petitions Committee chose to have a debate in Westminster Hall, and commissioned the protagonists to give oral evidence in advance to its committee members. GWCT submitted detailed written evidence (see **www.gwct.org.uk/petitionevidence**). Ironically, the Hen Harrier Joint Action Plan is designed to remedy the main issue that prompted the concern over grouse shooting – the persecution of hen harriers. The many speakers in the debate underlined that while grouse shooting ticks many boxes for biodiversity and its contribution to both the social fabric and rural economy in the uplands, we must get more hen harriers nesting in the English uplands.

A Farmer Cluster is a group of neighbouring farmers working together, voluntarily, to improve the conservation of wildlife on their farms. This concept grew out of a belief held, not just by the GWCT, but also by LEAF and FWAG, that farmland conservation schemes would deliver better outcomes if they were less 'top-down'. We called for schemes to be four things: bottom-up, farmer-led, landscape-scale and outcome-orientated. GWCT initiated a pilot (kindly funded by Natural England) in 2013 with five groups of farmers. It was immediately successful (we only had to make six phone calls to get five farmers to lead five separate Clusters). The Cluster concept moved rapidly into policy, with funding being provided from July 2015; the Facilitation Fund provides a Farmer Cluster with a wildlife advisor (chosen by the farmers), and funding for the conservation measures comes through Mid- and Higher-Level Agri-environment Schemes. Two application 'rounds' later, and there are 49 Farmer Clusters in England, involving nearly 2,000 farmers and covering over 200,000 hectares of farmland. This approach is set to become mainstream post-Brexit; we are proud of the role GWCT has played in its genesis.

In Wales there is a similar focus on landscape-scale, collaborative conservation with the launch of the Sustainable Management Scheme; it was great to see some of our members succeed in the first round. In Scotland our new research and demonstration farm has 'found its feet' in its second year (see page 70).

There are so many things happening and so much hard work; some of it set out in the pages that follow. We hope you enjoy our 2016 journey and we would like to warmly thank the trustees, every single member of staff, and our generous members and supporters for making it possible.

Our baseline monitoring work at Auchnerran is covered on page 70. © Marlies Nicolai/GWCT

Auchnerran, our new research and demonstration farm. © Marlies Nicolai/GWCT

Turning research into legislation

by Adam Smith, Director Scotland and Alastair Leake, Director of Policy

We had a good farming year at our Scottish Demonstration Project at Auchnerran and hosted a number of visits with people interested to find out more about the challenges we face.
© Marlies Nicolai/GWCT

Scotland

- Predation control for conservation and the contribution of land managers, was highlighted by the *Understanding Predation* report.
- We successfully informed the grouse shooting debate at Westminster.
- Our Auchnerran farm focused attention on the role of integrated farming and game conservation in supporting biodiversity.

Conservation and land management at times struggled to find a space among the debates over some truly international issues in Scotland in 2016. However, policy-making continued and the Trust's approach was to research and present the factual evidence of what we need from our countryside, and what farming, forestry and shooting can deliver. A consistent theme has been how private landowners are not being fully supported to deliver these goals. This message was relayed in consultation on the Land Reform (Scotland) Act, the Cairngorms National Park Plan and when we gave evidence at the Scottish Parliament in Holyrood on the modest performance of the Scottish Biodiversity Strategy.

The idea that practitioners have valuable 'local' knowledge on conservation of key species such as black grouse and wading birds was at the core of *Understanding Predation*, an important report from Scotland's Moorland Forum, which we steered and contributed to. The report identified a strong overlap between insight from local knowledge and peer-reviewed research on these species. It provided a strong base from which to undertake work with Scottish Natural Heritage. We began work on the *Principles of Moorland Management* best practice moorland management guidance and reviews of snaring and trapping, notably the replacement of the spring (Fenn) trap. We would like to thank our members and colleagues in other organisations for their support on these projects.

Our positions and insight into upland management, prepared with the combined efforts of the policy, research and public relations teams, were central to informing the debate over grouse shooting at Westminster in October. Upland conservation faced a real threat from partial, imbalanced lobbying. Had we left this unchallenged in raptor conferences and in front of politicians, the management that supports heather, mountain hares and golden plover, as well as red grouse could easily have been unjustifiably suppressed. We look forward to a debate that is more about developing better practice in the future. Such better practice includes our work on delivering practical conflict resolution. Although there remains much work to be done at the Langholm Moor Demonstration Project, the announcement of the Hen Harrier Joint Action Plan by Defra signals a clear intent to balance the needs of raptor and moorland conservation through better and novel practice.

Better practice is also the theme of the GWCT Scottish Demonstration Farm at Auchnerran in Aberdeenshire. On the back of one of the farm's best recent farming years, our farm manager was able to speak to the BBC with increasing confidence and we started the process of bringing Members of the Scottish Parliament (MSPs) to the farm. For those MSPs unable to travel to Aberdeenshire we brought a 'pop-up' farm to the GWCT Scottish Game Fair. We attracted 30,000 visitors, including six MSPs and the Cabinet Secretary for the Rural Economy to a celebration of sporting and land management; a fitting tribute to David Noble in his final year as fair director. Our

Golden Plover Award, run in conjunction with the Heather Trust, also highlighted the results of best practice moorland management integrated with hill farming.

The reception of our policy contributions, policy and public support for our projects, and the annual success of the Scottish Game Fair is very encouraging for game conservation in what remains a challenging Scottish policy environment.

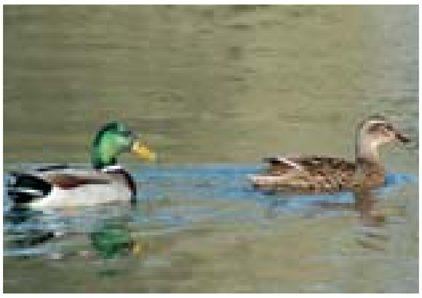
England

- There are no changes to the laws governing the use of lead ammunition.
- Codes of Practice were launched to improve welfare in the use of snares and rodenticides.
- There are new opportunities to develop farming and environmental policies.

We saw several challenges on the policy front during the year. After five years the remaining members of the Lead Ammunition Group (LAG) delivered their report to the then Secretary of State, Liz Truss. The group was unable to agree a common conclusion and around half resigned, including the GWCT, prior to the submission. The report stated that lead ammunition poses a risk to wildlife, has the potential to impact human health and that:

'An action plan is needed.... for a vigorous industry-led self-regulation of shooting sports; or alternatively, a clear directive from Defra and the Food Standards Agency (FSA)... developing statutory and regulatory measures for the restriction of lead in ammunition and replacement with alternatives'.

The Secretary of State responded, stating that this 'marked the end of the Group' and that: **"In both instances – human health and wildlife – the report did not show that the impacts of lead ammunition were significant enough to justify changing current policy; we therefore do not accept your recommendation to ban the use of lead ammunition."**



The importance of observing the law which bans the use of lead over wetlands and for shooting wildfowl generally (in England) has never been greater. © Peter Thompson/GWCT

Although this is clearly a reprieve for the use of lead in ammunition, the process has resulted in the Food Standards Agency updating its recommendations on game consumption, particularly aimed at those people who eat substantial quantities of lead shot game. Whereas current evidence of effects on wildlife in England may not be significant enough to force a change now, fresh evidence will emerge over time. It is the lack of evidence which undoubtedly persuaded the Secretary of State to advocate 'no change'.

The importance of observing the law which bans the use of lead over wetlands and for shooting wildfowl generally (in England) has never been greater. The remaining members of the LAG continue to meet and intend to re-focus their efforts on evaluating welfare impacts to wildlife as well as mortality.

In other areas self-regulation has proved an essential means of improving practice and removing the threat of restrictive legislation. Our predation department redesigned fox snares to make them more selective and humane, with the new breakaway snare meeting the Agreement on International Humane Trapping Standards (AIHTS). They also helped to devise a new Code of Practice. A debate in the House of Commons calling for a ban on snares moved the Minister, Dr Theresa Coffey, to announce the launch of this new Code as an alternative to an outright ban. Similarly, our advisory department has been running training courses to improve operator practice in the use of rodenticides to reduce the incidence of secondary poisoning. Importantly this allows us to continue to control rodents around wildlife feeders in the countryside.

Just as it is important that people observe the law on lead ammunition, so it is important that we improve our practice in the deployment of rodenticides and snares. Without this, withdrawal is a very real danger.

The UK's planned departure from the EU means that we can design our own agriculture and environmental policies. A lot of good policy work has already been done including Sir John Lawton's *Making Space for Nature* report and Sir John Beddington's Foresight report, *Future of Food and Farming.* Together these documents look at how we can improve our environment for nature and continue to grow food for the ever-expanding UK and global populations. We have always recognised the positive contribution that farmers and farming can make to the environment and we will continue to develop our vision for farming and the countryside.

Our departure from the EU means we can design our own agriculture and environmental policies. © Peter Thompson/GWCT

150 years of practical experience

by Roger Draycott,
Head of Advisory

Young shots enjoying a day at the Allerton Project shoot at Loddington. © Roger Draycott/GWCT

- Jennie Stafford adds much-valued expertise to our efforts in the north of England.
- 'Conservation through wise use' is clear to see at Rotherfield Park and the Allerton Project.

The primary role of the advisory department is to disseminate the Trust's applied research to farmers, land managers and gamekeepers to help them conserve and enhance the wildlife and habitats in their care. The small but growing team of experienced advisors, all passionate about the conservation of our countryside and with a wide range of interests, have over 150 years experience of practical farmland conservation and game management advice between them.

In 2016 we were delighted to welcome Jennie Stafford onto the team. Jennie is our new northern farmland biodiversity advisor. Jennie grew up on a farm in Northumberland and is an experienced farm conservation advisor having previously worked with FWAG and more recently as an independent advisor. Jennie is leading on a new partnership with the Duchy of Lancaster and Natural England. The aim of the project is to deliver landscape scale habitat improvement for wild pollinators and farm wildlife across the Duchy landholdings. This is one of a number of landscape-scale projects we are involved with and builds on our 'Farmer Clusters' – getting farmers working together over large areas and encouraging them to determine the conservation priorities and approaches for themselves. There are now 49 Clusters with facilitators funded through Countryside Stewardship across England. GWCT advisors support several of these providing training events on a range of issues from grey partridge conservation and farmland bird identification to predation control for ground-nesting birds. We also provide technical advice helping farmers set up Clusters of their own.

Jennie Stafford (left) is working with farmers in the north of England. © Roger Draycott/GWCT

Demonstrating good practice in all aspects of game management is vital for shoots to fully realise the environmental benefits that we know good game management can deliver. The GWCT is fortunate to run two lowland demonstration shoots at the Allerton Project at Loddington in Leicestershire and at Rotherfield Park in Hampshire. The aim of the Allerton Project shoot is to show how a small to medium-scale released pheasant shoot with a part-time gamekeeper can provide quality sport alongside significant wildlife recovery. Under the stewardship of Matt Coupe the gamekeeper and Austin Weldon our central England advisor, songbirds are almost double the level they were in 1992 when the GWCT took on the Allerton Project. We now run a wide range of game management training days for gamekeepers and shoot managers at the Project to complement the wide range of existing courses.

The aim of the shoot at Rotherfield Park Estate in Hampshire is to demonstrate how to build up a wild grey partridge population from zero and recover the wild pheasant stock from a low level, while simultaneously providing exciting and testing sport based on a mix of wild and released cock pheasants. Malcolm Brockless runs the shoot and shoot days are co-hosted by Francis Buner who co-ordinates the scientific monitoring. Again, wildlife is flourishing and both shoots are great examples of 'conservation through wise use'. All the shoot days at the Allerton Project and Rotherfield Park are auctioned at county events and the aim is to provide an enjoyable day's shooting, with the emphasis on quality rather than quantity, to learn a little more about the GWCT and see first-hand our approach to game and wildlife management.

A new Code for fox snaring in England

- Scientists, gamekeepers and farmers have played an important role in agreeing a new Code of Practice in England.
- Snare users must ensure that they are up to speed with the latest best practice recommendations.

by Roger Draycott, Head of Advisory

Snaring, when undertaken according to best practice guidelines, is an extremely effective and humane method of fox control. But poor practice in the field and using inadequate hardware can increase the risk of non-target capture and increase the likelihood that a captured animal may be injured. All responsible users of snares want to reduce the chances of this happening, so we were delighted to see the publication of a new Code of Practice for fox snaring in England in the autumn of 2016. This Code, nearly identical to the Welsh Code published in 2015, was written by the GWCT, NGO, Countryside Alliance and BASC and fully endorsed by Defra. It draws heavily on the research work undertaken by the GWCT's predation team. Since the previous Code was published in 2005, we have undertaken a considerable amount of research into the use of fox snares by different user groups, snare design, operating practices, selectivity and the condition of captured animals. We identified which practices led to a risk of poor welfare, and which designs help to minimise non-target captures. We also designed and tested a new snare.

Besides using quality materials, the new breakaway snare design included several features to increase selectivity, to avoid injury and death of retained animals, and to facilitate good operating practices. We then enlisted 34 professional gamekeepers to trial this snare for 12 months alongside whatever snare they ordinarily used. This work, published in 2012, demonstrated unambiguously that the new snare was much more selective than others, with no disadvantage in terms of fox captures. The work also showed that operating practices were critically important to the welfare of retained animals. In particular, it was essential to avoid places where a captured animal could entangle the snare with fixed objects like fences or saplings. The design of the GWCT snare makes it easy to use even in places that have no cover at all. Reassuringly, our own GWCT gamekeepers, Malcolm Brockless at Rotherfield Park and Matt Coupe at the Allerton Project, have been using a production version of the GWCT snare (available from Perdix Wildlife Supplies) for several years and they fully endorse them.

The new Code reflects our current state of knowledge and its publication was timely as it had already been submitted to Defra ahead of a debate on snaring in Westminster in July. Although we felt this debate was unlikely to trigger a change in legislation, any debate on snaring is important and represents an opportunity for GWCT to educate politicians, policy makers and the public. We prepared a detailed question-and-answer document and circulated it to over 60 MPs, with a number of MPs referring openly to our Q&A during the debate. The result was that Therese Coffey MP, Defra Minister, announced that Defra would formally adopt the industry-led Code of Practice as the way forward. We consider the wholesale adoption of the new Code by the entire snare-using community to be critical to the future continued use of fox snaring as a management tool.

This process of research, invention, practical application, policy work and education is an excellent example of how the GWCT works to help improve game and wildlife conservation in the countryside. The GWCT Advisory Service can provide further information and offers a training course for snare users which covers the new Code of Practice, recommended hardware and operating practices, as well as a comprehensive review of the GWCT science which underpins the new Codes. We strongly recommend all snare users attend a course to ensure that they are up to speed with the latest best practice recommendations. We also welcome feedback from snare users on how we can further improve snaring practice and hardware.

MORE INFORMATION

The latest Codes of Practice, research and advice for England, Wales and Scotland can be found at **www.gwct.org.uk/snaring**. To book a training course go to **www.gwct.org.uk/courses** or contact the Advisory Service on 01425 651013.

When they're handled and set correctly, the refined components and all-metal design of the GWCT designed snare make them virtually undetectable by foxes. They comply fully with the needs of the Codes. © Mike Short/GWCT

Vibrant and fun events

by Louise Jones,
Fundraising

A packed year of exciting events raised a staggering £1.3 million. © Josh Harrison Media

2016 has been another packed year of events for the fundraising team, holding just under 120 events and raising a staggering £1.3 million. GCUSA raised a superb £284,000 from its 30th anniversary New York auction. Sir Max Hastings spoke on behalf of the Trust and guests bid for shooting days in Sussex, Windsor, Spain and America. This was only made possible by our generous donors and the deft co-ordination of fundraising director, Edward Hay.

London continued to build on its reputation for vibrant and fun events with the 11th Le Gavroche dinner, kindly hosted by Michel Roux Jr, raising a fantastic £80,000 and the hugely successful 37th London Ball at the Dorchester, raising £180,000.

GWCT fundraising would not be possible without the dedication and commitment from our county chairman and committees, who voluntarily give their time to organise and run events. In turn these events could not run without the continued support of our members, and the generosity of our donors and local companies who sponsor our events. Thank you all for your on-going support. Below is a sample of the many and varied events run in 2016:

- The Cornwall committee launched the Cornwall Grey Partridge Recovery Project at the Royal Cornwall Show. The project is unique as it is funded by local donations secured by the committee.
- The North Yorkshire committee had a remarkable year raising a record £103,000. This amount is mainly attributed to the Swinton dinner which raised £68,000 and a clay shoot shared with the Army Benevolent Fund.
- Taunton Racecourse hosted a race day raising £8,000 and Kent held a clay day at Detling raising £70,000, split with the Demelza Hospice Care for Children. The winners of a 'Best of Essex' draw enjoyed a drive on four of the best shoots in the county and Northamptonshire ran a raffle for eight young shots to win a day at the Allerton Project shoot at Loddington.
- Twenty teams battled it out at the Thruxton go-karting race day in Wiltshire and Oxfordshire held a dinner at Highgrove and raised more than £27,000. Buckinghamshire raised more than £5,000 at its popular ferret racing evening.
- The Lancashire and Cumbria committees ran the Underley Team Challenge where teams took part in events such as clay shooting, quad biking and digger driving.
- The Nottinghamshire committee organised a wonderful Best of British summer picnic concert in July with classical chart toppers Blake and Rebecca Newman performing. £70,000 was raised with proceeds divided between the GWCT, NSPCC and the Lincs and Notts Air Ambulance.

Our clay days continue to grow in popularity and an advisory walk was held in almost every county over the summer. Thank you to the owners of the estates and farms who allow the Trust to showcase their work and demonstrate the wider conservation benefits to our countryside. Our sweepstake initiative continues to build, with individuals and syndicates across the country raising more than £100,000 through donations.

2016 saw the retirement of Edward Hay. Edward built the county committees and fundraising team into a very successful arm of the Trust, generating its biggest income stream, membership recruitment opportunities and a strong platform for communicating our message and research to the wider public. His boundless energy and resourcefulness will be greatly missed. Jeremy Payne took over his role in January 2017.

Shoot walks are immensely popular with one held in almost every county.

The Underley Team Challenge was great fun for all the family and raised more than £7,000.

We are reporting on the first results from our Scottish Demonstration Project at Auchnerran. © Marlies Nicolai/GWCT

The hallmark of GWCT research

by Nick Sotherton
Director of Research

The *Review* reports and showcases some of our research work undertaken over the last year. A recent feature of the *Review* has become an analysis of data from our National Gamebag Census (NGC) (see page 40). This unique dataset, brought together by the GWCT from the annual bag returns from a dedicated band of contributors (more than 650 in the 2015/16 season), enables us to report on trends in indices of abundance of a range of quarry species and their predators. Nicholas Aebischer reports on the six species of deer found in the UK and, for the first time, on wild boar now that they are established in some areas of Britain. The increases in some species are quite remarkable.

For the first time, we report on our new demonstration farm at Auchnerran in Aberdeenshire, unreasonably labelled by some of us 'McLoddington' (see page 70). Its importance will be stressed in other reports, but the research team will monitor changes in game and wildlife following the implementation of management changes on the farm. Such a long-term commitment to data collection is the hallmark of GWCT research. It might take a decade to produce informative trends in species abundance but in the long-term, such information is invaluable.

Our conservation work with declining species is also a hallmark of our work. In this *Review* we report on our work on capercaillie, lapwing, woodcock and swallow, all species needing conservation research and action to halt their declines.

In 2016, two of our PhD students successfully defended their theses and were awarded their doctorates. We also supervised 10 MSc students, nine of them achieved merits/distinctions for their projects. We congratulate them all and wish them well in their future scientific careers.

Wild boar are now established in some areas of Britain. © Dave Kjaer

We looked at the effectiveness of fallow plots for breeding lapwings (see page 24). © Andrew Hoodless/GWCT

River Frome salmon population

Frome parr: salmon (bottom), trout (middle) and potential salmon/trout hybrid (top). © *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 full river coverage PIT-tag systems in 2002 facilitated the study of life history traits of salmon and trout at not only population level, but also at the level of individuals. The PIT-tag installation also enabled us to quantify the smolt output. The River Frome is one of only 14 index rivers around the North Atlantic to report on the marine survival of wild salmon populations to the International Council for the Exploration of the Sea (ICES).

Smolts

Traditionally, smolt trapping at East Stoke starts on 1 April but in 2016 we started a week earlier because sea trout smolts start their migration earlier than salmon smolts and the first young-of-the-year trout tagged in 2015 were expected to migrate to sea in 2016.

Nearly 2,900 salmon smolts were caught in the trap and the total salmon smolt run in 2016 was estimated at 9,534 (see Figure 1), which is slightly up on the five-year average (9,033) but a little down on the 10-year average (10,597). In an average year, 10% of the fish caught are tagged but in 2016 only 8% were tagged, which reflects the difficult river conditions during the 2015 tagging campaign where we fell 1,500 salmon parr short of deploying the targeted 10,000 tags.

In addition to the salmon smolts detected, just under 80 trout smolts were detected, the first fish from our new trout research programme. However, the bulk of trout tagged in 2015 (2,700+) are expected to emigrate in 2017 as most Frome trout spend two years in the river before smolting, unlike the salmon where 98% smoltify after just one year in the river.

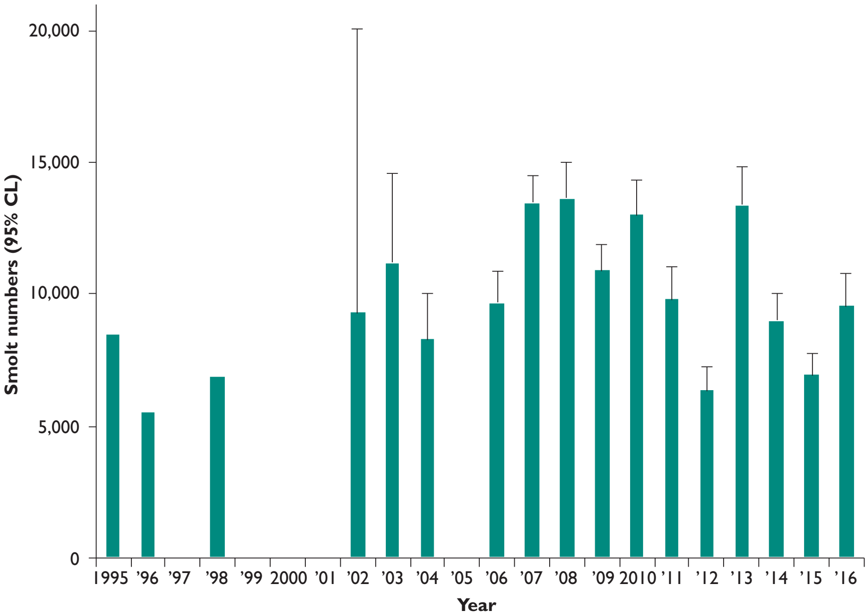
Adults

The early run of multi-sea-winter salmon returning to the Frome was strong in 2016, whereas most grilse were late migrating past East Stoke in autumn. These late grilse will most likely have been in the lower river since the summer – this is a well-known pattern on the Frome but is particularly pronounced in years with dry summers, like 2016. Overall, the run of adult salmon was average (see Figure 2) but exceeded the conservation limit unlike 2013 and 2014.

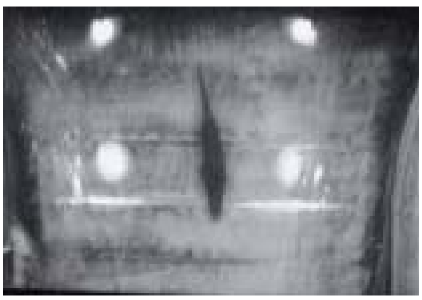
2016 marked the return of the first cohort of grilse with our new tags. The new tag system proved itself very successful with an adult detection efficiency of more than 95% for the systems at East Stoke. This is a big improvement on our old PIT system which

Figure 1

Estimated spring smolt population 1995-2016



An otter captured crossing the salmon counter in July last year. © *GWCT*



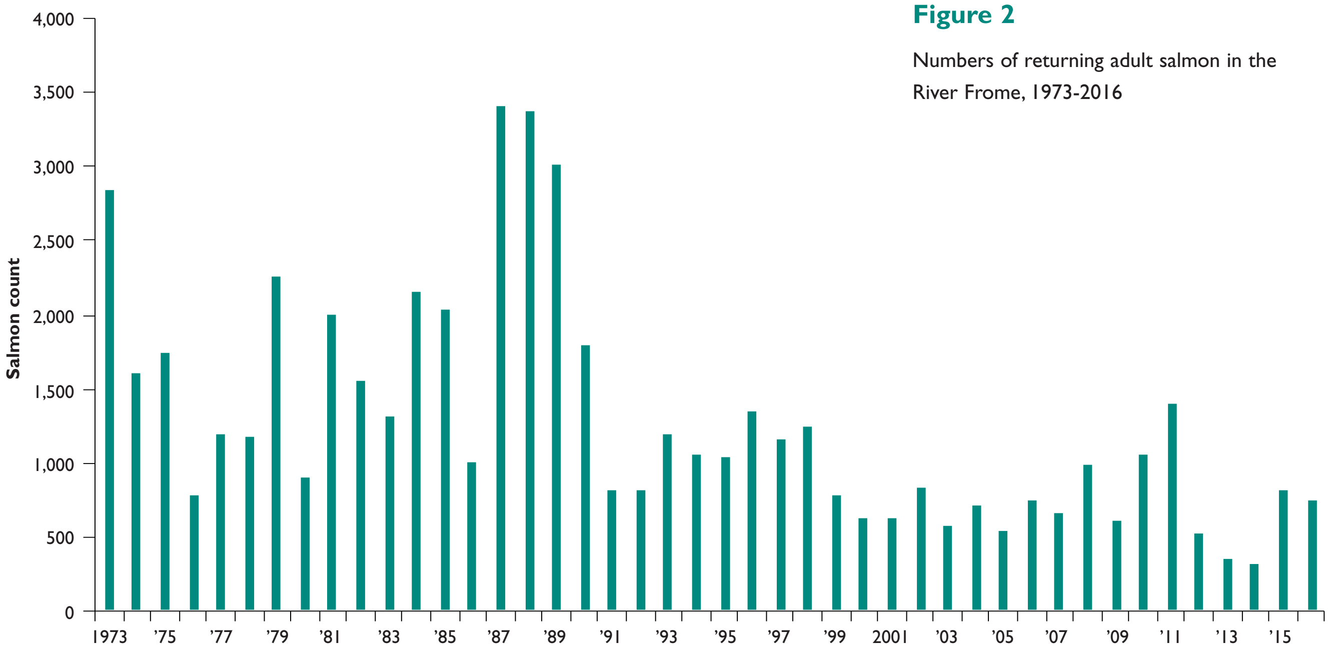


Figure 2

Numbers of returning adult salmon in the River Frome, 1973-2016

was designed for smolt detection and operated at approximately 50% efficiency for adults. This will greatly improve the quality of the data that we collect on returning adults.

Parr

We had excellent river conditions for our annual autumn parr tagging campaign with predominantly dry weather and a low river, yet we caught low numbers of salmon parr at most sites. This resulted in us tagging only half the targeted 10,000 salmon parr. Poor recruitment of salmon from the 2015/16 spawning season has been observed in many rivers across England and Wales so it appears to be a national, rather than a local, phenomenon. One thing of note during the 2015/16 spawning season was the warm weather during early winter. The high air temperature was reflected in very high water temperatures in the Frome where the average water temperature for December was 10.8°C. This was the highest December temperature recorded in the last decade, 3.4°C warmer than the average and 1.8°C warmer than the second warmest, recorded in 2006. The high water temperatures during spawning and early egg incubation may well have had a negative impact on egg survival and, therefore, parr recruitment.

The true measure of freshwater productivity is the smolt output and as salmon in the Frome only spend one year in freshwater before smolting, the parr from the 2015/16 spawning season will smoltify in the spring of 2017. The proportion of tagged smolts in the 2017 smolt run will tell us whether the density of parr in the catchment was low or whether our catch efficiency was poor. If the density of parr was indeed low in 2016, then it is possible that there will be compensation in the form of higher over-winter survival due to lower competition. With the PIT systems on the Frome we can determine this by the redetection probability (survival) of the tagged individuals and we are therefore in a unique position to answer such questions.

Electro-fishing and tagging salmon smolts. © GWCT

KEY FINDINGS

- Our new PIT-tag system of marking fish proved itself very efficient (90+%) at detecting returning adults as well as smolts.
- Parr densities recorded during 2016 tagging were very low indicating poor recruitment from the 2015/16 spawning despite good numbers of returning adults, a phenomenon reported across the UK. However, on the Frome we are equipped to determine the smolt output and any effect of parr density on survival to the smolt stage, which we will report on in 2017.

Rasmus Lauridsen

ACKNOWLEDGEMENTS

We thank Cefas for help with parr tagging and are grateful for financial support from the Environment Agency and Jock Miller for our salmon work.

Salmon redd spawning study

Salmon return to our rivers from October to December. © Laurie Campbell

BACKGROUND

Elinor Parry completed her Masters in research last year at Cardiff University, working with the GWCT's Salmon and Trout Research team at East Stoke, Dorset. She spent six months analysing a long-term dataset on the location of salmon redds on the river Frome and the effect river flow may have on redd distribution.

KEY FINDINGS

- The location of Atlantic salmon redds (egg-laying sites) varies across the Frome, with densities increasing until the middle reaches of the river, after which they decline.
- This pattern in redd density throughout the Frome changed over time, and was affected by flow during the critical spawning migration period (October and December) each year.
- As flow decreased, the redds became aggregated in the middle reaches. As flow increased from these drought conditions, redd density became more evenly distributed across the river.
- Under extreme low flows, high redd density may lead to poor salmon recruitment, as juvenile salmon survival is density-dependent.

Elinor Parry
Stephen Gregory

Whereas the rest of nature seems to be slowing down in autumn, below the river surface one of Britain's long-distance travellers is busy returning to our waters. Atlantic salmon can travel as far as the coast of Greenland in search of food and each year return to their natal river to breed. Once the females find an area of fast flow and clean river gravels, they spawn within a shallow depression in the gravel which they excavate with their tail. These nests, known as redds, can contain thousands of eggs and the future of the river's salmon. Few females survive to mate again, so reaching the river and locating suitable spawning grounds is crucial not only for each individual, but the survival of the river population. Over the past 30 years, the Environment Agency has been gathering data on the distribution of redds along the Frome, and our task was to understand how river flow may be affecting this distribution of redds. Understanding where salmon spawn is important for conservation, because the survival of juvenile salmon is highly density dependent. Under extreme low flow, it is possible that salmon may struggle to reach spawning grounds further upstream. This could lead to more redds in the middle reaches of the river, and a more competitive environment for emerging fry.

We aimed to answer two questions regarding Atlantic salmon redds and flow: firstly, is there a pattern in redd distribution over time, and secondly, does this pattern in redd density change with flow. To do this, we created a database of salmon distribution along the Frome by collating data between 1980 and 2015 from old maps, river bailiff totals and the modern redd distribution surveys. We then had to decide, crucially, what time of year over which to summarise flow. After discussions with other researchers, it was agreed that we should use average flow during October to December each year because it is the most crucial time period for salmon migration to the spawning grounds.

Using statistical modelling techniques, we were able to reveal both a pattern in redd distribution and that this pattern was related to river flow. We found that salmon redds gradually increased in number until the middle reaches, after which they decreased. This was expected as good quality habitat, such as ample river gravels and fast flowing riffles, are present in the main river and middle reaches of the Frome. We then analysed how flow may be affecting this distribution. What we found was that under extreme low flows, redd density increased in the middle reaches, and as flow increased the distribution of redds became more uniformly spread across the river.

Spawning salmon are less likely to access spawning grounds higher in the Frome catchment when there is insufficient water in the river. © Laurie Campbell

ACKNOWLEDGEMENTS

We would like to thank Nicole Caetano and Andy Martin of the UK Environment Agency, the Frome, Piddle and West Dorset Fishing Association, the Weld Estate and Casterbridge Fisheries Ltd. This work was part-funded through an EU Knowledge Exchange Skills Scholarships grant awarded to Elinor Parry.

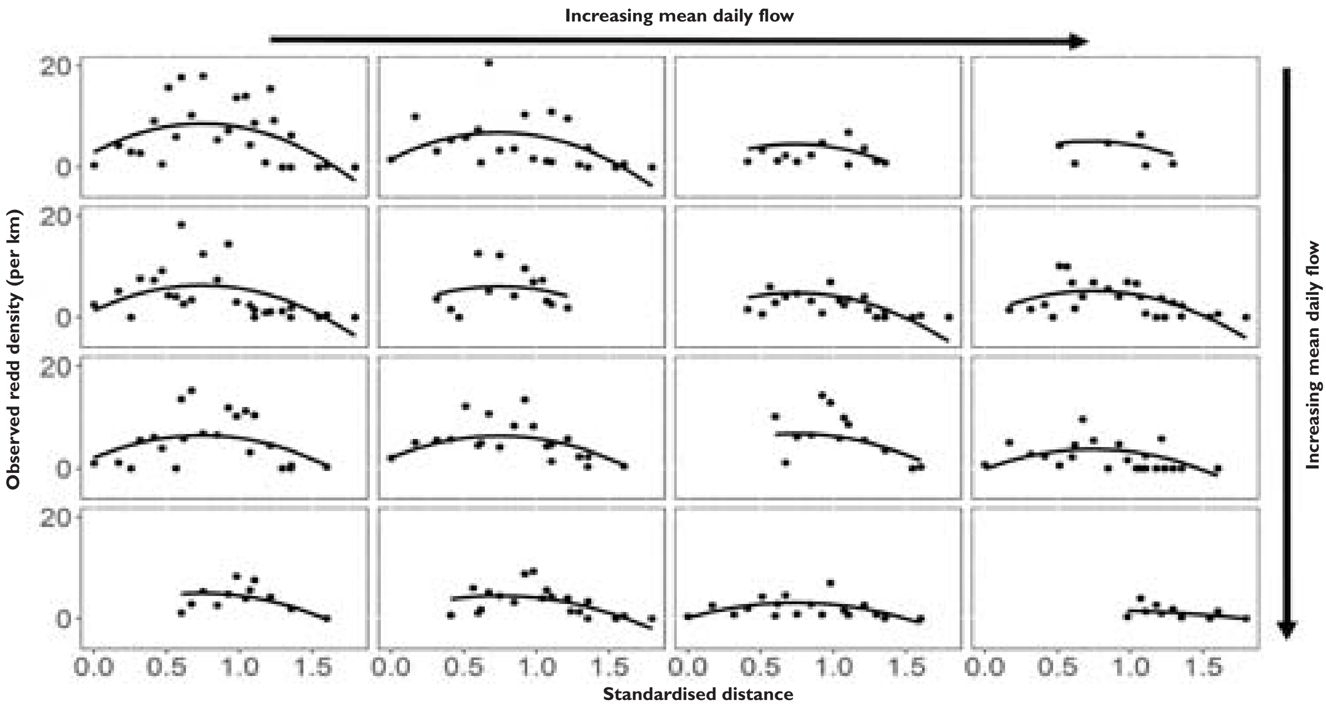
Therefore it seems that adult salmon tend to spawn within the middle of the river reaches under drought conditions. Perhaps they are aggregating under potential barriers, such as weirs, or perhaps some areas of the river, such as the lower reaches, tributaries and upper reaches, are too shallow for spawning. Under extreme high flows, low numbers of redds are found throughout the river. Although this may be due to the difficulty in locating redds under high flow, it is also possible that sedimentation and rough water may cause problems for salmon attempting to spawn in the river. Salmon may struggle to bounce back from their current decline, as climate change predictions suggest that drought and flood events will increase over the next century.

Understanding how flow is affecting salmon spawning behaviour will enable us to act to aid the species recovery. Improved access to upper reaches through carefully managed abstraction regimes, collaborating with farmers to reduce sedimentation and further improvements to our rivers will help to curb the effects of future climate change on this incredible migratory fish.

This study and its recommendations are now published in the international peer-reviewed scientific journal *Ecology of Freshwater Fish* http://onlinelibrary.wiley.com/doi/10.1111/eff.12330/abstract.

Figure 1

Plots showing redd densities against standardised distance from the tidal limit. Each panel represents a different year characterised by a measure of mean daily flow from 1 October to 31 December, and panels are ordered from low (top left) to high (bottom right) flow. Lines are the 'top-ranked' model fits. As flow and distance were standardised, no units are specified for these variables



Gapeworm in pheasants

Gapeworm can be picked up from infected soil and is capable of reducing pheasant body condition. © *Peter Thompson/GWCT*

KEY FINDINGS

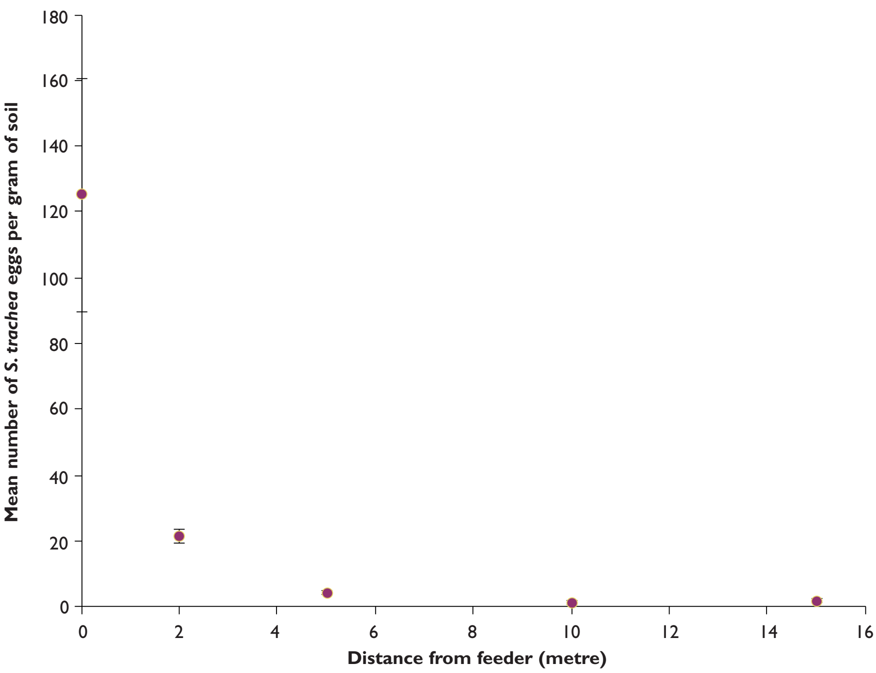
- In pheasant release pens, gapeworm eggs were highly concentrated within two metres of feed hoppers.
- Post-mortem examination of released pheasants found that body condition declined as gapeworm infection increased.

Owen Gethings
Rufus Sage

We undertook a field study from July to October 2014, to determine the spatial distribution of gapeworm eggs and larvae in the environment on two estates releasing pheasants. Five release pens (average size 3.32 acres ± 1.32 acres) were chosen per estate and the pens were split into 25 square metre quadrats. Quadrats were then designated as either 'feeder' or 'no feeder' depending on whether they contained a feed hopper, and were then compared for differences in the number of gapeworm eggs and larvae. Mean egg abundance was significantly higher in quadrats that contained a feeder (mean = 87.1 ± SE = 14.6 eggs per gram (epg)) when compared with empty quadrats (mean = 7.64 ± SE = 0.87 epg). A similar pattern was observed at site 2, with a higher abundance of eggs per gram of soil between quadrats with feeders (mean = 298.80 ± SE = 48.1 epg) and without feeders (mean = 10.13 ± SE = 1.08 epg). Eggs were clearly highly concentrated around feed hoppers. However, the number of eggs decreased rapidly with increasing distance from the feeder. The number of eggs decreased on average by 74% within the first two metres at site 1 (see Figure 1), and by 93% at site 2 (see Figure 2). The differences between sites may represent differing management techniques. Site 1 moved their feed hoppers

Figure 1

Distance from the feeder and the mean abundance of *S. trachea* eggs for all pens at site 1



Looking down a microscope at Syngamus trachea *parasites.* © *Owen Gethings/GWCT*

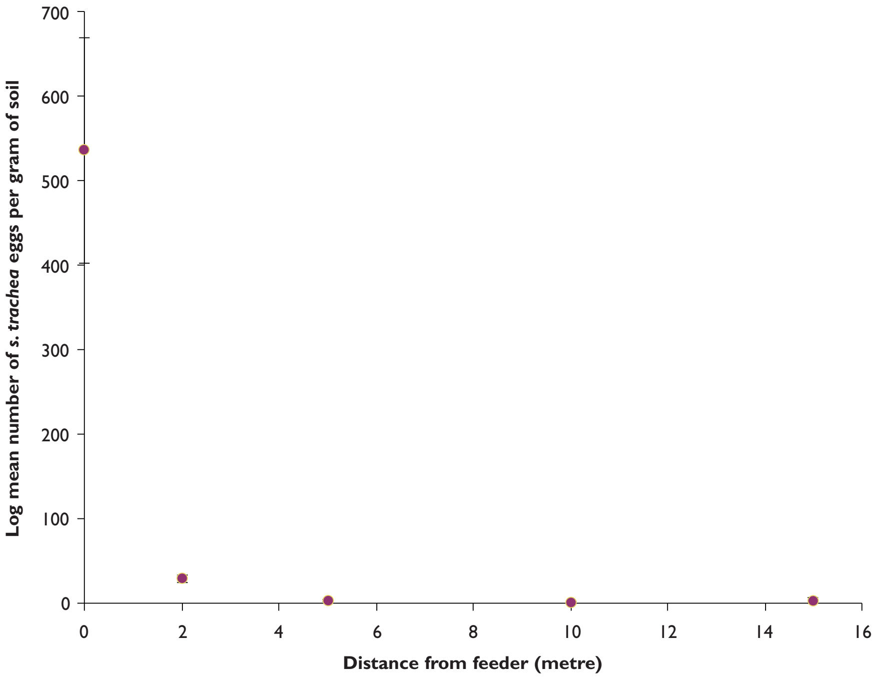


Figure 2

The number of *s. trachea* eggs per gram of soil at site 2

frequently, compared with site 2 where hoppers were left in place for ease of access. These results highlight the importance of hygiene around communal areas and demonstrate how simple management techniques such as avoiding faecal/grain contamination, may help reduce disease risk to released birds.

Though we now have a greater understanding of the epidemiology of gapeworm, very little research has determined what effect gapeworm is having on pheasants. Detailed post-mortem examination of 180 released adult pheasants was conducted to answer this question. Birds were weighed and their tarsus length measured to obtain a body condition score by dividing body mass by tarsal length which controlled for body size, and the number of gapeworms per bird were counted. Pheasants infected with *Syngamus trachea* were in poorer condition than uninfected birds. Birds lost, on average 26%, (range 10-40%) of their condition (see Figure 3), losing more as the number of gapeworms per bird increased. These results suggest that gapeworm is capable of reducing pheasant body condition, which may have implications for survival and reproductive success of pheasants following release.

BACKGROUND

The gapeworm *Syngamus trachea* is a highly pathogenic parasite of many bird species, and is arguably the most economically important parasite of released pheasants. Infection with *S. trachea* can occur either directly by the ingestion of worm eggs or infective larvae, or indirectly by the ingestion of an infected invertebrate host, most commonly an earthworm. This presents a number of challenges to gamekeepers because infectious eggs and larvae can build up over time in the environment making it a difficult disease to get under control. An understanding of how this parasite is distributed spatially on estates might enable gamekeepers to mitigate disease risk with alternative management techniques, potentially moving away from the use of anthelmintics (worming drugs). Parasites in the rearing system can reduce pheasant growth rates and condition, and though gamekeepers are aware of the losses associated with heavy gapeworm infections, very little is known about the effect of different levels of infection by this parasite on pheasants.

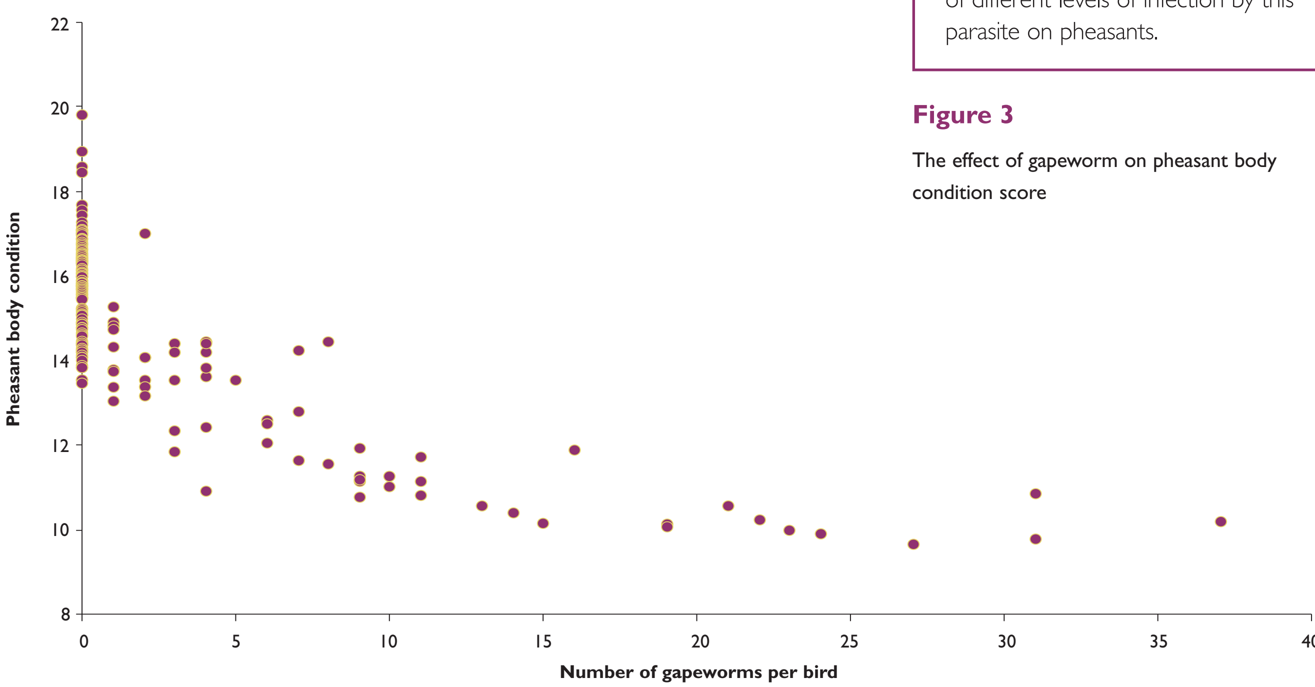


Figure 3

The effect of gapeworm on pheasant body condition score

Magpie predation on songbirds

Songbird nests near to magpie nests were more likely to be predated. © Peter Thompson/GWCT

KEY FINDINGS

- We found that artificial nests were heavily predated by particular individual territorial magpies.
- One third of 520 artificial songbird nests placed in hedgerows on a mixed farmland site were predated.
- At least 45% of these were predated by medium-sized birds. Cameras on one third of these nests identified magpie in 90% of cases.
- The data also suggest that songbird nests near to magpie nests were more likely to be predated.

Lucy Capstick
Rufus Sage
Joah Madden

To examine any potential difference in nest predation behaviour between territorial and non-territorial magpie individuals, we placed artificial nests in hedgerows adjacent to active magpie nests (magpie nest present) and at least 200 metres from magpie nests (magpie nest absent). This is a recognised technique used to gain an understanding of the pattern of nest predation and the identity of nest predators without disturbing natural nests. Both old songbird nests and man-made nests were baited with real and wax-filled quail eggs and approximately one-third of nests were also monitored by motion-activated trail cameras. A predator attacking a wax egg leaves an imprint, such as a beak or bite mark, and can therefore be identified.

At each site, five nests were placed along a hedgerow (hereafter, a transect) and left for five days. In 2015, three blocks of eight transects (four in magpie nest present sites and four in magpie nest absent sites) were set out, only once, in May and once in June. In 2016 transects were set out in five blocks of four (two in magpie nest present sites and two in magpie absent sites) each repeated four times from April to July. In total 520 nests were placed across the field site, a 1,500ha area of mixed farmland in Warwickshire.

Dunnock. © Peter Thompson/GWCT

TABLE 1

Predators identified predating artificial nests using either trail cameras at the nest or marks left on wax eggs

Year	Source of evidence (n)	Predator identified (%) Jackdaw	Jay	Magpie	Mammal	Rodent	Small bird	Unknown	Medium bird
2015	Camera (5)	0.00	0.00	3.01	0.00	0.00	0.00	0.00	0.00
	Wax (28)	0.00	0.00	0.00	0.00	0.60	0.00	8.43	7.83
2016	Camera (32)	0.60	0.60	8.43	0.60	3.01	1.20	3.61	1.20
	Wax (101)	0.00	0.00	0.00	0.00	7.83	1.81	27.71	23.49
Total	**(166)**	**0.6**	**0.6**	**11.4**	**0.6**	**11.4**	**3**	**39.8**	**32.5**

In total, 30% of nests were predated. We looked at the marks made on the wax-filled eggs and at the photos from the trail cameras to identify the predators. Medium-sized birds were identified as predators of 45% of predated nests, small mammals of 11%, and in 39% of nests predators were unidentifiable. Corvids were the only medium-sized birds seen predating nests on camera (90% of these were magpies). We therefore believe that magpies were the most frequent predators of our artificial nests. There was a difference in corvid predation between magpie nest present (corvids suspected in 50% of cases) and magpie nest absent transects (corvids suspected in 39% of cases).

We found that slightly more nests were predated in magpie nest present sites (32% of all nests) than in magpie nest absent sites (25%). This may indicate that territorial magpies are more likely to predate nests. As individual magpies were colour-ringed as part of this project, we could identify which magpies were predating nests. We found that the territory holders took the nests inside their territories.

This difference in predation between magpie nest present and nest absent sites was greatest in July (just after the magpie young had fledged). In 2016 more nests were predated in open hedgerows compared with hedges with a denser structure. In denser hedges the nests may have been better concealed and harder to find.

However, the biggest factor explaining difference in predation between nests was the specific location of transects. Transects placed in some magpie territories suffered significantly heavier predation. This happened each time nests were placed in those territories. It may be that there was unexplained habitat variation which made some locations more susceptible to predation, but it seems possible that some individual magpies predate nests much more than others.

This type of research may help inform more effective, better targeted, management of corvid numbers, potentially benefiting Britain's threatened songbirds. It may also show how management for game species can help prevent declines of other species.

BACKGROUND

The numbers of many farmland songbirds continue to fall, despite widespread conservation efforts. This decline has coincided with the growth in numbers of many songbird predators, including corvids such as magpies and crows. However, it is unclear whether or not predation by these greater numbers of corvids has contributed to the decline in songbird numbers. One reason for this unclear picture is the suggestion that some individual corvids take many eggs and nestlings from songbird nests whereas other individuals take very few or none. This project aimed to investigate whether individual corvids differ in the extent to which they predate songbirds.

Some individual magpies seem to predate nests much more than others. © Peter Thompson/GWCT

ACKNOWLEDGEMENTS

This work has been funded jointly by Songbird Survival and the University of Exeter, in collaboration with the GWCT. We would like to thank the Phillips and Glover families for allowing field work on their farms.

Breeding wader recovery in the Avon Valley

© Lizzie Grayshon/GWCT

An old, re-vegetated scrape (left) and a recently dug one (right). Scrapes with bare mud provide increased chick foraging habitat away from field edges.

ACKNOWLEDGEMENTS

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

Waders for Real

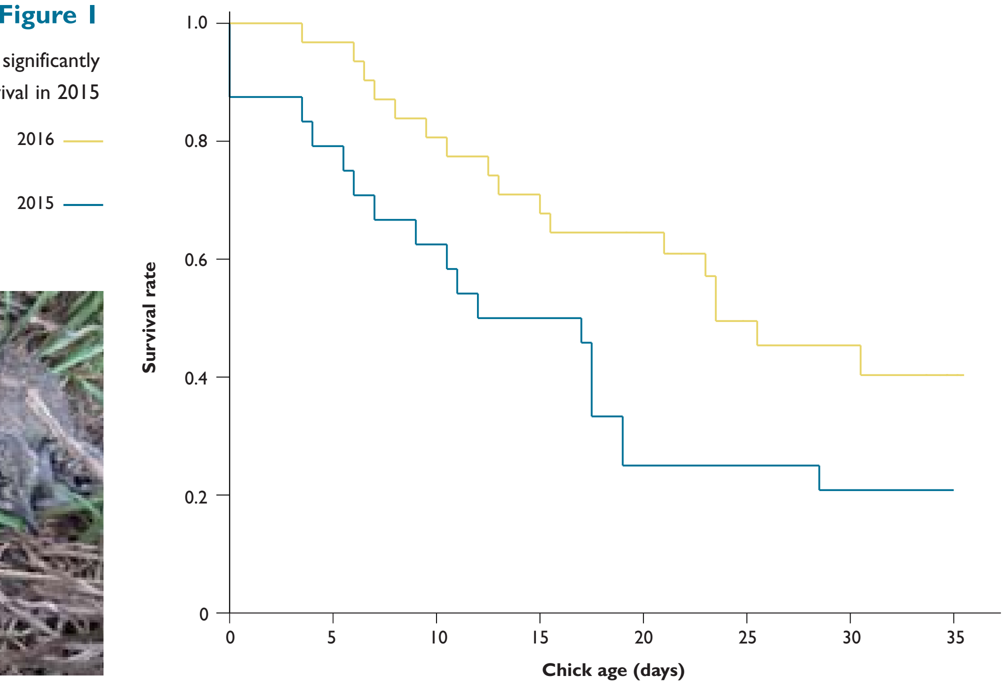
The Avon Valley is typical of lowland river valleys where breeding waders were once numerous and are currently a conservation priority, but where reducing predator impacts is constrained by the landscape and multiple land ownership. The 'Waders for Real' project combines a local farmer-led initiative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

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

We have removed 1.3 kilometres (km) of old fence lines, 1km of willow scrub and 14 small trees to open up some of the smaller fields and reduce the number of perching posts for corvids. This creates open areas where sward structure can be better managed to encourage lapwings to nest in loose colonies. We have re-profiled 2.9km of ditches, dug 1.6km of new ditches and created 23 scrapes to add more in-field wet features. These are providing increased chick foraging habitat away from

Figure 1

Lapwing chick survival in 2016 was significantly higher than survival in 2015



Lapwing chicks. © Lizzie Grayshon/GWCT

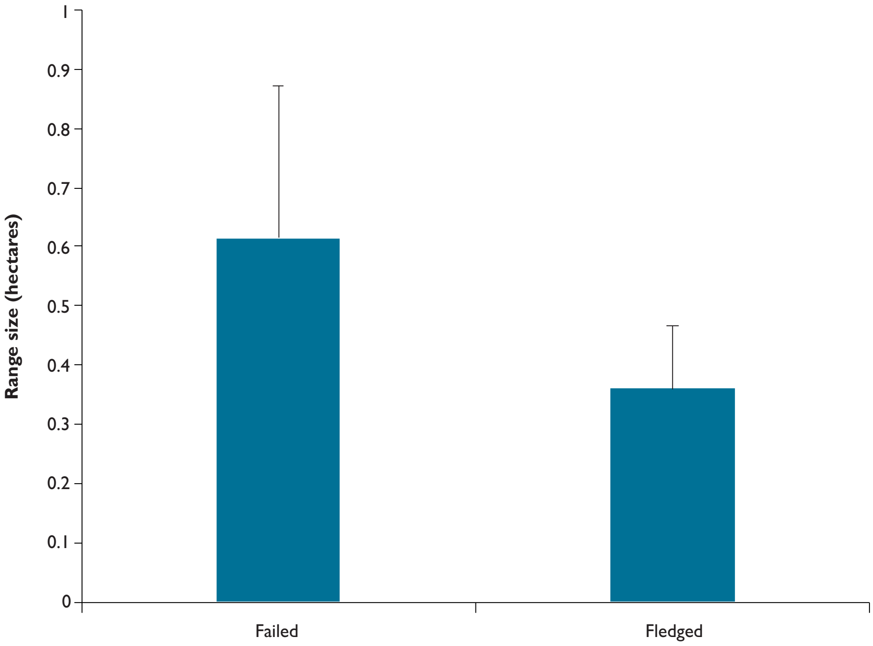


Figure 2

Mean range size (ha ± 1 se) of lapwing chicks which failed to fledge (n=14) was significantly higher than of chicks that fledged (n=15) in both 2015 and 2016

field edges, because the edges are often used by mammal predators when hunting. Patches of rushy cover near scrapes create a more complex habitat, providing escape areas for chicks from avian predators close to damp, open areas for foraging.

We recorded an increase in lapwing pairs from 62 in 2015 to 81 in 2016 and an increase in redshank pairs from 19 in 2015 to 28 in 2016. This is likely to have been the result of increased recruitment following a good breeding season in 2014 and wetter field conditions in spring 2016 (soil penetrability 6.9 ± 0.2 in 2015, 5.1 ± 0.2 in 2016). Samples of 58 and 64 lapwing nests were located in 2015 and 2016 respectively, with nest survival increased above the average from years preceding the project (50% in 2015 and 45% in 2016 compared with an average of 35% for 2008-2014).

To provide reliable estimates of lapwing chick survival, information on chick movements and the use of new scrapes and shallow ditches, we radio-tagged one chick in each of 25 lapwing broods in 2015 and 27 broods in 2016. The average age at the time of tagging was nine days. Survival up to 35 days (age of fledging) was estimated at 17% in 2015 and 46% in 2016. We believe that chick survival was higher in 2016 (see Figure 1) because field conditions were wetter and broods typically ranged over smaller areas from where they hatched to find food and cover. Chick survival in both years was inversely related to range size, meaning that the further the distance travelled the more likely to be predated, hence justifying the creation of new in-field wet features in fields favoured for nesting (see Figure 2).

Lapwings need an average productivity of 0.7 chick per pair per year to maintain stable numbers. In 2015, total productivity was 0.29 chick/pair, with the low value attributable to high levels of chick predation. 2015 was a particularly dry year and many wet features had dried out by the time nests had hatched, so chicks had to move further to find suitable foraging conditions. Productivity on four core sites was only slightly higher at 0.30 chick/pair. In 2016, total productivity reached 0.63 chick/pair and in the core sites productivity reached 0.78 chick/pair. Nest survival was very similar for the two years, but chick survival in 2016 was dramatically higher leading to the increased productivity.

A large amount of habitat work was undertaken at one core site in autumn 2015 (1.3km old fence lines removed, 1km willow scrub removed, 2.9km of ditches re-profiled and 1.6km of new ditches and seven scrapes dug) and the benefits were seen in 2016, with pairs of lapwing using the site increasing from five to 15. Further habitat work at other sites will continue in winter 2016/17 and we hope that by increasing our efforts to exclude mammalian predators though the use of nest exclusion cages and electric fences at these sites, we will have another season of high wader productivity in 2017.

BACKGROUND

Over the past 25 years the GWCT has documented a 70% decline in numbers of breeding lapwings and an 83% decline in breeding redshank in the Avon Valley, with evidence that the lapwing decline is driven by poor breeding success. The EU LIFE+ 'Waders for Real' project was launched in 2014 with the aim of halting these declines and reversing them.

Our approach is to create strategic hotspots of optimum habitat with reduced predation pressure, where the birds are able to fledge sufficient chicks to increase recruitment to the population in subsequent years.

KEY FINDINGS

- Breeding lapwing increased from 62 pairs in 2015 to 81 pairs in 2016.
- We recorded an increase in chick survival and overall lapwing productivity in 2016 owing to wetter field conditions.
- Over both 2015 and 2016 lapwing chicks that fledged had a significantly smaller range size than those who failed.
- Habitat work is increasing the amount of in-field wet features to create more chick foraging habitat.

Lizzie Grayshon
Andrew Hoodless

How effective are fallow plots for breeding lapwings?

Although lapwings will readily nest on fallow plots, there is very little information concerning fledging rates on these plots. © Andrew Hoodless/GWCT

BACKGROUND

The lapwing is an iconic bird of farmland, but the UK breeding population has declined by 65% since 1970, which has led to it being red-listed as a bird of conservation concern. Analysis of adult survival rates indicates no appreciable change during the last 40 years, suggesting that poor breeding success is the main demographic driver of lapwing declines. On arable land, the main Government-funded agri-environment scheme option available in England and Wales to benefit lapwings is the fallow plot for ground-nesting birds. Fallow plots are among the most expensive arable agri-environment options in terms of payment per hectare and, hence, it is important that we evaluate their effectiveness in producing fledged chicks.

Following the widespread switch from spring- to autumn-sown crops from the late 1970s, the availability of suitable nesting habitat for lapwings has reduced dramatically. There has also been a shift away from mixed farming, so that grass (a favoured chick-rearing habitat) is less commonly found adjacent to arable land. Nevertheless, in the late 1990s, 39% of breeding lapwings in England and Wales were recorded on arable farmland. To provide nesting and foraging opportunities on arable land, fallow plot options were included in the Higher Level Stewardship (HF13, HF17) and Entry Level Stewardship (EF13) schemes. Fallow plots are now an option within Countryside Stewardship (AB5). However, although it is known that lapwings will readily nest on fallow plots, there is very little information concerning fledging rates on these plots.

In a collaborative project with the RSPB, we monitored breeding lapwings on fallow plots and on conventional crops in Wessex (Hampshire, Wiltshire, Berkshire) and East Anglia (Norfolk, Cambridgeshire) during 2012-2013. We assessed overall productivity via regular visits to sites and conducted more intensive monitoring of

Nest survival was high on fallow plots. © Andrew Hoodless/GWCT

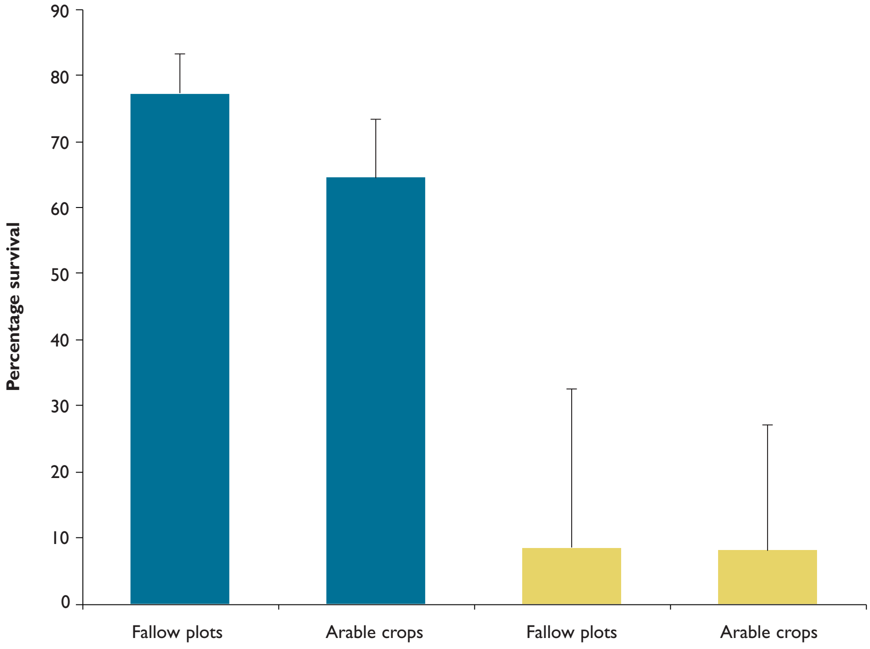


Figure 1

Comparison of lapwing nest and chick survival with respect to nesting locations on fallow plots and conventional crops in 2012 and 2013. Error bars are 95% confidence limits

Nests

Chicks

individual nests and chicks. We also measured other factors considered likely to influence lapwing productivity, such as predator abundance and chick food availability.

Our data indicated high nest survival on fallow plots (77%) and on conventional crop fields (65%). Chick survival, however, was very low, at less than 9% in both cases and was insufficient to maintain stable lapwing numbers (see Figure 1). This was supported by our estimates of overall productivity, which indicated that the number of chicks fledged per pair was 0.49 ± 0.08 on fallow plots and 0.35 ± 0.09 on conventional crops. The difference between these figures was not statistically significant, but both were lower than the level of productivity generally accepted to be required for a stable population (0.70 chick/pair/annum). We concluded that fallow plots were functioning as they were originally conceived, providing suitable habitat during nesting, but that they were not achieving the overarching aim of aiding lapwing population recovery, owing to the poor survival of chicks.

Lapwing chicks were lost largely to predators, including foxes, small mustelids, raptors and corvids. Over the four years of our study, predation accounted for 84% of

Lapwing chicks were lost largely to predators including foxes, small mustelids, raptors and corvids. © Dave Kjaer

Fallow plots were fenced with electric fencing to exclude foxes and badgers.
© Andrew Hoodless/GWCT

ACKNOWLEDGEMENTS

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chick deaths (n=208) and starvation 14%, with a small number of chicks killed by farm machinery or drowned. Consequently, in 2014-2015, we conducted an experimental trial of the effect of electric fencing, to exclude foxes and badgers from fallow plots, on lapwing chick survival and overall productivity. Breeding lapwings were monitored for a total of 85 plot-years, in which electric fences were present for 38. With the exception of one site, eight-strand 1.1-metre electric fences were largely effective at excluding foxes and badgers from fallow plots. Fencing made no difference to nest survival, which was again high, but we recorded no improvement in chick survival at the plot level (fenced plots 12.5%, unfenced plots 10.9%). The effect of fencing on overall productivity varied significantly between years, with lower productivity on fenced plots than unfenced plots in 2014 (0.36 ± 0.14 and 0.51 ± 0.12 chick/pair respectively), but higher productivity on fenced plots than unfenced plots in 2015 (0.35 ± 0.13 and 0.13 ± 0.05 chick/pair).

Why was there no improvement in chick survival with fencing? The chicks inside the fences were still vulnerable to avian predators, but we had calculated prior to starting the trial that stopping the majority of fox predation should have increased chick survival to about 35-40%. The issue was movement of chicks off plots and hence outside fences, despite brood ranges typically being smaller than the average plot size (two hectares). Analysis of chick survival in relation to location revealed that fences were beneficial when chicks remained inside them, with survival to fledging averaging 29%. We found that chick age had no bearing on the time that chicks spent inside fences and that the crop type surrounding the plot was the most important factor.

Chicks spent most time off plots when the surrounding crop was short, as is the case with maize, peas and beans at the time of peak chick hatch in late April. They spent more time on plots when they were adjoined by grass or spring cereals.

Given that some of the chicks we recorded as predated could have been scavenged after dying from starving, the availability of invertebrate food for chicks must also be important. Chicks on plots adjoined by grass and spring cereals possibly had to travel shorter distances into these crops to obtain sufficient food. We observed that some broods spent a lot of time at plot edges, foraging along the boundary with the crop, where in some cases there was greater cover of arable weeds than near the centre of plots. Vegetation such as this is likely to fulfil two functions: providing a source of invertebrate food for chicks and providing escape cover in which chicks can hide in the presence of avian predators.

It is likely that food availability and predation interact to influence chick survival, with chicks in poor condition, owing to the low abundance of food or adverse weather, potentially more susceptible to predation, but also chicks subject to high predation pressure less likely to be able to feed adequately. When we examined our data in more detail, we found that greater vegetation cover on fallow plots had a positive effect on chick survival in 2012-2013 and that greater invertebrate abundance on plots, sampled by pitfall traps, resulted in higher chick survival in 2014-2015, although both relationships explained less than 10% of the variation in chick survival. We are conducting further analyses to examine relationships between vegetation cover and food availability on chick diet, condition and survival.

The solutions to increasing lapwing chick survival on fallow plots would seem to be to create some form of brood foraging cover adjacent to the plot and probably fence this larger area or fence the whole field containing a plot. Stepping up fox and corvid control in spring might be an alternative to electric fencing or a valuable complement to it. Both potential solutions would add considerably to the cost of the fallow plot option if rolled out as part of an agri-environment scheme and would require evaluation first. If found to deliver the required level of lapwing chick productivity, then careful targeting within the landscape and more stringent conditions on option uptake would most likely be required to offset the higher option cost.

KEY FINDINGS

- Fallow plots provide suitable habitat for lapwings during nesting, but in many cases are not aiding lapwing population recovery, owing to the poor survival of chicks.
- It is likely that food availability and predation interact to influence chick survival.
- Electric fences around plot edges, which excluded foxes and badgers, increased the survival of chicks that remained on plots, but many broods moved off plots and were then not protected.
- Possible solutions for increasing lapwing chick survival on fallow plots are the creation of brood foraging cover adjacent to plots, fencing the whole field containing a plot or stepping up fox and corvid control.

Andrew Hoodless
Kaat Brulez
Carlos Sánchez

Lapwing chick survival was estimated from samples of chicks fitted with 0.4-g radio-tags.
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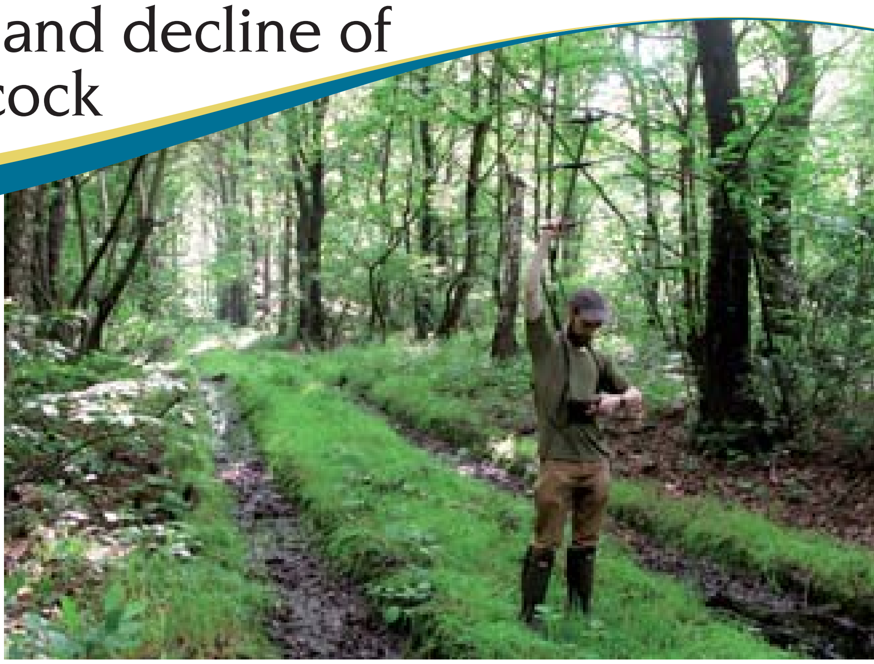
The distribution and decline of breeding woodcock



We locate tagged woodcock in woodland by radio-tracking. © Andrew Hoodless/GWCT

© Andrew Hoodless

BACKGROUND

In Britain, woodcock occur as both a resident breeding species and a migrant winter visitor. Britain's small breeding population has undergone severe declines, as highlighted by our national woodcock surveys in 2003 and 2013. The results of these surveys are now helping us identify possible causes of declines.

KEY FINDINGS

- Woodcock showed a strong association with the most heavily-wooded regions in Britain. Woodland was important on a very large spatial scale, suggesting a possible relationship with connectivity.
- Woodcock were more commonly recorded in wet woodland and coniferous woodland.
- Nationally, woodcock were less abundant in areas where foxes were more common.

Chris Heward
Andrew Hoodless

In 2013, in collaboration with the British Trust for Ornithology (BTO), we co-ordinated a nationwide survey of breeding woodcock. Counts of 'roding' males were used to estimate local abundance at over 900 sites nationally. It was the second survey of its kind and allowed us to assess population change against a baseline survey conducted in 2003.

These surveys found that Britain's breeding woodcock population had declined by 29% between 2003 and 2013 and, among woods that were surveyed in both years, 33% of occupied sites had completely lost their breeding woodcock by 2013. These trends are in broad agreement with the Bird Atlas surveys, which suggest the British breeding woodcock population has been declining since at least the early 1970s. Halting declines requires an understanding of the behaviour and habitat requirements of residents during the breeding season.

To identify potential causes of recent declines, we compared the national woodcock survey results with corresponding data on habitat, weather and mammal abundance. There is a strong association between woodcock abundance and very large, continuous networks of woodland, with many medium-sized or large-but-isolated woods that once supported woodcock no longer doing so. Connectivity of woodland may be important if young woodcock are unable to disperse over long distances or if male woodcock need to cover large roding areas to locate a mate.

TABLE 1

The percentage of sites occupied by woodcock in 2013 in relation to dominant tree type

Tree type	Occupied	Surveyed	%
Wet woodland	34	65	52.3
Beech	6	37	16.2
Oak (inc. oak-birch)	52	158	32.9
Other broadleaf	11	117	9.4
Sitka spruce	24	54	44.4
Other conifer	64	141	45.4
Mixed woodland*	24	81	29.6
Various**	15	36	41.7
Total	**230**	**689**	**33.4**

**Sites where an intimate mix of broadleaf and conifer dominate, **sites where no single woodland type makes up ≥50% of the wooded area.*

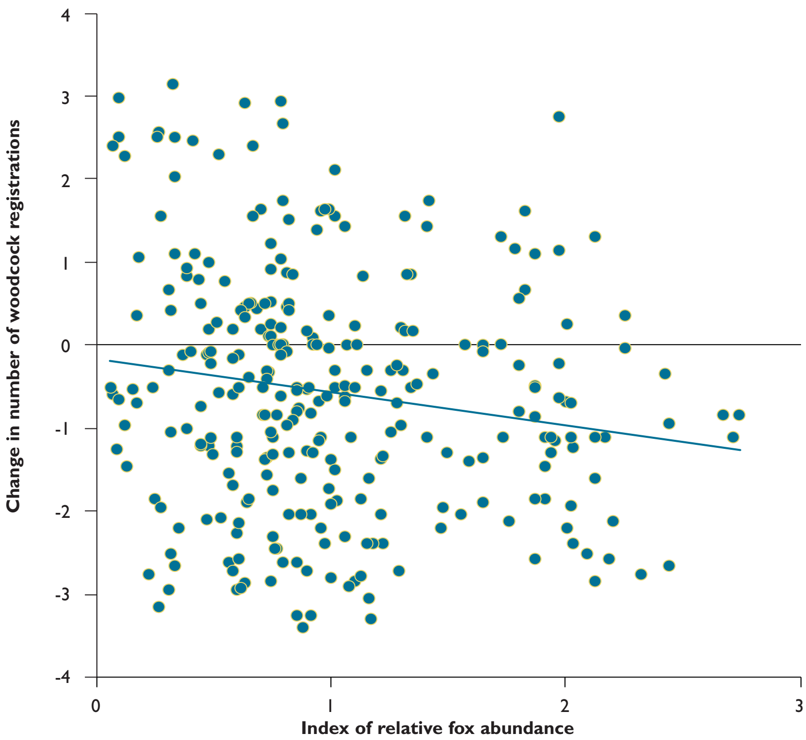


Figure 1

Change in mean number of woodcock registrations between 2003 and 2013 in relation to relative fox abundance in 2013. Relative fox abundance is derived from records of numbers culled and displayed as an index where 1 = national average.
Woodcock change = ln (mean registration in 2013/mean registrations 2003)

Additionally, very large woods are likely to be commercially managed, and it could be that active management benefits woodcock.

The likelihood of encountering woodcock varied according to woodland type. The highest levels of site occupancy in 2013 were associated with wet woodlands (52%), Sitka spruce (44%) and other conifers (45%). The association with wet woodland appears to be due to an association with birch, young stands of which provide dense cover in which woodcock can roost and feed. The association with Sitka spruce and other conifers may relate to the apparent preference for well-connected and managed woods as these tree species are common in areas where large forestry plantations exist. By comparison, only 16% of beech woods supported breeding woodcock, probably owing to their sparser ground vegetation, making them less suitable for nesting and their low availability of earthworms.

We used the GWCT's National Gamebag Census to assess how the abundance of three common deer species (roe, fallow and muntjac) and fox, as measured by the number culled, relate to local woodcock abundance. Deer are known to alter the structure and species composition of woodland vegetation through browsing, but our study found no obvious negative effect on woodcock. Woodcock abundance showed a negative relationship with fox abundance (see Figure 1) and, although we do not expect this to be the sole cause of declines, increasing fox numbers may have exacerbated declines in areas where woodcock productivity is low.

ACKNOWLEDGEMENTS

We are grateful to Greg Conway, Iain Downie and Rob Fuller of the BTO for their involvement in the Breeding Woodcock Survey. We thank the many volunteers who participated in the survey, particularly the BTO regional organisers who co-ordinated survey coverage. The analysis of survey results was made possible by datasets provided by the Forestry Commission, the Centre for Ecology and Hydrology and the Met Office.

Woodcock were less abundant in areas where foxes were more common. © Dave Kjaer

Partridge Count Scheme

Since 2015, grey partridge pair density dropped by 7.5%. © Dave Kjaer

KEY FINDINGS

- The average pair density across all PCS sites decreased by 7.5% compared with 2015.
- Autumn densities decreased by 12%.
- The national Young-to-Old ratio fell to 2.1, but was much better than in 2012, the worst year for chick production of the past decade.

Neville Kingdon
Julie Ewald

Partridge Count Scheme (PCS) members returned 623 counts in the spring of 2016 (see Table 1). In total 6,511 pairs were counted over 188,700 hectares (ha) (466,400 acres), compared with 211,800ha (523,400 acres) (-11%) in 2015. The average pair density over all PCS sites decreased by 7.5%. Only southern England recorded a regional increase (+12.5%) but the densities here remain low overall at an average of 1.8 pairs/100ha.

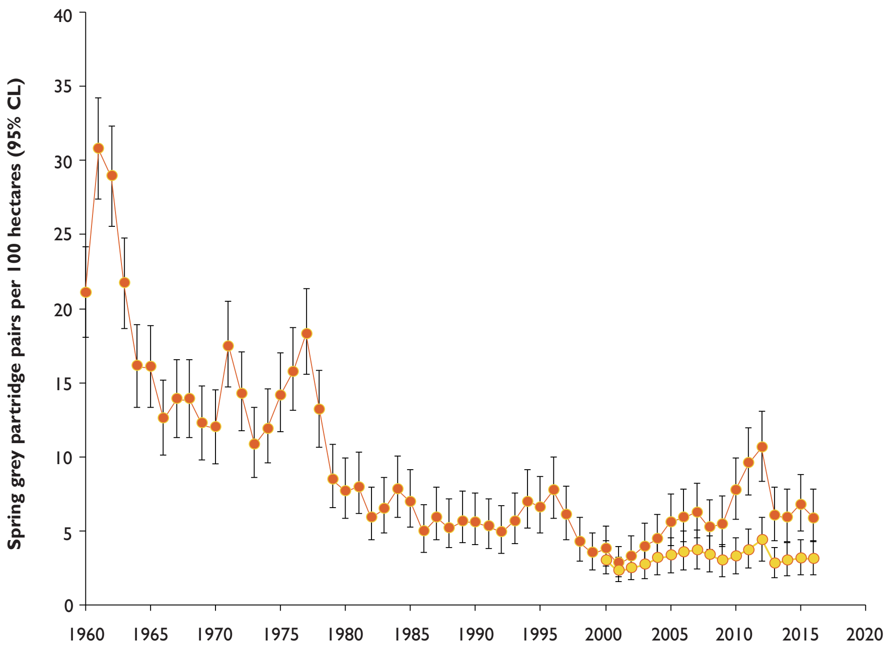
Nationally, over-winter survival (OWS) for 2015/16 fell slightly from 47% to 45%. Scotland's OWS remained stable, while over-winter survival in northern and southern English regions increased. Eastern England's OWS declined for the second year, falling by 25%. The need to improve winter survival to raise spring pair abundance should not be overlooked by anyone who has wild grey partridges.

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 on-going support of our grey partridge work.

The long-term index of grey partridge pair density (see Figure 1) shows that sites that have participated in the PCS prior to 1999 (long-term sites) recorded an average 13% decline in breeding density, giving a national average spring density of 5.9 pairs/100ha (250 acres), while new sites (joining since 1999) recorded a smaller decline of 1%, remaining at an average of three pairs/100ha (250 acres).

The warm, dry May fostered hope of a good summer for partridges. This was literally washed away when heavy rainstorms fell in mid-June at the peak of the grey partridge hatching period and continued for several weeks. East Anglia and the south-east were especially hard hit. Into July and August, Scotland and northern England were wetter than average, although the second half of August became more settled and warmer, particularly in East Anglia and the south-east.

The difficult harvest and problems with access to the ground for counting resulted in the PCS receiving 512 autumn counts, 20% fewer than were returned in autumn 2015 (see Table 1). The total number of partridges recorded nationally this autumn was 20,900. Nationally, the average autumn density reached 16.7 birds per 100 hectares, down from the 19 birds per 100 hectares in autumn 2015.

Despite poor productivity on many individual farms and shoots, the national average Young-to-Old ratio (YtO) was 2.1 chicks per old bird. Late broods may well have helped cushion the effects of the wet early summer. Productivity was similar to that in the damp summer of 2015 (2.2 YtO), well below the 2.5 YtO average of 2013-2014, but nowhere near as bad as the 1.2 YtO following the terrible summer of 2012. Southern England and the Midlands recorded large falls in productivity (-24% and -21%) compared with 2015. Only Scotland recorded a large improvement in productivity. Thankfully, despite the downpours during and after hatching, all regions (excluding Wales) exceeded the 1.6 YtO required for a stable population. In the wider countryside where less effective action is taken for grey partridges, the effects of this summer are thought to be generally worse for grey partridge numbers.

Adverse summer weather cannot be prevented and could be something partridges will face more regularly in the future. It should be appreciated that this summer's productivity could have been much worse for PCS members if they did not have chick-food-producing habitat and management in place to minimise losses. More farms and shoots throughout the country (not just those involved in the PCS) need to address this aspect of the grey partridge lifecycle and implement management if they are to improve brood survival – in both good years and bad.

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.
- In a high 4WD 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 2015 and 2016, 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	*2015*	**2016**	*2015*	**2016**	**Change (%)**	*2015*	**2016**	*2015*	**2016**	*2015*	**2016**	**Change (%)**
South	85	86	1.6	1.8	12.5	98	66	2.1	1.6	12.8	12.6	-6
East	192	177	5.6	5.2	-7	174	134	2	2	22.2	18.8	-15
Midlands	133	123	3.2	3.2	0	120	104	2.4	1.9	16.8	12.4	-26
Wales	2	2	5.2	0.7	-87*	1	1	1.1	0	35.6	2.9	-92*
North	163	142	4.7	4.4	-6	157	127	2.2	2.3	25	23.2	-7
Scotland	91	92	2.6	2.5	-3.8	89	79	2.1	2.7	11.7	11.7	0
N Ireland	-	1	-	5.9	-	-	1		2	-	20	-
Overall	**666**	**623**	**4**	**3.7**	**-7.5**	**639**	**512**	**2.2**	**2.1**	**19.0**	**16.7**	**-14**

** 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

Well-managed spring feeding forms an important part of the full grey partridge recovery management package at Rotherfield. © Carlos Sánchez/GWCT

KEY FINDINGS

- In 2016, the number of grey partridge spring pairs on the Trust's demonstration area was 19 pairs, three less than in 2015.
- On the Trust's area, grey partridge autumn stock was 69, 22 more than in 2015.
- Farmland songbirds of conservation concern have increased 66% across the whole estate since 2010, 77% on the area managed by the Trust.

Francis Buner
Malcolm Brockless
Nicholas Aebischer

The Rotherfield demonstration project in Hampshire began in 2010 when the Trust's gamekeeper was installed on c. 700ha (Trust side) and the estate's gamekeeper on an adjacent c. 700ha (Estate side). In 2011, the estate signed a 10-year Higher Level Agri-environment Scheme contract, which allowed for significant partridge habitats to be established (mainly wild bird seed mixes, uncultivated uncropped margins, beetle banks and over-wintered and extended stubbles). Because a wild-bird keeper is essential to recover grey partridges from zero, the project also demonstrates how shooting interests can be met during the recovery phase when partridges cannot be shot. To achieve this, we release 600 tagged cock pheasants annually and hold seven cock-only shoot days, four walked-up days and four spaniel trials per season.

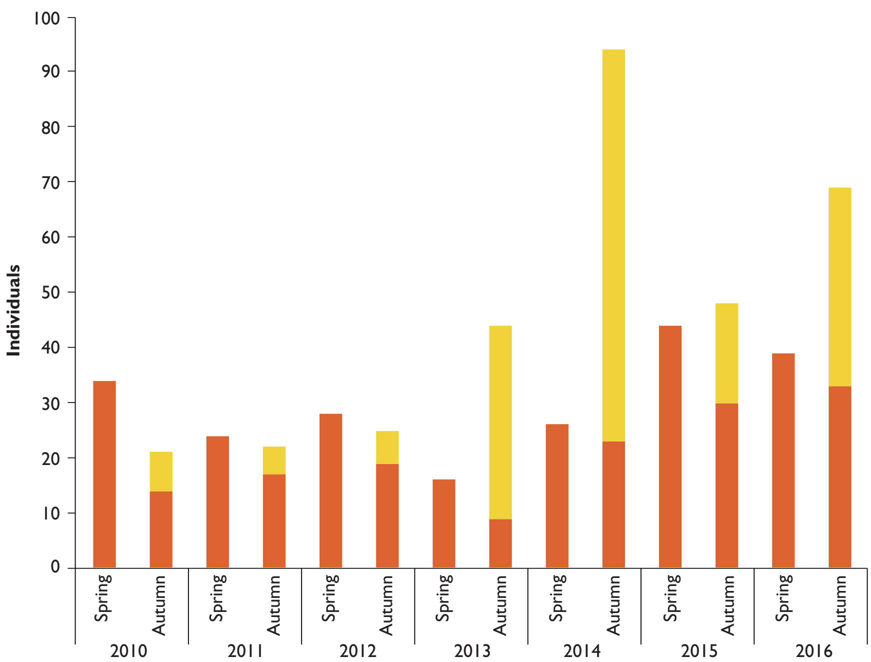
Despite the highest amount of rainfall ever recorded in the project area in June 2016 (145.2mm), the crucial hatching period for grey partridge broods, the partridges on the Trust side fared better than the national average. We counted 69 wild grey partridges (15 males, 18 females and 36 young from 10 broods, all but one from replacement clutches). The spring count was 19 wild pairs (see Figure 1). On the Estate side, only three spring pairs were counted of which none produced a brood. Although we fell short of our best autumn stock to date of just below 100 birds, we are encouraged by this year's count on the Trust side (see Table 1).

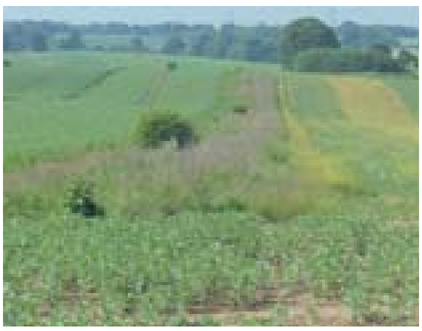
The number of wild pheasant young on the Trust side was 271, the second highest number since 2010. On the Estate side, we found 122 young just below its average of 128.8 young since 2011. The red-legged partridges had a poor breeding season, with six broods producing only 15 young on the Trust side, resulting in an autumn stock of 76 compared with 116 in 2015. On the Estate side, only one brood was recorded, producing six young (see Table 1).

Gamebird hens can suffer high mortality during the breeding season, mainly caused by predation on their nest. On the Trust side, between 2011-2016, grey partridge hen loss averaged 40.8%, while hen pheasant loss was 50.0% (see Table 2). On the Estate side, grey partridge hen loss averaged 57.2%, pheasant hen loss 58.4%. The percent-

Figure 1

Number of grey partridges on the Trust side





Provision of high quality habitat is key for any wild grey partridge recovery. © Francis Buner/GWCT

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							
2016 (2015)		19 (22)	3 (7)	22 (29)	69 (48)	3 (20)	72 (68)
Red-legged partridge							
2016 (2015)		38 (37)	24 (53)	62 (91)	76 (116)	74 (67)	150 (183)
Pheasant*							
2016 (2015)	Hens	180 (220)	131 (135)	311 (355)	481 (348)	214 (174)	695 (522)
	Cocks	185 (147)	109 (133)	294 (280)			

**For pheasants, spring pairs is the number of wild females encountered; autumn stock is the number of cocks, hens and young combined (released cocks excluded). On the Trust side, 600 cock pheasants were released each year since 2011.*

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 principles.

age of grey partridge pairs producing young averaged 66% on the Trust side, 32% on the Estate side. For pheasants, the average number of young per hen counted in autumn was 2.0 on the Trust side, whereas it was 3.3 on the Estate side. Nevertheless, gamebird recovery on the Estate side has improved little since the project began, whereas on the Trust side, recovery is making slow but steady progress.

Farmland songbirds of conservation concern such as yellowhammer, skylark and linnet, have also increased by an impressive 66% (77% on the Trust side, 49% on the Estate side), illustrating the benefits of grey partridge management for an otherwise nationally declining group of birds.

Songbirds of conservation concern have increased 77% on the Trust side. © Markus Jenny

TABLE 2

Hen breeding survival*, young per hen in autumn and percentage of successful pairs/hens**

Grey partridge***	Hen breeding survival (%)		Young per hen in September		Successful pairs/hens (%)	
	Trust	Estate	Trust	Estate	Trust	Estate
Baseline year 2010	23.5	71.4	1.8	2.4	25.0	20.0
2011	25.0	87.5	1.7	1.1	66.7	28.6
2012	57.1	12.5	0.8	0.0	12.5	0.0
2013	50.0	30.0	8.8	1.7	100.0	66.7
2014	69.2	36.4	7.9	0.8	100.0	50.0
2015	59.1	57.1	1.4	2.8	38.5	50.0
2016	94.7	33.3	2.0	0.0	55.6	0.0
Avg (SE) 2011-2016	**59.2 (9.3)**	**42.8 (10.7)**	**3.7 (1.5)**	**1.1 (0.4)**	**66.4 (14.1)**	**32.5 (11.4)**
Pheasants						
Baseline year 2010	18.7	25.0	2.7	2.3	12.3	23.0
2011	45.1	64.1	2.3	4.9	22.4	45.3
2012	45.6	16.5	1.0	3.4	17.1	15.2
2013	52.4	66.7	2.5	3.1	32.5	39.7
2014	41.1	42.3	2.1	2.3	28.6	34.1
2015	48.2	25.9	1.6	3.3	28.6	24.4
2016	67.8	34.4	2.2	2.7	43.3	23.7
Avg (SE) 2011-2016	**50.0 (3.9)**	**41.6 (8.3)**	**2.0 (0.2)**	**3.3 (0.4)**	**28.8 (3.7)**	**30.4 (4.6)**

**Percentage of spring hens still seen in autumn, **Percentage of pairs (grey partridge) and hens (pheasant) counted in the autumn that produced a brood, ***In grey partridges approximately 76% of breeding birds were reared released (24% were wild) in 2010, whereas only one breeding cock was reared released (98% of spring birds were wild) in 2016.*

Sussex Study – long-term insect trends

A conservation headland and a new wild bird seed mix on the Sussex Study. © Peter Thompson/GWCT

BACKGROUND

The GWCT's Sussex Study is the longest-running cereal ecosystem monitoring exercise in the world. The study has monitored both the cereal ecosystem and the farming decisions on 3,200ha of the Sussex Downs since 1970, collating information on cropping, pesticide use, cereal weeds and invertebrate abundance. This unique dataset allows us to examine the long-term changes in cereal invertebrates, both in terms of chick-food resources and other service providers. An important reason behind recent declines in the abundance of some farmland birds is a decline in food resources provided by invertebrates in crops. These invertebrates also provide ecosystem services such as pollination and integrated pest control. A knowledge of long-term trends in their abundance is key to understanding changes in both food resources for birds and these ecosystem services.

The most recent *State of Nature* report highlighted the effects of agricultural intensification and climate change on British biodiversity, while indicating that agricultural intensification seemed to be the strongest driver of negative changes. The GWCT's Sussex Study is uniquely placed to inform the debate on the relative importance of climate change versus changes in agricultural management on farmland biodiversity. Invertebrate monitoring began on the study area in 1970, after work in the previous two years had identified that a lack of insects was a key factor in the low grey partridge chick survival on the study area. Previous work on the Sussex Study invertebrate dataset has highlighted the negative effects of foliar insecticide applications on chick food resources (reported in the *Reviews of 2006* and *2014*). We have also put the effect of pesticide applications in perspective with that of extreme weather events and long-term changes in temperature and rainfall (reported in the *Review of 2015*). This showed that foliar insecticide use was associated with the measured declines in several other groups of cereal invertebrates. Our conclusions on the changes that have taken place in the abundance of invertebrates on the Sussex Study have broadly supported those in the 2016 *State of Nature* report.

Figure 1

Overall change in invertebrate numbers (excluding micro-arthropods) on the Sussex Study area

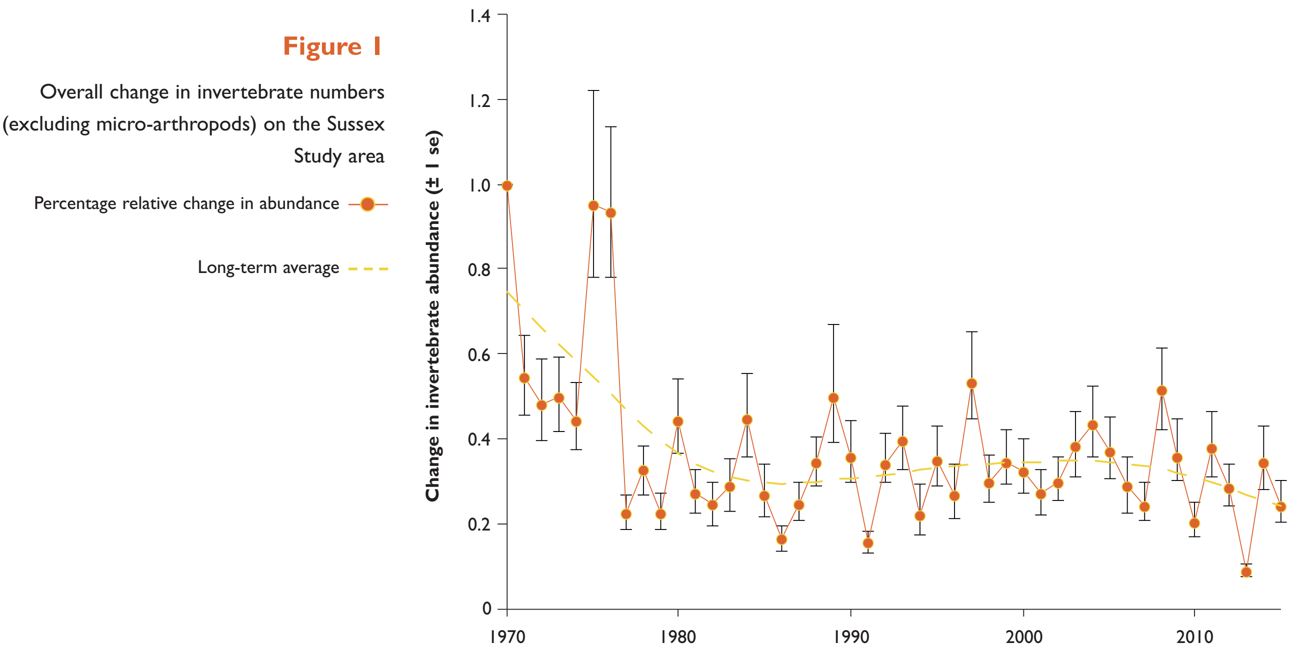


TABLE 1

Change in numbers of invertebrates overall, ecosystem services and farmland bird chick-food resources in the Sussex Study cereal invertebrate samples

Group	Overall 1970 to 2015	1970s	1980s	1990s	2000s	2010s
Invertebrates without micro-arthropods	-67%* (-72% to -61%)	-47%* (-51% to -43%)	-16%* (-23% to -10%)	12%** (6% to 19%)	-5% (-10% to 2%)	-24%* (-30% to -16%)
Pollinators	6% (-21% to 39%)	15% (-3% to 32%)	-4% (-13% to 9%)	20%** (9% to 30%)	-7% (-16% to 0%)	-9% (-23% to 11%)
Predators	-69%* (-73% to -64%)	-56%* (-60% to -52%)	19%** (13% to 27%)	17%** (11% to 23%)	-27%* (-30% to -23%)	-24%* (-31% to -18%)
Parasitoids	-70%* (-75% to -63%)	-35%* (-40% to -29%)	-16%* (-23% to -9%)	26%** (18% to 34%)	-1% (-6% to 5%)	-51%* (-58% to -43%)
Grey partridge chick-food index	-45%* (-54% to -34%)	-38%* (-43% to -32%)	10%** (4% to 17%)	-2% (-9% to 5%)	8% (-1% to 19%)	-22%* (-29% to -14%)
Corn bunting chick-food index	-25% (-46% to 5%)	-30%* (-43% to -11%)	-1% (-16% to 15%)	34%** (13% to 54%)	13%** (1% to 26%)	-29%* (-44% to -10%)
Skylark chick-food index	-69%* (-75% to -63%)	-50%* (-56% to -44%)	-15%* (-24% to -4%)	9%** (2% to 18%)	-9% (-16% to 1%)	-20%* (-29% to -11%)
Yellowhammer chick-food index	-75%* (-80% to -69%)	-49%* (-55% to -42%)	-23%* (-31% to -13%)	4% (-4% to 11%)	-10% (-19% to 0%)	-23%* (-32% to -13%)
Generic farmland bird chick-food index	-60%* (-64% to -56%)	-43%* (-47% to -40%)	-24%* (-28% to -20%)	8%** (3% to 13%)	2% (-3% to 8%)	-10%* (-16% to -4%)

*Results are percentage change (with 95% confidence intervals) calculated from the long-term trends in year to year change overall and for each of the five decades over the years that information was available. Significant declines are indicated by a *, significant increases by ** where the 95% confidence intervals of the change do not overlap zero.*

Here we look at changes in overall invertebrate numbers and the numbers in groups that provide ecosystem services. We consider how some of the recent management for grey partridge conservation has affected those invertebrate groups that are known to be important as chick foods for birds.

The numbers of invertebrates in cereals (excluding micro-arthropods – mites and springtails) have declined by two thirds (67%) from the 1970s to 2015 (see Figure 1). Most of the overall decline in invertebrates happened in the 1970s and 1980s, with a 47% and 16% significant decline respectively in these decades, followed by an increase in the 1990s (12% change), a 5% decrease in the first decade of this century followed by a 24% decline in the six years from 2010 to 2015 (see Table 1).

Using the Sussex Study dataset, we explored changes in groups of invertebrates providing two commonly considered ecosystem services, pollination and biocontrol, and in invertebrates that provide food resources for the chicks of farmland birds. Although bees are the insects most people commonly associate with pollination services, very few are collected in our suction samples in cereal crops. We sample other groups that provide pollination services (including thrips, butterflies and moths, sawflies, wasps, hoverflies and pollen beetles). The numbers of these pollinators did not change significantly since the 1970s (6% increase), with a 15% increase in numbers in the 1990s, although abundance has declined non-significantly in the 16 years since 1999.

Butterflies such as the small copper are important pollinators on farmland. © Peter Thompson/GWCT

KEY FINDINGS

- Overall invertebrate numbers (excluding micro-arthropods such as mites and springtails) declined by 67% across the Sussex Study area from 1970 to 2015.
- The numbers of pollinators in our samples has increased slightly (by 6%) over the 46 years, while agents of biocontrol (predators and parasitoids) declined by over 60%.
- Chick-food invertebrates for farmland birds have declined, with grey partridge chick-food index down by 45% since the beginning of the Sussex Study. All chick-food indices significantly declined from 2010 to 2015, indicating the on-going need for management to address these declines.
- Management undertaken to conserve grey partridges on part of the Sussex Study area resulted in significant increases in plant bugs (44%) and leaf beetle and weevil numbers (81%), with the change in numbers of sawfly larvae and caterpillars of butterflies and moths (25%) higher than that on the remainder of the Sussex Study.

Julie Ewald
Dick Potts
Ryan Burrell
Steve Moreby
Nicholas Aebischer

Two measures of biocontrol can also be calculated from the Sussex Study invertebrate samples, predatory invertebrates (including spiders, harvestmen, earwigs, lacewings, ground beetles, some rove beetles, soldier beetles, ladybird beetles and predatory flies) and parasitoids (insects, including several families of parasitoid wasps, big-headed and tachinid flies which live in a host insect and ultimately kill the host). Despite an increase in biocontrol abundance in the 1990s, both measures (predators and parasitoids) have shown a decline of over 60% since the beginning of the study (see Table 1). Predatory invertebrates recorded in our suction samples declined by over half (56%) in the 1970s alone and have continued to decline throughout this century. Parasitoids have shown similar trends with an additional decline in the 1980s.

The changes in five chick-food indices, measuring food resources for grey partridge, corn bunting, skylark and yellowhammer chicks, as well as the generic chick food index (see *Review of 2010*), show a similar pattern of overall decline (see Table 1). Declines in these indices were highest in the 1970s, from -30% to -50%. There was no clear pattern from 1980 to 2000 although there was some recovery and stabilisation through these three decades, particularly in the 1990s and 2000s. All indices show significant declines of between -10% and -27% from 2010 to 2015. This underlines the need for more widespread management directed at increasing chick-food invertebrate resources across the whole of the Sussex Study and beyond.

Recent management for grey partridge conservation on one farm on the Sussex Study has shown amazing success at turning around the fortunes of grey partridges (see *Review of 2014*). The management includes increased habitat provision through conservation headlands, beetle banks and undersown spring cereals, as well as establishment of over-winter habitat, feeding and legal predator control. We compared the numbers of the six groups of invertebrates that make up many of the chick-food indices on the area managed for partridges to the remainder of the Sussex Study area. We split the 46 years into pre-management (1970 to 2002) and post-management (2003-2015) (see Figure 2).

The long-term declines in the number of chick-food invertebrates from 1970 to 2002 occurred on both the area that went on to be managed and the remainder of the Sussex Study. Aphids, plant bugs, ground and click beetles and spiders and harvestmen declined on both areas, caterpillars declined on the area that went on to be managed and only leaf beetles and weevil abundance did not significantly change. After

Conservation headlands in the managed areas provide chick-food invertebrates such as sawflies.
© Peter Thompson/Tom Birkett/GWCT

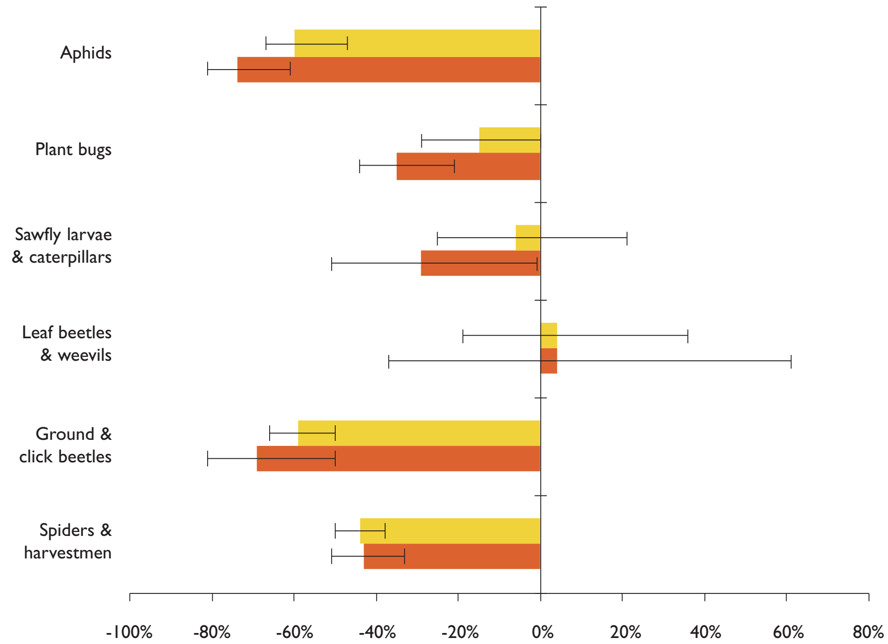


Figure 2a

Percentage change in the abundance of chick food invertebrate groups (with 95% confidence intervals) on the area managed for grey partridge conservation and the remainder of the Sussex Study area before grey partridge management began 1970-2002

Managed

Remainder

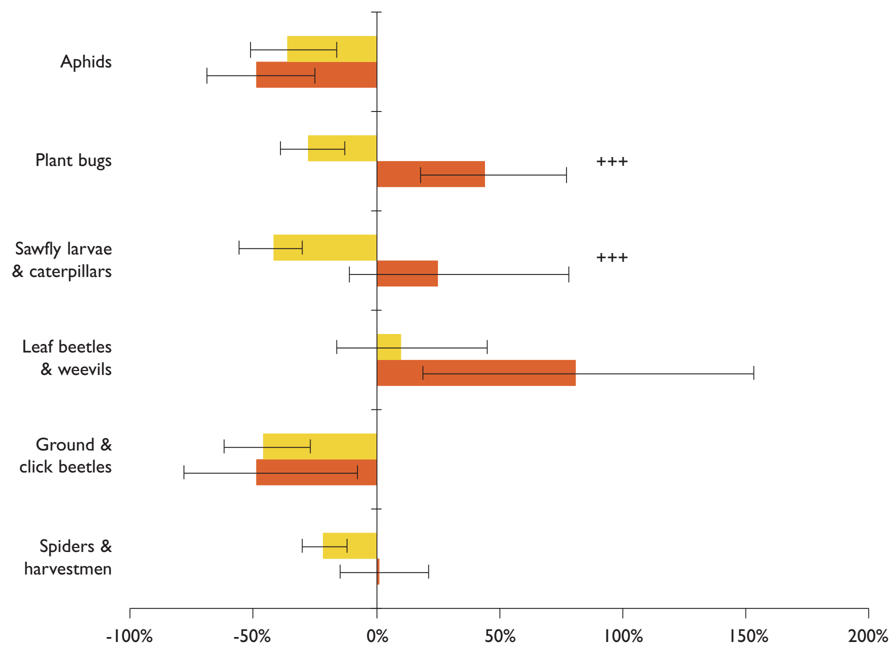


Figure 2b

Percentage change in the abundance of chick food invertebrate groups (with 95% confidence intervals) on the area managed for grey partridge conservation and the remainder of the Sussex Study area after grey partridge management began 2003-2015

Significant changes are where the 95% confidence intervals do not overlap zero. Significant differences between the managed area and the remainder of the Sussex Study are indicated by +++

Managed

Remainder

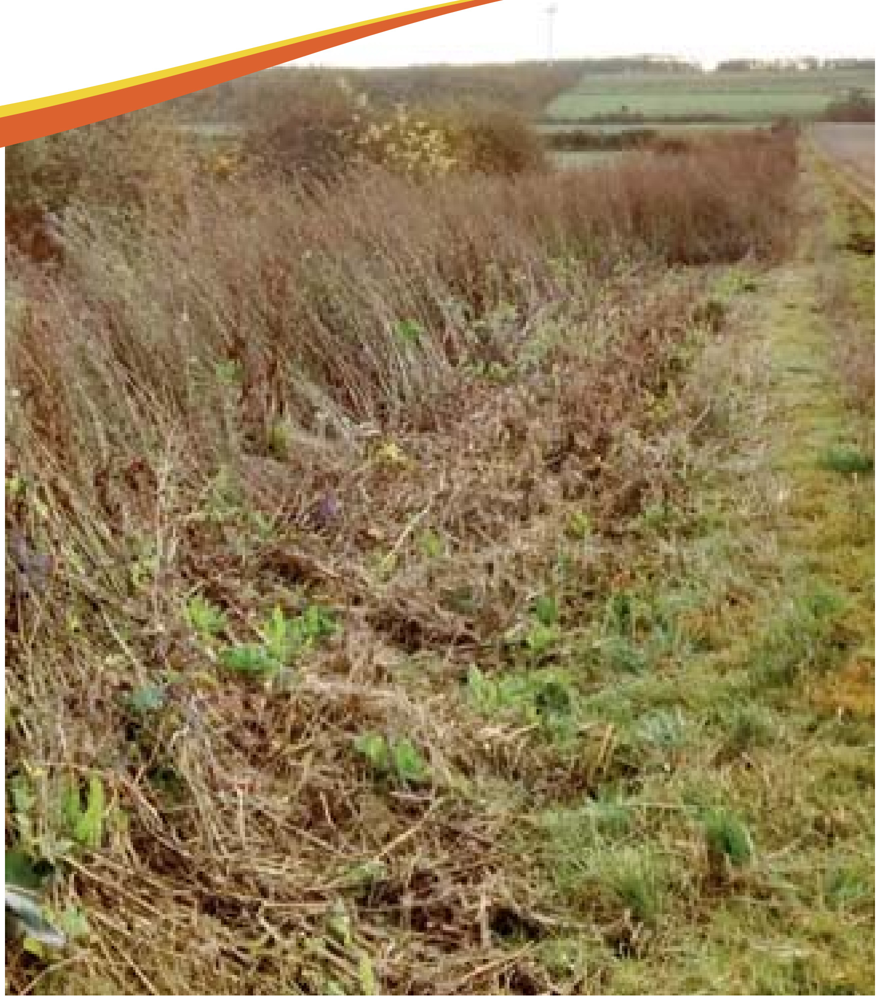
management, two groups of chick-food invertebrates significantly increased on the managed area, plant bugs (44% increase) and leaf beetles and weevils (81% increase). The increase in plant bugs was significantly higher on the managed area than on the remainder of the study area. The change in numbers of sawfly larvae and caterpillars on the managed area was significantly higher than the continual decline seen on the remainder of the study area, although the increase of this group after management began (25%) was not significant. However, both aphids and ground and click beetles continued to decline on both the managed area (-49% in both cases) and the remainder of the study area (-36% and -46%, respectively).

In summary, changes in the numbers of invertebrates on the Sussex Study area underline the importance of farm intensification on these important components of the cereal ecosystem. Efforts to restore grey partridge numbers have resulted in significant improvements in some invertebrates important in chick diets. Counteracting the long-term declines in invertebrate abundance since the 1970s is not an easy task but is possible with the grit and determination of landowners, their teams on the ground and Government support through agri-environment schemes that have options directed towards improving resources for cereal invertebrates.

ACKNOWLEDGEMENTS

We would like to thank all of the farmers, land managers and gamekeepers who have allowed us access to their land and shared their management information with us – the Sussex Study could not exist without their support.

Grey partridges at Balgonie



Patches are cut into the chicory to create a shorter, more open structure better suited to chicks.
© Dave Parish/GWCT

BACKGROUND

Balgonie is a site in Fife, Scotland where we are working with Balgonie Estates Ltd, Kingdom Farming, Scottish Agronomy and Kings Seeds to increase grey partridge numbers but also develop a long-term 'conservation crop' prescription for farmland wildlife. We hope this will be a more attractive option for farmers who dislike annual crops, which are currently all that are supported in the Scottish agri-environment scheme, and that we can convince the Scottish Government of its merits.

Since 2014 (our baseline year) we have been monitoring grey partridge numbers and a suite of other wildlife to document any wide-scale effects on biodiversity of the management changes that started in 2015, when Kingdom Farming sowed seven kilometres (km) of four-metre-wide chicory strips at the edges of several fields, alongside existing hedges.

Despite a poor year generally for grey partridge productivity (see the Partridge Count Scheme article on page 30) the birds at Balgonie performed well, with productivity and the total autumn density continuing to increase compared with the starting conditions in 2014, up 11% and 19% respectively on 2015 figures (see Table 1). All but one of the 21 coveys that included chicks comprised very young birds, suggesting they were from late, perhaps replacement, clutches. This would tie in with the harsh weather in the early summer.

The chicory headlands are now mature, standing around two metres tall. To try and improve their multi-functionality, we have cut small patches into the edges of the headlands to create less dense areas where grey partridge chicks might prefer to forage (see above picture). We had hoped to assess how important the new conservation-crop headlands were to grey partridges by radio-tagging a number of females, but despite catching and tagging 12 hens in February and March, we obtained very little information from them as the birds shed their tags quickly and, apparently, easily. This was because we used a novel method of gluing tags to the backs of the birds, rather than attaching them via a harness, and the birds were able to remove them (see picture right).

With the help of Arran Greenhop, a MRes student from Leeds University, we investigated the use of the headlands by other birds in more detail. We compared the number of birds seen in the new conservation headlands and in conventional crop headlands during spring and summer 2016. We found that there were no differences at all due to the headlands, but that hedge structure was more important, with larger, less gappy hedges supporting more birds (similar to recent findings at our other Scottish grey partridge site at Whitburgh). Within the conservation-crop headlands, we found that bird abundance increased slightly with decreasing crop density – something

TABLE 1

Grey partridge count results for Balgonie, 2014 (baseline year – no intervention) to 2016

	Spring pairs			Autumn totals					
	Pairs	Area counted (ha)	Pairs/ 100 ha	Adult	Young	Total	Y:O ratio	Area counted (ha)	Total/ 100ha
2014	24.5	570	4.3	48	49	97	1.02	688	14.1
2015	30.5	688	4.4	62	112	174	1.81	688	25.3
2016	31	688	4.5	69	139	208	2.01	688	30.2

we are keen to pursue in future years. Why these headlands were not more attractive to birds generally is not clear, as they were far weedier than the conventional crops and hedge structure was similar for all headland types. Perhaps more predictably given the amount of seed provided by these conservation crops, winter density of all farmland birds went up four-fold compared with 2014.

The project is moving into another exciting period as we are part of the EU-Interreg PARTRIDGE project. This provides partial funding that we hope to put towards further improvements in the quality of the habitat at Balgonie for grey partridges and, importantly, demonstration to a much larger audience of practitioners and policy makers across Europe of how grey partridge management works and the multiple benefits it can provide.

A radio tag removed by the bird still covered in feathers. © Dave Parish/GWCT

KEY FINDINGS

- The autumn density of grey partridges at Balgonie has increased each year since our baseline survey in 2014.
- Breeding success and total autumn density increased by 11% and 19% respectively in 2016 compared with the previous year.
- The number of all birds wintering on the farm increased four-fold after the conservation crops were introduced. Breeding songbird abundance does not appear to be higher in these habitats, but is higher where hedgerows are larger and with fewer gaps.
- Balgonie is now part of the GWCT's exciting new EU Interreg-supported project, bringing together demonstration sites across northern Europe to improve grey partridge habitats and show others how beneficial such management can be.

Dave Parish

National Gamebag Census: trends in deer and boar

The red deer bag index tripled over the first 30 years, stabilised and then declined by 16%. © 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').

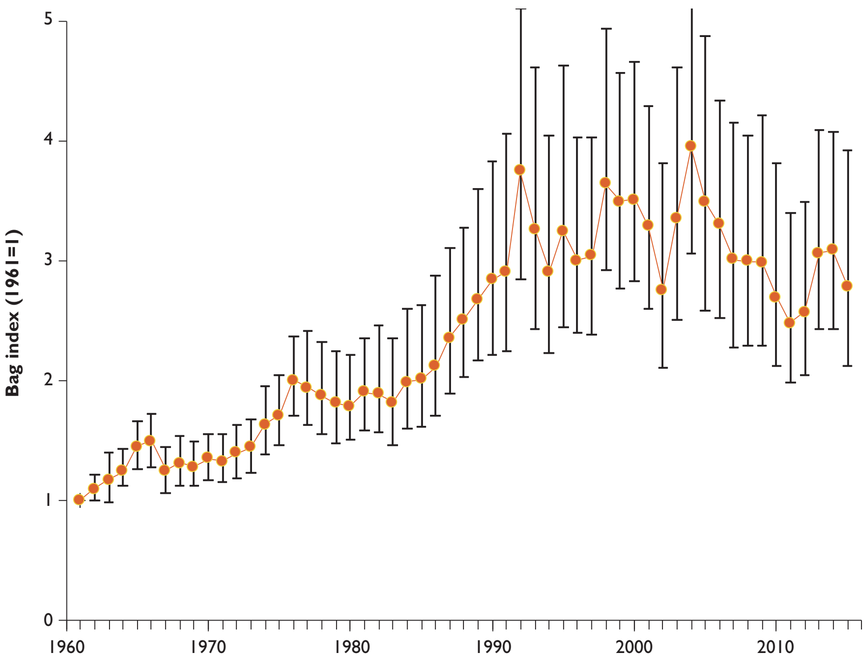
The National Gamebag Census (NGC) collects information on six species of deer and also wild boar. Of these, only the red and roe deer occur naturally in the UK, the others having escaped from captivity or been deliberately introduced. These ungulate species are shot for sport (stalking), and also to prevent damage to woodland and arable crops. We received 653 returns for the 2015/16 season, of which 347 contained data on ungulates. Participation in the NGC is voluntary, and as always we are very grateful to contributors for supporting the scheme, which provides an unrivalled insight into historical and current trends. To calculate trends, we need at least five returns per year, so the start year varies between species from 1961 to 1984. For each species (except water deer and boar, for which returns are too few), analysis is based on sites that have returned bag records for two or more years, and summarises the year-to-year change within sites as an index of change relative to the start year. In the graphs, this means that the first point is always set to a height of 1. A height of 2 indicates that numbers have doubled since the start year, one of 0.5 that they have halved.

Red deer (Figure 1)

The red deer's traditional stronghold is in Scotland, where it is most widespread on moorland, but is also found in woodland and farmland fringes. Outside Scotland it has concentrations in north-west and south-west England, Hampshire, East Anglia and Northern Ireland. Based on a total of 282 sites, the bag index tripled over the first 30 years, followed by stabilisation then a 16% decline. The increase reflects the rising

Figure 1

Index of red deer shot per km² on NGC sites across the UK, 1961-2015



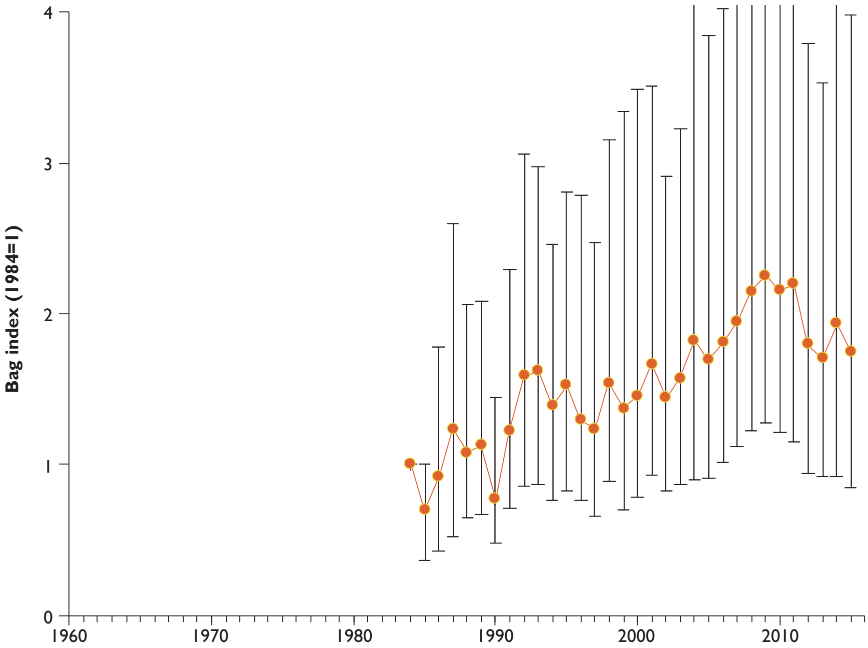


Figure 2

Index of sika deer shot per km² on NGC sites across the UK, 1984-2015

abundance and expanding range of the species, probably helped by a combination of underculling of females, improved food resources through afforestation, milder winters leading to better over-winter survival and reduced competition with hill sheep. The maturation of forestry and intraspecific competition may explain the decline apparent over the last 10 years.

Sika deer (Figure 2)

Sika deer, originating from Japan, Taiwan and the adjacent Chinese mainland, were introduced into British deer parks from 1860 onwards. Since then many escaped and the species is now widespread across northern and western Scotland, the Scottish Borders, Cumbria, Lancashire, Hampshire/Dorset and the western part of Northern Ireland. In all 70 NGC sites have reported sika deer, with sufficient records to evaluate trends since 1984. The bag index shows a doubling by 2010, followed by a possible decline (error bars are too large to draw firm conclusions). The increase matches what is known about the on-going range expansion and increasing abundance of sika deer.

Fallow deer (Figure 3)

Fallow deer were re-established in England in the 11th century after going extinct in Britain during the last Ice Age. It is currently widespread across England and Wales and

KEY FINDINGS

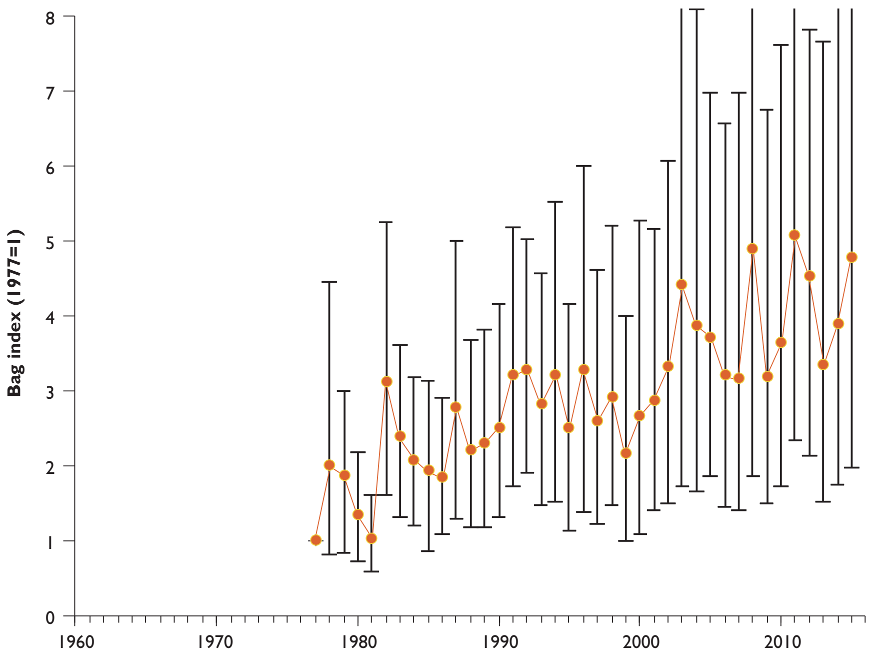
- Since 1961, numbers of red, sika, fallow and roe deer shot increased by two to seven times, but seem to have stabilised in recent years or even declined (red deer).
- Numbers of muntjac shot show a spectacular 15-fold increase, with no evidence of stabilisation, in line with its expansion and increasing abundance across England.
- Since 1993, NGC records include a sparse but increasing range of sites that have shot Chinese water deer and wild boar, reflecting their establishment and spread in different parts of Britain.

Nicholas Aebischer

Sika deer, originating from the Far East, were introduced into British deer parks from 1860 onwards. © Dave Kjaer

Figure 3

Index of fallow deer shot per km² on NGC sites across the UK, 1977-2015



Fallow deer were re-established in England in the 11th Century after going extinct in Britain during the last Ice Age. © Dave Kjaer

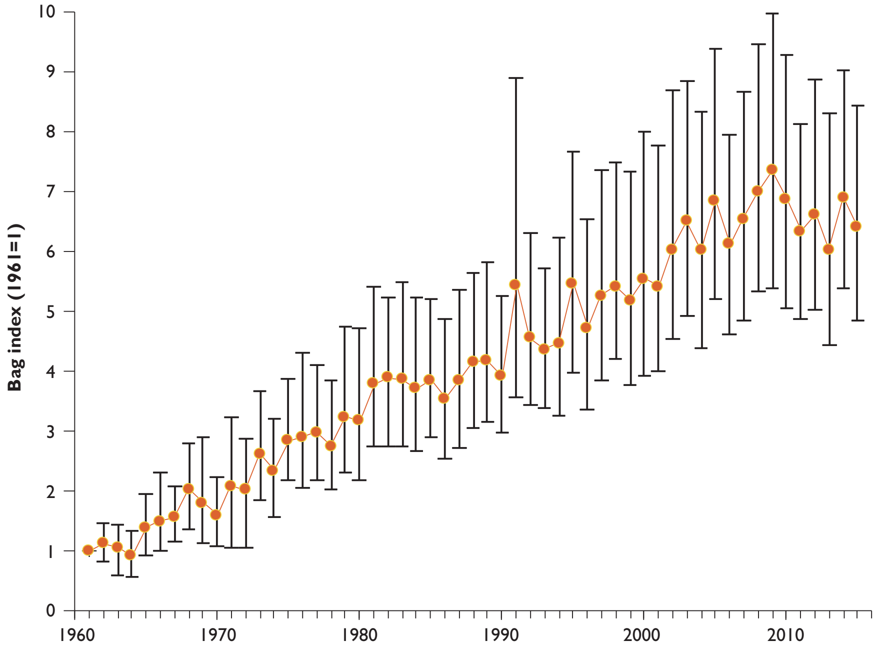
occurs in isolated pockets of Scotland and Northern Ireland. Sufficient NGC sites are available to evaluate trends from 1977, with 185 sites in total reporting shot fallow deer. The UK bag index increased four-fold, with perhaps some stabilisation since the mid-2000s (error bars are too large to draw firm conclusions). The increase is as expected from the species' recent expansion in range.

Roe deer (Figure 4)

The roe deer went nearly extinct 300 years ago. Helped by re-introductions, it has steadily expanded its range and now occupies mainland Scotland, most of England and patchy areas of Wales. The calculation of trends is based on returns from 666 sites. Since 1961 there has been a sustained rise amounting to a nearly seven-fold increase, with apparent stabilisation since 2010. The increase corresponds to a spectacular period of range expansion and increasing abundance, probably linked to a combination of habitat expansion (new forestry plantings) and changes in the law (control by snaring and shotgun drives no longer permitted), that led to greater use of stalking for control and for income.

Figure 4

Index of roe deer shot per km² on NGC sites across the UK, 1961-2015



Roe deer. © Peter Thompson

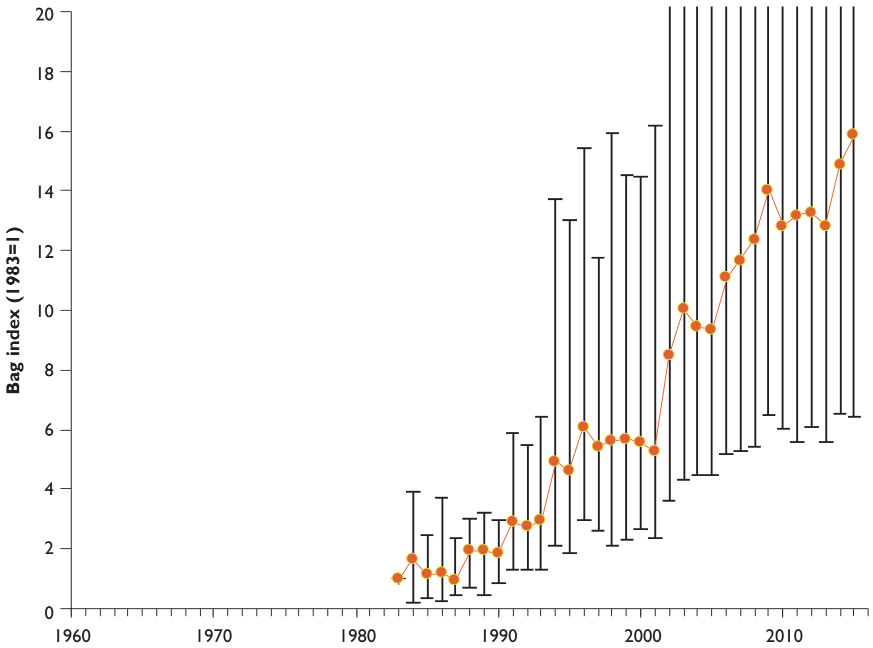


Figure 5

Index of muntjac shot per km² on NGC sites across the UK, 1983-2015

Muntjac, introduced from China in 1894, have shown an astonishing 15-fold increase from 1983 to 2015. © Dave Kjaer

Muntjac (Figure 5)

The muntjac originates from south-east China and Taiwan. Originally introduced to Woburn Park, Bedfordshire, in 1894, further releases and escapes led to establishment in the wild. It is currently present across most of southern and eastern England, and recently colonised Wales. Based on returns from 226 sites, trends can be evaluated since 1983. They show an astonishing 15-fold increase to 2015, with little evidence of stabilisation. The increase is in line with its on-going range expansion and increasing abundance.

Chinese water deer

Chinese water deer originate from China and Korea; they were introduced to Woburn Park, Bedfordshire, in 1896 and Whipsnade Park in 1929-1930. Deliberate releases and escapes have resulted in the species becoming established in the wild in south-eastern Britain, with current strongholds in west Bedfordshire, the Cambridgeshire fens and the Norfolk Broads. The first NGC record of water deer was in 1993. It has since been reported from 19 sites, in Norfolk (9), Bedfordshire (4), Suffolk (2), Cambridgeshire (1), Buckinghamshire (1), Oxfordshire (1) and Hampshire (1).

Wild boar

Wild boar were extirpated from the British Isles in medieval times. Imported for meat farming in the 1980s, escaped animals established themselves in the wild, with known hotspots in Kent, Dorset, Devon, Herefordshire and Gloucestershire. The NGC received its first record of the species in 1994, with reports now from 15 sites, in Dorset (3), Grampian (3), Kent (2), Suffolk (2), Devon (1), North Yorkshire (1), Powys (1), Gwent (1) and Tayside (1).

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, the National Gamebag Census Co-ordinator, by telephone 01425 651019 or email ggooderham@gwct.org.uk

Wild boar were imported for meat farming in the 1980s and escaped animals are now established in the wild. © Dave Kjaer

Uplands monitoring in 2016

Although spring densities were slightly lower than last year, breeding success was better. *© Laurie Campbell*

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.

Red grouse

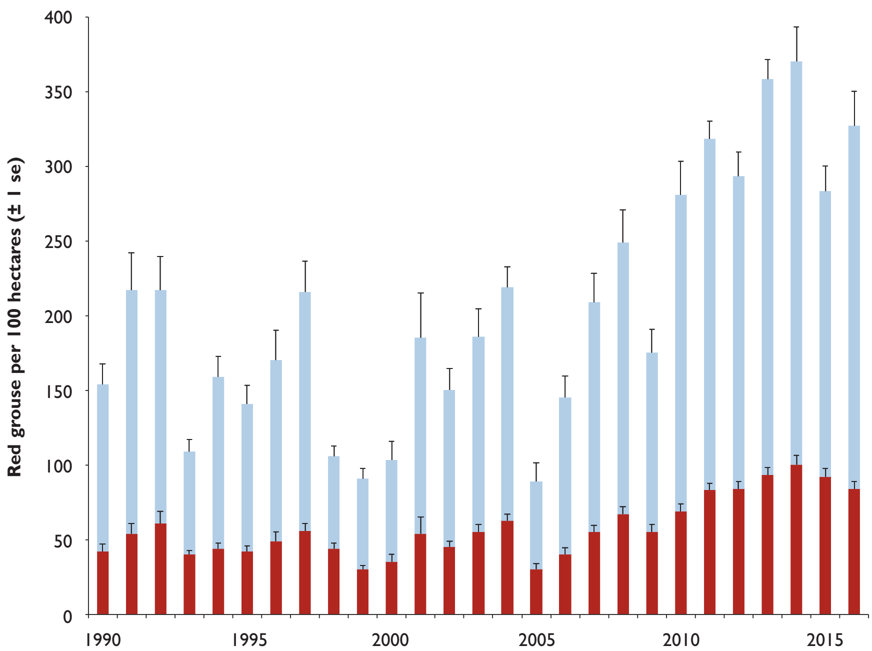
One of the main annual long-term monitoring undertakings by the upland research group are the red grouse counts, pre-breeding in the spring and post-breeding in July when numbers of adults and young are recorded. Counts started in 1980 in northern England and 1985 in Scotland and typically estimate grouse 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 moors in August or September. Historically a sample of 10 adults and 10 juvenile birds were collected. Since 2010, because of low worm burdens, samples are collected from 20 adults only.

Grouse counts

England: In 2016, spring densities were 6% lower than in spring 2015, with 110 birds per 100ha (117 in 2015). Breeding success in 2016 averaged 2.9 chicks per adult (2.0 in 2015), giving a post-breeding density in July of 327 birds per 100ha (283 in

Figure 1

Average density of young and adult red grouse in July from 25 moors in northern England 1990-2016



2015) (see Figure 1). Increased densities were not universal, but some moors in the Peak District and the Trough of Bowland had productivity similar to that in 2015. Grouse bags have reflected this increased density with large bags of grouse being shot, particularly on the Pennines and the North York Moors.

Scotland: Spring densities in 2016 averaged 69 birds per 100ha, 14% lower than in 2015 (80 in 2015). Breeding success was similar to 2015 at 1.5 chicks per adult. Post-breeding densities averaged 131 birds per 100ha, 23% lower than in 2015 (170 in 2015) (see Figure 2). This reduction in grouse densities has resulted in a reduced shooting programme in much of Scotland in the 2016 season.

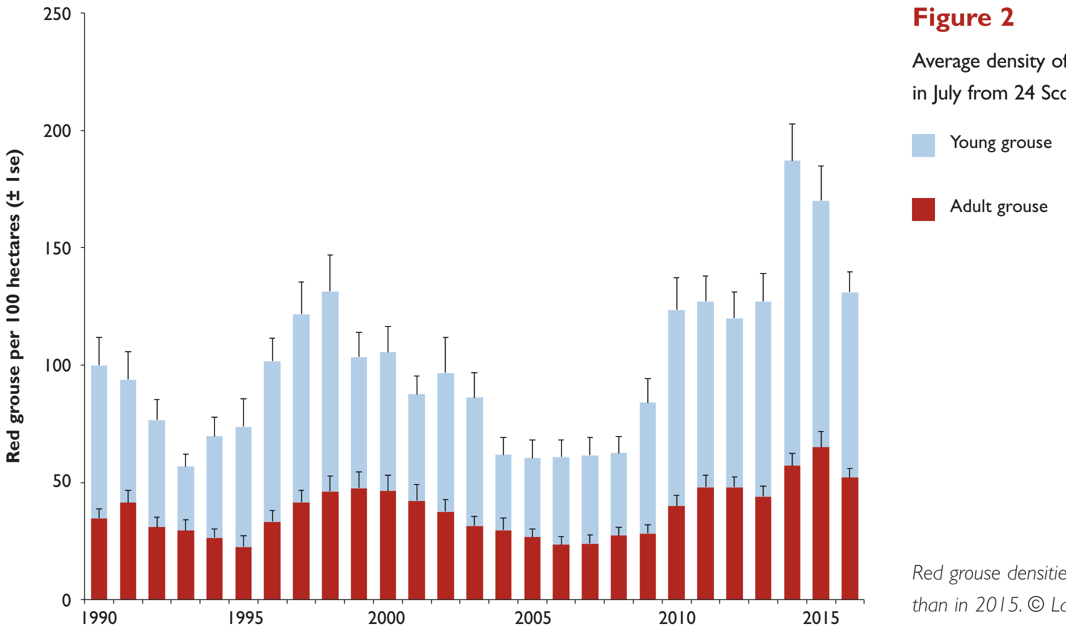


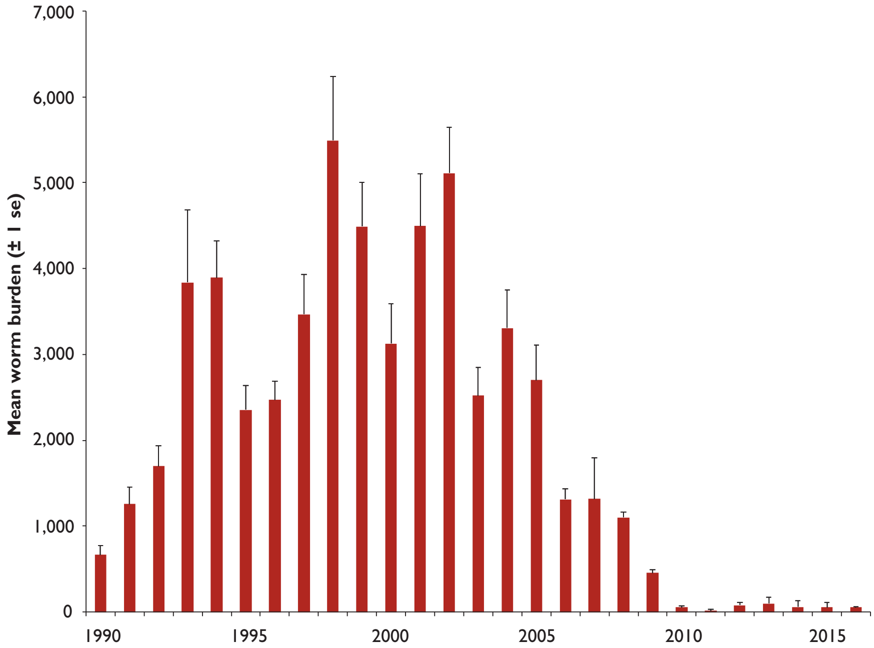
Figure 2

Average density of young and adult red grouse in July from 24 Scottish moors 1990-2016

Red grouse densities in Scotland were 23% lower than in 2015. © Laurie Campbell

Figure 3

Average annual worm burden for autumn shot adult red grouse from 8-18 moors in northern England 1990-2016



KEY FINDINGS

- July densities remained high in northern England, but fell by 23% in Scotland.
- Worm burdens following effective use of medicated grit remain very low.
- Black grouse breeding success was only moderate, but sufficient to retain population sizes.

David Newborn
David Howarth
Mike Richardson
Phil Warren
David Baines

Strongyle worms

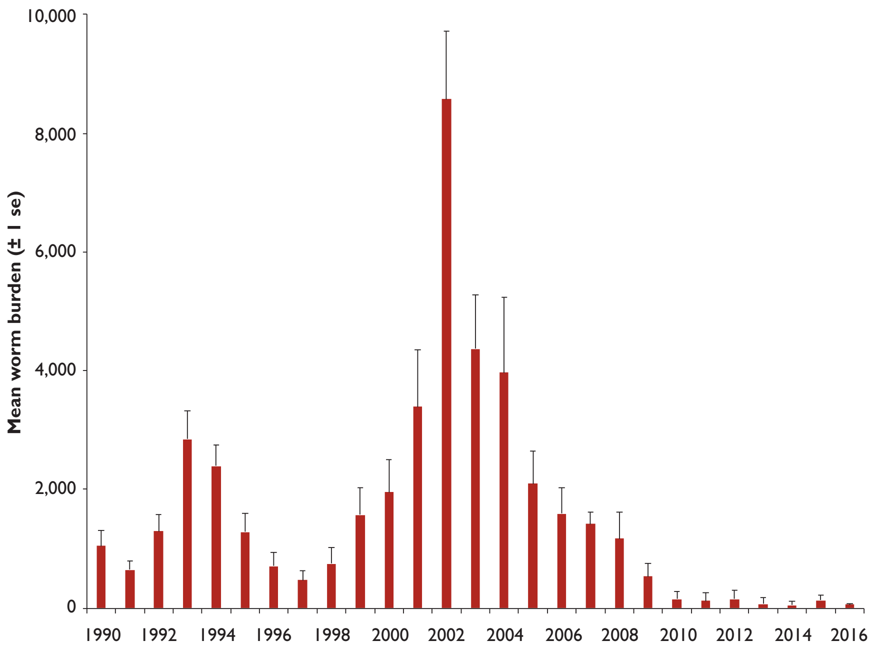
Parasitic worm burdens in grouse have again remained very low across our sample of core sites, in both England and Scotland, owing to the widespread use of medicated grit. Grouse population crashes caused by strongyle worms appear to be consigned to history on moors where medicated grit is effectively deployed. With the majority of moors in England and Scotland using medicated grit, strongyle worm burdens remain at an all-time low. The average number of worms per shot adult bird was below 100 worms for both England (see Figure 3) and Scotland (see Figure 4) again this year, with 20% of the adult samples containing no worms in England and 27% in Scotland.

Black grouse

In spring 2016, we sampled black grouse attendance at 55% of known leks in northern England. In the last national survey, these leks supported 67% of the English black grouse population of 1,437 males. Following good breeding in 2014, numbers attending these leks in 2015 had increased by 14%. However, subsequent poor

Figure 4

Average annual worm burden for autumn shot adult red grouse from 3-17 moors in Scotland 1990-2016



Despite good broods, 2016 was a moderate breeding year for black grouse. © Dave Kjaer

breeding in 2015 saw numbers fall by an equivalent amount returning the English population back to its 2014 level.

Across our survey areas in northern England we found 61 hens in August, 49% of these had broods totalling 76 chicks, giving an overall average of 1.2 chicks per hen. Despite some good broods observed (maximum seven chicks) this has overall been a moderate breeding year, below the 27-year north of England breeding productivity average of 1.7 chicks per hen.

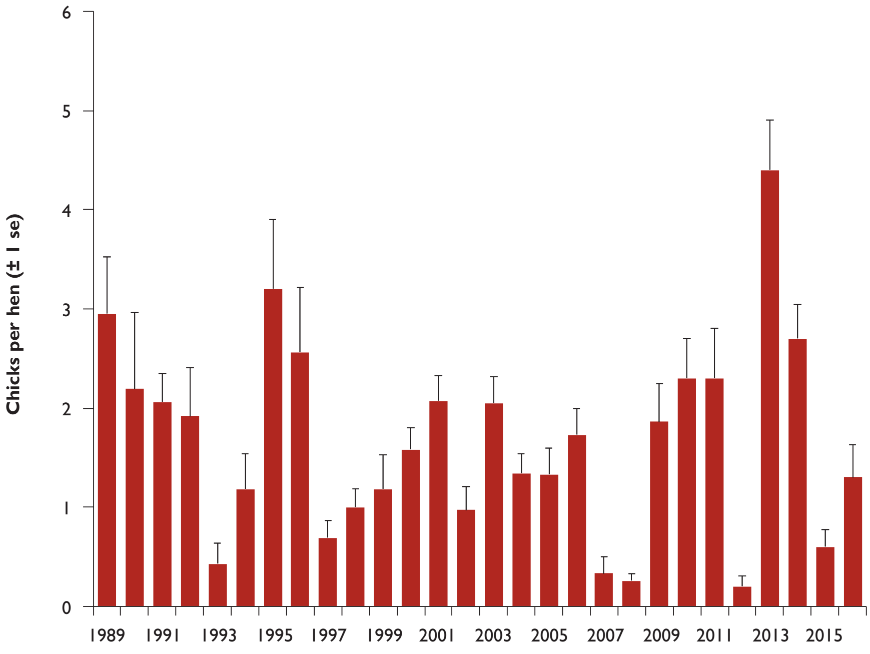


Figure 5

Black grouse breeding success in northern England between 1989 and 2016

Heather burning and red grouse

© Laurie Campbell

Using specialist machinery heather burning is now a more efficient and safer process.

KEY FINDINGS

- Rates of heather burning have increased in recent decades and concerns have been expressed by some that this may be impacting upon sensitive upland ecosystems such as blanket peat.
- Grouse breeding densities were not higher on moors where there was more heather burning, but breeding success was higher.
- Increased heather burning can be justified in terms of grouse moor economics, but we have no information on the impact on other ecosystem services

Dave Baines
David Newborn
Mike Richardson
Gail Robertson

Rotational burning of moorland vegetation is considered by most grouse moor managers to create structurally diverse habitat that helps maximise red grouse abundance for shooting by increasing the number of breeding territories that a moor can support. Hence, with arguably faster heather growing rates following general reductions in sheep grazing and an increasing use of specialised tractor mounted cutting, flailing and fire-controlling equipment that permits safer burning during dry conditions and better ignition during damp ones, burning rates have increased in the last decade. Consequently, there is growing concern that these increasing levels of burning, especially on designated sites of national and international habitat conservation status, and particularly on deep peat, are impacting upon upland ecosystems. Described impacts, some of which are the subject of bitter contention, include reductions in carbon sequestration following removal of peat-forming vegetation, especially species of Sphagnum moss, release of dissolved organic carbon into streams and rivers and flash flooding.

In the face of these growing concerns, we sought to establish whether there was an economic-based justification in terms of higher grouse production that may explain grouse managers' decisions to escalate their burning rates. To do this, we examined the influence of burning on heather height and structure, and on grouse density and breeding success at 36 moors in northern England. Driven grouse shooting was practiced on all moors and on each moor, full-time gamekeepers were employed not only to burn heather, but also to control generalist predators of grouse and strongyle worms that parasitize grouse and can cause boom-bust population cycles. On each moor, grouse were counted within 100 hectare (ha) blocks in spring to estimate the number of pre-breeding pairs and again post-breeding in July to count young and adult grouse. We measured vegetation composition, structure and its height, together with peat depth using a one-metre probe, at 100 points along a pair of transects running through each grouse count area. We used the collective measures of peat depth to assign each count area as either heath, where at least 50% of measures were less than 40cm of peat, or blanket bog, at least 50% of measures greater than or equal to 40cm.

Heather height showed greater variation on moors where more heather was burned and this relationship was similar on moors that were predominantly of deeper peat, ie. blanket bog and those moors on drier, more shallow peat sites, ie. heathland. Perhaps in contrast to the prior expectations of grouse moor managers, grouse pair densities in spring before breeding were not higher where there was more burning conducted. In contrast, both breeding success, measured by the number of young per adult grouse in July, and post-breeding density, ie. the number of young and adult grouse combined per unit area, were higher on moors where the frequency of recent burning was greater. Again, these relationships between grouse and burning were similar irrespective of underlying peat depth, ie. did not differ between moors comprising of heath or blanket bog.

The association between rotational burning and grouse breeding success and post-breeding densities provides a justification for recent increases in burning rates for moors seeking to maximise numbers of grouse available for driven grouse shooting. We must stress, however, that these results are non-experimental and hence do not necessarily imply cause and effect. They are based on statistical associations and whereas we tried to compare moors that had otherwise similar management so that we could focus on differences in burning rates, those moors with higher burning rates may also have been more efficient in other aspects of grouse moor management, ie. the keepers may also have been more effective in controlling grouse predators or parasites. The Trust are keen to develop long-term, multi-site, multi-discipline burning experiments to help collective stakeholder understanding of such complex relationships, with a view to helping overcome any apparent conflict between grouse management and other ecosystem services, particularly on deep peat sites.

Heather height showed greater variation on moors where more heather was burned. © Laurie Campbell

BACKGROUND

Rotational burning of moorland vegetation is considered by most grouse moor managers to create structurally diverse habitat that helps maximise red grouse abundance for shooting by increasing the number of breeding territories that a moor can support. However, there is growing concern that increased burning is impacting upon upland ecosystems.

ACKNOWLEDGEMENTS

We would like to thank all the owners and keepers who granted access to their moors for this study.

White seed heads of cotton grass, a peat forming species that is often encouraged by rotational burning of heather over peat-rich substrates. © Laurie Campbell

Expanding black grouse range

Males were successfully translocated into three formerly occupied sites in the Yorkshire Dales. © *Dave Mason*

KEY FINDINGS

- Released males have established new leks, which have attracted females to settle and breed.
- Fourteen new leks have been established attended by 44 males in 2015.
- Seven new 10x10-km grid squares have been recolonised, contributing to the delivery of range expansion targets.

Philip Warren
Frances Atterton
Matteo Anderle
David Baines

Black grouse were once widespread in England, but have declined over the past 150 years largely owing to habitat changes. In 1998, 773 males remained and were mainly confined to the North Pennines in northern England. Owing to their recent declines they have been red-listed as a species of high conservation concern and were a 'Priority Species' of the UK Government's Biodiversity Action Plan with its own Species Action Plan (SAP) to restore both numbers and range. The English SAP targets were (i) to stem or reverse the decline in numbers to 800 males recorded in 1995/6 by 2005, and (ii) in the long term (20 years) increase the range to its 1988-91 extent of 61 10x10 kilometre (km) grid squares occupied by displaying males in spring. Following the instigation of a range of conservation measures, numbers increased to 1,029 males in 2006, thus achieving the first set target. However, range increased only from 37 to 42, 10x10-km grid squares and the delivery period for achieving the target was extended to 2030.

The conservation effort subsequently focused on expanding range. Suitable, formerly occupied habitats were present adjacent to or beyond the southern fringe of the existing range in the Yorkshire Dales. Natural range expansion was considered to be limited by juvenile males, which move only short distances (up to 1km), whereas females disperse up to 19km (mean 9.3km). These findings, confirmed by field observations, suggested that yearling females may disperse into suitable habitat where few or no males are present.

To stimulate sustained range expansion, we started a male translocation programme into three formerly occupied sites in the Yorkshire Dales, following a successful pilot study at a site within the existing range. By translocating males we aimed to increase range through encouraging males to establish leks in formerly occupied sites, which would then attract dispersing females to settle and go on to breed. The degree of success was evaluated in (a) the short-term (one to three years post-release) using radio-telemetry to assess settling patterns, behaviour and survival of translocated individuals, and (b) the longer-term (one to nine years post-release) through annual lek surveys to assess the persistence of established leks through successful breeding and their contribution to the range expansion target.

Three release sites were chosen beyond the southern edge of the male range in the Yorkshire Dales, but were within the perceived dispersal distance of females, and where habitats were considered suitable and generalist predators were controlled. Between 2006 and 2010, 17 males were released at Mossdale, and a further 18 and 27 respectively in Coverdale and Nidderdale (see Figure 1) between 2011 and 2014. Males were caught at night, fitted with radio-transmitters and released immediately at the new sites.

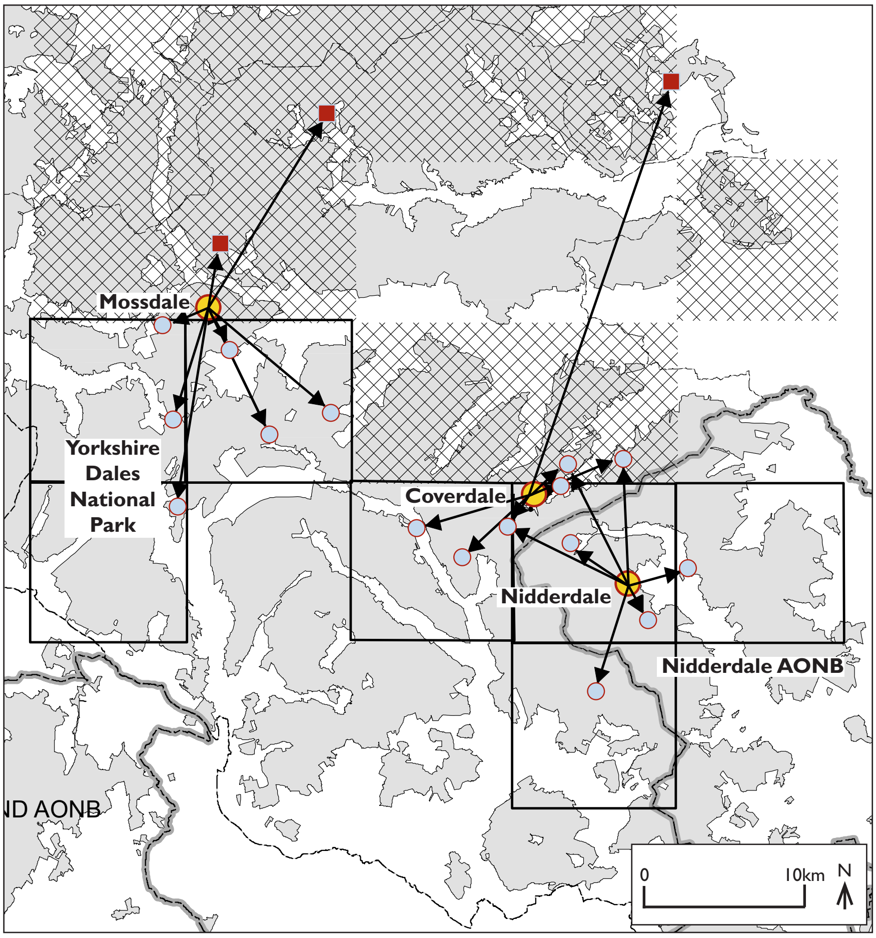


Figure 1

Movements by translocated males from the three release points in the Yorkshire Dales, to the leks where they displayed the following spring. Establishment of new leks by translocated males resulted in occupied range increasing by seven 10x10-km grid squares between 2006 and 2015

- Release sites
- New leks
- Existing leks
- 10x10-km grid squares occupied by black grouse in 2006 prior to translocation
- New 10x10-km grid squares occupied by translocation
- Moorland

In the first spring following translocation, 98% of males (n=47) were observed displaying. Males displayed at leks an average 3.6km (range 0.6 to 27.1km) from their release point. Leks were established at all areas. Females were seen in attendance with males and successful breeding was recorded. The total numbers of displaying males at release areas increased from one male in 2006 to 44 occupying 14 leks in 2015. This contributed to the re-colonisation of seven 10x10-km grid squares (see Figure 1), contributing two-thirds of the measured range increase from 37 to 48 occupied squares between national surveys in 1998 and 2014. Survival in the first year (n=62) following translocation was 0.77 (0.63-0.86, 95% CL) and was similar to that of birds measured in previous studies in the core northern England range.

The findings of the study suggest that under appropriate circumstances translocation can be a helpful conservation tool in stimulating range expansion.

BACKGROUND

Black grouse have declined in numbers and range over the past 100 years and in England they are now restricted to the edges of moorland in the north Pennines hills. Black grouse are red-listed and were a 'priority species' of the UK Government's Biodiversity Action Plan which aimed to initially stem the decline and then increase both numbers and range.

ACKNOWLEDGEMENTS

We would like to thank the landowners and gamekeepers at both the donor and recipient sites for their generosity donating males and allowing access to the study areas. We would also like to thank the project funders Sita Trust, Biffaward, Yorkshire Water, Nidderdale AONB Partnership, Friends of the Nidderdale AONB, the Ernest Kleinwort Charitable Trust and private landowners.

Successful breeding was recorded at the translocation sites. © Dave Kjaer

Capercaillie declines in Scotland

Reduced breeding success over the duration of the study was due to proportionally fewer females rearing chicks rather than a reduction in brood size. © Dave Kjaer

BACKGROUND

We have been counting capercaillie annually in Scotland since 1991. Low breeding success has been associated with dramatic declines in population and range of the capercaillie. Multiple factors have been associated with poor breeding including wet June weather when chicks hatch, increased predators, poor forest habitat and fences to exclude browsing deer causing increased mortality among full-grown birds.

Low breeding success has been associated with dramatic declines in population and range of the capercaillie in Scotland. Multiple factors have been associated with poor breeding. These include wet June weather when vulnerable chicks hatch, increased predators of clutches and chicks, inappropriate levels of deer browsing; either too much resulting in less bilberry that supports insect larvae preferred by chicks, or too little resulting in dominance of tall rank heather. Meanwhile, attempts to regenerate forest habitat by erecting fences to exclude browsing deer, most of which have now been marked or removed, caused increased mortality among full-grown birds, thus necessitating higher levels of productivity to offset this mortality.

We have been counting capercaillie annually in Scotland since 1991 and in that time have gathered data from 26 different forests distributed from Loch Lomond in

Figure 1

Annual capercaillie breeding success (chicks per female) measured from 11-20 forests per year between 1991 and 2009

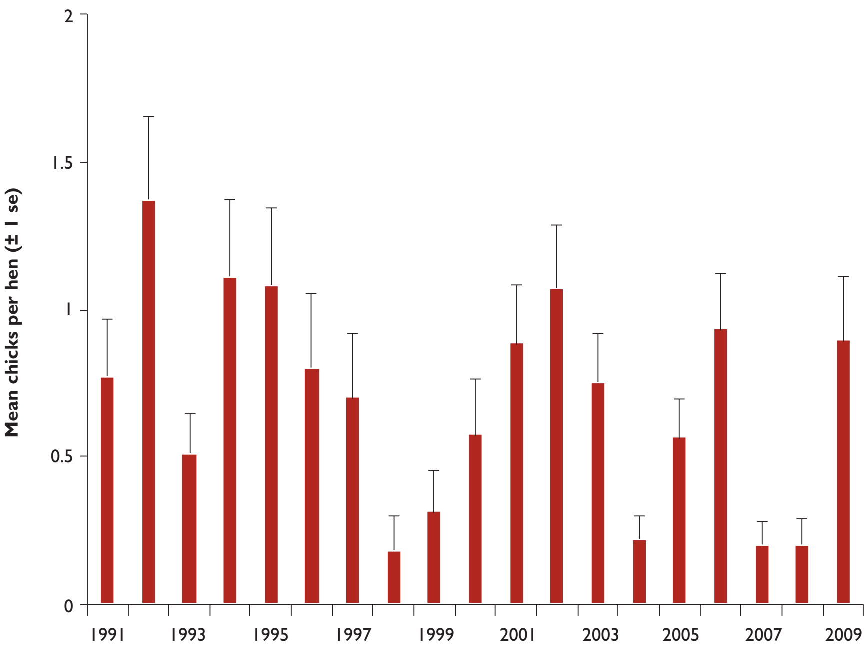


TABLE 1

Mean (SE) values of capercaillie breeding success and indices of female density and percentage annual female decline across six Scottish regions between 1991 and 2009

Region	Forests	Chicks per female	Broods size	Broods per female	Females km-²	% annual decline
Strathspey	8	0.86 (0.14)	2.34 (0.13)	0.41 (0.06)	1.92 (0.80)	-1.3 (0.9)
Aberdeenshire	6	0.69 (0.18)	1.88 (0.17)	0.42 (0.09)	1.62 (0.80)	-13.0 (1.3)
Perthshire	6	0.37 (0.09)	1.87 (0.18)	0.21 (0.06)	0.94 (0.48)	-16.4 (2.0)
Moray	2	0.55 (0.21)	2.59 (0.42)	0.22 (0.11)	0.77 (0.88)	-16.2 (2.8)
Easter Ross	3	0.47 (0.18)	1.94 (0.28)	0.26 (0.12)	0.66 (0.52)	-8.8 (4.3)
Argyll	1	0.67 (0.36)	1.92 (0.44)	0.39 (0.20)	3.19 (3.56)*	-23.0 (6.5)

**High density attributed to birds being confined to four small islands (combined area 1.9 km²) in the middle of a large lake (Loch Lomond).*

Argyll towards the south, to Morangie near Nairn in Ross-shire to the north. We do this in July/August to estimate breeding success and simultaneously to give an index of adult densities. In 1995 and again in 2009, we estimated predator levels within these forests by counting crows and raptors and recording scats of fox and pine marten along transects. In 1995 and in 2011 we also measured forest ground vegetation composition and height within the same forests. We then analysed the bird, habitat and predator datasets, together with weather records from the nearest weather station to each forest for breeding seasons between 1991 and 2009.

Annual breeding success from 26 Scottish forests surveyed between 1991 and 2009 averaged only 0.6 chicks per female, the lowest rate recorded in 16 previous studies within the species' entire range. Reduced breeding success over the duration of the study (see Figure 1) was due to proportionally fewer females rearing chicks rather than a reduction in brood size. Birds bred less well in Perthshire towards the southern edge of the range, where declines in indices of female and male density were highest (see Table 1). Only at the core of the range in Strathspey, which now hosts more than 75% of Scotland's capercaillie, did birds breed reasonably well and female densities were stable (see Table 1).

Two weather variables, April temperature in the pre-breeding period, and temperature at chick hatch in June, increased over the study period. Indices of pine marten increased 3.9-fold between 1995 and 2009, and those of fox 2.2-fold, whereas carrion crow and raptor numbers and forest floor vegetation showed no change. Neither forest type nor forest ground vegetation appeared to influence breeding success. Instead, females reared more chicks in years when hatch time in June was drier, and in forests with lower marten and crow indices. In addition, more females reared broods in years when Aprils were cooler. Brood size was unaffected by any of the measured variables. Densities of adult birds declined over time and were lower in forests with higher fox indices. Increased predation of clutches and chicks by martens and crows within these small, fragmented forests, as well as changes in climate, may explain reductions in breeding success and hence contribute to continued declines.

To date, breeding success and adult numbers have remained similar over time in Strathspey, now the last remaining stronghold for capercaillie in Scotland. This is despite increases in pine martens in this region too, but here the native forests are larger and less fragmented and hence generalist predators associated with the forest-agriculture interface such as crow and fox may have less impact. Under these conditions, it remains to be seen whether capercaillie breeding success can be maintained without further intervention or whether successful conservation of capercaillie may require adaptive predator management, including a licensed removal of martens to test the hypothesis that martens contribute to reduced breeding success. Such a short to medium-term approach would inform longer-term predator management policies and complement aspirations to increase the area and connectivity of forest habitat to benefit capercaillie.

KEY FINDINGS

- Capercaillie range retraction is linked to declines in breeding success.
- Breeding success was lower in forests where there were more crows and pine martens and in years when June rainfall was higher.
- Three-quarters of the population is now confined to the larger forests in Strathspey, the remaining Scottish strong-hold.

David Baines
Nicholas Aebischer

Red grouse and hen harriers on Langholm Moor

A hen harrier brood at Langholm.
© Sonja Ludwig/GWCT

KEY FINDINGS

- Grouse moor management had a positive effect on abundance and breeding success of red grouse and hen harriers.
- Fox abundance was negatively associated with grouse density and harrier breeding success.
- Crow abundance was negatively associated with grouse breeding success.

Sonja Ludwig
Dave Baines

Since 1992, Langholm Moor has hosted studies that focused on the conflict between grouse moor management and raptor conservation. During this time, the moor was subject to the cessation and subsequent restoration of grouse moor management. Up to 1999 and from 2008-2015 the moor was managed by gamekeepers for grouse shooting, which involved heather burning and legal control of generalist predators. In the intermediate years (2000-2007), no full-time gamekeepers were employed to routinely control predators. We considered how these changes influenced the abundance and breeding success of grouse and harriers, as well as the abundance of their likely predators, red fox and carrion crow.

Grouse moor management in both periods was associated with 50-70% lower crow indices and with 65% lower fox indices in the second period only as foxes were not measured in the first (see Figure 1). Furthermore, grouse densities (see Figure 2) and breeding success (see Figure 3) were two- to three-fold higher than when the moor was not managed for grouse. When looking at annual values, there were more grouse when there were fewer signs of foxes and grouse reared more chicks when there were fewer crows. However, as we cannot disentangle the relative contribution of predator control from simultaneous changes in heather management or the introduction of diversionary feeding in the second managed period, other factors may further explain changes in grouse breeding success and densities.

Grouse moor management also had a positive effect on harrier breeding success, which was two- to three-fold higher than during the unmanaged period (see Figure 3), and tended to be lower in years with higher fox indices. Since grouse moor management was re-established in 2008, no harrier nests have failed through fox predation. Hen harrier abundance decreased after the cessation of grouse moor management in 1999 (see Figure 2), however, despite the high breeding success numbers started to recover only six years after management was resumed in 2008.

This study confirms that both grouse, in the presence of low numbers of harriers, and harriers, if not controlled illegally, can benefit from grouse moor management.

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. For more details see Ludwig et al. (2016) *Wildlife Biology*, DOI 10.2981/wlb.00246.

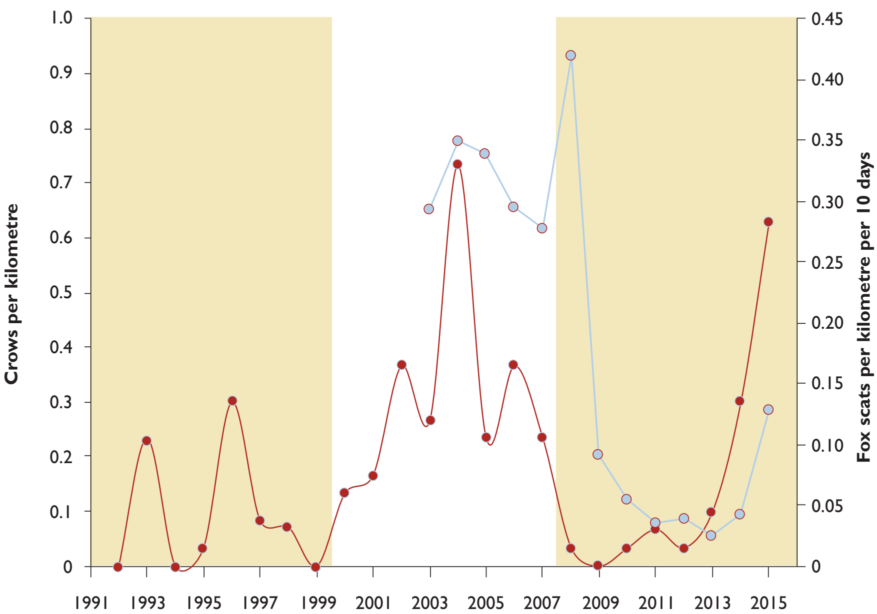
Figure 1

Annual variation in abundance of carrion crows and fox scat index

Carrion crow abundance

Fox scat index

Keepered periods



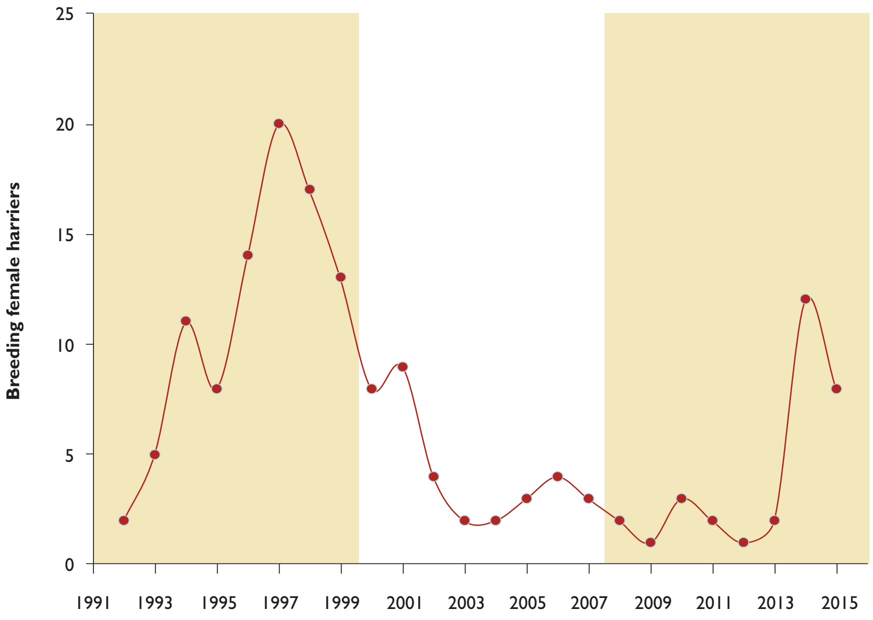


Figure 2a

Annual variation in the number of female hen harriers

Keepered periods

BACKGROUND

Increasing hen harrier numbers at Langholm during the Joint Raptor Study (1992-1996) contributed to increased raptor predation on grouse until shooting became unviable and ceased in 1996. Active grouse moor management was abandoned in 1999 and then resumed in 2008 to test whether sustainable driven grouse shooting could be restored in the presence of a viable harrier population (Langholm Moor Demonstration Project). Management ceased again in 2016.

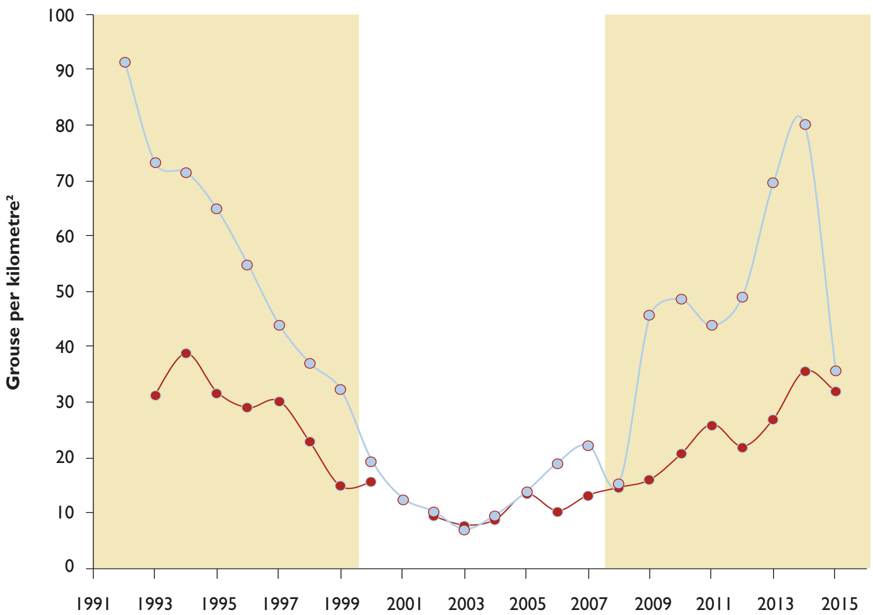


Figure 2b

Red grouse densities in spring and July

Spring

July

Keepered periods

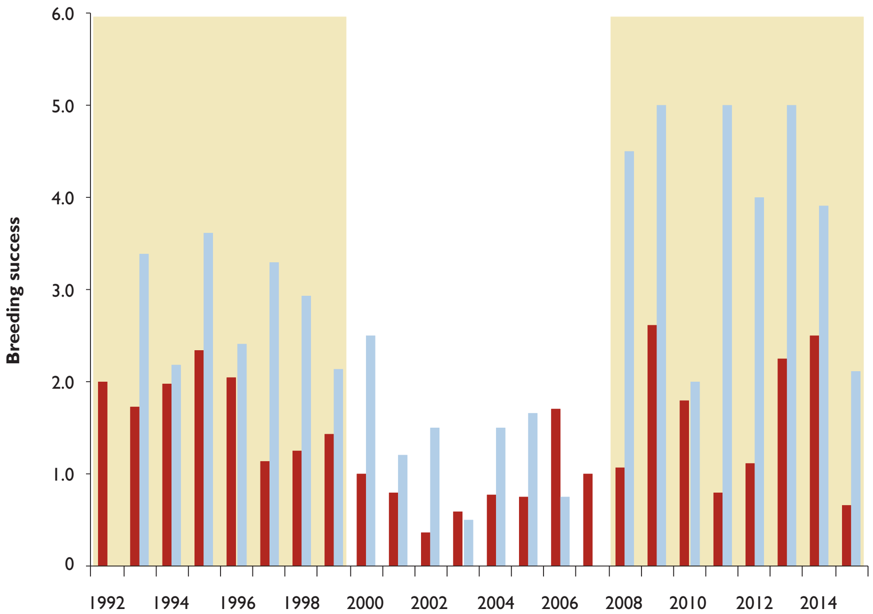


Figure 3

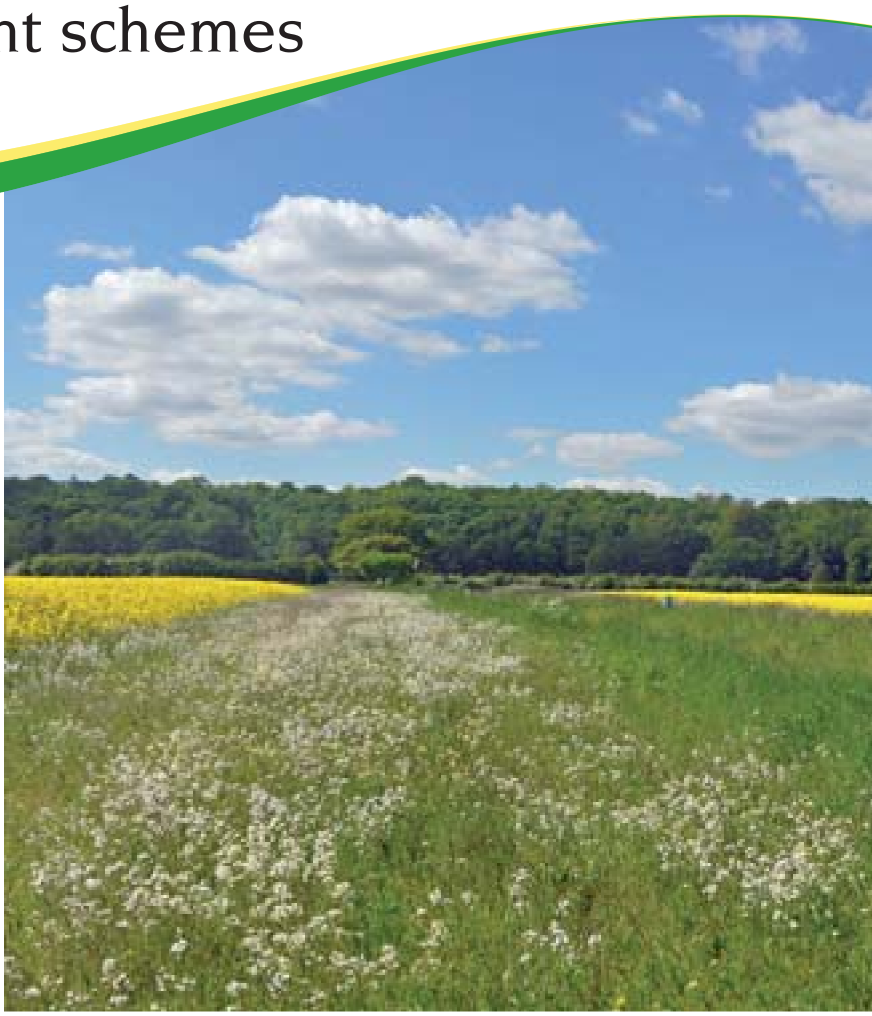
Annual variation in breeding success of red grouse (young/adult) and hen harrier (young/female)

Red grouse

Hen harrier

Keepered periods

Agri-environment schemes and swallows



Floristically enhanced margins may be more beneficial to foraging swallows when placed mid-field. © Peter Thompson/GWCT

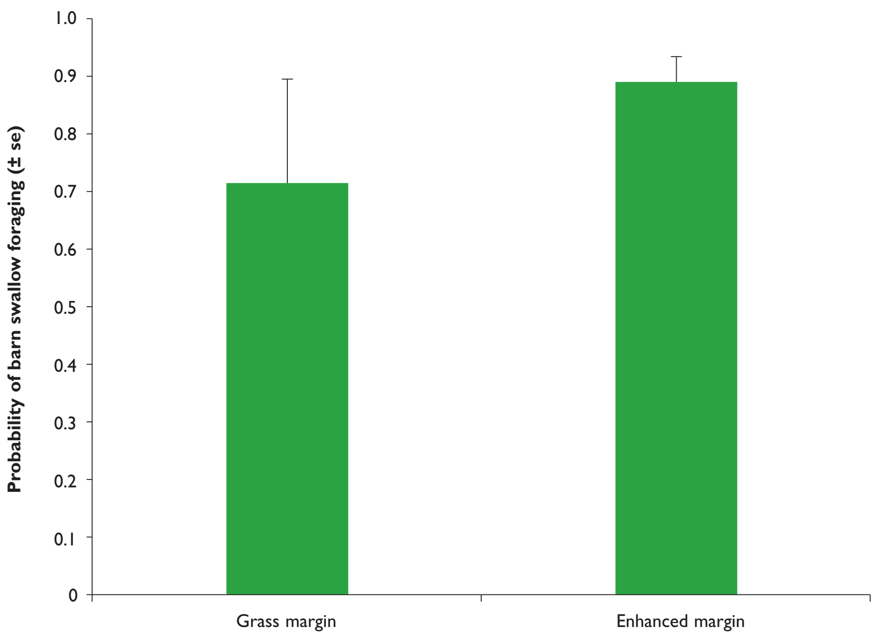
BACKGROUND

To date, research on the use of Agri-Environment Scheme (AES) habitats by farmland birds has been focused on invertebrate-eating species that forage on the ground or within the vegetation. This project aimed to investigate differential use of two AES arable field margin types – grass-only margins (EE3, HE3) and flower-rich margins (HE10, EF4 and HF4) – by swallows.

The swallow (also known as the barn swallow) is a bird typical of open habitats such as pastures, meadows and farmland. They are long-distance migrants and make a 10,000-mile migration from South Africa to spend the summer months in Europe. In Britain, swallows can often be seen on farmland, skimming fields for flying insects or building their characteristic cup-shaped nests inside old buildings. The aerial foraging strategy employed by swallows is unusual as the majority of Britain's farmland birds feed on the ground or within the vegetation. Because of this, research has been heavily biased towards species exploiting these foraging niches (eg. yellowhammer and cirl bunting). Measures of the success of agri-environment schemes (AES) have therefore

Figure 1

Mean (± SE) probability of observing foraging swallows along grass margin or floristically enhanced margin transects. Means (± SE) are back-transformed following analysis



Swallow. © Peter Thompson/GWCT

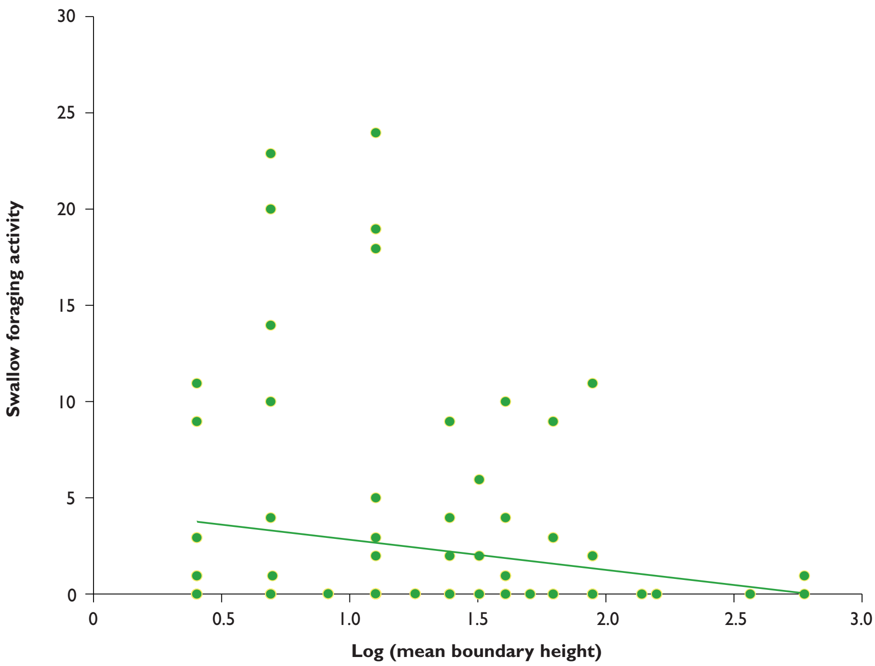


Figure 2

Relationship between swallow foraging activity and the log transformed mean adjacent boundary height ($p<0.05$)

KEY FINDINGS

- Foraging swallows were more likely to be present along margins containing wildflowers and legumes when compared to grass-only margins.
- The availability of swallow invertebrate food items was 36% higher on transects containing floristically diverse margins.
- Foraging activity decreased significantly with increasing boundary height.

Niamh McHugh

been directed at these species guilds and, although it has been suggested that field margins and hedgerows managed for birds and invertebrates under AES may have wider benefits, their potential benefit to aerial feeders remains unquantified.

To address this, we compared swallow foraging activity on arable farmland involved in an AES during the summer of 2016. Preliminary visits were made to seven arable farms in May to ensure breeding colonies were present for foraging surveys. When breeding, swallows are central-place foragers, meaning that all foraging watches needed to take place within their usual foraging range of 600 metres from the nesting colony. We selected all six-metre grass margin buffer strips (EE3, HE3) and floristically enhanced arable field margins, sown with wildflowers and legumes (HE10, HF4 or EF4), present within this zone for our surveys (n=56). Surveys were 20 minutes in duration, taking place twice (once in June and once in July) along field boundaries over a 200x35 metre transect belt, encompassing an arable margin and a cropped habitat. The average height of the boundary habitat present along transects was recorded to the nearest 0.5 metres. Surveys started no earlier than 6am and finished at 11am, taking place only when weather conditions were calm. We recorded the number of flies present above transect belts by taking four samples directly after foraging watches. Each sample consisted of 30 sweeps using a lightweight kite net. Cloud cover was recorded as a nuisance variable owing to the impact of air pressure on aerial invertebrate movements. Two measures of swallow activity were recorded: 1) swallow presence/absence on the transect belt over the survey period; and 2) an index of foraging activity calculated as the total of each maximum swallow count per minute.

The probability of observing swallows along belt transects that included a floristically enhanced margin was 25% higher than the probability of doing so along ones including grass margins (see Figure 1). This may be due to the higher aerial invertebrate abundance recorded in this habitat, as the total fly count was 36% higher along floristically enhanced than along grass margin transects, indicating that floristically enhanced margins may be an important feeding resource for swallows occupying arable farmland. Our measurement of swallow foraging activity, however, found no differences between the two margin types, but foraging activity decreased significantly with increasing boundary height (see Figure 2). This implies that providing floristically enhanced margins for foraging swallows may be more effective when placed either mid-field or along field edges with low or no hedgerows.

These findings suggest that there may be a role for AES in the conservation of swallows although more research is needed to determine whether AES can influence colony size or improve breeding success. This information will play a role in formulating arable farmland conservation strategies for this species.

Aerial invertebrates were sampled using a kite net. © Niamh McHugh/GWCT

ACKNOWLEDGEMENTS

We are grateful to Belinda Bown and Jasmine Clarke for their assistance in the field and to the landowners who allowed us access to their land to conduct this study.

QuESSA - the benefits of nature

Blow fly larvae sentinel with cage to exclude rodents. © John Holland/GWCT

BACKGROUND

European farming landscapes contain various types of semi-natural habitats (hedgerows, woodland and flower-rich grassland) and these can benefit farming by supporting beneficial invertebrates that pollinate crops or contribute to natural pest control leading to improved crop yields. They may also prevent soil erosion, store soil carbon and define landscapes that make them more attractive than crop monocultures. These are all classified as ecosystem services and have become the focus for much research in the last decade. Farmers can obtain funding through Agri-environment Schemes (AES) or as Ecological Focus Areas (EFAs) for the establishment or management of many habitat types, predominantly to encourage biodiversity and preserve historic landscapes, yet the value they provide for farming is relatively unknown.

In 2013 we started work on a four-year project called QuESSA (Quantification of Ecological Services for Sustainable Agriculture), funded by the European Union, with the remit to quantify the contribution of semi-natural habitats (SNH) to ecosystem services, but especially pest control and pollination for a range of crops and farming systems. Working with our 13 partners we developed a range of common methodologies and used these simultaneously in 16 case studies in eight European countries (England, the Netherlands, Estonia, Germany, Hungary, Switzerland, Italy and France) that included seven crops (wheat, oilseed rape, sunflowers, pumpkins, pears, olives and vines).

Overall approach

We first identified the key SNH in each country and assessed the vegetation structure and composition, along with the beneficial invertebrates in these habitats. From this we calculated a predictive score for each habitat for pollinators and pest control. Next we measured the actual levels of ecosystem services in our case studies in Hampshire and Dorset, each of which comprised 18 landscape sectors of 314 hectares (ha) of arable farmland centred around a focal field in which the studies were conducted. The landscape sectors were selected to ensure that the proportion of SNH varied from low to high for the region. The focal fields were selected so that they were adjacent to one of three types of SNH, with six replicate fields of each. In the UK the SNH studied were herbaceous linear strips, woody areas such as hedgerows and woodland while grass-only strips served as controls. In most case studies, we measured levels of pollination and pest control, alongside other ecosystem services including soil erosion, soil carbon storage and aesthetic value of the landscape. In the UK we focused on pollination of oilseed rape, pest control in wheat, carbon storage and aesthetics. The data were analysed using standard statistical methods and by approaches developed at Wägeningen University that took into account the type, proportion and distance of each SNH from the focal field. In this way we could identify not only the most important SNH, but the range over which they can have an impact. This approach was also used by the European Commission's Joint Research Centre in Ispra, Italy along with existing landscape-scale data to generate maps for the whole of Europe that predicted the abundance of pollinators and likely levels of pest control. A selection of our findings for the UK are presented here.

Pollination

Oilseed rape is both wind- and insect-pollinated but if pollinators are not sufficiently abundant there may be a pollination deficit and a subsequent yield loss. We measured this by comparing the weight of seed produced for flowers with natural levels of insect visitation to those in which seed set was maximised by additional hand pollination. This was conducted in each focal field and along single transects extending up to 70 metres from the SNH. In two of the six countries testing this (two of which

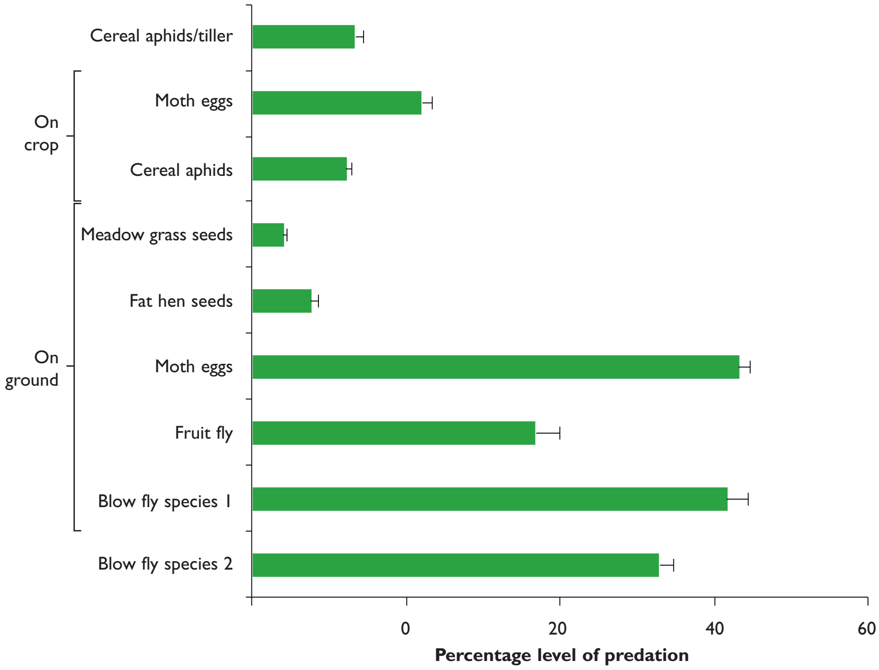


Figure 1

Mean levels of predation (± se) for the different sentinel systems located either on the ground or the crop and the naturally occurring numbers of cereal aphids per tiller

measured oilseed rape), there was a significant pollination deficit of 7%. The deficits occurred in Switzerland with oilseed rape and in Italy with sunflowers, despite there being many bee hives. In Switzerland the deficit may have occurred if they used oilseed rape varieties that did not fully self-pollinate. There are other crops (field beans) and wild plants whose seed set is more dependent on insect pollinators, therefore pollinator conservation is still of high importance in countries not showing a deficit. We also measured flower visitation on oilseed rape and found most was by flies (77%) that are poor pollinators, while wild bees comprised only 13% and honeybees 8% of visitors. Visits by wild bees declined with distance from the SNH.

Pest control

Crop pests do not always oblige by being present in sufficient numbers for study and the most important species vary considerably between crops. For these reasons, we developed a range of sentinel systems based upon surrogate pests to measure levels of pest predation by pest natural enemies. These included the larvae of two species

KEY FINDINGS

- Pollination levels of oilseed rape are generally adequate.
- High levels of natural pest control can occur but may be improved by adding herbaceous habitats to the landscape.
- Increasing soil organic matter from 1-2% to 6% would double the amount of carbon stored on farms.

John Holland
Niamh McHugh
Steve Moreby
David Stevenson

Hand pollinating oilseed rape.
© John Holland/GWCT

Sentinel system to measure aphid predation comprised of live cereal aphids attached to cards. © John Holland/GWCT

of blowfly, fruit fly pupae, moth eggs and cereal aphids, along with two species of seed (fat hen and rough-stalked meadow-grass) known to be consumed by ground beetles. These were placed either on the ground or on the crop according to the pest they were meant to represent, in each focal field along two transects extending up to 70 metres from the SNH.

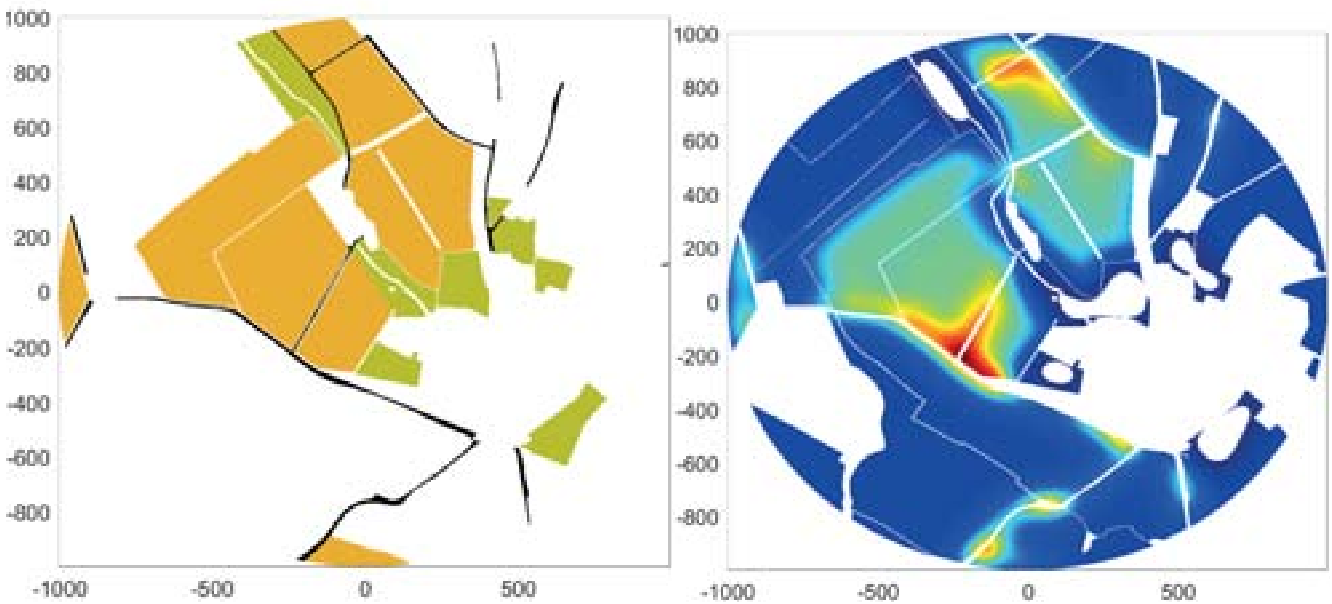
The average level of predation was higher for the sentinels with insect prey on the ground (37-53%) compared with on the crop (12-22%) or for the seeds (4-8%) (see Figure 1). The proportion of herbaceous habitats in the landscape had a positive effect on predation of three sentinel types, whereas woody habitats sometimes had a negative effect. Natural cereal aphid infestations decreased as the proportion of all SNH increased in the landscape. The type of SNH in the adjacent boundary had relatively little impact. Predation of larvae and seeds increased with distance from the SNH because this was predominantly by the larger carabid beetles that reside permanently within fields and derive no benefit from field margin habitats. Maps also revealed that some habitats including crops benefited overall levels of pest control and that there was considerable variation across the landscape (see Figure 2). We conclude that high levels of natural pest control can occur, but there is potential to improve this by introducing more herbaceous habitats into the landscape and to encourage predators that forage on the crop itself.

Soil carbon

Soil samples were taken within each SNH type and crop fields and the amount of carbon calculated from the levels of soil organic matter. Fields averaged 127 tonnes of carbon per hectare (t C per ha), herbaceous linear habitats 172 t C per ha, woodland

Figure 2

a) location of grasslands (moss green), wheat (brown) and roads (grey) in a landscape sector in the UK and b) heat map of the predicted predation rates on cereal aphids ranging from very low (blue tones) to low (red tones). (Maps produced by Marjolein Lof and Wopke van der Werf at Wägeningen University)



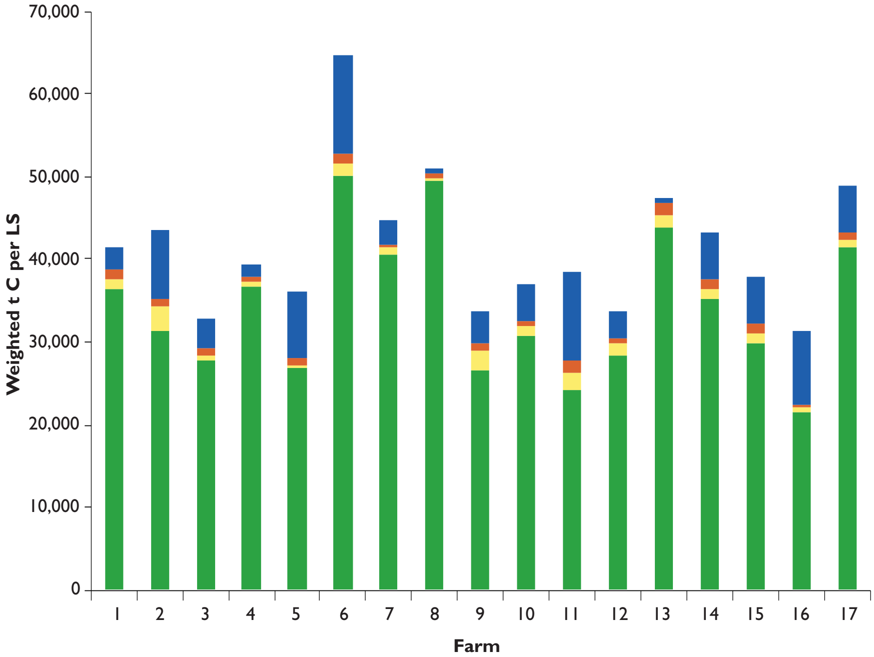


Figure 3

Mean carbon (t) stored in the soil weighted according to the area of fields and semi-natural habitats within a landscape sector (LS) of 1-km radius

- Fields
- Herbaceous
- Woody linear
- Woodland

165 t C per ha and woody linear habitats 136 t C per ha. Multiplying the soil carbon levels by the area occupied by each habitat in each landscape sector revealed that, on average, most carbon (82%) was stored in the soil within fields rather than in the SNH. However, there was considerable variation between the landscape sectors (see Figure 3). Furthermore, increasing soil organic matter in fields from 1-2% to 6% would double the amount of carbon stored on a landscape sector.

Conclusions

Our research showed that SNH can benefit some ecosystem services, but disentangling their contribution from the multitude of other factors influencing the levels of these services is difficult. Often the contribution of SNHs is context-dependent, not what farmers and policy makers wish to hear, and consequently we can often only support the existing recommendations for encouraging pollinators and pest natural enemies. We were reassured though from our socio-economic work within the project, that farmers take ecosystem services and biodiversity into consideration in their management decisions and that they valued the beauty of farming landscapes. As we enter a critical period for revisions to farming subsidies it will be imperative that we continue to financially support SNH as they are a key component in the delivery of more sustainable farming systems and are crucial for much of our wildlife and farming heritage.

For more information visit **www.quessa.eu** or **www.facebook.com/Quessa-129370957261348/**

ACKNOWLEDGEMENTS

We wish to thank every farmer that kindly helped with the project. This project received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No 311879. Our thanks to all the QuESSA partners: Agroscope Reckenholz-Tänikon Research Station, CH; Wageningen University, NL; Scuola Superiore Sant'Anna, IT; Szent Istvan University, HU; Bordeaux Sciences Agro, FR; Joint Research Centre of the European Commission, IT; University of Exeter, UK; SOLAGRO, FR; Stichting Dienst Landbouwkundig Onderzoek, NL; Estonian University of Life Sciences, EE; University of Pisa, IT; University of Koblenz-Landau, D; Environmental Social Science Research Group, HU.

Promoting the value of field margins was an important part of the project.

Allerton Project: game and songbirds

Song thrush numbers have increased 193% since 1992. © Dave Kjaer

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.

Through our long-term monitoring, we are able to evaluate the effect of the shoot management on game and non-game species. Reared pheasant shoots can rely less on control of predators during the breeding season compared with wild bird shoots. As our previous research has shown that predator control can influence breeding numbers of some songbird species, we attributed the lack of any substantial increase in their numbers, at least in part, to the absence of predator control. Our data also suggested that the prolonged wet weather during 2012 had also checked an already modest increase.

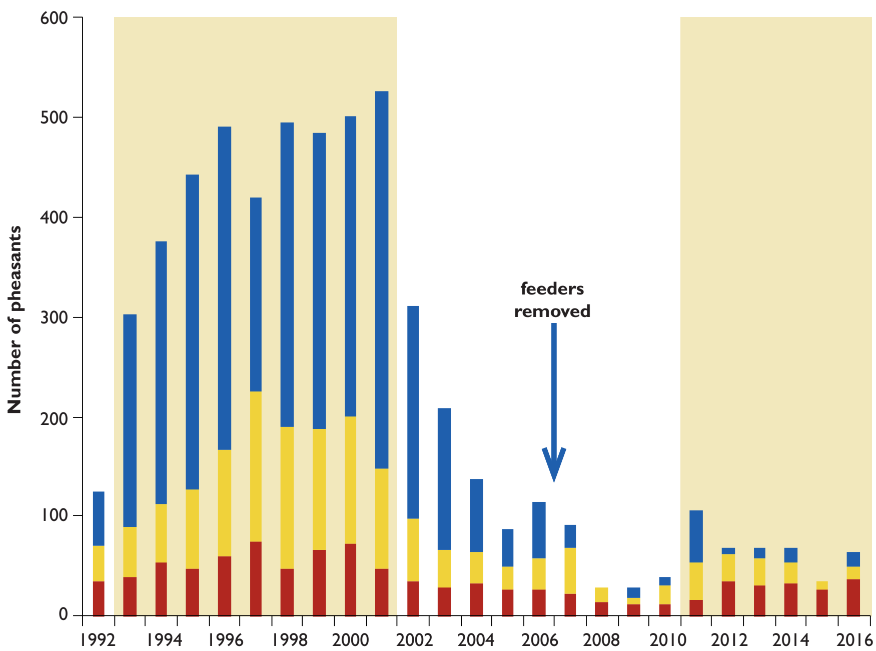
In the past two years, we have introduced additional predator control during the breeding season, specifically for the conservation of songbird species that are susceptible to nest predation. Overall songbird numbers are now 93% above the 1992 baseline (see Figure 3). Those species for which we have published the most convincing evidence for an effect of predator control on breeding numbers are among the species to be faring best under the new regime. Blackbird numbers almost doubled since 2010 when the new system started, and spotted flycatcher territories increased from just one to 10. Other species to have followed similar upward trends over the years with and without predator control include dunnock (165%), song thrush (193%), skylark (42%) and robin (140%).

The focus of the predator control is on crows and magpies, as these are known to be major predators of songbird nests, but there is also some trapping of small ground predators such as rats and stoats. This is a skilled and labour-intensive process. The cost of it amounts to about £25 per hectare, or £10 per acre per year. This figure will vary especially at farms with less suitable habitat for crows, magpies and other predators requiring lower levels of predator control, or none at all in the case of open farmland without trees.

Our earlier research on blackbirds showed that nest predation was highest where nests were exposed, especially in the early nesting season and when predator numbers were high. Although predator control is an obvious means of reducing nest losses, habitat management may also have a role. In *Dunn et al.,* 2016, published

Figure 1

Autumn wild pheasant numbers from 1992 to 2016



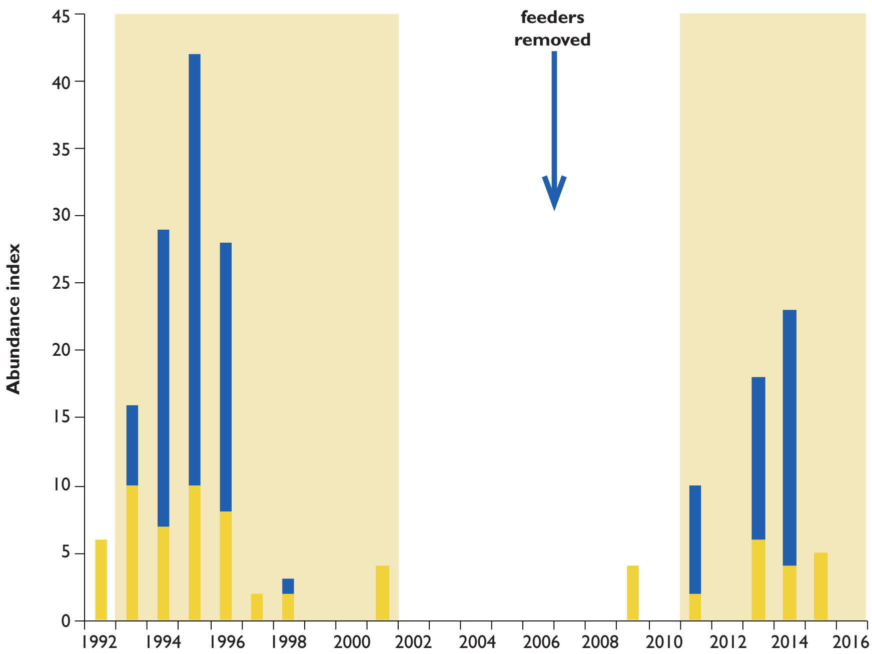


Figure 2

Autumn grey partridges

Young

Adults

Keepered period

recently with the RSPB, we were able to demonstrate that hedge management and resulting structure influences nesting success. Hedges that were neglected or cut annually were associated with lower nesting success than those that were cut less frequently but managed to maintain a dense structure.

Our long-term data, combined with shorter-term, more intensive studies, together demonstrate that a combination of habitat management and predator control can influence nesting success, and that this can influence breeding numbers of some species.

Hare numbers have increased in recent years, both against the 1992 baseline, and the local comparison site without game management, but we are not seeing the numbers that were present when we managed the farm for wild game. Although the reared pheasant shoot provides much-appreciated driven shooting for people from all over the country, wild pheasants and partridges on the farm have not responded to the current management (see Figures 1 and 2). Wild pheasant numbers in 2016 were half those of the 1992 baseline, and no grey partridges were recorded on the farm in the autumn. Throughout the current game management phase, we have seen very few young gamebirds being produced. We hope to investigate this as we know it is something that is experienced on many other farms and estates.

KEY FINDINGS

- A reared pheasant shoot with additional breeding season predator control has been associated with a 93% increase in songbird numbers.
- Poorly managed, open-structured hedges reduce nesting success.
- Hare numbers are eight times higher than the baseline.
- Wild gamebird numbers are not responding to the current management.

Chris Stoate
John Szczur

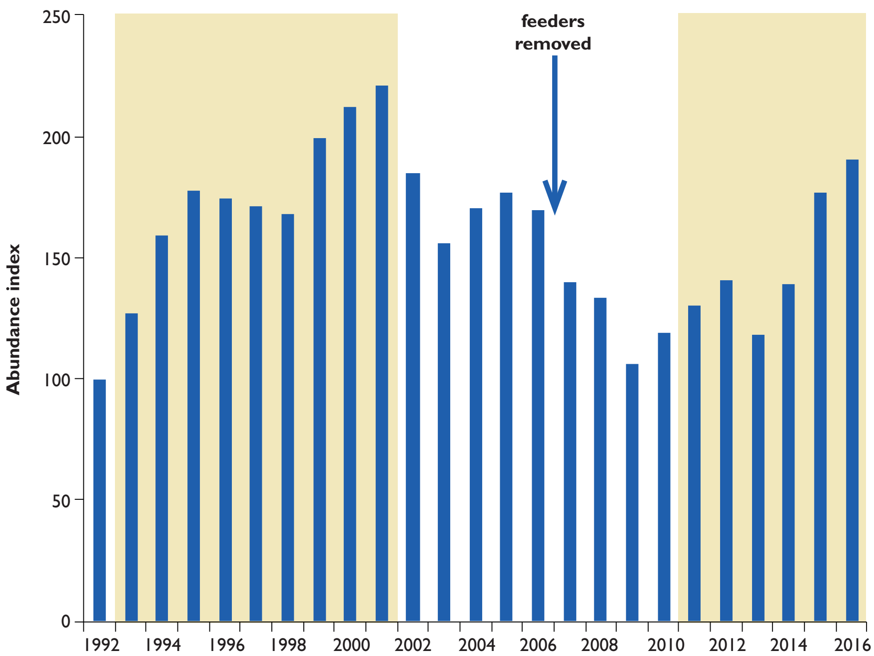


Figure 3

Songbird abundance

Keepered period

Dunnock. © Peter Thompson/GWCT

The farming year at the Allerton Project

In the last two decades we have seen monumental changes in farming methods. *© Amelia Woolford/GWCT*

Many farmers would have been dismayed reading the latest *State of Nature* Report, which continues to cast responsibility for the declines of many species on 'intensive' agriculture and farmers. Instead of being the solution to many of these problems, farmers are labelled as being the cause. Yet in at least the last two decades we have seen monumental changes in farming methods.

As the Allerton Project farm reaches its landmark 25th year it is worth reflecting on the changes that have taken place in farming over this period. Our benefactor, Lord Allerton, passed away in 1992 and the Loddington Estate became the Allerton Research and Educational Trust, the lowland research and demonstration farm for The Game Conservancy Trust. Around this time the European Commission ceased to incentivise agricultural production and introduced mandatory set-aside. LEAF was born and Integrated Farm Management, which embraces cultural, biological and mechanical pest control techniques ahead of chemical solutions, became the chosen approach for all progressive farmers. Our politicians signed the first Convention on Biological Diversity and Habitat and Species Action Plans (HAPs & SAPs) were rolled out; intensive plough/power harrow tillage gave way to minimal tillage; Environmental Stewardship take-up became widespread and agricultural yields plateaued or 'de-intensified'. Farm Assurance and the Voluntary Initiative (VI), an industry-led approach

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.

TABLE 1

Arable gross margins (£/hectare) at the Allerton Project 2010-2016

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

No single/basic farm payment included

** winter beans, **spring oats*

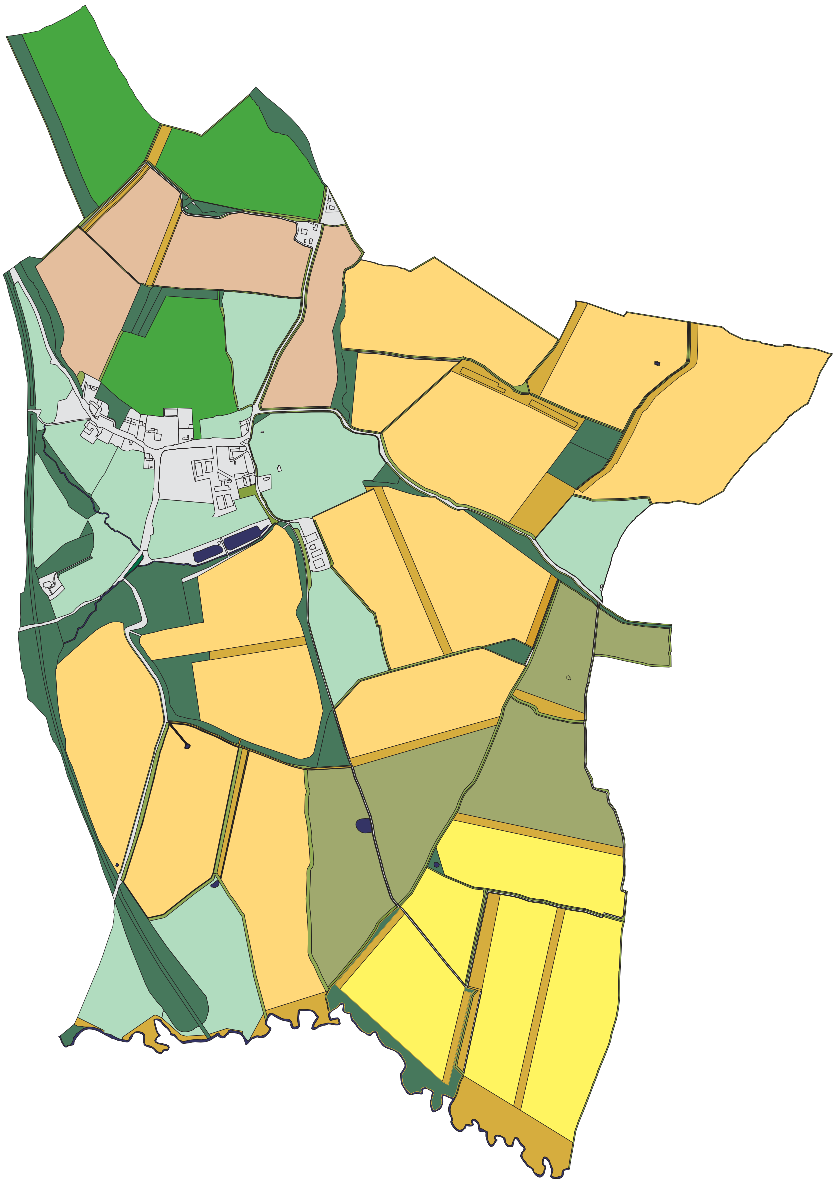


Figure 1

Allerton Project cropping 2015/16

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

KEY FINDINGS

- Twenty five years of farming at the Allerton Project have seen the environment take a front seat.
- Unprecedented changes from farm support to Environmental Stewardship have been adopted.
- Keeping farmers on the land will be essential for future environmental management.

Alastair Leake
Phil Jarvis

Yields have plateaued and crop prices remain low.
© Amelia Woolford/GWCT

Reduced tillage has been increasingly adopted. © Phil Jarvis/GWCT

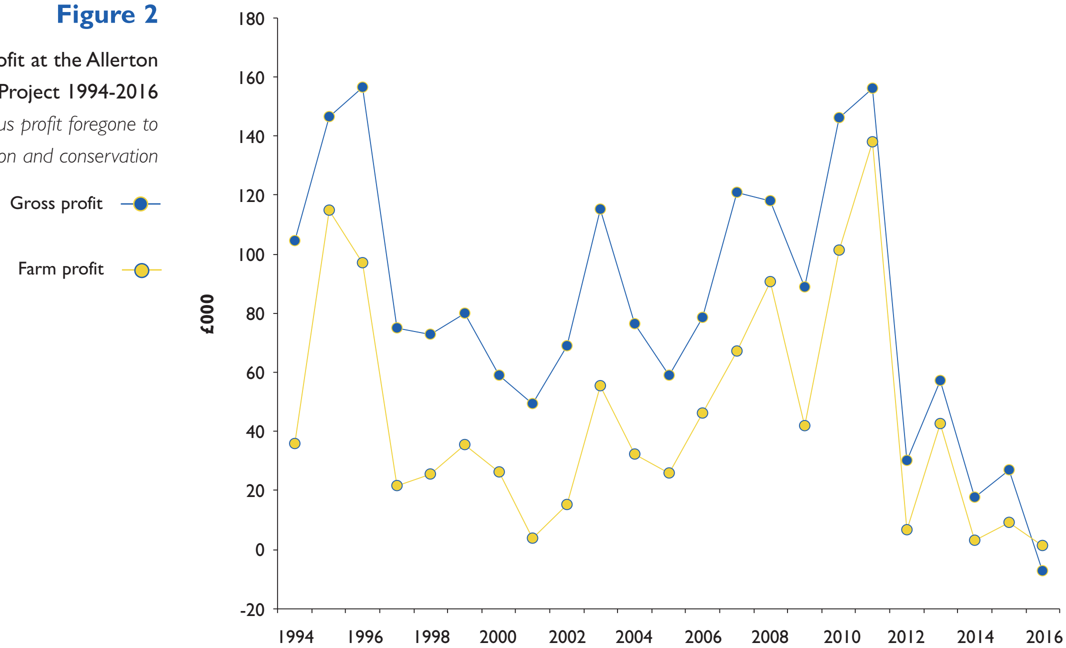
to reducing the effect of pesticides, and the National Register of Spray Operators (NRoSO) scheme were launched. Latterly we have seen zero-tillage being increasingly adopted, cross-compliance rules augmented with greening measures, the Farming & Wildlife Advisory Group (FWAG) re-emerge invigorated; hundreds of farmers, agronomists and farm advisors achieve the GWCT/BASIS Certificate in Conservation Management; the Campaign for the Farmed Environment (CFE) launched, which records the hundreds of thousands of hectares of land which are uncropped each year; the Sustainable Use Directive brought in compulsory sprayer 'MOTs' and farmers are required to be trained spray operators; the number of approved chemicals reduced by three-quarters, eliminating many products because of their negative environmental impact; and thanks to ground-breaking research by the GWCT, supplementary feeding has been added as a new stewardship option.

Visit our Allerton Project farm at Loddington and you'll see a wider range of crops being grown than ever before including wheat, oilseed rape, oats, beans, rotational grass and a record area of spring crops (see Figure 1). The fields destined for spring

Figure 2

Gross profit* and farm profit at the Allerton Project 1994-2016

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



About 11% of the land is now actively managed for game and wildlife. © Phil Jarvis/GWCT

drilling are direct-sown with winter cover crops, thereby retaining the stubbles, which help protect the soil from erosion, take up nitrate that might otherwise be leached and add organic matter to the soil when they are destroyed. Our fields are divided up with beetle banks and wildlife strips, while the riparian zones and ditches are all buffered with grass strips. In all about 11% of the land is now actively managed for the benefit of game and wildlife. All these measures are known to benefit wildlife and reduce our reliance on a dwindling number of effective herbicides. Our cultivation strategy consists of a single- or two-pass crop establishment system with slug damage reduced through deeper drilling, good soil consolidation post-drilling and the use of environmentally benign ferric phosphate pellets.

Yet despite these huge advances our own crop yields, as have the rest of the industry's, have plateaued in the last 25 years and crop prices remain low (see Figure 2). It is estimated that more than half the UK's farming enterprises will be loss-making in 2016 and that before we start the inevitable dismantling of the Common Agricultural Policy (CAP) support mechanisms. If we are to keep farmers on the land, stewarding our wildlife and countryside, then we will need to find ways to reward environmental goods and services that only land managers can provide.

TABLE 2

Farm conservation costs at the Allerton Project 2016 (£ total)

Higher Level Stewardship costs (including crop income forgone)	-18,507
Higher Level Stewardship income	29,316
Woodland costs	-6,115
Woodland income	2,706
Farm Shoot expenses	5,612
Farm Shoot income	5,612
Grass strips	-425
Total profit forgone	
- conservation	**6,975**
- research and education	**-15,461**
	-8,486

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

We need to find ways to reward environmental goods and services that only land managers can provide. © Amelia Woolford/GWCT

The benefits of cover crops

Soil structure had visibly improved where cover crops were drilled. © Felicity Crotty/GWCT

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.

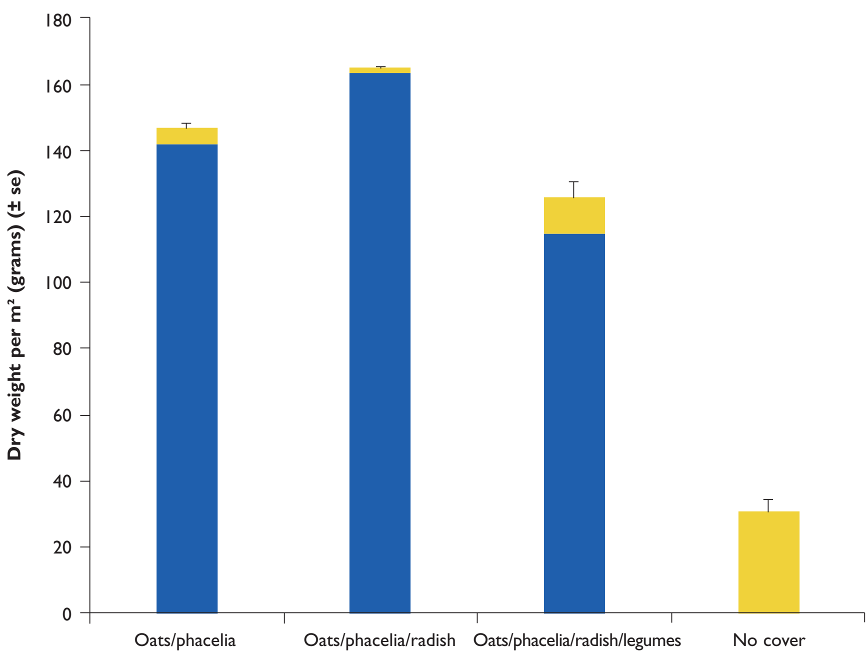
Cover crops seem to have much to offer, including improved soil structure and organic matter, retained nutrients, erosion limitation and even black-grass control. Our research is testing these potential benefits on our challenging clay soils in the East Midlands. We are doing so through a rigorously designed experiment that has been running for the past year.

We looked at three different mixtures: oats and phacelia; oats, phacelia and radishes; and oats, phacelia, radishes and legumes (vetch and clovers). We also had a bare stubble control plot in each of the three fields in which the experiment was replicated. So far we have been gathering data on soil physical, chemical and biological properties, but will also be investigating the economics of the various cover crops that we have sown.

We quantified the effect of drilling the cover crops on soil structure in comparison to the bare stubble control which had not been driven over by machinery, and by the end of the winter, the soil structure had visibly improved and compaction was reduced in all the cover crop treatments while the bare stubble control remained unchanged. The oats, phacelia and radish mixtures had slightly greater plant cover, but importantly, significantly lower biomass of weeds such as blackgrass (see Figure 1).

Figure 1

Dry weight per m² – February 2016



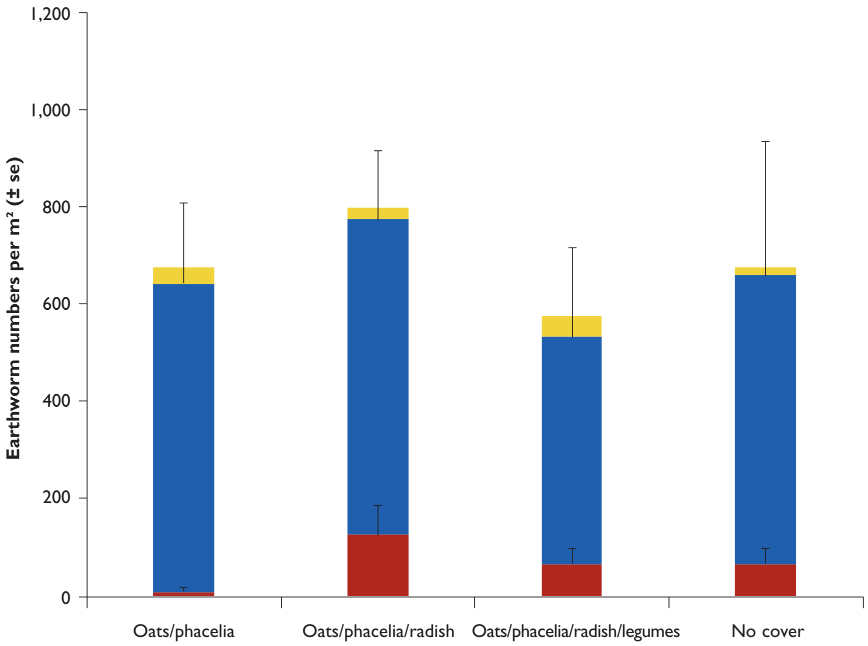


Figure 2

Abundance of earthworms per m²

Vertical burrowers

Horizontal burrowers

Surface dwellers

There were some significant differences between cover crop mixtures in soil biology, specifically surface-dwelling earthworms and millipedes, which may have implications for organic matter breakdown and incorporation into the soil (see Figure 2). The radish-based mixtures were also associated with the highest yield in the following spring oats crop, and lowest weed biomass, compared with the stubble control plots (see Figure 3). Further analysis, especially of the economic data, will enable us to evaluate these mixtures more fully.

Our interim findings for the first year suggest that cover crops can reduce weed abundance and enhance yield through improvements in soil function, but we now need to discover whether such benefits justify the cost incurred by establishing the cover crops in the first place. Meanwhile, cover crops have been established in a new experiment this autumn, looking in more detail at the specific components of the mixtures so that we can understand better the role of each species.

The spring oats following last year's cover crops have now been replaced by wheat. Next year we will assess the yields of that crop in relation to the different cover crop mixtures. Our aim is to understand the implications of cover crops, not just in terms of immediate costs and benefits, but also as part of a rotation.

KEY FINDINGS

- Improvements in soil structure through the winter are due to cover crops.
- Some cover crops suppress grass weeds and result in higher yields in the following cereal crop.
- Some cover crops modify soil invertebrate communities, with potential benefits for organic matter incorporation.

Felicity Crotty
Chris Stoate

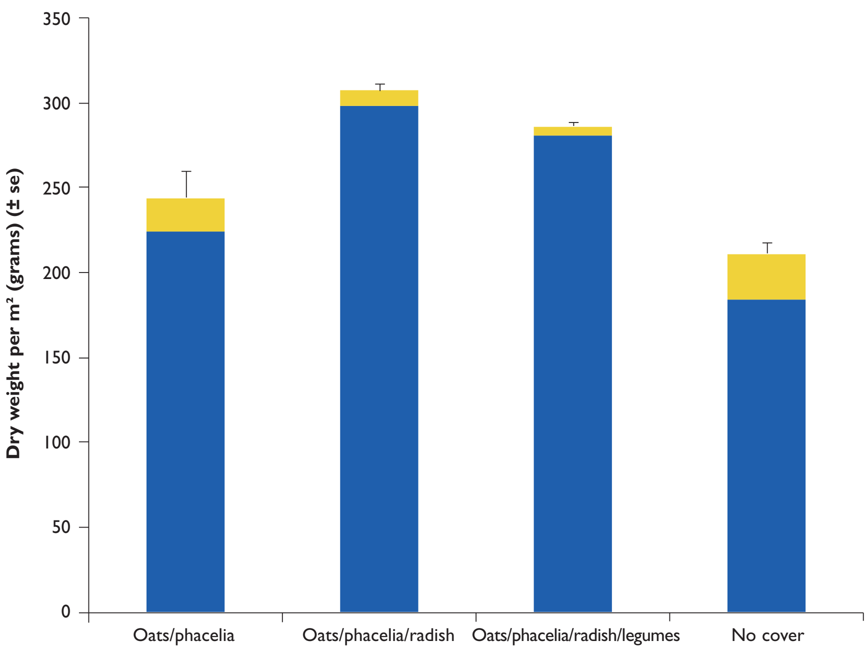


Figure 3

Dry weight per m² – June 2016

Weed

Oats

The Scottish Demonstration Farm - Auchnerran

We estimate about 30% of Scotland looks, and farms, like Auchnerran. © Marlies Nicolai/GWCT

In November 2014 GWCT took on one of its most significant, exciting and challenging projects, the Game and Wildlife Scottish Demonstration Farm (GWSDF) Auchnerran. In 2016 we were delighted that our Patron, HRH Duke of Edinburgh, was able to visit the farm and express his support for what we are trying to achieve – a profitable farm using game shooting and farmland conservation practices to deliver wildlife and habitats, clean water and healthy soils. The aim is to develop this project as a partner to our existing demonstration farm – the Allerton Project at Loddington in Leicestershire. The landscape and farming could not be more different so testing general principles will be fascinating.

We are tenant farmers at Auchnerran, whereas at Allerton we are owner occupiers. Auchnerran is a 480 hectare (ha) hill farm lying 250 metres above sea level in Aberdeenshire, with 5,000ha of contiguous moorland grazing rising to 870 metres. Allerton is 333ha, 120 metres above sea level. We estimate about 30% of Scotland looks, and farms, like Auchnerran – which makes it an important and very relevant demonstration. It is a broadly even mix of ploughable land (capable of growing barley, rotational grass or forage turnips), permanent grass and hill-edge rough grazings (woodland, scrub, heather, rushes), currently utilised by a black-faced sheep flock of 1,155 ewes.

At the Allerton Project 25 years ago, we took on a farm that had been 'farmed quite hard' and set out to continue to farm it commercially but to balance that with strong environmental and shoot management to improve biodiversity. This we did very successfully, and within five years we restored farmland bird numbers back to levels not seen since the 1960s, while continuing to produce wheat yields on a par with neighbouring commercial farms.

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.

Twenty five years on, the challenge at Auchnerran is the other way about. The farm has been 'let go' but the wildlife is much greater than one finds on neighbouring farms. Our key challenge is to improve the farming without damaging the wildlife; to 'sustainably intensify' our production. A major re-fencing programme has allowed the sheep to graze securely for the first time at Auchnerran in many years. Liming is proving to be important. The soil is very light, acidic (pH 5.2) after many years without lime, but surprisingly high in organic content, estimated around 15-20% (average organic matter at Allerton is only 2-3%). To protect soil organic content we have adopted techniques in use at the Allerton project – a direct drill very successfully reseeded 12.3ha of leys, much to the interest of local farmers who had not seen this machine in operation.

Twenty five years ago we took on the Allerton Project farm and increased biodiversity while still farming commercially. © Peter Thompson/GWCT

New fencing has allowed the sheep to graze securely for the first time at Auchnerran in many years. © Marlies Nicolai/GWCT

Improvement to the genetics of the flock is needed, including through careful selection of tups. © Marlies Nicolai/GWCT

KEY FINDINGS

- November 2014 saw the GWCT take on the tenancy of the Game and Wildlife Scottish Demonstration Farm (GWSDF) Auchnerran in Aberdeenshire.
- Two years of baseline monitoring and farm management show this 480ha hill farm is rich in wildlife and semi-natural habitats, with many productive wading birds.
- This farm provides the GWCT with the opportunity to demonstrate how to intensify farm production in grass and livestock dominated farming areas while protecting habitats, wildlife, soils and water.

Adam Smith
Allan Wright
David Parish

Allan Wright, our shepherd-manager, was employed in November 2015. His focus is to maximise production of the hefted sheep flock by improving over-winter nutrition, disease control and flock genetics to improve welfare and productivity. The basics have been important: copper, cobalt and selenium are very low so there is a regular and thorough drench/bolus and supplementary feeding regime. Poor mothering needs to be bred out of the flock with strong ewe culling and improved ram selection.

The sheep are turned out to graze the 5,000ha heather hill of Dinnet grouse moor at typical times of the year for a hill flock: April for the ewe-hoggs, and after lambing for ewes and singles. Once there they perform a key role written into our tenancy – they graze the moor, preventing grass and heather from becoming too rank, and they are treated against tick, allowing them to mop up these parasites, protecting red grouse and other species from excessive tick burdens. We work closely with the Dinnet Hill keeper team on gathering and treating sheep. In turn, we welcome Auchnerran Farm being part of the gamekeeper's beat so foxes, crows, rats and mustelids are controlled.

The relationship between sheep farm and grouse moor is a key facet of this project – the grouse do better because the sheep act as 'tick mops', the wildlife benefits from the predator control and habitat management undertaken by the keepers.

Red grouse are benefiting from the predator control by the local gamekeeper. © Marlies Nicolai/GWCT

Our monitoring has shown abundant wildlife with more than 60 pairs of wading birds nesting, including lapwing. © Marlies Nicolai/GWCT

As well as demonstrating good practice this is a research farm. The research is being led by Dr Dave Parish – who has been with the GWCT for 20 years as head of lowland research in Scotland. Monitoring a baseline and tracking the effect of modernising our farming is central to our research activity. Two years of baseline monitoring confirm that the apparent interaction of abundant semi-natural habitat and low predation pressure has led to abundant wildlife. In 2016 we recorded 18 roding woodcock, suggesting a very high breeding density, and over 60 pairs of other wading birds nesting, notably lapwing, snipe and curlew. As well as lapwing chicks, there are significant numbers of brown hare in the clover-grass leys, both tribute to the collaborative work of the farm and research teams spotting the wildlife and then working around it with machinery. We know sparrowhawk, barn and tawny owl, kestrel and buzzard nest on the farm, with red kite and goshawk present. Camera traps have recorded red squirrel, pine marten, otter, many rabbits but no wild cats yet.

This baseline monitoring has described a farm rich in game and wildlife. We expect to develop our lowland shoot on the farmland (another party is responsible for the grouse shooting on the moorland area) without needing to manage much habitat specifically for the farm shoot. Game crops have been so far restricted to small areas, and no hopper feeding in these two baseline monitoring years. Ultimately the shoot aims to be typical for a farm of this size, relatively small, focused on the season's available wild game. The first let day was sold to a team of four guns at the Scottish Auction, and they had a small mixed bag of pheasants, snipe and woodcock.

Since November 2014 we have created a secure base from which this project can now develop. The interest is substantial: as well as our Patron, we have hosted our member-supporters, Members of the Scottish Parliament and 15 organisations including Scottish Natural Heritage staff, the Cairngorms National Park Authority, Scottish Wildlife Trust and Scotland's Rural Colleges. Demonstrating the challenges of renovating a hill farming operation, integrating it with a grouse moor, and creating a lowland shoot contributing to both income and biodiversity, as well as recording baseline information has been a full-time job. We would like to thank all the staff and Trustees involved in getting this project to such a promising stage.

Setting an ink track tunnel to detect small mammals such as stoats. © Marlies Nicolai/GWCT

We are already hosting groups of visitors who are interested in the challenges we face. © Marlies Nicolai/GWCT

Auchnerran game and songbird counts

Pheasant chick being brooded by the hen. Our pheasants will provide an important resource for the farm shoot in the future. © Marlies Nicolai/GWCT

2016 was the second and final baseline year at the Game and Wildlife Scottish Demonstration Farm, Auchnerran. This period has been very important and insightful, as it has allowed us to uncover the wildlife treasures we have on the farm so that we might then be better able to manage the land in a targeted, wildlife-friendly manner into the future. There are currently no grey partridges in the area, though they were last recorded a couple of kilometres away in the early 2000s. We are hoping to reintroduce them across an area much bigger than just Auchnerran in due course, with the co-operation of a number of farmers nearby who have expressed an interest in seeing them return. There is much habitat work to do first so this will not happen quickly, but the level of enthusiasm among some of our near-neighbours is encouraging. We hope to harness this by further expanding our Farmer Cluster on the MacRobert Trust land around Tarland.

The previous owner at Auchnerran ran a reared pheasant shoot and many of the birds have survived and now breed on site. The peak count in April/May from 2015 was of 91 males and 58 females, while in 2016 it was 77 males and 18 females. Although this shows year-to-year variation, it also suggests a reasonable number of cocks that could be available to the fledgling farm shoot that we are developing.

We also have a wealth of other bird life on the farm, the stars undoubtedly being the waders. The habitat in the area has been close to ideal for them, with minimal impacts from farming over the years and the rigorous control of crows and foxes.

BACKGROUND

Auchnerran was born from the desire to emulate the huge success and influence the Allerton Project at Loddington has had on English policy makers and practitioners. We think Auchnerran is representative of at least a third of Scottish farms and so has the potential to be an important role model to inspire many others. It comprises 480 hectares of typical hill-edge land, dominated by grass, and lies at the foot of a productive grouse moor, falling within the area of predator control for that moor. Farming on site has been at a very low intensity for many years and coupled with the predator control, this has resulted in high densities of wildlife, especially birds.

TABLE 1

Numbers of waders seen at Auchnerran (480ha) in April/May when adults are starting to breed, but before chicks have hatched

	2015	2016
Lapwing	46	92
Oystercatcher	32	61
Curlew	11	15
Woodcock	n/a	18 roding males

** Woodcock were surveyed during May and June, but not in 2015*

There are around five pairs of buzzards. © Marlies Nicolai/GWCT

Table 1 shows the numbers of some wader species recorded in spring over the last two years, revealing some impressively high numbers plus, again, some yearly variation. In this instance, the variation is probably due to the cold and wet weather experienced in early 2015. Emily Sheraton from Leeds University joined us in the summer to study lapwings in more detail. Her repeat counts to search for adults and chicks suggested that there was an average of approximately one chick for each breeding pair at Auchnerran, an excellent level of productivity that should be sufficient to maintain numbers on site. As we develop our management plans for the coming years we will work closely with Allan Wright, the farm manager, to do whatever we can to maintain these impressive wader numbers while improving farm economics.

As well as the waders we have found quite a diverse array of other species including around five pairs of buzzards, perhaps our first record of breeding red kite, a few barn owls and kestrels, plus tree pipit, wheatear, stonechat, siskin and the occasional group of twite passing through. One species notable by its absence is the skylark. None were recorded in 2016 and only four in the previous year, despite an abundance of rough grazing areas that should make good-quality nesting habitat.

The next few years will be extremely busy at Auchnerran and exciting for those of us lucky enough to be involved in shaping the future of the farm.

KEY FINDINGS

- Baseline surveys at Auchnerran have highlighted a high abundance of pheasant, lapwing, oystercatcher, curlew and woodcock, to name but a few.
- The bird species diversity present is also impressive with many raptors and songbirds, including red kite, barn owl, tree pipit and twite found on the farm.
- The next few years will be crucial as we work towards improving the farming at Auchnerran but without losing the unusual abundance of wildlife.

Dave Parish

A newly-hatched lapwing chick. Studies show that lapwings probably produce sufficient chicks to maintain numbers on site. © Marlies Nicolai/GWCT

Research projects

by the Game & Wildlife Conservation Trust in 2016

FISHERIES RESEARCH IN 2016

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- on-going*
Monnow habitat improvement project	*Large-scale conservation project and scientific monitoring of 30 kilometres of river habitat on the River Monnow in Herefordshire*	*Dylan Roberts, Sian Griffiths Janine Burnham*	*Defra, Rural Enterprise Scheme, Monnow Improvement Partnership, KESS EU*	*2003- on-going*
Salmon life-history strategies in freshwater (see p14)	*Understanding the population declines in salmon*	*Rasmus Lauridsen, Dylan Roberts, William Beaumont, Luke Scott, Stephen Gregory*	*Core funds, EA, CEFAS, Mr A Daniell, Winton Capital*	*2009- on-going*
Salmon smolt rotary screw trap assessment	*Calculating the effects of rotary screw traps on salmon smolts*	*Rasmus Lauridsen, Dylan Roberts, Luke Scott William Beaumont, Stephen Gregory, Bill Riley*	*CEFAS, Core funds*	*2009- on-going*
Grayling ecology	*Long-term study of the ecology of River Wylye grayling*	*Stephen Gregory, Luke Scott*	*NRW, Core funds, Grayling Research Trust, Piscatorial Society*	*2009- on-going*
Juvenile salmon and hydro	*The effects of a hydropower installation on salmon smolts*	*Rasmus Lauridsen, William Beaumont, Graeme Storey (EA)*	*EA, Core funds, Salmon & Trout Conservation UK, Lulworth Estate*	*2012-2016*
Sea trout smolt survival	*Monitoring sea trout smolts through the lower Frome and its estuary, Poole harbour*	*Rasmus Lauridsen, William Beaumont, Luke Scott*	*Sir Chips Keswick, Anthony Daniell, Winton Capital, Clay Brendish Foundation*	*2014-2016*
Gyrodactylus salaris in salmon	*Modelling to predict the impacts Gyrodactylus salaris infection of salmon stocks*	*Rasmus Lauridsen, Alastair Cook, Nicola McPherson and Nick Taylor*	*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*
Flows and Frome salmon redd distribution (see p16)	*How does flow affect the inter-annual distribution of salmon redds in the Frome*	*Stephen Gregory, Rasmus Lauridsen, Dylan Roberts, Sian Griffiths (Cardiff University), Elinor Parry*	*KESS EU, Core funds*	*2015-2016*
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, invert-ebrates and fish, with particular focus on salmonids*	*Jessica Marsh. Supervisors: Rasmus Lauridsen, Dr Iwan Jones (QMUL)*	*G and K Boyes Trust*	*2015-2019*

LOWLAND GAME RESEARCH IN 2016

Project title	Description	Staff	Funding source	Date
Pheasant population studies	*Long-term monitoring of breeding pheasant populations on releasing and wild bird estates*	*Roger Draycott, Maureen Woodburn, Rufus Sage*	*Core funds*	*1996- on-going*
Game marking scheme	*Study of factors affecting return rates of pheasant release pens*	*Rufus Sage, Maureen Woodburn,*	*Core funds*	*2008- on-going*
Farmland birds and game	*Monitoring the response of birds to changes in farmland habitat and management*	*Roger Draycott*	*Sandringham Estate*	*2009- on-going*
Pheasant releasing on Exmoor	*Impacts of released pheasants and game manage-ment work on woodlands and farmland in Exmoor*	*Rufus Sage, Aidan Hulatt, Jenny Peach, Alice Deacon*	*Greater Exmoor Shoot Association*	*2015-2016*
PhD: Gapeworm and pheasants (see p18)	*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 (see p20)	*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 2016

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- on-going*
Woodcock migration	*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*
Lapwings on fallow plots (see p24)	*Assessment of lapwing breeding success on AES fallow plots*	*Andrew Hoodless, Kaat Brulez, Carlos Sánchez, collaboration with RSPB*	*Defra, The Dulverton Trust, The Manydown Trust, Private donor*	*2012-2016*
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*
LIFE+ Waders for Real (see p22)	*Wader recovery project in the Avon Valley*	*Lizzie Grayshon, Clive Bealey, Mike Short, Tom Oakley, Daniel Upton, Andrew Hoodless*	*LIFE+ Waders for Real*	*2014-2018*
PhD: Factors influencing breeding woodcock abundance (see p28)	*Landscape-scale and fine-scale habitat relationships of breeding woodcock and investigation of drivers of decline*	*Chris Heward. Supervisors: Andrew Hoodless, Prof Rob Fuller/BTO, Dr Andrew MacColl/Nottingham University*	*Private funds, Core funds*	*2013-2018*

PARTRIDGE AND BIOMETRICS RESEARCH IN 2016

Project title	Description	Staff	Funding source	Date
Partridge Count Scheme (see p30)	*Nationwide monitoring of grey and red-legged partridge abundance and breeding success*	*Neville Kingdon, Nicholas Aebischer, Julie Ewald, William Connock, Emma Popham, Anna Jones, Peter Wood*	*Core funds, GCUSA*	*1933- on-going*
National Gamebag Census (see p40)	*Monitoring game and predator numbers with annual bag records*	*Nicholas Aebischer, Gillian Gooderham, Ryan Burrell, William Connock, Emma Popham, Sean Elliott, Anna Jones, Peter Wood*	*Core funds*	*1961- on-going*
Sussex study (see p34)	*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- on-going*
Partridge over-winter losses	*Identifying reasons for high over-winter losses of grey partridges in the UK*	*Nicholas Aebischer, Francis Buner*	*Core funds, GCUSA*	*2007-2016*
Wildlife monitoring at Rotherfield Park (see p32)	*Monitoring of land use, game and songbirds for the Rotherfield demonstration project*	*Francis Buner, Malcolm Brockless, Peter Thompson, Roger Draycott, Julie Ewald*	*Core funds*	*2010-2018*
Grey partridge management	*Researching and demonstrating grey partridge management in Scotland*	*Dave Parish, Hugo Straker, Adam Smith, Merlin Becker*	*Whitburgh Farms*	*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- on-going*
Cluster Farm mapping	*Generating cluster-scale landscape maps for use by the Advisory Service and the Farm Clusters*	*Julie Ewald, Neville Kingdon, William Connock, Emma Popham*	*Core funds*	*2014- on-going*
Game crops	*Developing perennial game cover mixes*	*Dave Parish, Anna McWilliam, Hugo Straker*	*Balgonie Estates Ltd, Core funds, Kingdom Farming, Kings Seeds*	*2014-2020*
Grey partridge recovery (see p38)	*Monitoring grey partridge recovery and impacts on associated wildlife*	*Dave Parish, Hugo Straker Anna McWilliam*	*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, Philip Nasser, Sean Elliott, Ryan Burrell*	*Core funds*	*2015-2017*
British Deer Survey	*Map the distribution of British deer species*	*Ryan Burrell, Anna Jones, Peter Wood, Julie Ewald*	*British Deer Society*	*2016-2017*
PARTRIDGE	*Co-ordinated demonstration of management for partridge recovery and biodiversity in UK, Netherlands, Belgium and Germany*	*Francis Buner, Julie Ewald, Peter Thompson, Nicholas Aebischer, Chris Stoate, Dave Parish Roger Draycott, John Szczur, Austin Weldon, Fiona Torrance*	*Interreg (EU North Sea Region) Core funds*	*2016-2020*

UPLANDS RESEARCH IN 2016

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, Phil Warren, David Howarth*	*Core funds, Gunnerside Estate*	*1980- on-going*
Long-term monitoring of breeding ecology of waders in the Pennine uplands	*Annual measures of wader density, lapwing productivity, recruitment and survival*	*David Baines, Harriet Fuller*	*Core funds*	*1985- on-going*
Black grouse monitoring	*Annual lek counts and brood counts*	*Philip Warren, David Baines, David Newborn, Matteo Anderle*	*Core funds*	*1989- on-going*
Capercaillie brood surveys (see p52)	*Surveys of capercaillie and their broods in Scottish forests*	*Kathy Fletcher, David Baines, David Howarth, Mike Richardson, Phil Warren, Amy Withers*	*SNH, Forest Enterprise Scotland*	*1991- on-going*

Timing of breeding in red grouse	*Long-term assessment of changes in laying dates in relation to climate change*	*David Howarth, Kathy Fletcher, Amy Withers*	*The Samuels Trust, Core funds*	*1995- on-going*
Black grouse range expansion (see p50)	*Black grouse range restoration in the Yorkshire Dales by translocating surplus wild males*	*Philip Warren, Matteo Anderle, Nancy Parsons*	*Biffa, Private funder, Yorkshire Water, Nidderdale AONB*	*1996-2016*
Langholm Moor Demonstration Project (see p54)	*Research data for moorland restoration to achieve economically-viable driven grouse shooting and sustainable numbers of hen harriers*	*Sonja Ludwig, David Baines, Emily Trevail, Hannah Greetham*	*Core funds, Buccleugh Estates, SNH, Natural England, RSPB*	*2008-2018*
Alternative grouse diseases	*Cryptosporidiosis in red grouse: study of spread of disease, prevalence and impacts on grouse survival and fecundity*	*David Baines, Mike Richardson, David Newborn, Harriet Fuller, Rhodri Evetts, Nancy Parsons, Helen Allinson*	*Core funds, G and K Boyes Trust, Derbyshire & South Yorkshire County Group, Anonymous donors*	*2013-2016*
Black grouse in Wales	*Analysis of interaction of habitat and predator management in determining increases in black grouse at Ruabon Moor*	*David Baines, Merlin Becker, Rhodri Evetts*	*World Pheasant Association*	*2014-2016*
Capercaillie, martens and generalist predators	*Development work for anticipated trial that experimentally considers the role of martens and other generalist predators in determining capercaillie breeding success*	*Kathy Fletcher*	*SNH, Forestry Commission Scotland, Cairngorms National Park Authority*	*2014-2016*
How best to count mountain hares	*Test of a variety of count methods used to determine local densities of mountain hares*	*Dr Scott Newey (JHI), Kathy Fletcher Helen Allinson, Rhodri Evetts*	*SNH, James Hutton Institute*	*2014-2016*
Black grouse in southern Scotland	*Development of recovery protocol*	*Philip Warren, Nancy Parsons*	*SNH, Southern Uplands Partnership, RSPB, FES*	*2015-2016*

FARMLAND RESEARCH IN 2016

Project title	Description	Staff	Funding source	Date
QuESSA (see p58)	*Quantification of Ecological Services for Sustainable Agriculture*	*John Holland, Barbara Smith, Niamh McHugh, Steve Moreby, Tom Elliott, Sophie Potter, Belinda Bown, Jasmine Clark*	*EU FP7*	*2013-2017*
Aphid infestations in autumn	*Investigating influence of landscape features on autumn aphid infestations in cereals*	*John Holland, Jasmine Clark, Belinda Bown, Tom Elliott, Sophie Potter, Anna Forbes, Jade Hemsley*	*Core funds*	*2015- on-going*
Insecticide effects on beneficial invertebrates	*Secondary feeding effects of insecticides on beetles*	*John Holland, Niamh McHugh, Belinda Bown, Tom Elliott, Sophie Potter*	*Core funds*	*2015- on-going*
Chick-food and farming systems	*A comparison of grey partridge chick-food in conventional and organically farmed crops and habitats*	*John Holland, Steve Moreby, Niamh McHugh, Sophie Potter, Anna Forbes, Jade Hemsley*	*External funds*	*2015- on-going*
Long-term trends in beetles	*Beetle abundance and diversity in Sussex 40 years on*	*Dick Potts, Steve Moreby, Jasmine Clark, Belinda Bown*	*Core funds*	*2016*
Foraging preferences of barn swallows (see p56)	*Use of arable crops and field margins by foraging barn swallows*	*Niamh McHugh, Jasmine Clark, Belinda Bown*	*Core funds*	*2016*
Invertebrates in cover crops	*Comparison of invertebrates in cover crop mixes*	*John Holland, Belinda Bown, Jasmine Clark*	*External funds*	*2016*
Wild bird seed mixtures	*Extending the life of wild bird seed mixes using a sticking agent*	*John Holland, Niamh McHugh, Sophie Potter, Anna Forbes, Jade Hemsley*	*External funds*	*2016-17*
PhD: Bumblebees and agri-environment schemes	*How effective are agri-environment schemes in boosting bumblebee populations?*	*Tom Wood Supervisors: John Holland, Professor Dave Goulson (University of Sussex)*	*NERC/CASE studentship*	*2013-2016*

ALLERTON PROJECT RESEARCH IN 2016

Project title	Description	Staff	Funding source	Date
Monitoring wildlife at Loddington (see p62)	*Annual monitoring of game species, songbirds, invertebrates, plants and habitat*	*Chris Stoate, John Szczur, Alastair Leake, Steve Moreby*	*Allerton Project funds*	*1992- on-going*
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- on-going*
Water Friendly Farming	*A landscape scale experiment testing integration of resource protection and flood risk management with farming in the upper Welland*	*Chris Stoate, John Szczur, Jeremy Briggs, Penny Williams, (Freshwater Habitats Trust), Professor Colin Brown (University of York)*	*EA, Syngenta, Regional Flood and Coastal Committee,*	*2011- on-going*
School farm catchment	*Practical demonstration of ecosystem services*	*Chris Stoate, John Szczur*	*Allerton Project, EA, Anglian Water, Agrii SoilQuest*	*2012- on-going*
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	*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- on-going*
VALERIE	*Farmer oriented participatory research into biological mobilisation of soil P*	*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 (see p68)	*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*
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 those of scientists and policy makers with societal objectives*	*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*

AUCHNERRAN PROJECT RESEARCH IN 2016

Project title	Description	Staff	Funding source	Date
GWSDF Auchnerran baseline monitoring (see p74)	*Wide-ranging environmental audit to establish a baseline for biodiversity*	*Dave Parish, Alison Espie, Marlies Nicolai, Ruth Highley, Emily Sheraton*	*Core funds*	*2015-on-going*
Rabbit population monitoring	*Assessing rabbit numbers in relation to control methods and impacts on other species*	*Dave Parish, Marlies Nicolai, Ruth Highley, Sarah Wingrove, Augustin Calas*	*Core funds*	*2016-on-going*
GWSDF Tarland farmer cluster	*Establishing the first farmer cluster in Scotland*	*Dave Parish, Alison Espie, Marlies Nicolai*	*Core funds*	*2016-2018*
LIFE Laser Fence	*Experimental trials of laser technology as a deterrent for various mammals*	*Dave Parish, Marlies Nicolai, Ruth Highley, Adam Smith*	*LIFE+, Core funds*	*2016-2020*
Liming experiment	*Split-field experiment investigating impacts of liming on invertebrates*	*Dave Parish, Marlies Nicolai*	*SRUC, Core funds*	*2016-2020*

PREDATION RESEARCH IN 2016

Project title	Description	Staff	Funding source	Date
Fox control methods	*Experimental field comparison of fox capture devices*	*Jonathan Reynolds, Mike Short*	*Core funds*	*2002- on-going*
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*	*2006-2017*
Grey squirrel trapping strategy	*Exploratory research on optimal trapping strategy for grey squirrel control*	*Jonathan Reynolds, Mike Short Emma Popham*	*Core funds*	*2013-2016*
Small mammalian predators in the Avon Valley	*Use of ink tunnels and mink rafts to determine distribution and activity of small mustelids, hedgehogs and rats in the Avon Valley, in the context of declining wading bird populations*	*John Flothmann, Will Connock, Tom Porteus, Mike Short, Jonathan Reynolds*	*LIFE+ Waders for Real, Core funds*	*2015-2016*
Foxes in the Avon Valley	*Use of GPS tagging to determine breeding density, territory size and movement behaviour of foxes in the Avon Valley, in the context of declining wading bird populations*	*Mike Short, Jonathan Reynolds, Tom Porteus*	*LIFE+ Waders for Real, Core funds*	*2015-2018*

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; FES = Forest Enterprise Scotland; GCUSA = Game Conservancy USA; H2020 = Horizon 20:20; Interreg = European Regional Development Board; KESS = Knowledge Exchange Skills Scholarships; 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; SNH = Scottish Natural Heritage

Scientific publications

by staff of the Game & Wildlife Conservation Trust in 2016

Aebischer, NJ, Bailey, CM, Gibbons, DW, Morris, AJ, Peach, WJ & **Stoate, C (2016)** Twenty years of local farmland bird conservation: the effects of management on avian abundance at two UK demonstration sites. *Bird Study,* 63: 10-30.

Awan, MN, **Buner, F** & **Kingdon, NG** (2016) A review of published and unpublished surveys of a red-listed 'flagship species', the Western Tragopan *Tragopan melanocephalus* in Azad Jammu and Kashmir, Pakistan. *Bird Conservation International,* 26: 380-395.

Baines, D, Aebischer, NJ & MacLeod, A (2016) Increased mammalian predators and climate change predict declines in breeding success and density of capercaillie *Tetrao urogallus*, an old stand specialist, in fragmented Scottish forests. *Biodiversity and Conservation*, 25: 2171-2186.

Baines, D & Taylor, L (2016) Can acaricide-impregnated leg bands fitted to female red grouse reduce sheep tick parasitization of chicks and increase chick survival? *Medical and Veterinary Entomology*, 30: 360-364.

Basu, P, Parui, AK, Chatterjee, S, Dutta, A, Chakraborty, P, Roberts, S & **Smith, B** (2016) Scale-dependent drivers of wild bee diversity in tropical heterogeneous agricultural landscapes. *Ecology and Evolution*, 6: 6983-6992.

Beaumont, WRC (2016) *Electricity in fish research and management, theory and practice.* John Wiley & Sons Limited, Chichester.

Buner, FD, Dhadwal, DS, Ranganathan, L, Dhiman, SP, Hoare, D & Walker, T (2016) Pioneering bird-ringing capacity-building at Nagrota Surian, Pong Dam Lake Wildlife Sanctuary, Himachal Pradesh, India. *BirdingASIA*, 26: 59-64.

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Dunn, JC, Gruar, D, **Stoate, C, Szczur, J** & Peach, WJ (2016) Can hedgerow management mitigate the impacts of predation on songbird nest survival? *Journal of Environmental Management,* 184: 535-544.

Ewald, JA, Wheatley, CJ, Aebischer, NJ, Duffield, SJ & Heaver, D (2016) *Investigation of the impact of changes in pesticide use on invertebrate populations.* Natural England Commissioned Report, NECR182. Natural England, York.

Francksen, RM, Whittingham, MJ & **Baines, D** (2016) Assessing prey provisioned to common buzzard *Buteo buteo* chicks: a comparison of methods. *Bird Study*, 63: 303-310.

Francksen, RM, Whittingham, MJ, **Ludwig, SC** & **Baines, D** (2016) Winter diet of common buzzards *Buteo buteo* on a Scottish grouse moor. *Bird Study,* 63: 525-532.

Gethings, OJ, Sage, RB & Leather, SR (2016) Density-dependent regulation of fecundity in *Syngamus trachea* infrapopulations in semi-naturally occurring ring-necked pheasants *(Phasianus colchicus)* and wild carrion crows *(Corvus corone). Parasitology,* 143: 716-722.

Gethings, OJ, Sage, RB, Morgan, ER & Leather, SR (2016) Body condition is negatively associated with infection with *Syngamus trachea* in the ring-necked pheasant *(Phasianus colchicus)*. *Veterinary Parasitology,* 228: 1-5.

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Goodwin, JCA, King, RA, Jones, JI, **Ibbotson, A** & Stevens, JR (2016) A small number of anadromous females drive reproduction in a brown trout *(Salmo trutta)* population in an English chalk stream. *Freshwater Biology,* 61: 1075-1089.

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Holland, JM, Bianchi, FJJA, Entling, MH, Moonen, AC, **Smith, BM** & Jeanneret, P (2016) Structure, function and management of semi-natural habitats for conservation biological control: a review of European studies. *Pest Management Science,* 72: 1638-1651.

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McHugh, NM, Goodwin, CED, Hughes, S, Leather, SR & **Holland, JM** (2016) Agri-environment scheme habitat preferences of yellowhammer *Emberiza citrinella* on English farmland. *Acta Ornithologica,* 51: 199-209.

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Phang, SC, Stillman, RA, Cucherousset, J, Britton, JR, **Roberts, DE, Beaumont, WRC** & Gozlan, RE (2016) FishMORPH - An agent-based model to predict salmonid growth and distribution responses under natural and low flows. *Scientific Reports*, 6: 1-13. DOI:10.1038/srep29414.

Pinder, AC, Hopkins, E, **Scott, LJ** & Britton, JR (2016) Rapid visual assessment of spawning activity and associated habitat utilisation of sea lamprey (*Petromyzon marinus* Linnaeus, 1758) in a chalk stream: implications for conservation monitoring. *Journal of Applied Ichthyology,* 32: 364-368.

Pringle, H (2016) *Nesting and brood-rearing opportunities for farmland birds in and around miscanthus and short rotation coppice biomass crops.* Unpublished Ph.D thesis. Imperial College London, London.

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Sánchez-García, C, Alonso, ME, Tizado, EJ, Pérez, JA, Armenteros, JA & Gaudioso, VR (2016) Anti-predator behaviour of adult red-legged partridge *(Alectoris rufa)* tutors improves the defensive responses of farm-reared broods. *British Poultry Science,* 57: 306-316.

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Financial report
for 2016

KEY POINTS

- Overall funds increased by £403,921, including an increase of £246,277 on unrestricted funds.
- Income was £7.66 million, an increase of 7% from 2015.
- Expenditure on research was £3.9 million.
- The Trust's net assets were £8.73 million at the end of the year.

The summary report and financial statement for the year ended 31 December 2016, 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 2017 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 returned to surplus in 2016 due once again to the generosity of our supporters and effective management by our staff. Our results benefited from the receipt of legacies of £324,120 for which we are very grateful and also from the performance of our investments. We have managed to maintain our expenditure on research at around the £4 million mark, despite the fact that some of our large public sector grants have been succeeded by fundraising income which is inevitably more costly to raise.

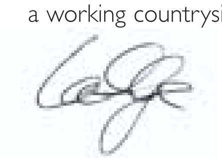
The unrestricted investments and Underwood endowment produced total returns of 8.2% which is considerably better than their manager's investment policy which remains to significantly exceed the return on cash. The ARET endowment achieved a total return of 11%, compared with its blended benchmark of 8.6%.

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 2016 the Trust's reserves (according to this definition) were around £1.1 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

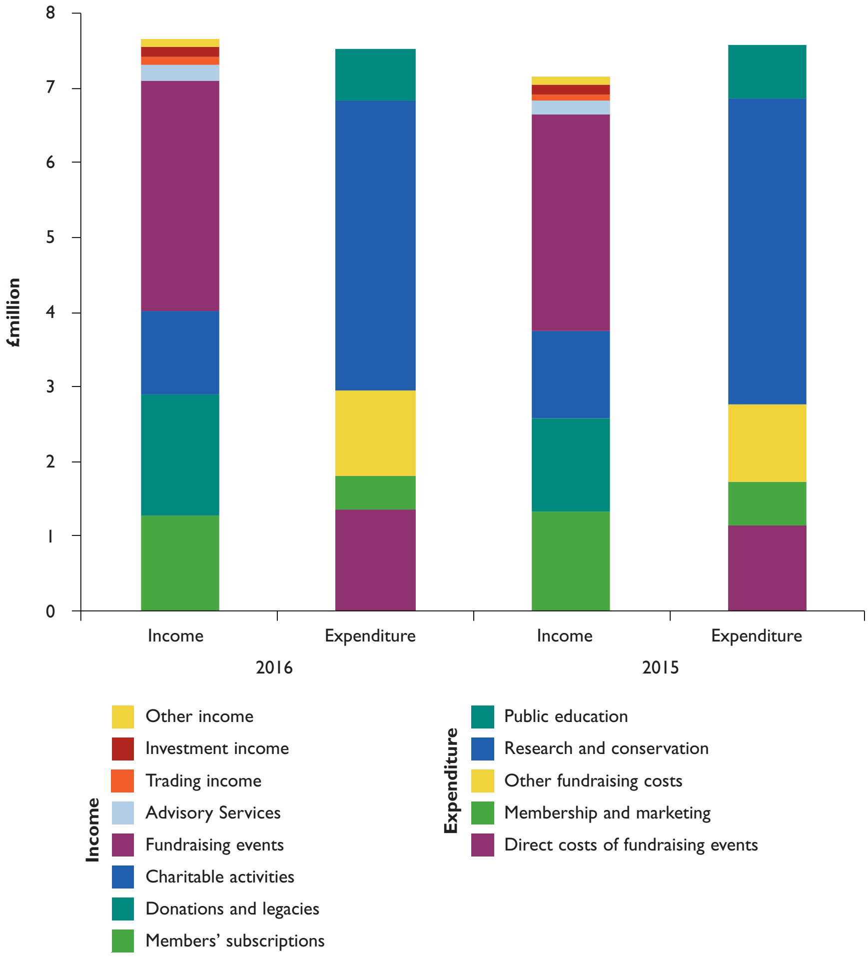


Figure 1

Total incoming and outgoing resources in 2016 (and 2015) 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 2016 which is set out on pages 84 and 85.

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 misstatements or inconsistencies with the summary financial statement. The other information comprises only the Review of Financial Performance.

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 2016 and complies with the applicable requirements of Section 427 of the Companies Act 2006 and the regulations made thereunder.

FLETCHER & PARTNERS
Chartered Accountants and Statutory Auditors
Salisbury, 28 April 2017

Consolidated

Statement of financial activities

	General Fund £	Designated Funds £	Restricted Funds £	Endowed Funds £	**Total 2016 £**	Total 2015 £
INCOME AND ENDOWMENTS FROM:						
Donations and legacies						
Members' subscriptions	1,260,105	-	10,750	-	**1,270,855**	1,310,558
Donations and legacies	1,159,280	-	472,939	-	**1,632,219**	1,254,975
	2,419,385	-	483,689	-	**2,903,074**	2,565,533
Charitable activities	20,431	-	1,094,923	-	**1,115,354**	1,176,884
Other trading activities						
Fundraising events	3,068,614	-	18,435	-	**3,087,049**	2,920,444
Advisory Service	217,436	-	-	-	**217,436**	161,591
Trading income	95,325	-	-	-	**95,325**	89,009
Investment income	9,143	-	121,616	13,130	**143,889**	137,006
Other	65,449	-	35,222	-	**100,671**	111,270
TOTAL	5,895,783	-	1,753,885	13,130	**7,662,798**	7,161,737
EXPENDITURE ON:						
Raising funds						
Direct costs of fundraising events	1,345,699	-	-	-	**1,345,699**	1,137,364
Membership and marketing	467,128	-	-	-	**467,128**	583,232
Other fundraising costs	1,122,204	-	-	8,140	**1,130,344**	1,028,248
	2,935,031	-	-	8,140	**2,943,171**	2,748,844
Charitable activities						
Research and conservation						
Lowlands	1,289,779	-	288,252	-	**1,578,031**	1,604,353
Uplands	382,971	-	141,545	-	**524,516**	662,675
Demonstration	228,874	-	1,153,071	4,150	**1,386,095**	1,437,823
Fisheries	282,033	-	115,670	-	**397,703**	399,272
	2,183,657	-	1,698,538	4,150	**3,886,345**	4,104,123
Public education	573,677	-	76,313	50,000	**699,990**	741,543
	2,757,334	-	1,774,851	54,150	**4,586,335**	4,845,666
TOTAL	5,692,365	-	1,774,851	62,290	**7,529,506**	7,594,510
Net gains/(losses) on investments:						
Realised	(60,297)	-	(1,197)	(83,168)	**(144,662)**	7,053
Unrealised	103,156	-	2,048	310,087	**415,291**	9,275
NET INCOME/(EXPENDITURE)	246,277	-	(20,115)	177,759	**403,921**	(416,445)
Transfers between funds	-	-	155,000	(155,000)	**-**	-
NET MOVEMENT IN FUNDS	246,277	-	134,885	22,759	**403,921**	(416,445)
RECONCILIATION OF FUNDS						
Total funds brought forward	2,066,752	136,492	340,770	5,784,320	**8,328,334**	8,744,779
TOTAL FUNDS CARRIED FORWARD	£2,313,029	£136,492	£475,655	£5,807,079	**£8,732,255**	£8,328,334

Consolidated

Balance sheet

as at 31 December 2016

		2016		2015
	£	£	£	£
FIXED ASSETS				
Tangible assets		3,340,057		3,318,239
Investments		4,070,486		3,894,952
		7,410,543		7,213,191
CURRENT ASSETS				
Stock	374,921		403,426	
Debtors	967,475		789,528	
Cash at bank and in hand	1,075,188		1,049,698	
	2,417,584		2,242,652	
CREDITORS:				
Amounts falling due within one year	549,253		567,490	
NET CURRENT ASSETS		1,868,331		1,675,162
TOTAL ASSETS LESS CURRENT LIABILITIES		9,278,874		8,888,353
CREDITORS:				
Amounts falling due after more than one year		546,619		560,019
NET ASSETS		£8,732,255		£8,328,334
Representing:				
CAPITAL FUNDS				
Endowment funds		5,807,079		5,784,320
INCOME FUNDS				
Restricted funds		475,655		340,770
Unrestricted funds:				
Designated funds	136,492		136,492	
Revaluation reserve	375,723		302,722	
General fund	1,893,468		1,720,351	
Non-charitable trading fund	43,838		43,679	
		2,449,521		2,203,244
TOTAL FUNDS		£8,732,255		£8,328,334

Approved by the Trustees on 12 April 2017 and signed on their behalf

I COGHILL

Chairman of the Trustees

Staff

of the Game & Wildlife Conservation Trust
in 2016

CHIEF EXECUTIVE	Teresa Dent BSc, FRAgS, CBE
Personal Assistant	Laura Gell
Chief Finance Officer	Nick Sheeran BSc, ACMA, CGMA
Accountant	Leigh Goodger *(from August)*
Senior Finance Assistant	Lin Dance *(until December)*
Accounts Assistant	Tessa Daniel *(until September)*
Senior Accounts Assistant	Hilary Clewer *(from September)*
Accounts Assistant (p/t)	Jill Reid *(until September)*
Accounts Assistant (p/t)	Helen Aebischer
Head of Administration & Personnel	Jayne Cheney Assoc CIPD
Head Groundsman (p/t)	Craig Morris
Headquarters Janitor/Handyperson	Steve Fish *(from January)*
Head of Information Technology	James Long BSc
DIRECTOR OF RESEARCH	Prof. Nick Sotherton BSc, PhD, ARAgS
Personal Assistant (p/t)	Lynn Field
Head of Database	Corinne Duggins Lic ès Lettres
Public Sector Fundraiser	Paul Stephens BApp.Sc
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
PhD Student *(University of Southampton)* - beavers and salmonids	Robert Needham BSc
PhD Student *(University of Queen Mary London)* - *Ranunculus*	Jessica Marsh BSc
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
Contract Ecologist	Aidan Hulatt BSc *(June)*
PhD Student *(Harper Adams University)* - *Syngamus* in pheasants	Owen Gethings MSc
PhD Student *(Exeter University)* - corvids and songbirds	Lucy Capstick MSc
PhD Student *(Exeter University)* - pheasant release pens	Andy Hall MSc
MSc Student *(Newcastle University)*	Rebecca Pinkham BSc
Placement Student *(University of Leeds)*	Alice Deacon *(until September)*
Placement Student *(University of Plymouth)*	Sam Gibbs *(from June)*
Head of Wetland Research	Andrew Hoodless BSc, PhD
Research Ecologist	Kaat Brulez MSc, PhD
Research Ecologist	Carlos Sánchez Garcia Abad PhD, BVSc
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 Newcastle)* - lapwings on fallow plots	Aidan Crowl BSc
MSc Student *(University of Reading)* - lapwings on wet grassland	Charlotte Pilcher BSc
MSc Student *(University of Brighton)* - predator responses by lapwings	Alex Weeks BSc
Placement Student *(University of Bath)*	Tom Oakley *(until July)*
Placement Student *(University of Plymouth)*	Sophie Brown *(from September)*
Placement Student *(University of York)*	Daniel Upton BSc *(April-July)*
Head of Predation Control Studies	Jonathan Reynolds BSc, PhD
Senior Field Ecologist	Mike Short HND
Research Ecologist	Tom Porteus BSc, MSc, PhD
Head of Farmland Ecology	Prof. John Holland BSc, MSc, PhD
Senior Entomologist	Steve Moreby BSc, MPhil
Post Doctorial Scientist	Niamh McHugh BSc, MSc, PhD
Research Assistant	Tom Elliott *(until April)*
Research Assistant	Sophie Potter BSc, MSc *(from August)*
PhD Student *(University of Sussex)* - stewardship on wild bees	Tom Wood BSc, MSc
Placement Student *(University of Nottingham)*	Belinda Bown *(until September)*
Placement Student *(University of Bath)*	Jasmine Clark *(until September)*
Placement Student *(Reading University)*	Jade Hemsley *(from September)*
Placement Student *(University of York)*	Anna Forbes *(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
Research Assistant	Gail Roberston BSc, MSc, PhD *(until June)*
Research Assistant	Helen Allinson *(September-December)*
Research Ecologist Langholm	Sonja Ludwig MSc, PhD
PhD student *(University of Newcastle)* - buzzards and grouse	Richard Francksen BSc, PhD
Placement Student *(Liverpool John Moores)*	Hannah Greetham *(until August)*
Placement Student *(University of Bangor)*	Rhodri Evetts *(until August)*
Placement Student *(University of Bath)*	Nancy Parsons *(until August)*
Placement Student *(Nottingham Trent University)*	Hollie Fisher *(from August)*
Placement Student *(Harper Adams)*	Natalie Elms *(from August)*
Senior Scientist - North of England Grouse Research	David Newborn HND
Senior Scientist - Scottish Upland Research	Kathy Fletcher BSc, MSc, PhD
Research Assistant - Scottish Upland Research (p/t)	David Howarth *(until December)*
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)
Head of Education	Mike Swan BSc, PhD[3]

Regional Advisor – central England	Austin Weldon BSc, MSc[4]
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
Game Manager	Matthew Coupe
Head of Research for the Allerton Project	Prof. Chris Stoate BA, PhD
Ecologist	John Szczur BSc
Soil Scientist	Felicity Crotty BSc, PhD
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
Head of Education and Development	Jim Egan
Project Development Officer	Amelia Woolford BSc *(from June)*
Farm Manager	Philip Jarvis MSc
Farm Assistant	Michael Berg
Farm Assistant	Ben Jarvis
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
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 Bangor)*	William Connock (until September)
Placement Student *(University of Bath)*	Philip Nassr (until September)
Placement Student shared with Predation *(University of Bath)*	Emma Popham (until September)
Placement Student shared with Predation *(University of Cardiff)*	Anna Jones (from September)
Placement Student shared with Predation *(University of the West of England)*	Peter Wood (from September)
Placement Student *(Nottingham Trent University)*	Sean Elliott (from September)
DIRECTOR OF FUNDRAISING	Edward Hay *(until December)*; Jeremy Payne MA, MInstF *(from October)*
London Events Manager	Pip Menzies *(until December)*; Jo Langer *(from December)*
London Events Assistant	Florence Kerr *(until March)*; Jo Langer *(until December)*; Molly Smith *(from October)*
London Events and Sponsorship Assistant	Isabel Stewart *(until July)*
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)	Sarah Matson *(until March)*
Regional Organiser (p/t)	Louise Jones
Regional Organiser (p/t)	Jill Scorer *(from March)*
Regional Organiser (p/t)	Pippa Hackett *(from August)*
National Development Manager (p/t)	Jennifer Thomas
Administration Assistant	Daniel O'Mahony
DIRECTOR OF COMMUNICATIONS, MARKETING & MEMBERSHIP	Andrew Gilruth BSc
Communications & Fundraising Manager	Annabel Cook *(January-July)*
Communications Officer	Emma Graver *(until April)*; Holly Howe *(from May)*
Direct Mail Fundraising & Marketing Officer	James Swyer
Publications Officer	Louise Shervington
Digital Fundraising & Marketing Officer	Rob Beeson
Website Editor	Oliver Dean
Membership & Marketing Administrator (p/t)	Beverley Mansbridge
Membership Assistant (p/t)	Kathryn Kelleher *(until May)*; Heather Acors *(from July)*
National Recruitment Manager	Andy Harvey *(until January)*
Writer & Research Scientist (p/t)	Jen Brewin MSc, PhD *(from January)*
Events Manager (p/t)	Adrienne Tollman (until March)
DIRECTOR SCOTLAND	Adam Smith BSc, MSc, DPhil
Scottish HQ Administrator (p/t)	Irene Johnston BA
Policy Officer Scotland	Gemma Hopkinson MA *(until August)*
Head of Events (Scotland)	Sarah McDowell BSc *(from October)*
Policy & Advisory Officer (Scotland)	Merlin Becker BSc *(from October)*
Senior Scottish Advisor & Scottish Game Fair Chairman	Hugo Straker NDA[1]
Head of Scottish Lowland Research	David Parish BSc, PhD
Research Assistant - GWSDF Auchnerran	Alison Espie *(until March)*; Marlies Nicolai *(from March)*
Research Assistant - Scottish Grey Partridge Recovery Project	Anna McWilliam *(until December)*
MSc Student *(University of Aberdeen)* - rabbit impact at GWSDF	Sarah Wingrove
MSc Student *(University of Leeds)* - lapwing breeding success	Emily Sheraton
MSc Student *(University of Leeds)* - novel conservation crops	Arran Greenhop
MSc student *(University College London)* - human disturbance and birds	Christian Andreou
Placement Student *(University of Leeds)*	Ruth Highley *(from November)*
Intern *(University of Purpan)* - rabbit impact at GWSDF	Augustin Calas
Shepherd Manager GWSDF Auchnerran	Allan Wright

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

Key to abbreviations: ACP = Advisory Committee on Pesticides; BAP = Biodiversity Action Plan; BASC = British Association for Shooting and Conservation; BCPC = British Crop Production Council; CAAV = Central Association of Agricultural Valuers; CFE = Campaign for the Farmed Environment; COT = Committee on Toxicity; FWAG = Farming & Wildlife Advisory Groups; IAF = International Association for Falconry; IUCN = International Union for Conservation of Nature, JNCC = Joint Nature Conservation Committee; LEAF = Linking Environment And Farming; MESME =Making Environmental Stewardship More Effective; NGO = National Gamekeepers' Organisation; NIA = National Improvement Area; PAW = Partnership for Action Against Wildlife Crime; 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