Review of 2020

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

Game & Wildlife CONSERVATION TRUST

www.gwct.org.uk

Thank you

Your membership has helped us to achieve so much in the past year.

With your support we:

- Published over 30 scientific papers in 2020 on topics including 50 years of gamebags, woodland rides, fox control, woodcock, mountain hares, soil health and cover crops.
- Responded quickly and comprehensively to Government consultations in England, Wales and Scotland, especially about General Licences.
- Tagged 10,000 salmon parr on the River Frome – all undertaken by just seven staff.
- Furthered national understanding of fox behaviour, including groundbreaking modelling and tagging individual foxes.
- Briefed politicians at Westminster All-Party Parliamentary Groups.
- Had 21 letters of reply printed in the press, with a total of £5.8 million worth of press coverage.

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Game & Wildlife CONSERVATION TRUST

REVIEW OF 2020

Game & Wildlife Conservation Trust

Issue 52

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

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GAME & WILDLIFE CONSERVATION TRUST CHARITABLE OBJECTS

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

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as of 1 January 2021

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Cornwall	Gary Champion
Cumbria	William Johnson
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Wales

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Powys	Tom Till *(Julian Salmon)*
South-East Wales	Roger Thomas
South-West Wales	no chair

Names in brackets were chairmen that stepped down during 2020.

CONTENTS

Review of 2020

WELCOME

2 GWCT council and county chairmen

4 A privilege to thank you all for your support

5 Pulling together in a difficult year

6 Using our experience to respond to challenges

8 Testimonies recognised in *Community Spirit*

9 Using research to inform species and landscape management

10 Principles of sustainable game management

12 Giving LIFE to waders

14 Thank you for your generous support

UPLANDS RESEARCH

16 Uplands monitoring in 2020

20 Mountain hare distribution and abundance in Scotland

22 Increasing forest cover threatens black grouse

24 Blanket peat vegetation responses to burning and cutting

26 Winter feeding grey partridges on the fringe

FARMLAND RESEARCH

28 Are field beans suffering from a lack of pollinators?

30 Cultivated margins and invertebrates

RESEARCH AND DEMONSTRATION FARMS

34 Allerton Project: game and songbirds in 2020

36 Allerton Project: the farming year

40 Allerton Project: Water Friendly Farming

42 Allerton Project: benefits of feeding willow leaves to ruminants

44 Allerton Project: Conservation Agriculture

46 Auchnerran: game and songbird counts in 2020

48 Auchnerran: the farming year

50 Auchnerran: using lasers to control mammalian pests

FISHERIES RESEARCH

52 River Frome salmon population

54 SAMARCH overview and progress

58 What is causing River Wylye grayling to decline?

60 Timing of migration by juvenile Atlantic salmon

62 Low summer discharge and salmonid ecosystems

LOWLAND GAME RESEARCH

64 Ecological effects of releasing for shooting

WETLAND RESEARCH

68 Breeding woodcock outcomes

70 Wandering waders - using tracking technology

PARTRIDGE AND BIOMETRICS RESEARCH

72 Partridge Count Scheme

74 The Rotherfield Demonstration Project

76 Interreg North Sea project PARTRIDGE

78 Grouse, snipe and hares in England and Scotland

GWCT ROUNDUP

82 2020 GWCT research projects

86 2020 GWCT scientific publications

88 2020 GWCT financial report

92 2020 GWCT staff

94 External committees with GWCT representation

Game & Wildlife CONSERVATION TRUST

Habitat at Rotherfield. © Francis Buner/GWCT

A privilege to thank you all for your support

Teresa Dent CBE,
Chief Executive

© Hugh Nutt

Our scientists and students worked above and beyond last year to make sure our fieldwork and long-term data collection continued. © GWCT

- **Long-term data collection and scientific fieldwork continued.**
- **Policy work increased with our research coming to the fore.**
- **All our members and supporters were unbelievably generous in supporting us through 2020.**

2020 was an extremely difficult year for everyone; charities including the GWCT being no exception. However, I am proud of the outcomes we achieved, even though the way we went about our work had to change dramatically after the first Covid-19 lockdown in March 2020. Almost all our scientific fieldwork took place, all under Health England, Health Scotland and Public Health Wales guidelines, with the permission of landowners. Our scientists were very creative (and committed) in achieving this within households, bubbles and enlisting kind family members willing to get up early, walk miles, get cold, hot, wet or muddy to support our fieldwork. Our long-term data collection underpins all our science and this hard work prevented a very damaging gap in our data collection.

It was a very busy year in terms of taking GWCT science into policy in Westminster, Holyrood and the Senedd. All that work shifted online and if anything got busier. The GWCT is probably the only scientific organisation in the UK with a team of scientists specialising in predation management and control. Our body of science was essential evidence for the review of General Licences (for the control of pest species to protect agriculture and species of conservation concern) that took place in England, Wales and Scotland. That issue kicked off in March 2019 and was still unresolved for European Protected Sites by Christmas 2020 (see pages 6-8).

The GWCT has also done the bulk of the research into the environmental benefits and disbenefits of gamebird management; whether wild or released gamebirds. A review of this evidence was commissioned by Natural England (NE) as a result of the Wild Justice judicial review into whether Defra had undertaken sufficient assessment of the impact of releasing gamebirds on or near European Protected Sites. We collaborated with Exeter University to produce the evidence review for NE (see page 64). It showed clearly that any negative impacts from gamebird releasing are very localised to the release site, with positive impacts on habitats and other wildlife at both the local and landscape scale. Our evidence and expertise on gamebirds also fed into the Werritty Review in Scotland (see page 6) and the ongoing review of the release of gamebirds in Wales (see page 8).

We were honest with our members and supporters about the impact Covid-19 was likely to have on our fundraising. GWCT has always been blessed with committed volunteers around the country, who as part of our county groups in England, Scotland and Wales do an amazing job fundraising for us through local events. We also have

big-ticket events in Edinburgh and London, as well as our New York auction run by our sister charity Game Conservancy USA. Collectively these raise considerable funds, but all events stopped immediately in March, so we knew from the start that Covid-19 was going to have a serious impact.

Our members and supporters were unbelievably generous in increasing their support through online appeals, joining as members, taking part in online auctions, responding to direct mail and fundraising campaigns, or simply by giving more and more often. Staff were also incredibly supportive accepting a salary sacrifice through short-timing, and many being furloughed for parts of the year. I have often said that being chief executive of a charity is a humbling experience due to the generosity of spirit that so many demonstrate; 2020 was a very strong reminder of that.

It is a privilege to have the opportunity in this *Review* to thank members, supporters, donors, county groups, staff, trustees, vice-presidents, sponsors and those field-working friends and families for all they did to help us keep going in 2020.

Pulling together in a difficult year

Sir Jim Paice
GWCT Chairman

Our excellent chief executive Teresa Dent explained the challenges we all faced in her introduction, but I must add my thanks and appreciation to all involved with the GWCT for their support during the most difficult year imaginable. Our staff have all been affected both financially and in their work but without them, we would be nothing whether in the field or the office; a huge thank you to all of them.

For our supporters around the country I can only commiserate over the lack of social events, clay days and of course the shooting season itself, but I am also hugely grateful for the funds and donations raised in difficult circumstances.

When I wrote my piece for last year's *Review* I referred to the challenges affecting us. They have not gone away and more have presented themselves. The decision by the Scottish Government to ignore the report of the Werritty Review and decide to license grouse shooting flies in the face of science. Yet GWCT's evidence was clearly instrumental in persuading Defra to limit its restrictions on heather burning to areas of deep peat despite the pressure from the ill-informed. I must confess to extreme frustration every time I hear or read the expression 'peat burning'. That is a typical abuse of language to give the wrong impression.

As I write we are trying hard to persuade Defra to follow the evidence over the release of gamebirds on or near European protected sites; its initial decision was better than if it had given in to Wild Justice, but nevertheless we are still working hard to ensure Defra base its policies on the science, much of which was undertaken by the GWCT.

> "nevertheless we are still working hard to ensure Defra base its policies on the science, much of which was undertaken by the GWCT"

The Agriculture Bill has now completed its passage through Parliament and I am pleased that the principles of the new ELMS scheme follow the advice of GWCT. As always the devil is in the detail, which at the moment is sorely lacking. Much will depend on the rates of payment as to whether farmers take up the options with the enthusiasm which we hope.

Last year I also mentioned that the shooting and rural organisations are working together more to promote best practice, and I hope that in the coming months we will see more evidence of this joint work with a more unified approach. In my view it must be more than defensive; it must face up to bad practice where it exists and seek to raise the standards of all to the best. The GWCT is not a shooting organisation, but we act as scientific advisers to the shooting community. The best practice is based on our research and proves beyond doubt that a well-run shoot delivers more biodiversity than similar ground without a shoot.

Using our experience to respond to challenges

Adam Smith,
Director of Policy Scotland

(Above) Our response to 'Werritty', policy objectives and advisory work was guided by our 'Best Practice with Proof' approach, developed through 2020. (Below) The Epicollect app is used to help record species seen.
© Graeme Hart/Perthshire Picture Agency

Scotland

- Grouse moor matters dominated the year's policy work.
- Best practice management and new data gathering approaches were used to inform the development of new regulation.
- Natural capital, including carbon management, was developed as a practical and policy tool at GWSDF Auchnerran.

Much of GWCT Scotland's policy effort focused on advising the moorland sector and Scottish Natural Heritage, now NatureScot, on the recommendations of the 'Werritty' Grouse Moor Management Review delivered in late 2019.

Our response to 'Werritty', policy objectives and advisory work was guided by GWCT Scotland's 'Best Practice with Proof' approach, developed through 2020. This draws on our research, delivers it through our advisors and backs it by providing data gathering facilities and interpretation. The evidence base generated should provide the information Scottish Government and NatureScot need to value the management delivered on Scottish moorlands.

We gave extensive advice to the Rural Environment and Land Management (RELM) group of Scottish sporting and land management organisations, including the representative bodies for gamekeepers, owners and guns. RELM co-ordinates this sector's policy and public relations on moorland issues and advised on shooting practice under lockdown.

Our knowledge about hare conservation was accepted by NatureScot who advised the Minister in the run-up to the Scottish Parliamentary debate on an Animal Protection Bill, but scrutiny by-passed at committee stage yielded a wholly political vote which implemented a ban culling mountain hares. We have worked since then to ensure a practical licensing system is introduced to permit the taking of some mountain hares for defined purposes.

Scottish Government's formal response to 'Werritty' eventually materialised in November 2020. Despite all the evidence, much from GWCT including compelling data from the Langholm Moor Demonstration Project, Ministers pledged to licence 'driven grouse businesses', muirburn and further regulate traps and snares. Our focus has been on maintaining regular contact with NatureScot to build agreement on practical management licensing options and accepting raptor surveys by keepers for conservation assessment, and with Scotland's Moorland Forum regarding the delivery of our muirburn advisory service and updating the muirburn code.

In a year of challenges, there were also successes. We reduced some of the pressure on moorland management by funding and initiating the development of a new vaccine against the tick-borne Louping-Ill disease at the Moredun Research Institute. Though delayed, as so many projects were by Covid, this project is a priority for completion in 2021.

We also completed our first carbon audit and natural capital assessments at our Scottish Demonstration Farm. This is an extremely important move as the farm begins to show both progress towards net farming income and net environmental gain.

England

- **Our work on the new Agriculture Bill sees soil management recognised.**
- **The new scheme aims to deliver for farmers, wildlife, the environment and society.**

Alastair Leake
Director of Policy and Parliamentary Affairs

© Hugh Nutt

Re-nationalising policymaking following our departure from the European Union meant 2020 was a very busy year. For the Trust, there are two areas of particular interest that impact directly and indirectly – game and wildlife conservation. The first concerns the way we farm our land and this policy is embedded, unsurprisingly, in the Agriculture Act. One might have thought that this would not be too difficult a task to get agreement on across the political spectrum given the universal unpopularity of its predecessor, the EU Common Agricultural Policy, or the CAP, as we came to know it. Indeed reforming the CAP is the only political theme I can recall that unites all parties. Yet still there were areas of profound disagreement, particularly over the promise that environmental and welfare standards in this country would be maintained as a condition of any Trade deal, but then not legally enshrined in the Act. Government backbenchers in the Commons sought to bring an amendment which was swept aside, and the Lords did likewise. The hastily assembled Food and Trade Commission was given greater authority to scrutinise Trade deals, but still can only provide non-binding recommendations. It is important that farmers who are delivering environmental benefits are not economically disadvantaged and potentially put out of business by those elsewhere who are not.

We were, however, pleased that soil management was included within the Act. Originally soil had been designated as a private asset which meant it was not for the State to involve itself with. But we, and others, argued that this was too narrow a definition and given about half of our food supply is dependant upon it surely it represented something of public interest. This was recognised, which is important because while we cannot use public money to support private assets, we can to support public ones. This means we can fund soil preservation and restoration measures in the new Environmental Land Management Scheme, which is the flagship scheme that the Government is rolling out to support farmland conservation.

This is the second policy area we have been busy helping co-design. We have learnt a great deal about what does and doesn't work from previous environment schemes and it is imperative that we use this experience to shape a scheme that delivers for farmers, wildlife, the environment and society going forward.

It is important that farmers who are delivering environmental benefits are not economically disadvantaged and potentially put out of business by those elsewhere who are not. © Peter Thompson

Testimonies recognised in *Community Spirit*

Sue Evans, Director of Wales

(Above) We have continued to work on the future of farming. (Below) The Community Spirit, *report incorporated testimonials as to why shooting was important to you. © GWCT*

Wales

- *Community Spirit* report was published highlighting why shooting is important to you.
- Informing Natural Resources Wales' Wild Bird Review.
- Four point-plan for improving the health of our watercourses.
- Highlighting the great benefits derived from game management for nature in mainstream farming to influence the future Sustainable Farming Scheme.

2020 saw further pressures on the traditional management of the countryside with a Judicial Review in December. The challenge was unsuccessful and the High Court ruled that Natural Resources Wales' (NRW) General Licences to control wild birds are lawful. This pressure inspired us to ask you (our members and supporters) why shooting is important, particularly in relation to your physical and mental wellbeing. Five hundred and eighty-one of you responded with some beautifully written, heartfelt testimonies which we then incorporated in a report, *Community Spirit*, under the seven headings of the Wellbeing of Future Generations (Wales) Act 2015. Though we have indisputable science on the benefits that shooting can deliver for biodiversity, this is our first report with a social focus and it is a powerful document that should help to bridge the gap of understanding between those that shoot and those that don't.

In December, the Minister for Environment, Energy and Rural Affairs announced that she had decided to add pheasants and red-legged partridges to schedule 9 of the Wildlife and Countryside Act 1981, with the intention of introducing an appropriate licensing regime for the release of gamebirds in time for the 2022/23 season. This, along with a continued review of General Licences, is part of the ongoing Wild Bird Review looking at all elements relating to shooting, including trapping. Members helped again to inform the call for evidence by providing us with your views in December which proved to be of great importance as we were able to give NRW evidence specifically from Wales.

There has been continued work on the future of farming with the Agriculture in Wales White Paper Consultation launched in December. This sets out the Welsh Government's intentions for primary legislation and provides the basis of the Agriculture (Wales) Bill which we will continue to feed into. We have a growing number of farmers approaching us to become part of a network of Welsh Demonstration Farms which will help us to showcase how game management principles can deliver more biodiversity into mainstream agriculture.

The problem of pollution to our watercourses continues so we are working with fishing groups, farming unions and policy writers to promote a four-point plan of better regulation, effective enforcement, proportionate fines and collaboration.

The number of projects we are involved in continues to grow with a focus on Farmer Clusters, cover crops on two very different grassland farms, overwinter feeding of seed-eating birds and even a short project looking at soil health using woodcock as a potential indicator species.

Using research to inform species and landscape management

- Long-term research is crucial to understanding species declines and devising management solutions.
- Our research continues to inform farming and game management practices.

Andrew Hoodless,
Director of Research

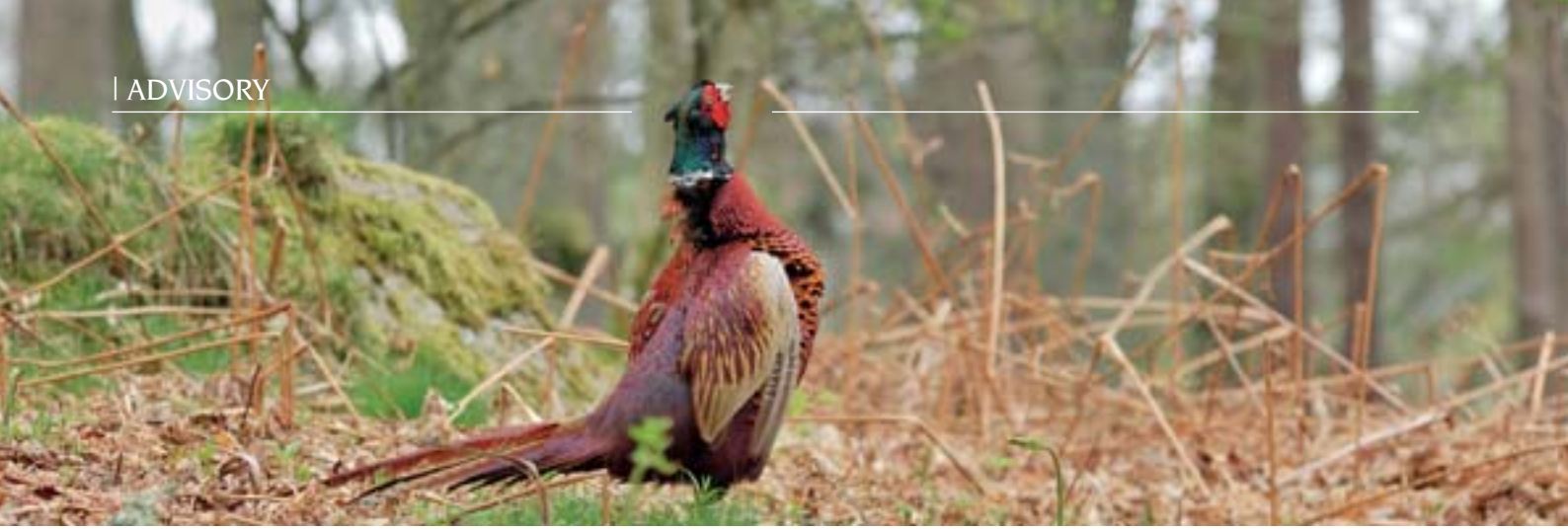
Large-scale, long-term datasets such as counting black grouse, enable us to better understand the ecology of declining species and the reasons for their reduced numbers, and to propose and monitor management solutions. © Nick Hesford/GWCT

The *Review* reports on and showcases some of the research undertaken at the GWCT in the last 12 months. Owing to the applied nature of our research, our scientists rely on the collection of data in the field. 2020 was a difficult year because there was great uncertainty about what fieldwork would be possible, just at the time when most teams were about to start their most intensive periods of fieldwork. I am pleased to report that by co-opting partners and other family members our research teams managed remarkably well, ensuring that time-sensitive tasks were completed, and therefore we did not suffer gaps in long-term datasets.

Large-scale, long-term datasets enable us to better understand the ecology of declining species and the reasons for their reduced numbers, and to propose and monitor management solutions. The articles on grayling, black grouse, and grey partridge (see pages 58, 22 and 72 respectively) illustrate the value of some of our long-term datasets. Our long-term monitoring of salmonids on the River Frome in Dorset continues (see page 52), but the SAMARCH project has enabled us to undertake novel work to investigate movements and survival of fish at sea (see page 54).

Work towards more sustainable farming systems continues at our Allerton Project at Loddington and some of our pioneering research on improving water quality and reducing catchment-scale flood risk, and on Conservation Agriculture, is described in this *Review* (see pages 40 and 44). Closer working between the team at Loddington and our farmland ecology and Sussex study teams under the Allerton Project umbrella was instigated in the latter half of 2020, and I am confident that the increased dialogue between scientists will place us in a strong position for future farmland research. Two of our projects with European partners, BEESPOKE and PARTRIDGE (see pages 28 and 76), were selected as exemplars and showcased at the EU Green Week in October, and these are good examples of the type of work we will be looking to build upon.

Scrutiny of game management practices continues, so it was good to see our upland team set up an experiment and collect baseline data to investigate the effects of burning and cutting of vegetation on blanket peat (see page 24). A report to Natural England reviewing the effects of gamebird releasing on woodland and farmland habitats and species was produced, followed by the timely publication of a scientific paper (see page 64).



Principles of sustainable game management

Roger Draycott, Director of Advisory & Education

Our best practice and sustainable game management aim to deliver a net gain for biodiversity. © Laurie Campbell

- The principles provide a blueprint for shoots to deliver a net biodiversity gain.
- They are supported by all the major UK shooting and rural organisations.
- The principles are closely aligned with international guidelines on sustainable use of natural resources.

Why do we need these principles?

GWCT promotes best practice game management as a force for good for nature conservation and environmental improvement on farmland, woodland, moorland and wetland. By establishing principles, based on science and conservation through wise use, we want to promote best practice and sustainable game management that aim to deliver a net gain for biodiversity.

Biodiversity net gain is a concept that is embedded in Defra's 25 Year Environment Plan and is an approach to land use that leads to an increase in biodiversity. The principles are designed to function and to have relevance across a wide range of interest groups from game managers and participants in game shooting, through to conservation organisations, Government and the general public.

How did we develop on them?

To promote best practice, we produced a set of draft principles in autumn 2019, which were presented and discussed at over 20 private shoot briefing meetings held between autumn 2019 and spring 2020, each with an audience of approximately 30 shoots, varying in size but including some large commercial shoot operations. An online consultation, via the GWCT website was live from May to June 2020. More than 340 responses were received, with more than 90% support for the principles.

We reviewed internationally agreed guidelines on sustainable use and biodiversity. Many of the principles align closely with the Bern Convention European Charter on Hunting and Biodiversity. This charter has guidelines for game managers but also regulators so that they can help game managers to benefit the conservation of biodiversity. The charter is based on two important agreements of the Convention on Biological Diversity. These are the Addis Ababa Principles and Guidelines for Sustainable use of Biodiversity and the Ecosystem Approach to Conservation (Malawi Principles). The Charter on Hunting and Biodiversity, and the Malawi and Addis Ababa Principles are supported by the IUCN (the global authority on the status of the natural world and the measures needed to safeguard it). All the major UK shooting and rural organisations fully support the GWCT's principles of sustainable game management.

The principles of sustainable game management

1. **Biodiversity**. All shoots, whether based on wild gamebirds, released gamebirds or a combination of both, should strive to achieve a net biodiversity gain on their land.
2. **Landscape**. Through active management of the rural landscape, effective game management supports the growth of game populations, allowing a sustainable harvest with positive benefits for other species, while avoiding population levels which could damage other land uses such as farming, forestry and nature conservation.
3. **Densities**. Gamebirds should only be released and managed at densities appropriate to the local circumstances, so that there is a net environmental gain from undertaking such activity.

Wildlife such as songbirds and butterflies benefit from habitat created and managed for gamebirds. © Peter Thompson, GWCT

4. **Diversity**. Appropriate habitat creation, management and sometimes restoration is needed for all gamebirds. Maintaining this critical and appropriate diversity of habitats is a feature of our advice and recommendations, based on our scientific research and observation. Habitats created, restored and managed to support gamebirds include woodland, hedgerows, field margins, game cover crops, wild bird seed mixes, moorlands and wetlands.
5. **Timing**. Releasing gamebirds in the summer increases the number of birds available to shoot in the autumn and winter. Shoot managers should only release gamebirds in habitats that enable them to acclimatise quickly to life in the wild, following the guidelines and recommendations outlined in the Code of Good Shooting Practice and the British Game Alliance standards.
6. **Development**. Following the release of gamebirds, habitats should be provided to encompass their year-round needs. All birds should be fully adapted to life in the wild before the first shoot day.
7. **Responsibility**. Shoots should ensure that all game that is fit for human consumption is eaten.
8. **Science**. Grouse and wild partridge shoots should assess their proposed bag by calculating the sustainable yield based on annual game counts and follow GWCT recommendations for sustainable harvest of wild game.
9. **Sustainability**. Game management provides an incentive to privately fund the creation, restoration and management of habitats across large areas of the countryside specifically for wildlife – something which is usually only incidental to other forms of land use such as forestry or farming.
10. **Wildlife**. Habitats created and managed to support released gamebirds include woodland, hedgerows, field margins, game cover crops, wild bird seed mixes and wetlands. Much other wildlife benefits from this habitat provision. Alongside the habitat provided and managed for gamebirds, predation control and supplementary feeding are often important aspects of game management. These activities can benefit a wide range of other wildlife.
11. **Balance**. Predation control is undertaken to reduce predation pressure. This is especially important in spring, to reduce levels of predation on nesting birds, nests and chicks, and during summer to protect young birds. Many species, including several of conservation concern, benefit from predation control undertaken to conserve gamebirds.
12. **Legal control**. The predators targeted are common and successful generalists so a temporary reduction in their numbers locally will not jeopardise their population or conservation status. Predation control activities should be undertaken according to best practice guidelines to ensure they are legal, humane and effective. In no circumstances should any protected species ever be illegally killed to protect game, nor should any predation control activity risk negatively affect the conservation status of a species.

GWCT BIODIVERSITY ASSESSMENTS

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

Giving LIFE to waders

Lizzie Grayshon reflects on the success of the LIFE Waders for Real project for recovering waders, understanding predators and working together

The lapwing is one of the nation's favourite birds, with its distinctive crest, flight pattern and 'peewit' call heralding the arrival of spring. Only a generation ago, large flocks of lapwing were a familiar sight across the country, but the population has fallen by 80% since 1960 in England and Wales. Lapwings remain in decline and on the UK's red list of endangered species. Over the last five years you may have read about the LIFE Waders for Real project and the exciting work the project team and land managers have been doing in the Avon Valley. The project came to an end at the beginning of 2020, which gives us an opportunity to reflect on the successes for waders, conservation and policy from the project.

> "There were 61 pairs on the study area in 2015 rising to 105 in 2019. But the greatest achievement has been improving breeding success, which is critical to reversing declines"

Wader recovery

Since the project began, the numbers of lapwing started to rise. There were 61 pairs on the study area in 2015 rising to 105 in 2019. But the greatest achievement has been improving breeding success, which is critical to reversing declines. To remain stable, a local population needs to fledge an average of 0.7 chicks per pair each year. Prior to the project, annual lapwing productivity had dropped as low as 0.4 fledged chicks per pair. In 2019, after just five years, the figure was 0.96.

Over the course of the project, the average annual figure for the hotspots where habitat and predator management were focused, went from 0.51 to 0.75 fledged chicks per pair. Redshank numbers have also increased dramatically from 19 to 35 pairs, and initial signs of snipe returning to breed have been observed. Waders for Real has demonstrated how, given the right kind of funding, advice and encouragement, and by working with conservation experts, farmers can boost biodiversity in the wider working countryside.

Understanding and limiting predation

The foundation of most successful conservation projects is providing enough good-quality habitat, but this alone is not always sufficient. In the Avon Valley, despite the creation of plenty of suitable habitat, predation of lapwing nests and chicks was too high to maintain a stable number of breeding pairs. Temporary electric-fencing around nests proved successful at improving hatching success. The lethal control of foxes, crows and American mink carried out by gamekeepers and riverkeepers on some of the Avon Valley sites reduced predation pressure further and further increased breeding success in these areas. The best approach

Lizzie Grayshon, Waders for Real Ecologist

(Top) Large flocks of lapwing used to be a familiar sight across the country, but the population has fallen by 80% since 1960 in England and Wales. They remain in decline and on the UK's red list of endangered species.

depends on the resources available and intended area, but a thorough understanding of the predators responsible, their densities and movements around breeding waders can improve the success of lethal and non-lethal management options aimed at wader recovery. Over the course of the Waders for Real project, GWCT predation scientist Mike Short, caught 37 foxes and fitted them with GPS collars to understand their lives on the river meadows. This research has filled important knowledge gaps and provides a much better understanding of the density, movement and diet of foxes in river valleys.

Collaboration and community

Building trust and a feeling of co-operation between everyone involved, from estate owners to tenant farmers, gamekeepers and riverkeepers, ecologists and the local community was a crucial objective. To achieve long-lasting wader recovery, we needed the experience and knowledge from all of these groups. Regular meetings allowed farmers and wildlife managers to discuss the challenges faced and gave them the opportunity to share their valuable experience. This was very much a two-way street, with land managers able to gain advice and support from our ecologists on topics from effective predator control to AES derogations, and our ecologists were able to gain important insights from the people who see their land and birds every day. In total, 64 land managers were involved in the project and continue to work towards wader recovery. Over 429 students were involved in educational activities, along with 31 undergraduate or masters students who conducted their projects as part of the Waders for Real programme. Over 40 networking events, involving more than 50 conservation projects/organisations and Government conservation agencies, were organised.

2020 and the future

Although LIFE funding ceased at the end of 2019, the project will benefit waders for years to come and the GWCT is committed to building on its success by securing funding for further wader projects in the Avon Valley. In 2020, funding was gained for a new project investigating the spatial ecology of redshank to start in 2021. The land managers engaged in the Waders for Real Project were keen to make their Farmer Cluster official and made a successful application to the Natural England Facilitation Fund.

Find out more at gwct.org.uk/wadersforreal.

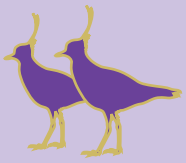
Regular meetings allowed farmers and wildlife managers to discuss the challenges faced and gave them the opportunity to share their valuable experience.

A TEAM EFFORT

The LIFE Waders for Real successes could not have been achieved without the passion of the valley landowners, farmers and keepers for the waders, their desire to halt and reverse the declines and their willingness to work collaboratively. The project benefited from a great GWCT team, valuable assistance from Clive Bealey, undergraduate, masters and PhD students, and advice from Natural England, Environment Agency, RSPB and Hampshire and the Isle of Wight Wildlife Trust. The LIFE Waders for Real project was co-funded by the EU LIFE programme and the GWCT.

PROJECT ACHIEVEMENTS

40
FARMERS, GAMEKEEPERS AND LANDOWNERS WERE INVOLVED



61
LAPWING PAIRS IN THE STUDY AREA IN 2015

105
LAPWING PAIRS IN THE STUDY AREA IN 2019

84%
INCREASE IN REDSHANK NUMBERS BETWEEN 2015 AND 2019

37
FOXES FITTED WITH GPS TRACKING COLLARS

80
CAMERA TRAPS USED ON HOTSPOTS EACH YEAR

1.3KM
OF FENCING REMOVED

31
NEW SCRAPES

7.5KM
OF DITCHES CREATED OR RESTORED

Thank you for your generous support

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

(Above) Guests enjoyed a virtual tour of the Englefield Estate, as enjoyed in previous years by the Cotswolds Grey Partridge Group. (Below) The New York Auction went online and raised a fantastic £133,000.

England & Wales

- Major donor income of £1.14 million.
- £133,000 from the New York auction (subject to exchange rate).
- County committees projected at £477,000.
- London events at £105,000.

The fundraising department has worked very hard to deliver the above numbers amidst a difficult year for so many in 2020. To have received our best ever response from major donors, is a testament to this group's generosity and recognition of both our contribution and our need.

The major donor total includes some acts of conspicuous generosity from key supporters, but also represents a widening and deepening of support for the GWCT, and the widening is crucial as it reflects our success in getting in front of more people. We asked for support for our Challenge Fund (a response to the headwinds that amassed in 2019), but also for our Special Appeal which was based on the impact of the virus on our wider income, and both were generously supported.

The New York auction successfully went online thanks to hard work by Ron Beck and Robyn Hatch and the main limiting factor was the understandable reluctance of donors to give us days to auction amidst such uncertainty.

County committees suffered from the end of normality in March by which time only a few events had taken place. The online auction was proof of everyone's determination to do what they could despite the restrictions, and we are very grateful to auction lot donors and buyers alike. Northamptonshire also held our first ever online shoot walk which was a great success.

The only London event we held was another excellent dinner at Le Gavroche dinner hosted by Michel Roux Jr. As with all the counties, everything else was first postponed and then cancelled, so we put a few special lots that would have been sold at the Ball into the online Big Auction. This auction, which was put together in less than a month, was a resounding success due to everyone who supported it. We would like to thank you all – we couldn't do this without you.

Finally, we didn't allow lockdown to stop us from having our usual annual lecture, so more than 100 people were treated to a very insightful and highly personal talk from Richard Benyon in July.

Scotland

- Major donor income of £194,000.
- Scottish online auction income of £172,000.
- West of Scotland dinner & auction income of £79,000.

In Scotland, we asked our supporters to help with the shortfall that was inevitably going to transpire following the cancellation of both the Scottish Game Fair and our programme of events. We were delighted and humbled by the incredibly generous support we received and continue to receive from individuals and family trusts. With increased political pressure north of the border, we need enhanced funding more than ever in 2021.

The regional committees in Scotland were affected much in the same way as their English counterparts with all but one live event having to be cancelled. Even the one that went ahead, the West of Scotland dinner and auction, had several call-offs on the day of the event but still managed to raise more than the projected total for the evening. As always this is due to the generosity of the donors and attendees, as well as the experience of Fred MacAulay as auctioneer.

When everything ground to a halt in March, our two northern events (Highland & Grampian auctions) were in full planning mode, so a swift decision was made to incorporate their auction lots with our regular Scottish Auction which was moved online. Given the time constraints in organising our first ever fully-online auction, the result was truly magnificent and a testament to the generosity of both the donors and regular supporters of all three events.

We also launched the first-ever Scottish 'Big Four' raffle which ran from May to October and was a huge success. One hundred and eighty eight tickets were sold, and the raffle raised £25,630 in total. It was touch and go whether the day would happen, but we managed to squeeze it in between restrictions and a big thank you must go to the four estates, owners, keepers and their teams who enabled such a smoothly run day.

On behalf of all at the GWCT, sincere thanks to all of you who did whatever you could in 2020, we can't wait for the resumption of normality.

(Above) Our auctions moved online and were a magnificent success and a testimony to your generous support. (Below) The team enjoying the prize of the 'Big Four Raffle' in Donside.

Uplands monitoring in 2020

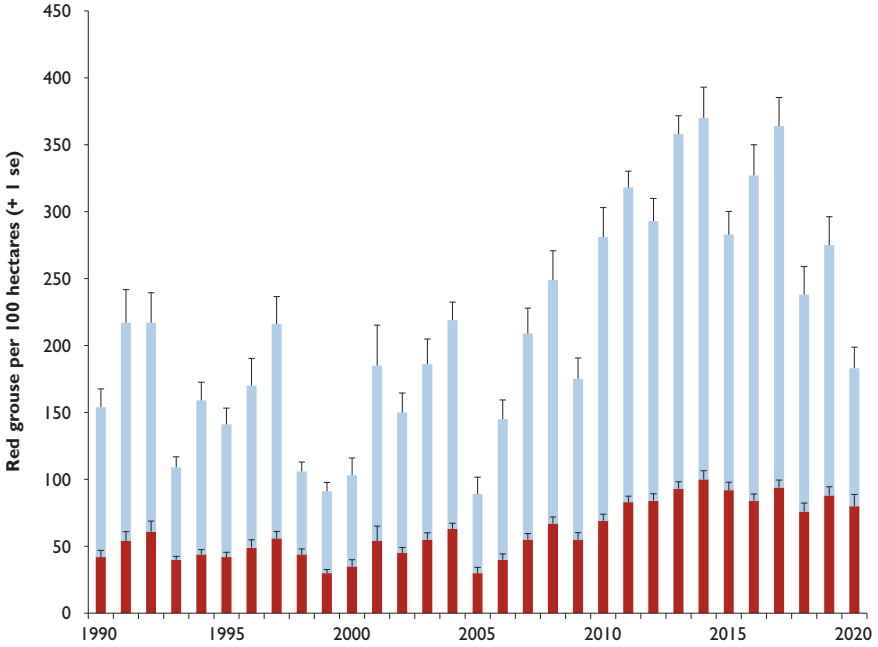
BACKGROUND

Our uplands research team conduct annual counts of red grouse in England and the Scottish Highlands to assess their abundance, breeding success and survival, which may change according to *Trichostrongylus tenuis* parasitic worm infestations. We also count black grouse at leks and estimate their breeding success in August. These data enable us to consider any long-term changes so we can recommend appropriate conservation or harvesting strategies. Such information is vitally important if we are to base such decisions on accurate estimates.

The counts of red grouse conducted in both spring and July are one of the main annual long-term monitoring tasks undertaken by the upland research group. The spring counts form pre-breeding density estimates, while those in July are post-breeding density estimates, when numbers of both adults and young are recorded. We estimate grouse abundance using pointing dogs typically on 100ha blocks of predominantly heather-dominated moorland. Counts are completed by lone fieldworkers and their dogs and we were able to complete most of the counts in 2020, while following the necessary Covid-19 induced restrictions. Counts of parasitic strongyle worms were collected from 20 shot adult grouse on a sample of these moors in early autumn. We also sampled parasite levels in the early spring to establish the importance of parasites to maternal condition and breeding productivity. We did this by counting worm eggs within fresh grouse caecal material and using measured egg abundance to predict numbers of adult worms.

Figure 1

Average density of young and adult red grouse in July from 25 moors in northern England 1990-2020



Grouse counts - England

In 2020, spring grouse densities were similar to those in spring 2019, with an average of 102 birds per 100ha (100 in 2019) across the 25 sites counted. Survival through to breeding was lower than in 2019, with the number of adult birds seen on the same area in July falling by 17% to a mean of 85 birds per 100ha. Breeding success was also poor in 2020, averaging 1.2 young per adult (2.1 in 2019), giving a post-breeding density of 187 birds per 100ha, a 35% decrease on 2019 (see Figure 1). Consequently, summer densities were the lowest recorded since 2009. This average masks both marked regional and altitudinal differences, with breeding success particularly poor in the North York Moors at only 0.4 young per adult compared with 3.1 young per adult at some high-altitude blanket peat sites in the North Pennines.

Scotland

Spring densities in 2020 averaged 50 birds per 100ha, an 8% decline from 2019 across 23 sites counted. The number of adults seen on the same area in July had fallen by 16% (42 adults per 100ha in July) which is a smaller loss during the breeding season than reported in 2019 (31%). Breeding success in 2020 was 1.2 young per adult compared to 1.0 young per adult in 2019. Post-breeding densities averaged 96 birds per 100ha in 2020, higher than the 82 birds per 100ha in 2019.

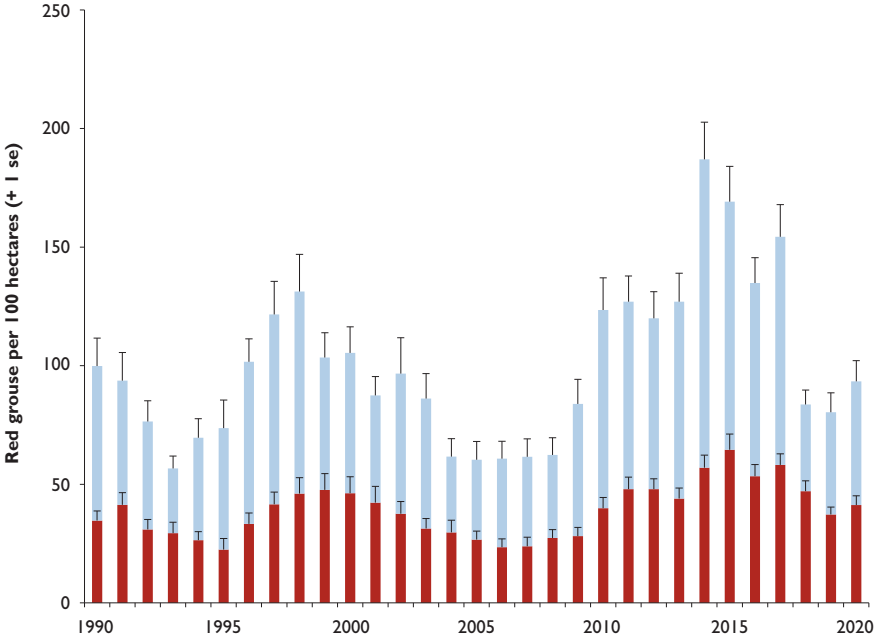


Figure 2

Average density of young and adult red grouse in July from 23 moors in Scotland 1990-2020

Young grouse

Adult grouse

KEY FINDINGS

- Both red and black grouse breeding success in 2020 was generally low in northern England.
- Neither parasitic worm egg abundance in spring nor that of adult worms in autumn were related to red grouse breeding success.
- Instead, damage to heather by heather beetle outbreaks negatively influenced both grouse density and chick survival.

David Baines
David Newborn
Kathy Fletcher
Michael Richardson
Sonja Ludwig
Phil Warren

Red grouse breeding success was poor in 2020 in England with summer densities the lowest recorded since 2009. © GWCT

Strongyle worm burdens in northern England and Scotland

Autumn numbers of parasitic worms in grouse in both northern England and Scotland were low overall, although some sites in northern England had higher levels than in recent years (see Figures 3 and 4). In England, 24 beats across nine moors were monitored for parasitic worms in spring 2020: those using medicated grit (n = 13) had a geometric mean of 409 worms per bird and those not using medicated grit (n = 11) had 1,145 worms per bird. Those with access to medicated grit had lower autumn worm burdens (367 worms per bird, n = 11 sites) than those not using medicated grit (1,235 worms per bird, n = 9 sites). In Scotland, four beats across two moors in Strathspey were monitored in spring. In spring the average worm burden was 168 worms per bird, with similarly low levels reported in autumn (166 worms per bird) after birds had access to medicated grit during the breeding season.

In northern England, neither worm eggs in spring nor adult worms in autumn were related to grouse breeding success. Instead, heather quality following outbreaks of heather beetle influenced grouse distribution and breeding success, with the ratio of young to adult birds in July negatively correlated with the degree of heather damage by beetles.

Figure 3

Average (geometric mean) annual worm burden for autumn-shot adult red grouse from 8-20 moors in northern England 1990-2020

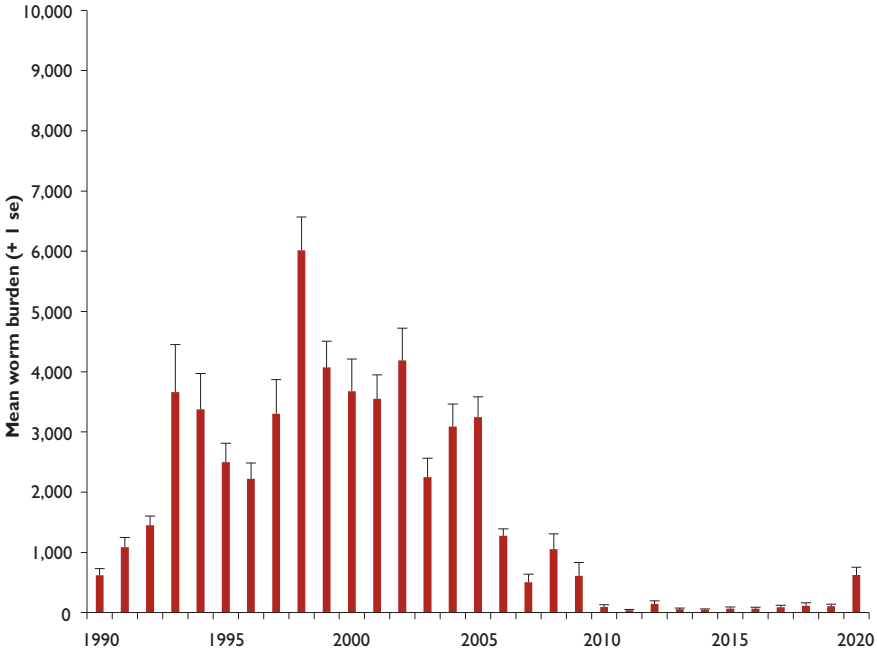
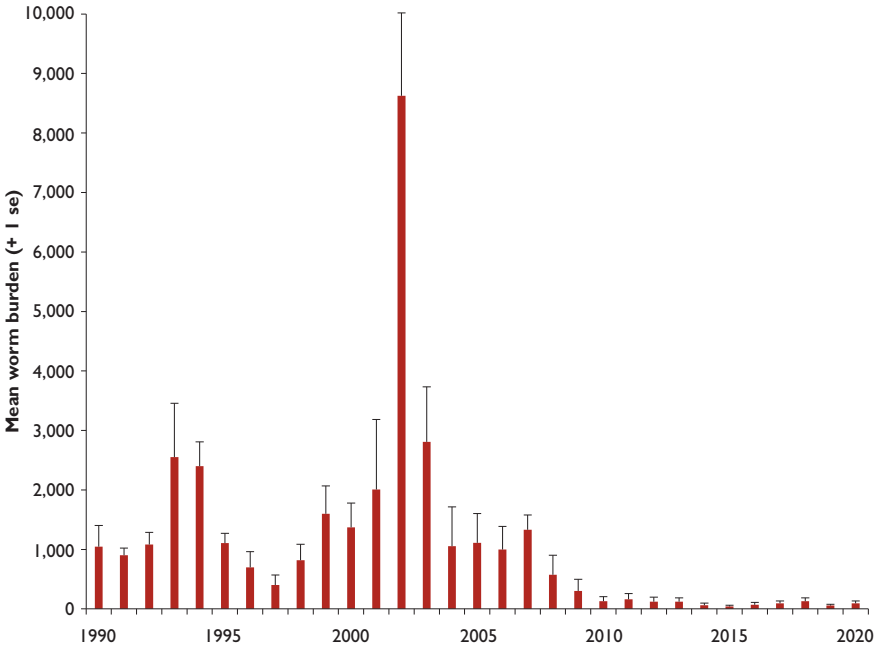


Figure 4

Average (geometric mean) annual worm burden for autumn-shot adult red grouse from 3-17 moors in Scotland 1990-2020



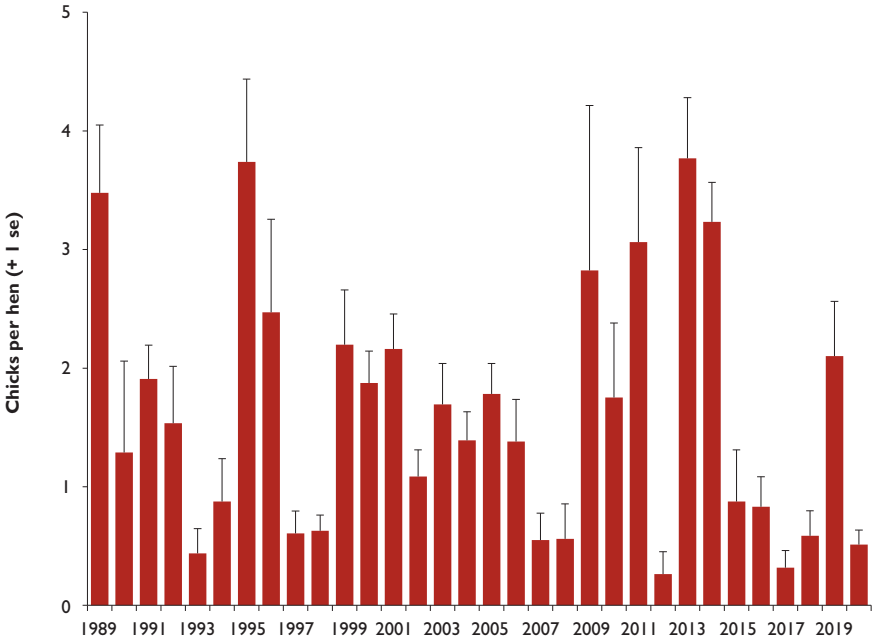


Figure 5

Black grouse breeding productivity in northern England between 1989 and 2020

In the Pennines, heath moors on shallow peats lower down the valleys were generally more impacted by heather beetle, while high altitude sites on deep peat at the head of the dales were often least affected and here grouse tended to breed well, especially at sites where grouse had low parasite intensities having previously crashed from strongylosis in 2018.

Black grouse

In spring 2020, 88 leks in northern England were visited and 603 males counted, 5% more than last year. August brood counts averaged only 0.5 chicks per hen, the fourth-worst value since records commenced in 1989 (see Figure 5) and associated with a wetter than average June. Given the current run of poor breeding years, it is important to maintain high adult survival rates through continuing predator control, establishing pockets of native woodland to provide food sources in severe winters and continuing to make efforts to minimise any accidental shooting of greyhens through mistaken identity for red grouse.

Continuing predator control, establishing pockets of native woodland to provide food sources and continuing to make efforts to minimise any accidental shooting of greyhens will help to maintain high adult survival rates.
© Sarah Grondowski/GWCT

Mountain hare distribution and abundance in Scotland

Mountain hares were more likely to be found on estates practising driven grouse shooting. © Laurie Campbell

BACKGROUND

The mountain hare is a species of European importance, whose UK population is found almost entirely in Scotland. Concerns regarding the extent to which mountain hares are controlled on grouse moors has contributed to a growing public debate about the environmental impact of grouse shooting in the UK. However, the conservation status of mountain hares in Scotland is unclear, with recent research on mountain hares presenting conflicting evidence regarding regional and national trends.

In Scotland, mountain hares are strongly associated with heather moorland managed for red grouse, where they benefit from enhanced habitat management and control of generalist predators. However, mountain hares are a potentially important reservoir for the tick-borne Louping ill virus, which can reduce grouse chick survival. Consequently, hares are culled in large numbers on some grouse moors, with 50% of the national hare bag culled for this reason. These large-scale culls have contributed to a public debate about the alleged environmental impacts of driven grouse shooting. However, the status of mountain hares in Scotland is unclear and recent research on mountain hares has presented conflicting evidence on regional and national trends. As species population trends are usually positively correlated with shifts in range, identifying changes in species distributions can help inform conservation status.

We assessed mountain hare distribution and numbers culled in Scotland during 2016/17 using questionnaire surveys of landowners and managers and compared the results with matching surveys in 1995/96 and 2006/07. We asked questionnaire respondents to provide a boundary of their estate and indicate the areas where mountain hares had been observed since 2016. We categorised the respondents' estates into four Scottish regions (north-west, north-east, south-west and south-east) and three intensities of grouse management: those where the estate practised either driven grouse shooting (driven), walked-up grouse shooting (walked-up) or no grouse shooting (not-shot).

We received 1,173 survey responses covering an area of 92% of Scotland making this the most extensive distribution survey of mountain hares to date. We found that mountain hare distribution patterns were similar to those reported in previous surveys with the greatest presence in the north-east, an area of predominantly driven grouse shooting. Across all regions, the average area occupied by mountain hares was greater on estates practising driven grouse shooting (70%) than on those practising either walked-up grouse shooting (18%) or where grouse were not shot (5%), with 68% of the mountain hare's range occurring on estates with driven grouse shooting. From comparisons of estates covered in all surveys (1995/96, 2006/07 & 2016/17) we found that mountain hare range remained stable in north-east Scotland, but contracted on estates in southern Scotland with the greatest reductions in the south-

west (see Figure 1). In north-west Scotland, hare range had expanded on average by 61% on estates practising driven grouse shooting but had declined by 57% on estates practising walked-up grouse shooting and remained low, but stable on estates that did not shoot grouse.

Described changes in hare range in relation to grouse management were inconsistent with recent findings by the RSPB and the Centre of Ecology and Hydrology, which reported that large-scale culls of mountain hares on driven grouse moors may be causing declines in north-east Scotland. Our survey responses reported a total of 33,582 mountain hares culled in 2016/17 representing a 71% and 48% increase from the numbers culled in 1995/96 and 2006/07 respectively. However, we found no relationship between cull intensity and contractions in mountain hare range, and changes in the numbers culled may simply reflect annual fluctuations in hare densities. Instead, the observed retractions in mountain hare range were consistent with those of some moorland birds (eg. curlew, golden plover, black grouse and red grouse) and may be attributed to large-scale changes in upland land-use, whereby heather moorland had been either afforested or lost to over-grazing. These changes have resulted in fragmentation of remaining moorland habitats, especially in south-west Scotland, where management of moors for driven grouse shooting has largely ceased and generalist predators have increased accordingly. We suggest that these factors may be more important than increases in hare culls as drivers of declines in mountain hare range, particularly in south-west Scotland.

KEY FINDINGS

- Driven grouse moors accounted for 68% of the total area where mountain hares were reported present.
- Between 1996 and 2017, mountain hare range contracted in southern Scotland but remained stable in the north-east and increased in areas managed for driven grouse shooting in the north-west.
- There was no relationship between mountain hare culling intensity and contractions in their range.

Nicholas Hesford
Dave Baines
Adam Smith
Julie Ewald

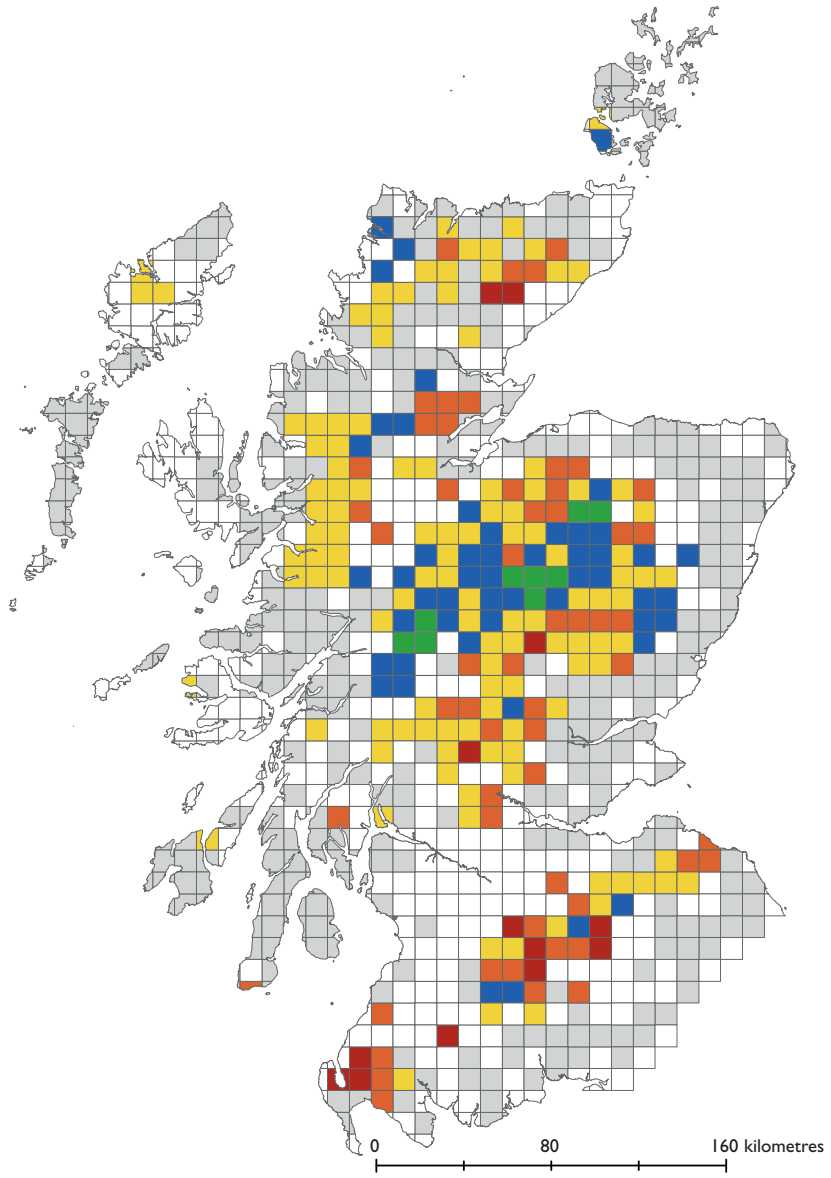


Figure 1

Change in mountain hare distribution between the last survey in 2006/07 and the most recent survey in 2016/17. Distribution compared at a 10x10-km grid square scale, limited to the areas surveyed in both time periods. Areas were marked as surveyed if mountain hares were reported absent in both survey periods and were marked as 'non-surveyed' if <10% of the grid square had been surveyed in common

- Non-surveyed
- Surveyed
- 51-100% decrease
- 10-50% decrease
- <10% change
- 10-50% increase
- 51-100% increase

ACKNOWLEDGEMENTS

We would like to thank all the respondents who provided data on mountain hares as well as Irene Johnston (GWCT), Tony Stevenson (Scottish Land & Estates) and Carol Anderson (Scottish Gamekeepers Association) for helping co-ordinate questionnaire responses.

Increasing forest cover threatens black grouse

Within a forest/moorland landscape it is important to retain sufficient moorland and rough grazing habitats for lekking and breeding. © Nancy Parsons/GWCT

BACKGROUND

Black grouse were once widespread in the UK but following an 80% decline in numbers over the past 25 years they are now red-listed as a species of high conservation concern. In 2005, 5,100 males remained, two-thirds of which were found in Scotland. Increasing forest cover in southern Scotland could threaten the remaining black grouse populations.

The black grouse was once a common and widely distributed bird in southern Scotland. However, numbers and range have declined. This has accelerated in recent years, with 49% and 69% declines in the south-west and south-east of Scotland respectively, between national surveys in 1995/96 and 2005. Estimates of remaining males for the two regions in 2005 were 807 and 257. This has resulted in southern Scotland being identified as a priority area for conservation action for the species.

Black grouse frequent a mixture of moorland, moorland fringe, young coniferous forest and broadleaved forest habitats, with birds using a range of these habitats within a one-kilometre (km) radius of the focal display site, known as a lek. In suitable continuous habitats, these leks typically occur at intervals of 2-3km, allowing females to disperse between them. We know from recent studies in north Perthshire that retaining enough heather moorland habitat within a forest-moorland landscape is important, as this provides key habitats for lekking and breeding. In Scotland, Government policy aims to increase forest cover from 18% to 25% by 2050 and remaining moorland habitats may be under increasing threat of afforestation. New woodland planting in the short term may provide favourable conditions prior to canopy closure, but in the longer term it is predicted to further impact on remaining populations by reducing and fragmenting remaining moorland. To help inform black grouse conservation programmes in southern

Planting of new forests of Sitka spruce in the short-term can provide suitable conditions for black grouse, but birds are quickly displaced following canopy closure after 10-12 years. © Laurie Campbell

Scotland we quantified recent trends in numbers, assessed habitat composition within lek ranges and evaluated the size of suitable habitat patches.

We investigated changes in the numbers of males at leks counted between 1989 and 2018 and related these to habitat and gamekeeping levels, categorised according to moorland management: (1) driven grouse shooting, (2) walked-up grouse shooting and (3) no shooting interest. We also used wider surveys of leks counted by a range of partners between 2006 and 2012 in the south-west and south-east to measure habitat within lek ranges and to compare with that in the wider landscape. We also explored whether the number of males attending leks was related to habitat and gamekeeping levels, and whether moorland patch size influenced occupancy.

We found that the number of males at a sample of 121 leks surveyed between 1989 and 2018 fell from 70 males to zero in south-west Scotland and from 340 to 44 in south-east Scotland, with 82% of leks no longer occupied. Leks that were still occupied had more rough grassland (53%) and less conifer cover (6%) within a 1km radius than lek sites which no longer supported any birds (32% and 29%), with declines similar across gamekeeping levels.

Results from wider lek surveys across the south-west and south-east between 2006 and 2012 found that rough grassland and heather moorland were the two preferred habitats within 197 lek ranges. Twice as many males attended leks where driven red grouse shooting was practised, than on walked-up moors or sites with no shooting interest. Remaining birds were found associated with larger contiguous areas of moorland: the extent of occupied moorland habitat patches averaged 157km^2, 26 times larger than unoccupied patches (6km^2).

This study and similar ones in northern England and Perthshire have found moorland to be an important habitat for black grouse. With Government targets to plant more woodland, remaining moorland habitat patches are likely to become more fragmented making them less able to support sustainable connected populations, which may exacerbate declines and enhance the risk of regional extinction. Therefore, to help prevent black grouse extinction in southern Scotland, instigation of immediate conservation measures is required. These include the retention and restoration of rough grassland and moorland surrounding occupied leks, the establishment of small pockets of new native woodlands to provide winter food and cover in areas which do not fragment existing moorland, such as along ghylls and streams, combined with predator control.

KEY FINDINGS

- Numbers of males at a sample of 121 leks surveyed between 1989 and 2018 fell from 70 males to zero in south-west Scotland and from 340 to 44 in south-east Scotland, with 82% of leks no longer occupied.
- Retained leks had more rough, acid grassland and less conifer cover within a one-kilometre radius than abandoned leks.
- Remaining birds were associated with large contiguous moorland areas.

Philip Warren
Chris Land
Nick Hesford
David Baines

Black grouse like some woodland in the landscape, with small patches of native woodland (pictured) providing important winter food resources particularly in periods of prolonged snow. © Phil Warren/GWCT

Blanket peat vegetation responses to burning and cutting

On each site we have four spatially separated experimental blocks looking at the vegetation and hydrological responses of burning and cutting over blanket bog. © Siân Whitehead/GWCT

KEY OUTPUTS

- We initiated a long-term cut and burn experiment on five moorland sites in the northern dales.
- We collected baseline data in winter 2019/20, before management treatment began, and shall continue to collect data on post-treatment vegetation responses for the next 10 years at least.
- Post-treatment responses by vegetation were measured after the first growing season.
- Complementary collection of data on invertebrate abundance at the experimental sites will measure food availability to grouse and waders during the critical nesting and pre-fledging period.

Siân Whitehead
Madeleine Benton

In 2018, we started a study to look at the vegetation and hydrological responses of burning and cutting over blanket bog. With four treatments (burning, cutting with brash left, cutting with brash removed and no-treatment control) replicated at five sites in the north Pennines, it is planned as a long-term study to last at least 10 years. However, shortly after selecting our study sites and starting pre-treatment baseline monitoring, Natural England's (NE) position statement on burning on blanket peat was published. Unable to secure the requisite consents for burning, we had to find alternative sites at very short notice.

Thanks to the support of landowners and keepers, we not only managed to identify alternative sites, but also managed to complete baseline vegetation surveys and get the burn and cutting treatments in place before the end of the burning season in mid-April 2020.

We now have our study up and running at five sites, spread from the North Yorkshire Dales, through Upper Teesdale, Weardale, and into Tynedale with sites offering a range of altitudinal conditions and peat depths (see Table 1). On each site we have four spatially separated experimental blocks. Each block comprises four plots, to each of which one of the four treatments was randomly assigned.

From each of these sites, we are collecting a range of data to look at the vegetation and hydrological responses to the burning and cutting treatments; this year we also conducted some preliminary investigations into the abundance of invertebrates. We collected baseline vegetation measurements over the winter 2019/20, collecting information on vegetation structure and composition as well as collecting samples of heather tips which we sent to Forest Research for analyses of nutritional content. Alongside this, we started monthly measurements of water table depth (with a subset of plots also being monitored continuously with the use of automated data loggers) and soil moisture content. Water samples are taken from some of the plots and are sent to Manchester University for determination of the extent of water discolouration and carbon content.

As soon as the burn and cut treatments had been completed, we quantified the immediate effects of those treatments (mowing height, depth of moss removed, burn severity), and we returned in autumn to look at vegetation responses after the first post-treatment growing season. As part of this, we went back to the control plots (with no experimental manipulation), to re-measure the vegetation so we can see how vegetation changes in the absence of burning or mowing.

TABLE 1

Mean (and range) peat depth and altitude of experimental burn and mow treatment plots at each of five sites. Site values are the means of all 16 experimental plots (four replicates of four treatments) at each site

Site	Mean (and range) altitude (m)	Mean (and range) peat depth (cm)
Teesdale	439 (434-446)	306 (185-520)
Weardale	456 (365-507)	198 (105-290)
Tynedale	491 (463-528)	104 (40-175)
Coverdale	539 (535-543)	262 (80-350)
Swaledale	629 (614-644)	198 (105-205)

In April, May and June, we sampled surface-active arthropods (mainly spiders and beetles) by sinking plastic cups into the ground (pitfall traps), to catch them. We also trialled the use of 'emergence traps' to get an index of craneflies emerging from within each type of management plot. These traps, comprising plastic baskets lined with sticky fly paper, are inverted and pegged down to the substrate to provide a simple, but effective means of measuring insect emergence following over-winter pupation. Although this measure will have been strongly influenced by site conditions 12 months previously, when adult craneflies were selecting where to lay their eggs, our measures provide an indication of how much of this important food source is available to grouse and waders during the critical nesting and pre-fledging period.

Initial sorting of samples shows that the most abundant arthropods caught were wolf spiders *(Lycosidae)* and ground beetles *(Carabidae)*, together with bugs and flies. We also caught large numbers of heather beetles, which will form a valuable annual index of outbreak likelihood.

We collected baseline vegetation measurements, samples of heather tips to analyse nutritional content and took water samples.
© Siân Whitehead/GWCT

BACKGROUND

Burning of heather on blanket peat habitat is a contentious issue. Although it can still currently be used as a tool to restore blanket peat habitat in certain circumstances, Natural England (NE) advocate the use of cutting as a preferred alternative wherever possible. However, although there have been several studies exploring moorland vegetation responses to burning, little work has been done to date to look at the effects of cutting. The biggest study, which is comparing both management treatments, is that being led by Andreas Heinemeyer (Stockholm Institute, York University). His work is now starting to yield results, but is still restricted to just three sites, which won't be entirely representative of the diverse range of conditions across the northern uplands. Our study, also a multi-site experiment but drawing on five sites on a more northerly geographic range than that covered by Andreas' study, will therefore complement his ongoing work by providing similar data from additional sites that are representative of a wider range of conditions of altitude, peat depth and wetness.

Winter feeding grey partridges on the fringe

We want to encourage more people to feed partridges on hill farms to provide emergency food sources to help survival in severe winters. © Phil Warren/GWCT

BACKGROUND

In the UK, grey partridge numbers have declined by 93% between 1970 and 2018 and the species has been red-listed as a Bird of Conservation Concern since 1990. Declines have chiefly followed intensification of cereal production. Grey partridges are also found on hill farms in northern England, but numbers here are susceptible to high mortality during severe winters and poor breeding in wet summers.

Grey partridges in the UK are mainly associated with lowland cereal farms, but they are also found on marginal hill farms in northern England where they frequent rough grasslands created by low-intensity sheep farming. Here, availability of winter food, particularly in years with prolonged snow, appears a major limiting factor, with birds lost from formerly occupied habitats following the severe winter in 2009/10. Winter feeding is a widely adopted component of wild partridge management in lowland cereal systems. However, in the uplands, although winter feeding occurs, it is largely targeted at pheasants and feeders are often in woodlands, which are generally avoided by partridges. To investigate whether food shortages in winter limited partridge survival, we experimentally increased the provision of supplementary food over two winters. We hypothesized that feeding would improve over-winter survival and breeding productivity.

We selected 10 study plots in Upper Teesdale, County Durham, which were paired in relation to their size and altitude. Plots were on average 2.1km². A low level of winter feeding was already present, with partridges using 17 feed hoppers provided by the local wild pheasant shoot. These were all mapped and we then randomly assigned the increased feeding treatment to one of the paired plots and a network of feed hoppers were installed. We aimed to provide two hoppers for each known autumn covey present, with 57 hoppers provided in the first winter (2010/11), increasing to 76 in the next (2011/12). Owing to the presence of grazing livestock, all hoppers were fenced to exclude sheep and cattle. Feeding was undertaken between November and May, with hoppers checked weekly and filled where necessary. At each visit, partridge use was assessed through recording sightings of birds and searches for their droppings around the hopper.

We surveyed partridges across all study plots at dawn or dusk in spring (March, repeated in April) and again in summer (August, repeated in September) using a call-playback method. The surveyor played an audio recording of a calling male from a vehicle at 10 vantage points along a four-kilometre route along minor roads and tracks through each study plot. At each stop, the observer listened for calls of responding birds and mapped all encounters.

Grey partridges were attracted to feed hoppers, with birds using them a median of 31 days (range 2-104 days) after hoppers were installed, with 96% of hoppers used in the first year, and all were used in the subsequent year. We found no differences in over-winter survival between feeding treatments or years, which averaged 62% (see

TABLE 1

Grey partridge over-winter survival, breeding productivity and spring and summer densities in relation to feeding treatment

Site	2010/11				2011/12			
	Treatment mean (+ se) (n=10)		Control mean (+ se) (n=10)		Treatment mean (+ se) (n=10)		Control mean (+ se) (n=10)	
Over-winter survival	0.61	(0.16)	0.73	(0.22)	0.67	(0.13)	0.46	(0.18)
Breeding productivity								
(chicks/ hen)	5.2	(0.8)	4.2	(1.7)	-		-	
(mean brood size)	6.2	(0.5)	5.4	(2.0)	-		-	
Spring densities								
(birds km²)	6.9	(1.7)	3.2	(1.4)	10.6	(1.8)	4.4	(1.7)
Summer densities								
(birds km²)	20.0	(5.8)	11.5	(5.1)	8.9	(2.4)	2.4	(1.9)

Table 1). No differences in breeding productivity (chicks per hen and mean brood size) between feeding treatments were recorded in 2011, with no chicks raised to fledging in either feeding treatment in 2012 when chick hatch coincided with the wettest June since 1910. Spring densities were 2.3 times higher on the increased feeding plots and densities increased between years by 54% on increased feeding plots and by 38% on controls. Similarly, summer densities were 2.1 times higher on increased feeding plots, declining between years by 56% on increased feeding plots and by 79% on controls.

We expected feeding to increase over-winter survival, but the study coincided with two of the mildest winters (2010/11 and 2011/12) in the past 30 years, with only 15 days and two days with snow greater than 10 centimetres recorded each year. This was in stark contrast to the previous severe winter (2009/10) where 39 consecutive days of snow were recorded. It is therefore likely that the provision of supplementary food is more important to grey partridges in winters with prolonged snow when natural food sources are inaccessible to foraging birds.

Our aspirations in northern England are to encourage further farmers and gamekeepers to feed partridges on hill farms to provide emergency food sources to help survival in severe winters. Grey partridges in the study area have struggled to recover following the severe winter 10 years ago, and this has been exacerbated by a succession of poor breeding seasons caused by untimely wet weather just after chick hatch in mid-June. Filling this winter hungry gap and increasing survival in severe winters will mean that fewer chicks will need to be reared to offset adult mortality. This will buy partridges occupying the hill fringes key time while longer-term land-use based solutions are sought through agri-environment schemes.

KEY FINDINGS

- Neither over-winter survival nor breeding success differed in relation to winter feeding. However, the study coincided with two mild winters with little snow and the provision of supplementary food may be more important in more severe winters with prolonged snow.

Philip Warren
David Baines

Grey partridges have struggled to recover following severe winters and a succession of poor breeding seasons caused by wet weather just after chicks hatch in June. © Laurie Campbell

Are field beans suffering from a lack of pollinators?

Pollination of field beans varied considerably within and between fields and can be increased by planting wildflower margins. © John Holland/GWCT

BACKGROUND

Global declines in insects have attracted much media attention in recent years and this includes reductions in the levels of pollinating insects that threaten our food production. In the UK, we have had agri-environment options to support pollinators, especially bumblebees, for two decades (pollen and nectar mixes were first offered in 2002). These measures appeared to have paid off, at least for the common species, with greater spread across the landscape. Solitary bees are declining, however, and these are important pollinators of some crops.

In 2019 we started a new project – BEESPOKE (Benefiting Ecosystems through Evaluation of food Supplies for Pollination to Open up Knowledge for End users), funded by the EU North Sea Region Interreg programme, to develop and test new seed mixes targeted at the types of pollinators needed by each crop type, and to evaluate the contribution of existing flower-rich habitats to crop pollination. To address the latter aim, we investigated the level of pollination currently being achieved in field bean crops. Field beans are predominantly pollinated by long-tongued bumblebees, but previous research has shown that this pollination, and therefore the yield of bean crops, can be less than optimal. If there is a deficit in pollination, then it may be that provision of flower-rich habitat (and associated pollen and nectar resources) can boost the number of pollinators and consequently increase pollination. We therefore also looked at whether levels of pollination varied across fields according to the type of field boundaries and variation in their floral resources.

To achieve this, we measured levels of pollination and plant yield in one field on eight farms of spring-sown beans in June, using a grid of sampling locations (50 x 50 metre (m) spacing) within each field. At each location, on four plants we compared open pollination (inherent level of insect plus self-pollination) and hand cross-pollination (to simulate maximum pollination) and on one plant self-pollination only (bagged flowers to exclude insects) and hand tripping of flowers as that can also maximise pollination. These studies were conducted on open flowers, one truss per plant. We also measured the number and types of pollinators visiting the crop along a

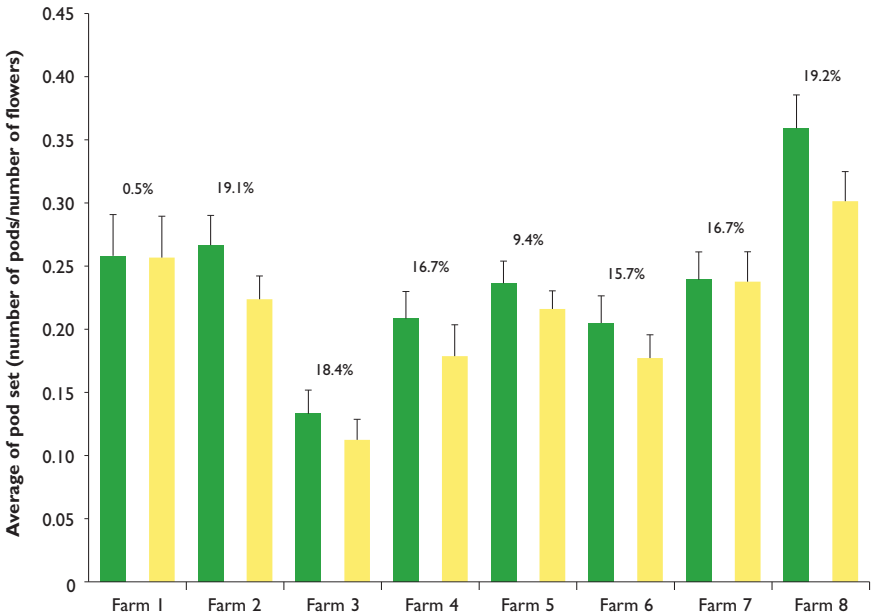


Figure 1

Difference in seed set between hand (green bars) and open (yellow bars) pollinated field beans across eight farms (percentage difference per farm above each pair of bars). Number of grid points sampled per farm (four open and hand pollinated plants per grid point). Farm 1: 9, Farm 2: 14, Farm 3: 20; Farm 4: 13; Farm 5: 20; Farm 6: 18; Farm 7: 18 and Farm 8: 20)

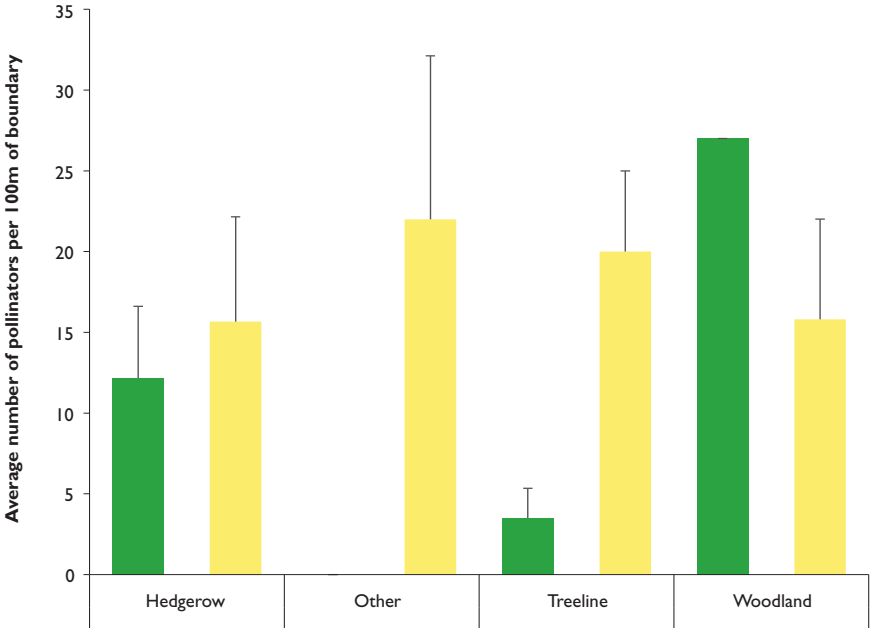


Figure 2

Difference in average (± SE) number of pollinators seen per 100m of field boundary depending on boundary habitat type and presence or absence of a margin. 'Other' includes roads, fence lines and other crop margins. Number of boundaries surveyed = 25 (hedgerow: 9, other: 4, treeline: 6, woodland: 6)

Absent

Present

5m transect close to the pollination treatments and observed along the field boundaries along 100m transects in each separate boundary type. In crops it was noted whether the insects were pollinating or robbing the flowers. This was repeated after 10 days, but these results along with the self-pollination treatment were discarded because drought was severely affecting the development of pods. Just prior to harvest in July the bean pods from each of the treatments were collected and measures of yield (the number of pods per truss, seeds per pod and dry weight of beans) were recorded.

Ten species of pollinator were observed across all farms, with four bumblebee species and honeybees present on every farm. Only one farm had all 10 pollinator species, and this was part of a Farmer Cluster with improved field margins around most fields. The most important pollinator was the garden bumblebee *(Bombus hortorum)* as this pollinated the flowers 97% of the time whereas honeybees only did this for 34% of their visits, otherwise robbing the flowers.

The level of the pollination deficit was calculated for each sampling location across the fields by examining differences in the measures of yield between hand (maximum pollination) and open (insect and self) pollinated plants. This revealed that overall seed set (conversion of flowers to pods) was higher when plants were hand pollinated (seed set for hand pollinated plants 23.8% ± 0.8; seed set for open pollinated plants 21.1% ± 0.8). This suggests that the level of insect pollination was not sufficient to achieve maximum pollination; there was a small pollination deficit.

However, there was considerable variation in this deficit between sites and across fields (see Figure 1) (the percentage increase in seed set between open and hand pollinated plants ranged from 0.5% to 19.2% across sites). We examined whether this variation in pollination deficit could be related to a difference in flower-rich habitat in the boundaries and pollinators in the boundary. There was some evidence that floral resources differed between boundary types. For example, the number of umbellifers increased when a margin was present. Pollinator abundance along the field boundaries also varied with the type of boundary and whether a margin was present. Having margins next to treelines and other types (roads, fence lines) increased pollinators but there was no benefit in placing them next to woodland (see Figure 2).

We did not identify a direct relationship between this variation in boundary habitat, pollinators seen in the boundary and pollinators seen in the field. However, there was an indication that yield was higher when pollinator richness was higher in the nearest boundary.

To better understand these results, we hope to replicate and expand this study in 2021. It is likely that pollinators observed in bean fields are affected by habitat beyond the nearest field boundary. It may be that availability of flower-rich habitat at a wider scale influences pollination of crops. In 2021 we will relate the abundance of flower-rich habitat in a 1-km² area around the field to field bean pollination and yield.

The garden bumblebee pollinated the flowers 97% of the time. © Ellie Jackson-Smith/GWCT

KEY FINDINGS

- Field beans were pollinated primarily by one bumblebee species, the garden bumblebee.
- Improving and increasing wildflower habitat increased the diversity of bumblebees in a Farmer Cluster.
- Increasing pollination of field beans can increase seed set by up to 19%.
- Levels of pollination varied considerably within fields.
- Having flower-rich margins increased the number of pollinators, but not when they were located next to woodland.

John Holland
Lucy Capstick
Ellie Jackson-Smith
Jayna Connelly
Niamh McHugh

ACKNOWLEDGEMENTS

We would like to thank the eight farmers that kindly allowed us to work in their fields.

Cultivated margins and invertebrates

Floristic margins were much more attractive to bumblebees, but solitary bees preferred cultivated margins (above), so it is important to have both habitats on farms. © Belinda Bown/GWCT

BACKGROUND

Cultivated margins are an agri-environment scheme option designed to conserve rare arable plants, but they are unpopular for a variety of reasons, including their perceived untidy appearance. Their potential wider benefits are poorly understood, but in addition to rare arable plants they provide suitable growing conditions for more common annual plant groups which may be beneficial to foraging pollinators and natural pest enemies, many of which have been in decline in the UK since the 1980s.

Arable plants are the most threatened group of British flora with 10 species extinct and 57 classified as near threatened or critically endangered. The agri-environment scheme option 'uncropped cultivated margins for rare arable plants' (hereafter cultivated margins) has been available since 1991 and is effective for conserving arable plants, but the potential benefits to other taxa are poorly understood.

Our project aimed to identify how cultivated margins could be best managed to benefit foraging pollinators and natural pest enemies. Thirty cultivated margins across the UK were monitored, covering four regions of England: South, Midlands, East Anglia and Oxfordshire. Management data and information on other key attributes thought to influence invertebrate communities were recorded including margin age, width, soil fertility, year (2018 or 2019) and survey month. We also collected information on cultivation type (plough or minimum/non-inversion tillage) and if the margin was rotational or non-rotational. Cultivated margins are ploughed to turn over the top layer of soil, thereby changing the soil structure and burying vegetation deep in the soil. In contrast, with minimum tillage, which involves less soil disturbance, the vegetation debris remains on or close to the soil surface.

Bumblebees, solitary bees and hoverflies were monitored using a standard 'bee walk' methodology monthly, from April to September. Surveys took place only when the temperature was above 10°C, wind levels were below four on the Beaufort scale (ie. below 13mph) and in the absence of heavy rain or thick fog. All bees seen foraging or actively nest-searching within two metres (m) of the observer were recorded. Hoverflies were recorded only when sitting on flowers, or hovering close to flowers, within one metre of the observer.

Pitfall traps were used to measure terrestrial invertebrates, which were predominantly night-active natural enemies. These were deployed on three occasions for a week each in May, July and September. Six pitfall traps were set per plot, located 20m apart along a transect. D-vac suction sampling was also conducted to capture the smaller natural enemies that are difficult to observe (eg. parasitic wasps important for biocontrol, some generalist predators (spiders, ground and rove beetles). In total, four suction samples were collected along the middle of each margin; the first sample was taken 5m from the transect start with 10m intervals between samples.

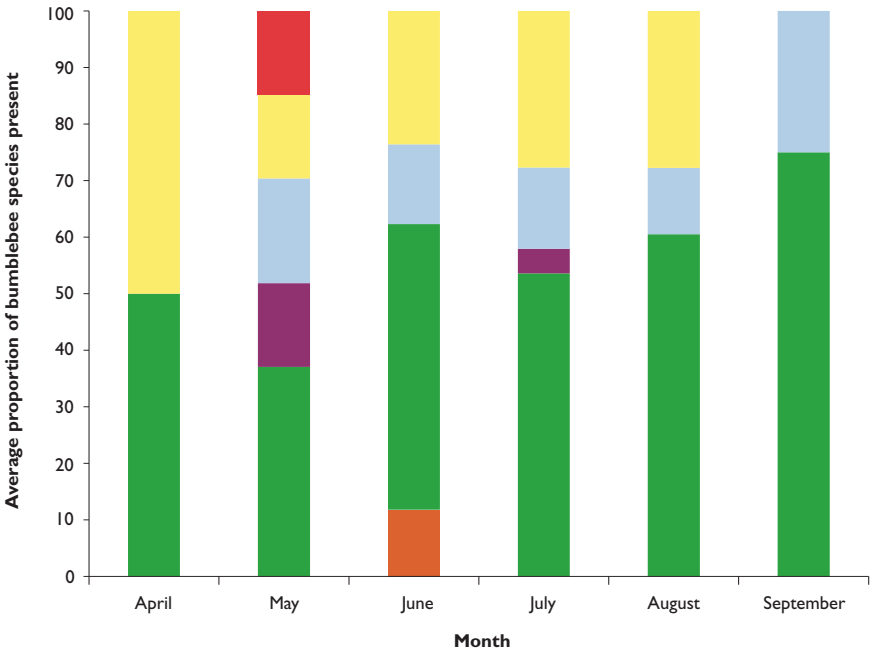


Figure 1

Average proportion of each bumblebee species present during monthly pollinator walks along cultivated margins

- Garden bumblebee *(Bombus hortorum)*
- White-tailed bumblebee *(Bombus lucorum)* & buff-tailed bumblebee *(Bombus terrestris)*
- Early bumblebee *(Bombus pratorum)*
- Common carder bee *(Bombus pascuorum)*
- Red-tailed bumblebee *(Bombus lapidarius)*
- Tree bumblebee *(Bombus hypnorum)*

A total of 1,066 bees were recorded on cultivated margins over the project, 10% (109) of which were honeybees. Of the wild bees 34% (322) were bumblebees and 66% (635) were solitary bees. Hoverflies were the most abundant taxa (1,480) with an average of 8.2 per survey. The bumblebees comprised the six most common and widespread species, of which common carder bees, white/buff-tailed bumblebees and red-tailed bumblebees were the most frequently observed (see Figure 1). The presence of the different families of solitary bee differed considerably over the monitoring period as workers are shorter-lived and more seasonal in activity than bumblebees; the typical activity period of worker solitary bees was two to three months. Target rare annual plants were frequently recorded on plots and were repeatedly visited by pollinators. The pollinators and natural enemies also foraged on many of the weed species. Hoverflies, for example, commonly foraged on dandelions, spear thistle, mayweed, ragwort and sowthistle (see Figure 2). Cultivated margin

KEY FINDINGS

- Cultivated margin management significantly influenced use by pollinators and pest natural enemies.
- Margins created by minimum tillage attracted more pollinators and natural enemies than those created by ploughing.
- Non-rotational margins were better for bees than rotational cultivated margins as they had more flower heads, higher cover of broad-leaved species and taller vegetation.

Niamh McHugh
Belinda Bown
Adam McVeigh
Roseanne Powell
Emily Swan
John Szczur
Philip Wilson
John Holland

A red-tailed bumblebee and a Western honey bee.
© Ellie Jackson-Smith/GWCT

Hoverflies were commonly found foraging on hawk's-beard and cow parsley. © Peter Thompson

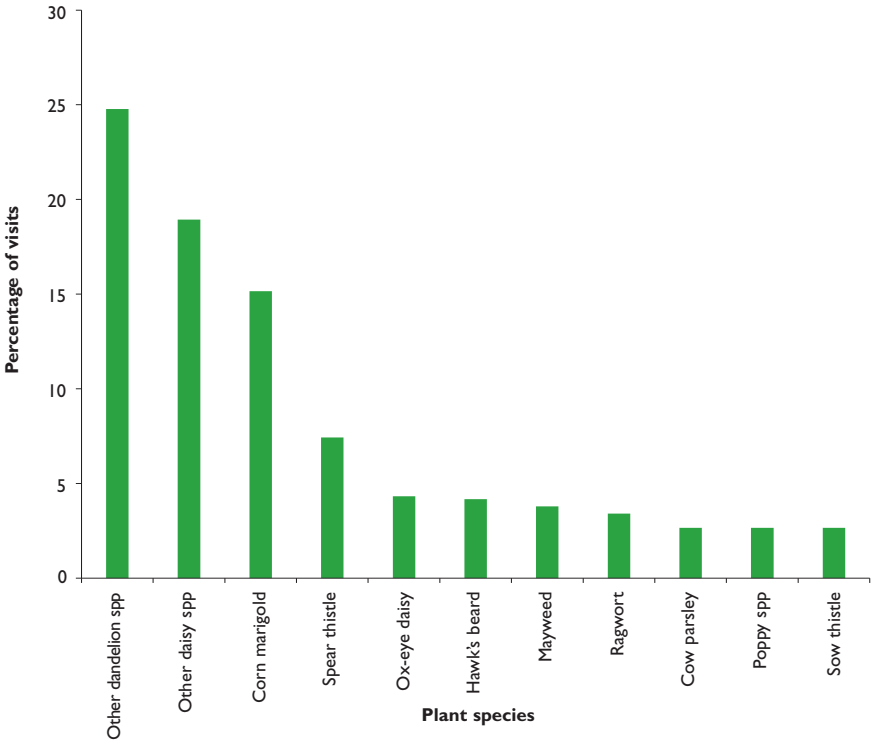
management significantly influenced visitation rates. For example, plots which had been created by ploughing attracted fewer solitary bees, and bees overall, than those created with minimum tillage. Annually-rotated cultivated margins were associated with broad-leaved species cover which was 32% lower and vegetation height that was 18% shorter. This resulted in total bee abundance which was on average 18% lower in annually-rotated margins. We therefore advise that cultivated margins be left in situ on farmland over longer periods.

Our pitfall trapping results demonstrated that cultivated margins supported a diverse community of beneficial invertebrates including groups of key natural enemies active on the ground and crop, such as ground and rove beetles, and spiders (see Figure 3). High numbers of flying natural enemies were also found, especially parasitic wasps, but also hoverflies, predatory long-legged flies and ladybirds. Except for the long-legged flies, having a greater abundance of all of these groups is known to improve crop pest control. As they are relatively common in field margin habitats this

Figure 2

Proportion of visits to different plant species by hoverflies in 2019

Where daisy and dandelion species could not be identified to species they were assigned to the species groups other daisy spp or other dandelion spp



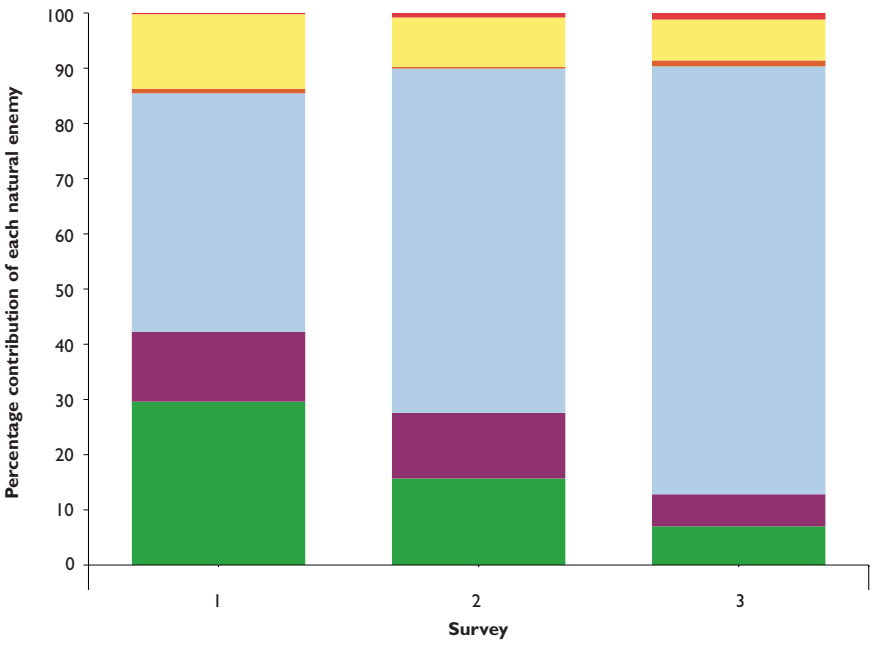


Figure 3

Proportion of each family and life stage present in pitfall traps in floristically enhanced margins in each survey

Wolf spider

Money spider

Ground beetle adult

Ground beetle larvae

Rove beetle adult

Rove beetle larvae

can be achieved by having more and wider margins, including cultivated margins and other flower-rich agri-environment scheme options. Cultivated margin management was found to influence the abundance of natural enemies present in D-vac suction samples; natural enemies were on average 48% lower on ploughed plots compared with those managed by minimum tillage. Many invertebrates (eg. some beetle species) overwinter in the soil, including all life stages (egg, larva, pupae, adult), and ploughing in the autumn or winter will increase the mortality rates of such invertebrates.

Our findings highlight the importance of cultivated margin habitats and show that when managed appropriately, in addition to providing growing conditions for scarce arable plants, they can provide a wide range of foraging resources for farm wildlife. We would encourage landowners to incorporate this habitat into their management regime, not only to help arable flora, but also to help pollinators and natural enemies.

ACKNOWLEDGEMENTS

We would like to thank the farmers that allowed us to monitor pollinators on their farms. This study was funded by Defra and the European Agricultural Fund for Rural Development as part of the project 'Evaluation of cultivated margin option effectiveness', administered by Natural England (project code LM0471).

Cultivated margins can help not only arable flowers, but also pollinators and natural enemies.
© Belinda Bown/GWCT

Research and demonstration farms - Allerton Project

Allerton Project: game and songbirds

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.

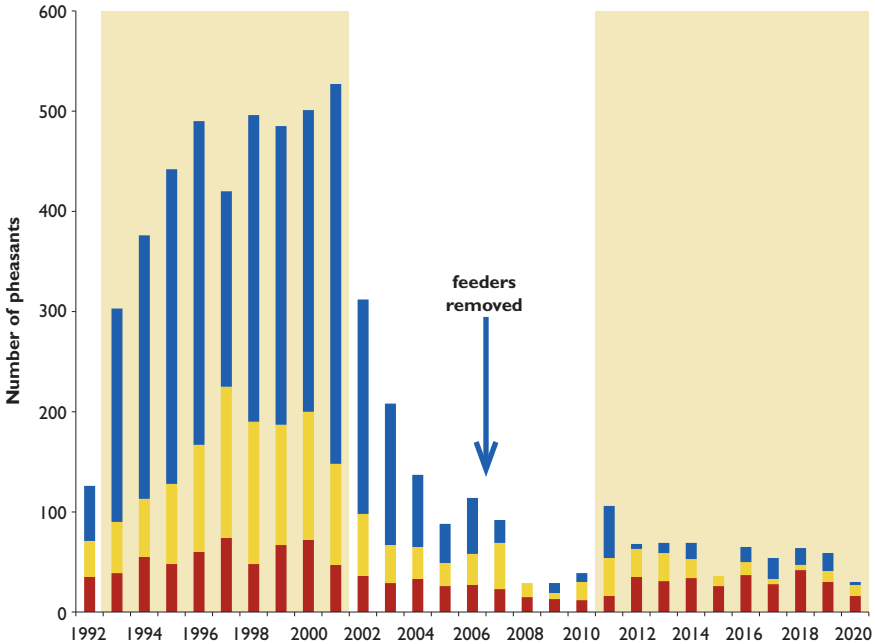
The Allerton Project farm at Loddington has been managed as a released pheasant shoot since 2011, following nine years of no game management. This was preceded by nine years of wild game management. The current regime includes habitat management and winter feeding, as in the period of wild game management in the early years of the project. In that sense, it is similar to other small scale pheasant shoots across the country. However, the level of predator control is intermediate between that in the wild game management phase of the project and that of a conventional released bird shoot as our previous research has demonstrated the benefits of predator control to some songbird species.

The Allerton shoot achieves exceptional shoot days but we continue to struggle with the recovery of wild gamebirds. Our predator control records and wildlife monitoring indicate that the numbers of generalist predators, which we can control legally, and of protected predators have increased in number locally. We also reported last year the prevalence of disease in pheasants in the spring, contributing to poor body condition in the breeding season (see *Review of 2019*, page 18). Our autumn gamebird counts reveal very low productivity and that wild pheasant numbers remain well below those present in the wild game management phase of the project (see Figure 1).

Grey partridges have not bred on the farm since 2014, and 2020 continued this trend. Although red-legged partridges are present each spring, the breeding success is consistently very low, with no young birds being recorded in 2020. Winter hare numbers on the other hand were 5.8 times higher at Loddington than on the comparison site, and 3.8 times higher than the 1992 baseline. Overall songbird numbers were 97% above the 1992 baseline, just 13% lower than the peak recorded during the period of wild game management (see Figure 2). Biodiversity Action Plan songbird

Figure 1

Autumn wild pheasant numbers from 1992 to 2020



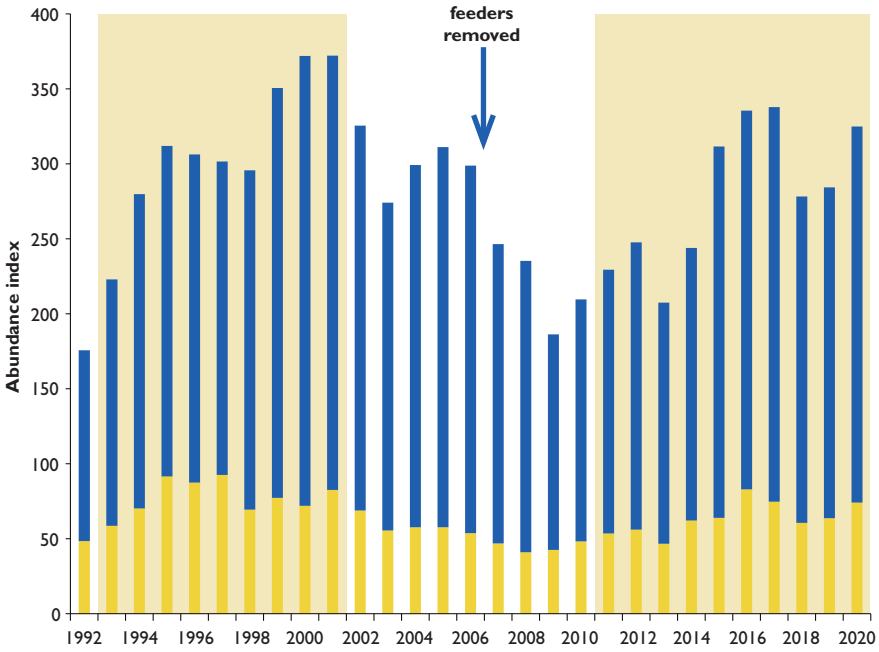


Figure 2

Songbird abundance

Biodiversity Action Plan species

Others

Keepered period

species are currently 53% above the 1992 baseline, demonstrating a continuing benefit of the management system to species of conservation concern.

One bird species that has received increased attention in the past two years is woodcock. This is not a breeding species at Loddington, but regularly winters in woods that form part of the shoot. Very low-level shooting of woodcock is carried out in one of the woods, with the rest of the woodland being left as a sanctuary with no shooting of woodcock. The scale of the shooting is dependent on numbers of woodcock present, with standardised counts being conducted in late November and early December. Woodcock shooting takes place on three or four dedicated days which finish with two woodcock drives involving three to five guns, each of whom is limited to one bird.

This low level of shooting has enabled us to learn about the breeding range of the woodcock wintering at Loddington, as feathers from each of the shot birds have been collected for isotope analysis. This identifies the geographical area in which the birds grew their feathers as chicks or moulting adults. Woodcock that winter at Loddington come from along a migration route spanning from Russia through the Baltic States, Poland and Germany (see Figure 3). The evidence available from eastern Europe suggests that woodcock breeding numbers are stable in this region.

KEY FINDINGS

- Overall songbird numbers are currently 97% above the 1992 baseline.
- Biodiversity Action Plan songbirds are 53% above the 1992 baseline.
- Wild gamebirds are not responding to our management.
- Woodcock wintering at Loddington are mainly from the Baltic States, Poland and Russia.

Chris Stoate
John Szczur
Austin Weldon
Matthew Coupe
Andrew Hoodless

ACKNOWLEDGEMENTS

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

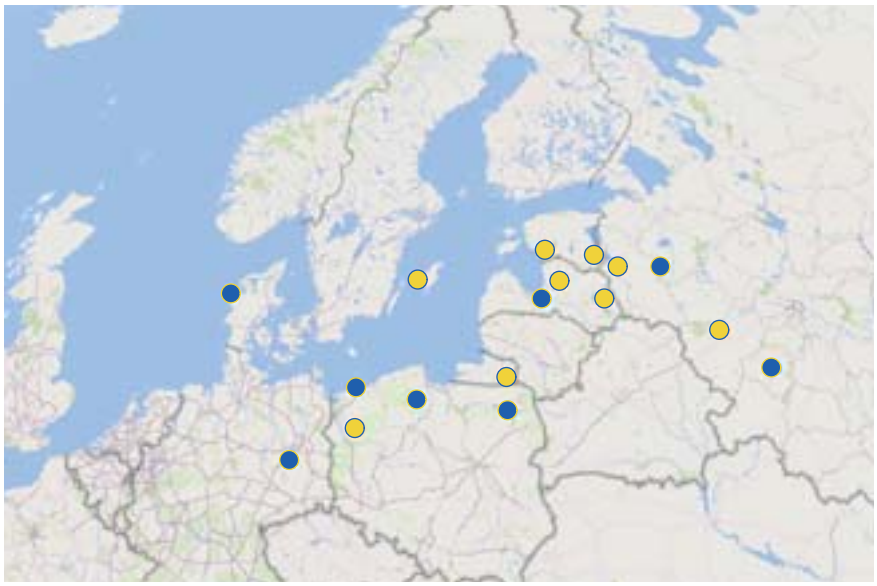
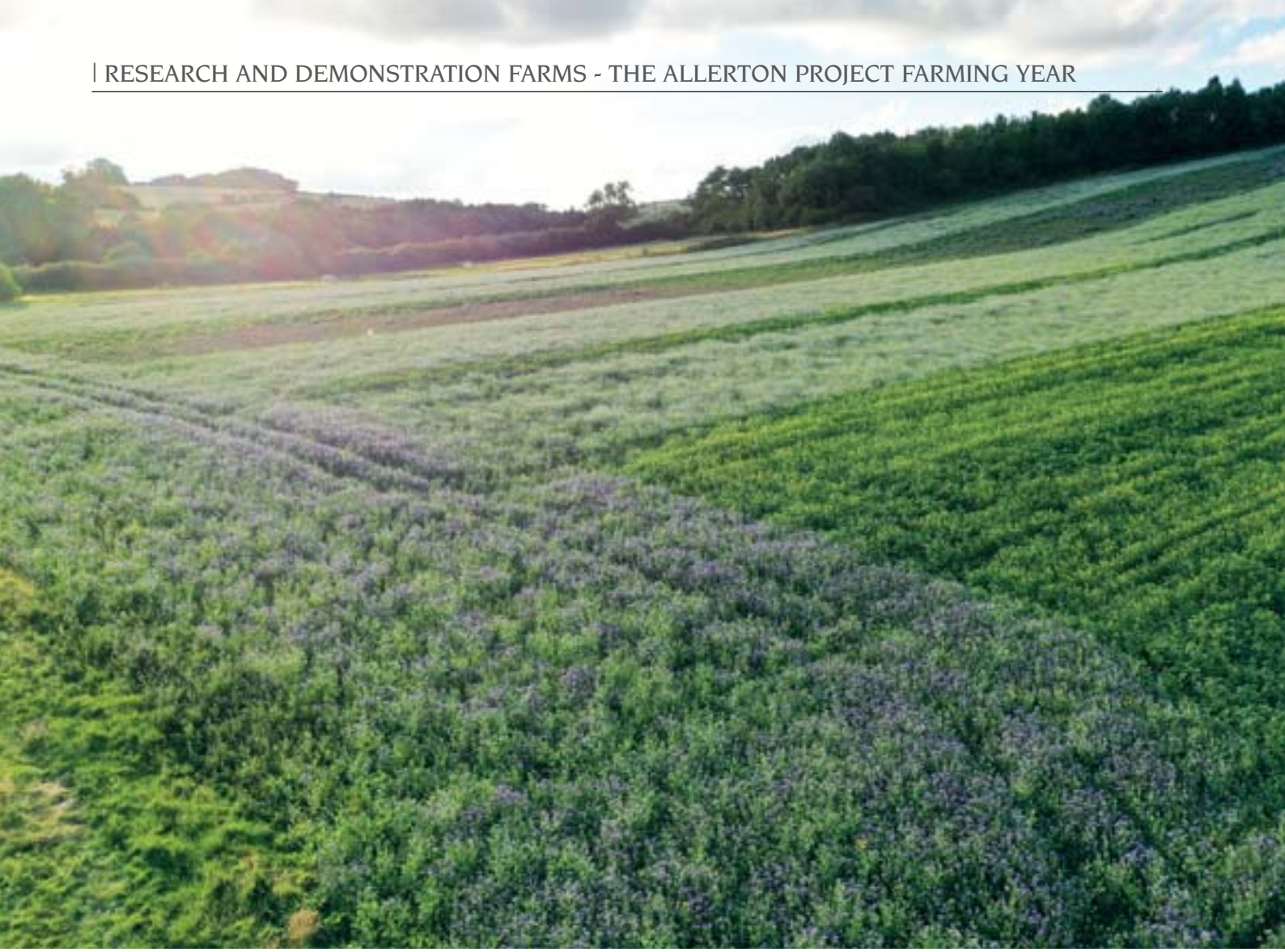


Figure 3

The estimated breeding range of woodcock wintering at Loddington based on stable hydrogen isotope analysis of feathers

2017/18

2018/19



The farming year at the Allerton Project

Trials continue to be an important part of our work at the Allerton Project. © Phil Jarvis/GWCT

In the past year, we have witnessed dramatic scenes across the planet exacerbated by climate change. Wildfires have blazed in Australia, California and the Arctic regions of Russia. It is easy to think that we are immune to these extremes – and largely, on the face of it, we are, but in reality we are facing our own challenges and we are certainly not escaping unscathed. Many farming businesses are examining their rotations carefully, and moving away from those which would normally deliver maximum profit to those which provide resilience against climate change.

Our Allerton Project farm at Loddington is like a great many across the country, on a heavy, Grade 3 soil type. These soils have narrow windows for crop establishment moving from impossibly wet to impossibly dry in a short space of time. Traditionally

TABLE 1

Arable gross margins (£/hectare) at the Allerton Project 2010-2020

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Winter wheat	673	783	255	567	590	457	442	766	780	837	568
Winter oilseed rape	799	1,082	490	162	414	533	524	713	377	528	-
Spring beans	512	507	817	580	646*	396*	289*	436*	176*	459*	301
Winter oats	808	873	676	570	354	507	156**	-	-	386	324
Winter barley								367	733	423	630

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

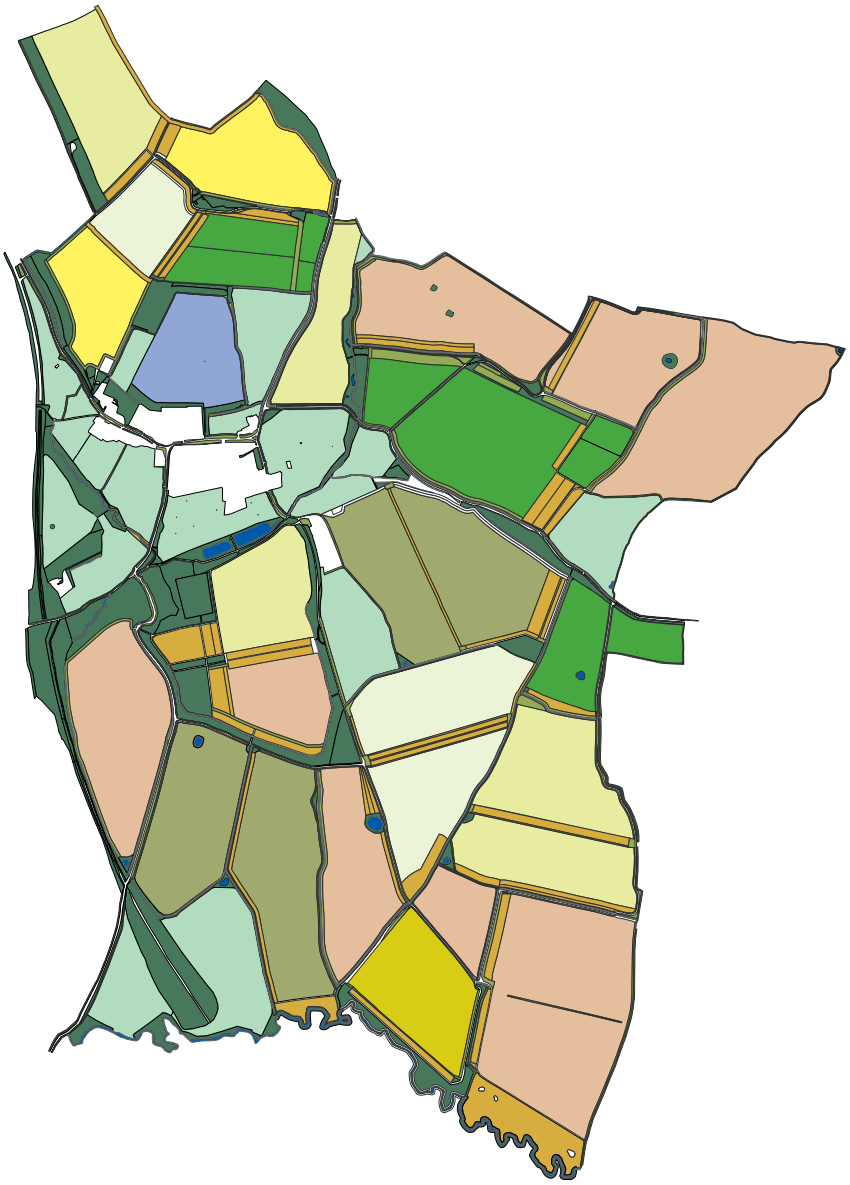


Figure 1

Allerton Project cropping 2019/20

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

BACKGROUND

The Allerton Project is based around an 333-hectare (822 acres) estate in Leicestershire. The estate was left to the GWCT by the late Lord and Lady Allerton in 1992 and the Project's objectives are to research ways in which highly productive agriculture and protection of the environment can be reconciled. The Project also has an educational and demonstration remit. The Project celebrated its 25th anniversary in 2017.

Green headlands mop up nutrients, improve soil structure and deliver an abundance of nectar for a wide range of pollinators and beneficial insects.
© Kings Crops

Agri-environment habitats will become even more important in the future. © Phil Jarvis/GWCT

KEY FINDINGS

- The impacts of more varied weather patterns caused cropping challenges in 2020.
- Blackgrass and flea beetle are antagonists that we continue to address with the development of different farming systems.
- Environmental habitats thrived, providing birds, butterflies, bees and many other crop pest predators beneficial habitats.

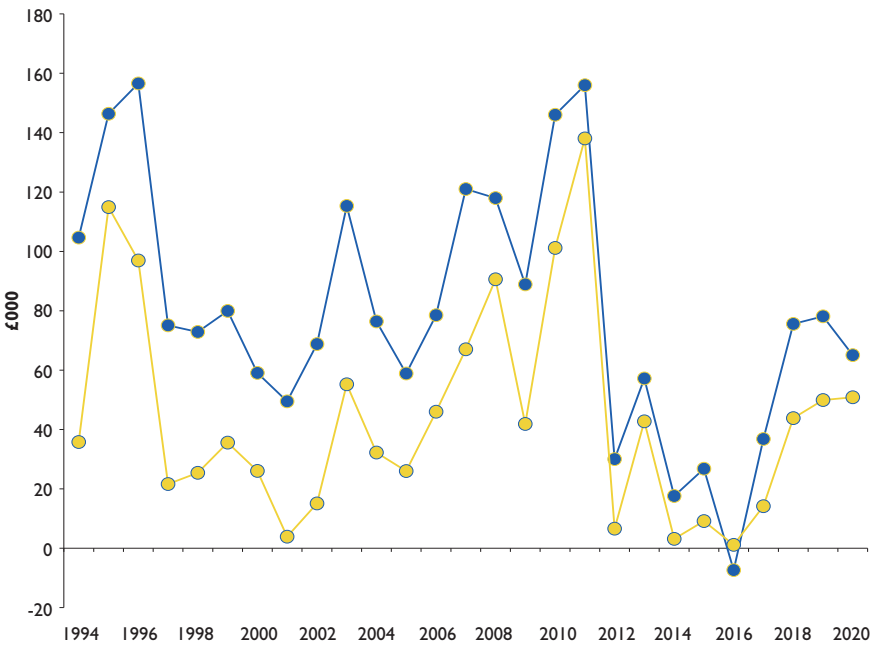
Alastair Leake
Phil Jarvis

we have avoided the former by drilling early in the autumn before soils become saturated, but the advent of black-grass and cabbage stem flea beetle means that early drilling can result in the crop being overwhelmed by antagonists. In 2019 the rains came early and never relented and for the first time in living memory no crops were sown. When the soils did eventually dry out in the spring, we seized the moment and drilled the whole farm with spring crops, omitting the low-yielding headlands (see Figure 1). These crops came through well, but then faced the stress of six weeks of drought. Crops on lighter land perished and many of the tillers on our cereal crops did too, only to resurge once the rains came and give rise to 'green ears' within

Figure 2

Gross profit* and farm profit at the Allerton Project 1994-2020

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



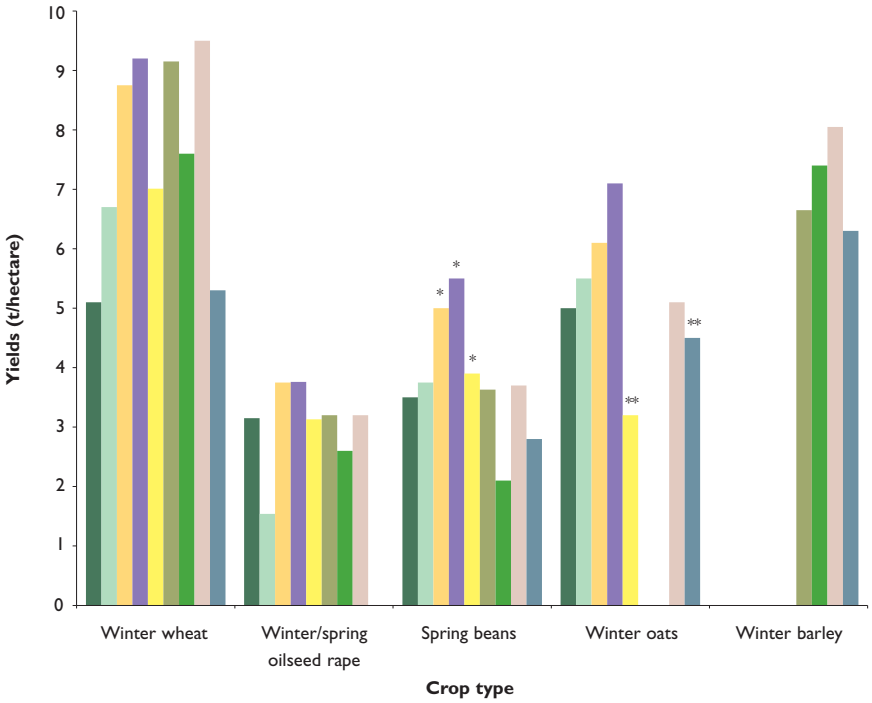


Figure 3

Crop yields at the Allerton Project 2012-2020

*Spring oilseed rape was sown in 2013, spring wheat was sown in 2020, *spring beans, **spring oats*

the otherwise ripe crops come harvest. This then delayed our harvest and, in the meantime, a late summer storm shook the ripe grains to the ground. All in all, we find our yields (see Figure 3), along with much of the rest of the country, down on average by 40%, making the UK deficient in cereals for the first time in a generation.

To add to our difficulties the shed grain then germinated as volunteers, delaying autumn drilling again, until the rains came and stopped us altogether, with still 45% of the farm left to drill again in the spring, putting us back on the same treadmill. Looking ahead, our rotations will need to minimise these risks, and our machinery will need to work faster to take maximum advantage of windows in the weather.

TABLE 2

Farm conservation costs at the Allerton Project 2020 (£ total)

Higher Level Stewardship costs (including crop income forgone)	-18,911
Higher Level Stewardship income	29,016
Woodland costs	-1,721
Woodland income	915
Farm Shoot expenses	-4,485
Farm Shoot income	4,485
Grass strips (not in Stewardship)	-500
Total profit forgone	
- conservation	**8,799**
- research and education	**-23,000**
	-14,201

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

Farming businesses will have to mix food production and habitat management in the future.
© Phil Jarvis/GWCT

Water Friendly Farming

Creating clean water ponds increased landscape-scale aquatic plant species richness by 26%, and the number of rare species by 181%. © Chris Stoate/GWCT

BACKGROUND

Water Friendly Farming is a long-term research demonstration project, designed to test the effectiveness of landscape-wide agri-environment measures, intended to reduce the impact of rural land use on freshwaters – ponds, streams, lakes, rivers and ditches – and the services they provide.

The Water Friendly Farming (WFF) project is a landscape-scale before-after control-intervention experiment covering 3,000 hectares (ha) in the upper Welland river basin, about four miles upstream from Loddington. The study area comprises three headwater catchments. In two of the catchments, we have been introducing measures to improve water quality and aquatic biodiversity, and reduce flood risk at the base of the catchment. The third catchment is a control in which no changes are made to the management. The project celebrated its first 10 years in 2020. An exceptional strength of the project is that the first three years were used to collect baseline data, without making any changes, so that we could be confident in our interpretation of data collected in the subsequent years. We have no direct control of any of the land and any changes we make need to have the agreement of landowners and farmers, ensuring that the project has practical relevance as well as scientific credibility.

Our partner, the Freshwater Habitats Trust, monitors around 300 sites across the study area for aquatic plants each year to provide a comprehensive record of changes in the number of species present at individual sites, and at the landscape scale. In 2013, 20 clean water ponds were created in the 900ha Stonton headwater with the specific objective of increasing aquatic biodiversity. These were carefully sited in micro-catchments in low-input grassland or open areas of woodland that did not receive runoff from arable land or other potential sources of pollution.

In the absence of these and other management, there was an annual decline in the number of overall aquatic plant species at the landscape scale of 1%, and for rare

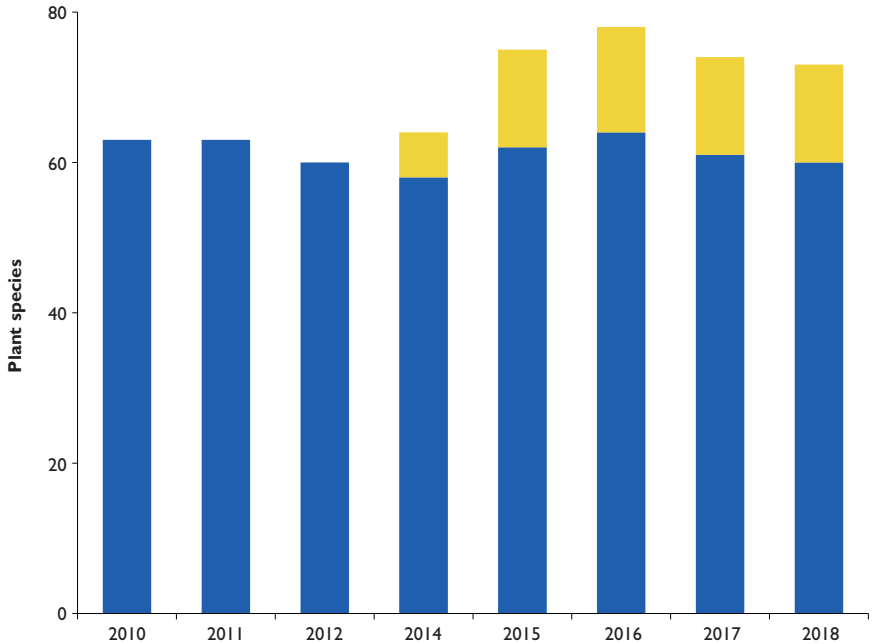
Figure 1

Plant species

No plant data were collected in 2013

Number of plant species present in the baseline period

Number of additional plant species following creation of ponds



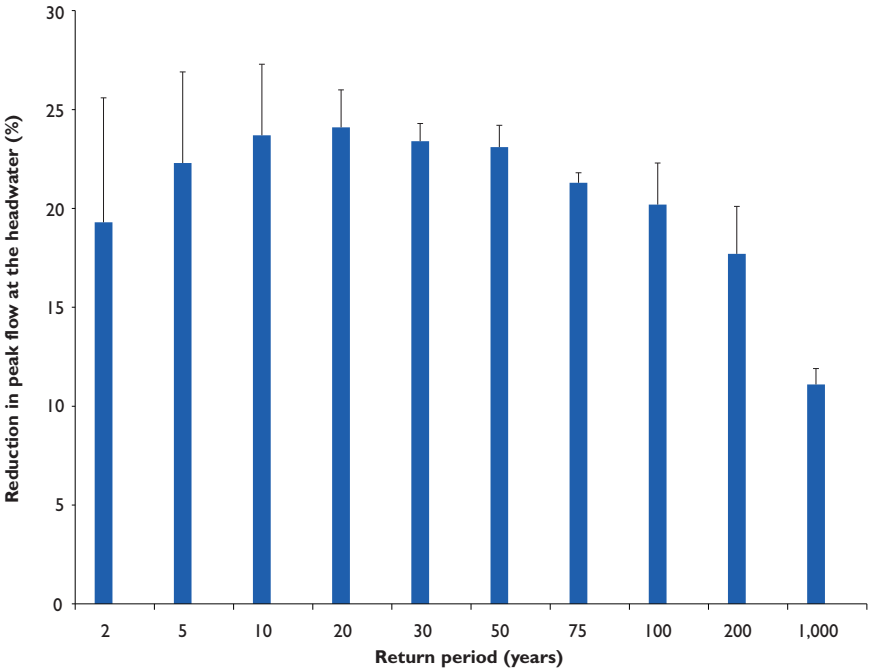


Figure 2

Reduction in peak flow from the headwater catchment for a range of modelled flood events

species alone, this figure was 2%. Adding clean water ponds increased landscape-scale species richness by 26%, and the number of rare plant species by 181% (see Figure 1). Other management practices such as creating sediment traps and earth dams in ditches contributed to cancelling out the decline in plant species, but were not sufficient to result in an increase. These results suggest that creating clean water ponds specifically targeted for biodiversity could hold considerable potential as a tool to help reverse ongoing declines in freshwater plant biodiversity in agricultural landscapes.

Since 2016, we have been creating permeable timber dams at a range of scales in ditches and streams in the Eye Brook headwater catchment to hold back water during storm events and control flood risk at the base of the catchment. This work is particularly important given popular concern about increasing flood risk associated with climate change, and there is increasing interest in the role of nature-based solutions in headwaters to complement traditional flood defence measures in flood-prone parts of river basins.

By using base-of-catchment flow data and hydrological modelling by York University, we have been able to confirm that the creation of 28 permeable dams in the 1,000ha headwater results in a 19-24% reduction in peak flow at the base of the headwater (see Figure 2). This applies across a range of storm events up to those that occur at one-in-a-hundred-year intervals. Even for one-in-a-thousand-year storm events, there is an 11% reduction in peak flow. We have also learnt important lessons about the practical design and construction of permeable dams which we will be sharing with others planning similar work.

KEY FINDINGS

- Creating clean water ponds increased landscape-scale aquatic plant species richness by 26%, and the number of rare species by 181%.
- Creating permeable timber dams reduced peak flow at the base of the catchment by 19-24%.
- Our research and practical experience have enabled us to produce practical guidelines for permeable dam design and construction.

Chris Stoate
John Szczur
Jeremy Biggs (FHT)
Penny Williams (FHT)
Colin Brown (York University)

The creation of 28 permeable dams in the 1,000ha headwater resulted in a 19-24% reduction in peak flow at the base of the headwater.
© Chris Stoate/GWCT

Benefits of feeding willow leaves to ruminants

Our results suggest that feeding willow to ruminants could contribute to climate change and air quality targets. © Chris Stoate/GWCT

BACKGROUND

There is increasing interest in agroforestry as a means of achieving multiple objectives on farmland and it is well established that trees enhance the welfare of livestock by providing shade and shelter. Through our long-running links with the University of Nottingham, our collaboration with the Woodland Trust, and our Gasmet gas analyser, we have started to explore other potential benefits of trees to ruminant livestock. This project extends our continuing research into grass and livestock systems, first started in 2015 in our role as one of the core research and demonstration farms in the Sustainable Intensification research Platform.

Trees provide shelter and shade for livestock, and some offer additional forage. We were one of three research sites which contributed to a study of the potential of goat willow, oak and alder leaves as a source of supplementary minerals. Willow was consistently higher in zinc and cobalt which is often deficient in grass and is important for the synthesis of vitamin B12.

In 2019, we carried out an experiment with Nottingham University School of Veterinary Science in which we fed an average of 300 grammes (g) of goat willow leaves per day to two groups of six weaned lambs over a two-week period. Another two groups of six lambs were not fed willow. We wanted to determine whether the higher cobalt in leaves was reflected in higher concentrations in the animals. Blood samples taken before and after feeding willow for a two-week period confirmed that blood cobalt concentrations doubled and vitamin B12 was 2.6 times higher in willow-fed lambs.

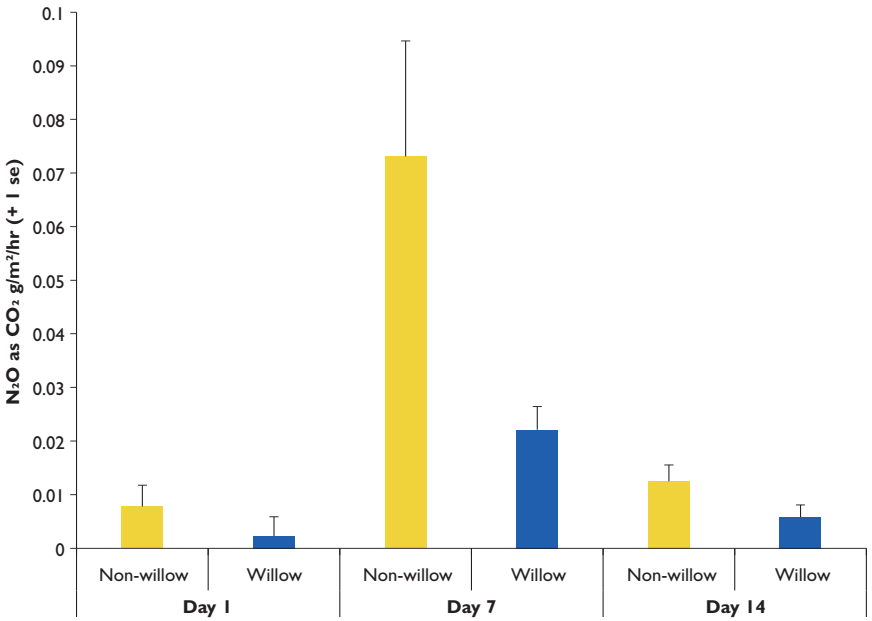
Condensed tannins in willow leaves have also been shown to inhibit development of larval intestinal worms in ruminants. This has important ecological implications as anthelmintics can have substantial negative impacts on dung beetles which have an intrinsic conservation value, provide food for other wildlife and perform an important ecological function in terms of breakdown of dung.

Condensed tannins also have the potential to suppress microbial activity in the rumen, reducing the uptake of nitrogen into the blood, and ultimately into urine. This has the potential to reduce emissions of nitrogenous gases, primarily nitrous oxide and ammonia from urine patches. Inhibition of microbial activity in the soil could have the same effect. As nitrous oxide is a major greenhouse gas and ammonia has negative air quality implications, the use of willow to reduce these gaseous emissions from urine could potentially contribute to climate change and human health targets.

In August 2020, we fed an average of 200g of goat willow leaves per day to two groups of six weaned lambs over a two-week period. Another two groups of six lambs were not fed willow. Faecal egg counts were used as a measure of the intestinal worm burden at the start and end of the experiment. At the end of the experiment, we

Figure 1

Mean N_2O flux from urine patches for three sampling occasions



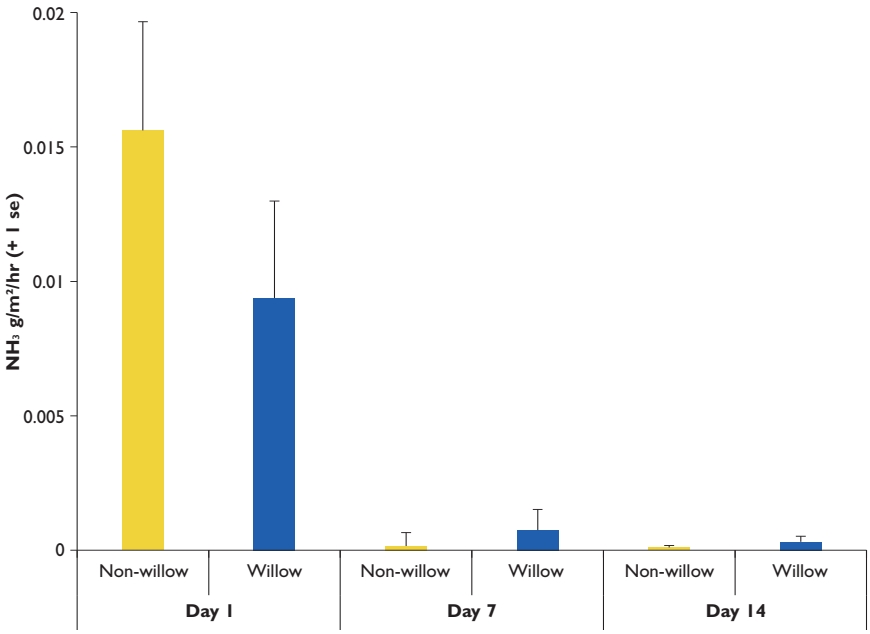


Figure 2

Mean NH_3 flux from urine patches for three sampling occasions

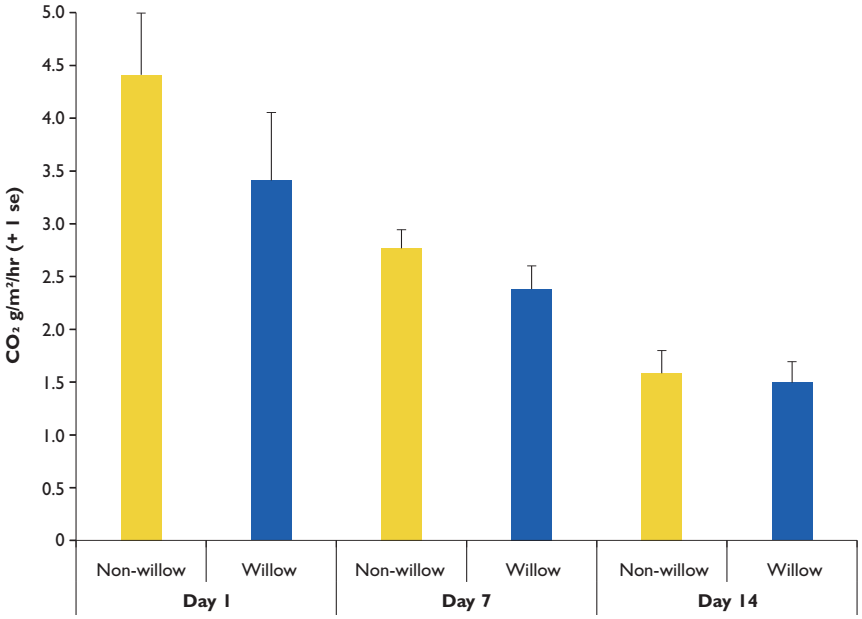


Figure 3

Mean CO_2 flux from urine patches for three sampling occasions

also identified fresh urine patches by direct observation of the lambs (six willow-fed, and six not willow-fed) and used our Gasmet gas analyser to measure emissions of carbon dioxide, as well as nitrous oxide and ammonia. We did this within 20 minutes of urination, and again one and two weeks later.

The faecal egg counts revealed high numbers of intestinal worms at the start of the experiment, and there was no evidence of a decline over the two-week period. Our findings are therefore not consistent with those of other studies, but condensed tannins have been reported to influence mainly worm egg and larval development, which could not be tested in our short study.

There was a consistent trend for urine patches in pens with lambs that were fed willow to have lower emissions than those that were not fed willow for each of the three gases, although this was only statistically significant for nitrous oxide in Week 2, probably because of the small number of urine patches sampled (see Figure 1). Ammonia emissions declined rapidly, nitrous oxide emissions were mainly in Week 2 (see Figure 2), and carbon dioxide emissions declined gradually over the two-week period (see Figure 3). Lower carbon dioxide emissions suggests that microbial activity was suppressed in the soil, rather than in the rumen, but we cannot discount a contribution from the latter. Willow is well suited to mechanical harvesting, or to direct browsing of coppiced trees if livestock access is managed to ensure sustainability, and our results suggest that feeding willow to ruminants could contribute to climate change and air quality targets.

KEY FINDINGS

- Feeding willow to weaned lambs increases blood cobalt and vitamin B12 concentrations.
- Greenhouse gas emissions from urine patches are lower where lambs have been fed willow.
- Ammonia emissions from urine patches are also reduced when willow is fed.

Chris Stoate
Gemma Fox
Jenny Bussell
Nigel Kendall (University of Nottingham)

Conservation Agriculture

Direct drilling can help stabilise and protect the soil.
© Alastair Leake/GWCT

BACKGROUND

The Allerton Project Farm is part of a network of five European farms looking at three different approaches to arable cropping over a five-year period. The results will indicate the economic and environmental impact of each of the systems.

The transformation of natural habitat to agricultural land involves the clearance of the native vegetation and a repurposing of the soil, traditionally achieved through inverting the top-soil using the mouldboard plough. In natural systems, soils are relatively immobile and although even in stable habitats low levels of soil erosion are normal, most movement occurs through activities of macro-invertebrates, such as earthworms, that 'churn' the soil in situ.

Repeated annual ploughing in cropping systems produces a more homogeneous 'tilth' which is conducive to even crop germination and onward growth. But using a plough to create an aerated seedbed also gives rise to oxidation of the essential organic matter component, built up by years of deposition of decaying plant material. This loss of soil organic matter depletes fertility and structure while making the soil more vulnerable to erosion, capping, compaction, water-logging and drought – all things which are detrimental to crop production. It is, however, useful in burying freshly shed weed seeds and crop volunteers to a depth which precludes their germination in the subsequent crop.

In some climates, particularly in the Americas, ploughing has rendered large swathes of land uncroppable and farmers abandoned the use of the plough. Farmers found that if they combined three key practices they could stabilise and protect their soils:

1. Minimum soil disturbance pre-sowing and through the cropping season. This is done by using so-called 'direct drills' – crop seeders which slot the following crop seed into the previous crop's stubble.
2. Maximum soil cover. Farmers seek to ensure that at no time is the soil surface left bare. This is done by chopping the crop residues at harvest and spreading them on top of the stubble, and/or by sowing fast-growing 'cover crops' during the inter-crop period. This protects the soil against erosion by proving a protective 'armour'.
3. Practising a diverse crop rotation. Different crops have different rooting characteristics, while their residues decompose over different lengths of time, both of which help to provide increased soil protection.

Farmers switching to Conservation Agriculture (CA) techniques have also noticed other benefits arising in time, including a dramatic increase in earthworms, better soil structure and nutrient recycling, better rainfall infiltration and greater crop resilience during times of drought, a decrease of up to 70% in tractor fuel usage and an increase in soil carbon at the soil surface.

As we become more aware of the adverse impacts of food production on the health of the planet, it becomes increasingly important that we understand the full

More skylarks were counted consistently on the lower tilled plots. © David Mason

life cycle impact of the measures we employ to cultivate crops. In 2017 the Allerton Project joined up with global crop protection experts Syngenta to begin an ambitious five-year, full-rotational trial into CA, comparing it with conventional and intermediate approaches. In 2018 we were joined by sister-sites in Kent, France and two farms in Spain. The breadth of data being gathered is the most detailed we have ever obtained, including environmental, soil, agronomic and profit metrics. After just three harvests there are some clear differences developing between the systems, including marked differences in winter foraging by farmland birds, which tend to prefer the direct-drilled stubbles, and the prevalence of different weed species within the systems.

Herein lies a future challenge because weeds are effectively controlled by the use of the herbicide glyphosate, which is threatened with regulatory withdrawal in the near future. The loss of this key tool within the CA system could result in large-scale reversion back to ploughing and consequences for the whole range of benefits we are recording. Hence the importance of our studies – we need to understand the full impact across a range of parameters to ensure we make the most informed, and best, decisions.

KEY FINDINGS

- Bird numbers and green-house gas emissions from soils differed according to crop establishment cultivations.
- Profitability is driven by a combination of crop output, variable and fixed costs.

Alastair Leake

Ploughing causes the loss of soil organic matter which depletes fertility and structure, making the soil more vulnerable to erosion, capping, compaction, water-logging and drought. © Peter Thompson

Scottish demonstration farm - Auchnerran

Auchnerran: game and songbird counts

Curlew at dawn. © GWCT

BACKGROUND

Our monitoring at our Game & Wildlife Scottish Demonstration Farm, Auchnerran (GWSDF) started in 2015 when we began a two-year baseline period to assess biodiversity before any major changes to farm management. This revealed a huge array of abundant wildlife and our annual monitoring since then has quantified the abundance of the indicator groups that are relatively efficient to survey, and are directly relevant to the farm's aims. These are: game, breeding birds (general farmland birds with additional focus on waders and raptors), rabbits, foxes, corvids, sheep tick and fluke (with help from the Moredun Research Institute). More detail can be found in our annual report **gwct.org.uk/auchnerran**.

The year 2020 was challenging for many people owing to the Covid-19 pandemic and our fieldwork was affected by the travel restrictions imposed by the Scottish Government and the financial pressure on the Trust. Marlies was furloughed from early April, leaving our students Max Wright and Elizabeth Ogilvie to take most of the strain – which they did admirably. Most of our monitoring and research work was carried out as normal, with relatively few aspects having to be dropped.

Game are counted via vehicle transects focusing on fields in spring and autumn, supplemented with Breeding Bird Surveys in spring and counts of birds flushed from cover using dogs in autumn. Both the spring and autumn surveys were partially affected by the pandemic, with either the timing of surveys affected or the number of repeats reduced, suggesting caution should be exercised when considering the results. Our surveys suggest that brown hares at Auchnerran are doing well, having increased from 0-7 animals per 100 hectares (ha) (depending on the survey method) in spring 2015 to 3-14 in 2020. Our wild pheasants are probably holding steady at a relatively low density of 8-13 per 100ha in spring, having declined from 62-73 per 100ha in

Our surveys suggest that brown hare numbers are increasing. © GWCT

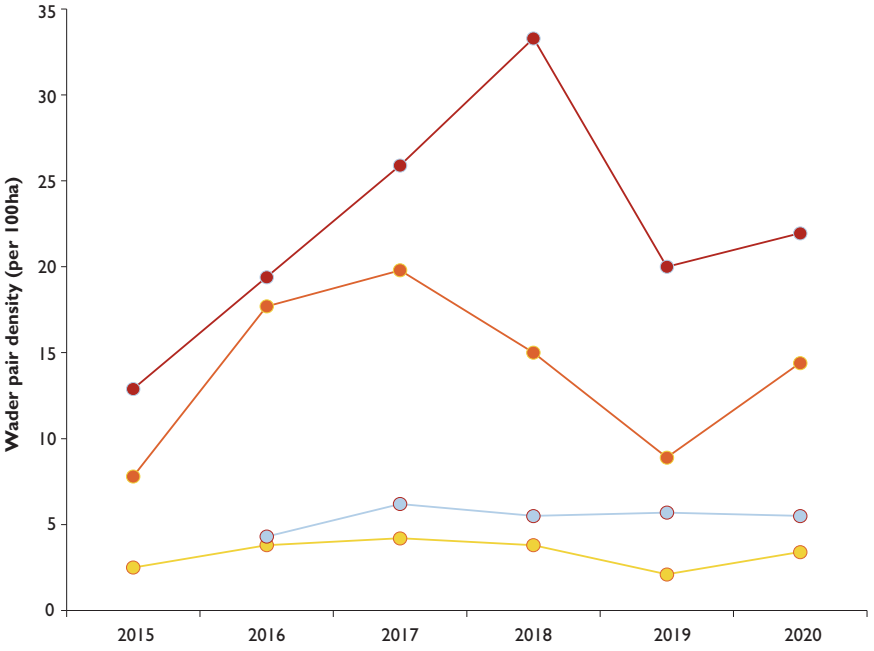


Figure 1

Lapwing, oystercatcher and curlew pair density (number per 100ha) from Breeding Bird Surveys, woodcock counts from dusk roding-male surveys, at GWSDF 2015-20. We have assumed monogamy for lapwing

2015 following a large release of pheasants the previous autumn by the farm's former owner. The monitoring of pheasant numbers has taken on renewed importance in 2020 as we have expanded our wild-bird shoot, so having an accurate estimate of the autumn stock available for shooting is crucial.

Readers may recall that we reported a sharp downturn in numbers for most of our breeding birds in 2019. Happily, they have bounced back somewhat in 2020 with a 78% increase relative to last year for the species in the Scottish Government's index of 'Scottish Terrestrial Breeding Birds (Farmland)', which is still approximately twice as high as when we started surveying at Auchnerran in 2015. Twenty of the 27 species in the index showed an increase on 2019 densities. This upturn in breeding density was replicated among those wader species that we monitor, with overall numbers of lapwing, oystercatcher and curlew pairs 28% higher than in 2019 (see Figure 1). Lapwing, oystercatcher and curlew also had a relatively productive breeding season with 1.0, 0.3 and 0.8 chicks produced per pair in 2020 – maintaining the high productivity that we have had to date at Auchnerran.

KEY FINDINGS

- Much of our research continued unaffected by the Covid-19 pandemic and its associated impacts.
- Our brown hare numbers remain steady in spring (3-14 per 100ha) after a recent increase in abundance; spring pheasant density is low (8-13 per 100ha) relative to recent years, though these are now wild birds.
- Breeding birds, including waders, increased by 78% compared with 2019 after a substantial decline in that year.
- Breeding waders had a productive year, with lapwing, oystercatcher and curlew producing 1.0, 0.3 and 0.8 chicks per pair in 2020.

Dave Parish
Marlies Nicolai

ACKNOWLEDGEMENTS

Thank you to Working for Waders and Perdix Wildlife Supplies for supporting our research at GWSDF Auchnerran.

Wader productivity, including lapwings, was high in 2020. © Marlies Nicolai/GWCT

The farming year at Auchnerran

Max Wright and Elizabeth Ogilvie counting ticks on sheep. © Marlies Nicolai/GWCT

BACKGROUND

Auchnerran is a hill-edge farm in east Aberdeenshire, bordering the Cairngorms. The main body of the farm extends to 417ha with another 50ha or so shared with a neighbour. About 70% of the land is grass with some woodland, fodder crops and game cover. The soils are mostly acidic and sandy in nature. The principal commodity on the farm is the sheep flock, which also serves to mop up ticks on the adjacent grouse moor where the sheep graze from around April to November. More information about Auchnerran, including our annual report, can be found at **gwct.org.uk/auchnerran**.

Auchnerran had a good year. Helped by relatively benign weather, the final lambing figures for 2020 were 129% (see Figure 1), which is our highest yet (see Table 1). We also produced a good silage crop and the best crop of turnips since we started growing them in 2017. The sheep flock now sits at around 1,400 ewes plus followers, after declining in number over the last few years as the unproductive, old ewes were gradually removed to improve overall flock health and productivity. The improvement in the quality of the animals has been evident at market, where we topped the blackface section on each occasion bar one in 2020.

We expect to reach our target flock size of around 1,500 ewes in 2021. This is the level that we think is optimal for the available grazing on the farm in winter, which is the main pinch point in the annual cycle, plus the optimal size for tick control on the summer hill-grazing area. This is where our flock performs an important role in reducing tick numbers to reduce burdens on sheep, wildlife and people, thereby reducing the transmission of pathogens like louping ill and Lyme disease. We achieve this by periodically gathering the sheep throughout their time on the hill to treat them with a pour-on acaricide which kills any ticks that attach over the subsequent six to eight weeks. Again, in 2020 the average number of ticks per sheep was less than one.

Our battle against rabbits continues with around 1,000 metres of new rabbit netting installed, incorporating 13 rabbit boxes, which to November enabled the removal of 740 rabbits from that section alone. Our monitoring had suggested numbers may have been dropping since control measures began, but it seems the rabbits had a good breeding season like many other species at Auchnerran.

2020 saw the start of a carbon audit on the farm as part of our Integrated Land Management Plan. Using the Scottish Rural College 'Agrecalc' tool, this involves

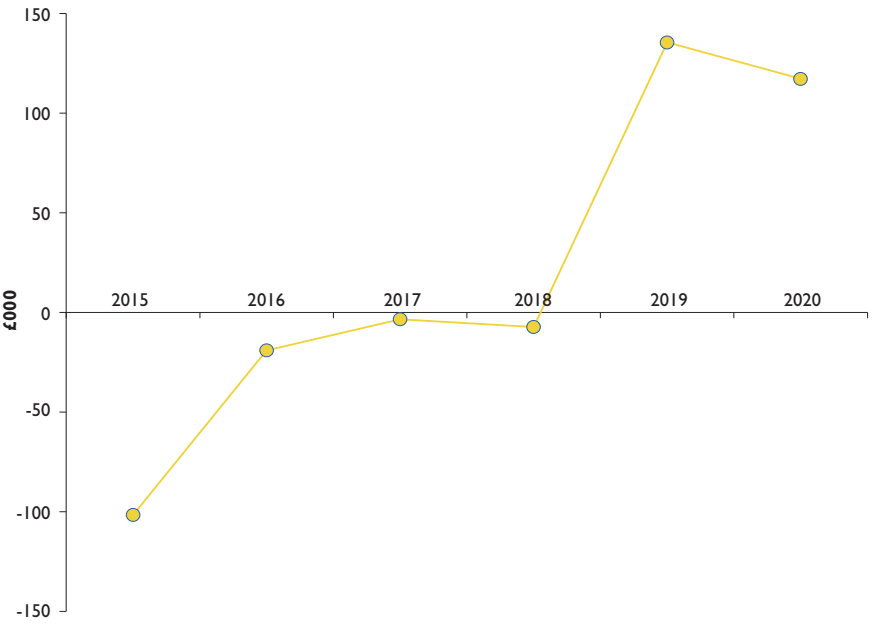


Figure 1

Auchnerran farm profit, 2015-2020 (figures for 2020 are provisional)

These have been updated since published last year

a review of all aspects of how the farm is run, its infrastructure, land use (eg. area of pasture, woodland, etc) and weather patterns, and is being led by our advisors Laurence Gould. For example, to accurately estimate the amount of carbon stored on the farm in its woodland, our students Olivia and Sophie, who started in September, have been identifying and measuring trees and their spatial arrangement in each wood. This process is not yet complete as we have yet to incorporate the estimate of carbon sequestered in our soils.

As readers may have seen in our GWSDF blog, our landlord, Andrew Salvesen, has now finished renovating the old mill buildings on the farm, for which we are extremely grateful. They now provide us with new offices, a laboratory and a large meeting room, opening up new opportunities for how we use the farm. The main mill building will now be our base of operations and allow us to host large groups of visitors in comfort. This also means we can accelerate our education and training programme which, subject to funding, will include developing educational materials in the education centre and on-farm, plus installing signposted routes around the farm with boardwalks across some of our wetter areas. We are currently exploring links with local schools and are in discussion with the Scottish Rural College about potential collaboration on several of its courses.

KEY FINDINGS

- The farm had a good year in 2020 with high lambing rates and a good crop of silage and turnips.
- The sheep flock is on target to reach optimal size for the available winter grazing and for tick management on the hill in 2021.
- Work has begun on a carbon audit of the farm as part of the Integrated Land Management Plan, with preliminary results suggesting lots of carbon stored in the farm woods.
- Renovation work on more farm buildings by our landlord, Andrew Salvesen, is now complete, providing better office space, a new lab, a bigger storage area and a large meeting room.
- This will facilitate further plans to expand all areas of our work at Auchnerran, especially in education.

Dave Parish
Allan Wright
Ross MacLeod

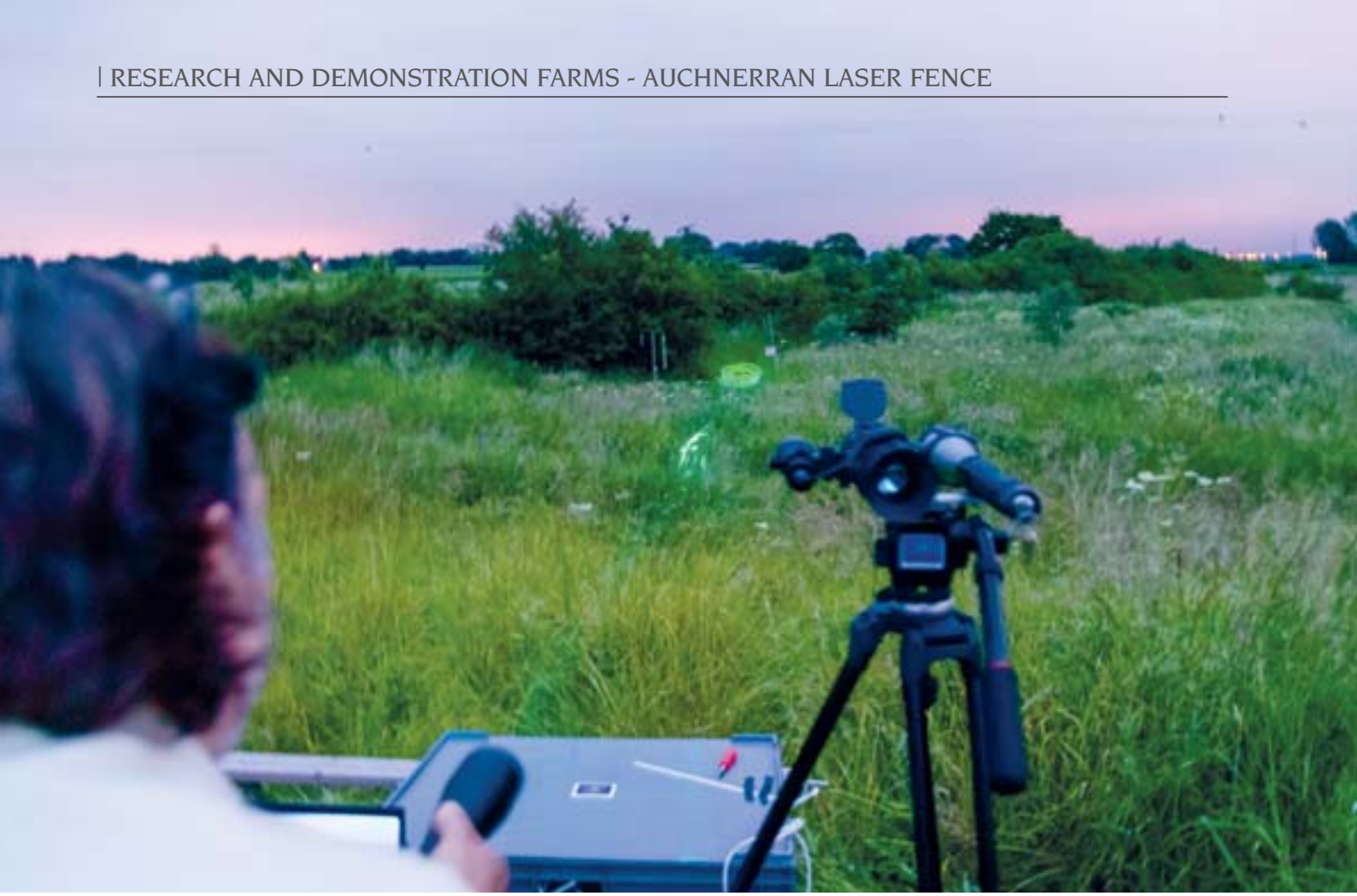
TABLE 1

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

	Ewes	% weaned	Silage bales per year	Bales per hectare
2015	1,440	60%	730	17
2016	1,205	97%	717	20
2017	1,126	120%	1,100	25
2018	1,000	126%	460	12
2019	986	124%	986	23
2020	1,400	129%	830	24
2021	1,500*			

**Projected ewe numbers for 2021.*

Sophie McPeake taking tree measurements for the carbon audit. © Olivia Stubbington/GWCT



Using lasers to control mammalian pests

One of the lasers in action on a partner site.
© Liverpool John Moores University

BACKGROUND

The Laser Fence project was part-funded by the EU LIFE+ programme and led by Liverpool John Moores University, with GWCT, Bird Control Group (Netherlands), Iris Drone Specialists (Spain), Volterra (Spain) and Angel Camacho (Spain) as partners. It ran from 2016 and finished in September 2020, with the final report submitted at the end of December. The standard lasers used in the trials were classed as 3B: this is an international rating indicating that the lasers are potentially damaging to eyes. This influences the manner in which they can be used and a risk assessment must be produced before deployment.

The Laser Fence project aimed to test a commercially available laser bird-scaring system on mammalian pests of agricultural crops and food stores. The movement of the laser spot across the substrate scares the animals away – it does not need to touch them at all. It was hoped that this might provide a non-lethal alternative to rodenticides and traps under certain circumstances. This project is now finished and this article reports some of the findings from Auchnerran.

The GWCT ran trials at Auchnerran focused on rabbits and rats. The laser system came as a handheld device or a standalone, programmable unit which could run from a large battery charged via solar panels, offering the opportunity to have the laser running in a particular area for long periods of time. The standard colour for both was green. The handheld lasers were used to explore behavioural responses, mostly of rabbits, to the laser beam shone on the ground close to them, while the standalone option was ideal for testing whether the laser could keep animals out of areas where the laser was projected.

The standalone devices quickly became almost useless for our purposes when the Health & Safety Executive (HSE) deemed them unsafe to use in the open while unsupervised, despite recognising the extremely low probability of someone damaging their sight from exposure to the beam (which is constantly moving). Results from these trials are not mentioned further; instead we focus on the behavioural responses of rabbits to the handheld laser.

There are few published data on the efficacy of lasers on birds, but the manufacturer and many users report high response rates, with birds quickly leaving an area when a laser is used. It was clear early on that this was not the case for mammals, which were more circumspect in their reactions. The proportion of tested rabbits that showed one of several 'fear' responses to the green handheld laser when it was projected nearby in the evening (low light levels but not dark), varied between approximately 20% and 36% once background activity levels were taken into account (as indicated by control-rabbit responses) across all trials.

Rabbit responses to the green handheld laser beam were not impacted by the pattern, speed or duration of laser movement. This suggests that no complex style

Green and blue lasers were found to be equally effective at eliciting a fearful response from rabbits at dusk, more so than yellow and red.
© Peter Thompson

of laser presentation is needed to produce a measurable response in rabbits. A 12% response rate among rabbits (after controlling for background activity levels) was detected at a green laser power output of approx. 0.4 mW (which produces a relatively dull light). This was around half the response rate achieved with the 450 mW output in the same trial. This suggests that low-powered laser emissions may have some potential as a deterrence after dark (ie. very low light levels). If confirmed, this would mean the HSE restrictions on automated use of lasers would not apply to this safe output level – an important milestone if this is to become a practical tool. Green and blue lasers were found to be equally effective at eliciting a fearful response from rabbits at dusk (36-42% response rate), more so than yellow and red, although the yellow handheld laser had a lower power output (100 mW vs 450 mW).

These results, coupled with the findings from the partner trials which suggest habituation to the laser is minimal over the course of a month or two, suggest the response of mammals to the laser is not as clear-cut as for birds, but does offer hope that it may be possible to develop a system that will deter some pests from defined areas under perhaps limited circumstances. More trials are planned to explore this further at Auchnerran as part of the follow-up 'After LIFE' project.

KEY FINDINGS

- A moderate proportion (20-36%) of rabbits showed a range of fearful responses to the green laser irrespective of the speed and pattern of laser movement.
- A small response rate (12%) was found even to the low-powered laser (ie. producing a relatively dull light), raising the possibility that this safe laser output might be useful at deterring rabbits after dark.
- Blue-coloured lasers had a similar deterrent effect on rabbits to the green laser.
- Further work is needed to test whether the moderate response rate detected in trials (replicated among the project partners) might form the basis of a practical deterrence system to protect crops and food stores from pests.

Dave Parish
Marlies Nicolai

Introducing the project to visitors at the GWCT Scottish Game Fair. © GWCT

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River Frome Atlantic salmon population

Poor recruitment, particularly in the upper part of the River Frome catchment from last winter's spawning, resulted in fewer juvenile salmon than normal available for tagging. © GWCT

BACKGROUND

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

SALMONID GROWTH

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

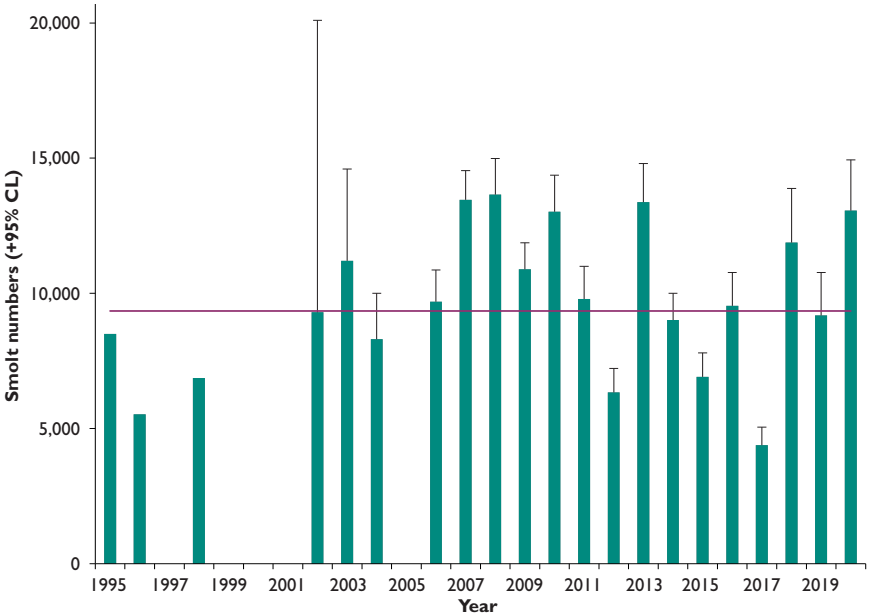
Smolts: Monitoring salmon smolts is hard work. Starting in March each year, we spend six weeks checking our rotary smolt screw trap day and night. A challenging task in any year, but the 2020 smolt run came just as the nation found itself in lockdown. Despite the restrictions we managed to operate, but only thanks to the support of partners. The fieldwork was divided across research staff and a PhD student, each joined by their partners who volunteered to help during night shifts to reduce potential risk.

An estimated 13,062 (95% CI ±1875) salmon smolts left the River Frome, 40% up on the 10-year average (9,345, see Figure 1). This is the highest number of emigrating smolts recorded since 2013 and they were also on average large smolts (see Figure 2). Our previous research has shown that larger smolts are three times more likely to return from the sea than smaller ones. It is more than 10 years since we have observed this number of large smolts leave the river and, given the relationship between return rate and smolt size, we are hopeful that good numbers of adult salmon from the 2020 smolt cohort will return in 2021 and 2022.

Parr tagging: Ensuring that all team members stayed safe during our late summer parr-tagging campaign provided challenges, but with the help of dedicated volunteers staying for weeks on end we managed to visit all our regular monitoring sites in the River Frome catchment. We easily reached our target of 3,000 tagged young-of-the-year juvenile trout, but we encountered fewer juvenile salmon than normal. As a result, we tagged just over 8,000 juvenile salmon, which is somewhat short of our 10,000 target. Salmon recruitment from the previous winter had been poor, particularly in the upper part of the catchment. In previous years we have deployed 10-22% of the salmon tags upstream of Lower Bockhampton (30km upstream of the tide), but in 2020 it was only 1%. We know from the redd survey undertaken the previous winter that there

Figure 1

Estimated spring smolt population, (with 95% CI) 1995-2020



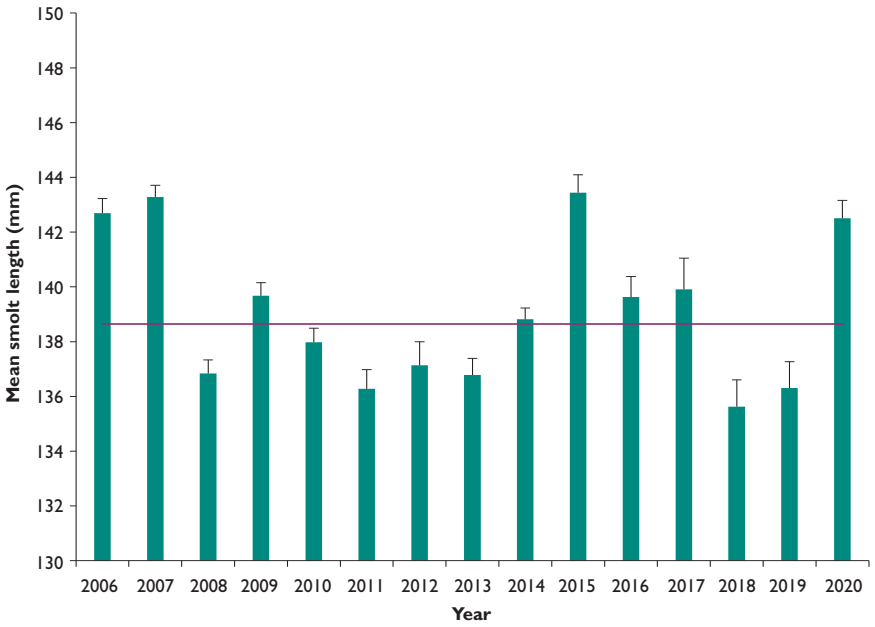


Figure 2

Mean length (with standard deviation) of tagged one-year-old smolts caught in the rotary screw trap during 2006-2020

10 year average = 138.6

were salmon redds in the upper catchment, but recruitment from these redds had all but completely failed. We are currently analysing our historical dataset to get a better understanding of the drivers of recruitment success from egg to parr in the catchment. These findings will be compared with our previous findings from Welsh rivers.

Adults: With the help of our SAMARCH project, our fish counter at East Stoke had a new fibreglass base with new electrodes installed at the bottom of the river in 2019. We were due to update the electronics decoding the signal from the electrodes in 2020, but this was delayed due to Covid-19. Despite this, the new base improved the electronic signal and provided better contrast for the video images. As is the case in most years the bulk of the adult salmon moved past our fish counter in late autumn. From the fish counter we estimated that 653 adult salmon returned to the river in 2020, which is better than the two previous years (see Figure 3). We had a decent run of 1SW salmon (individuals that have spent one year at sea before returning) and a surprisingly good run of 2SW salmon. The 2SW fish originated from the 2018 smolt cohort from which we had a poor return last year as 1SW fish; more PIT-tagged salmon from the 2018 smolt cohort were recorded returning as 2SW in 2020 than as 1SW in 2019. Provided egg survival is reasonable, the 2020 run of spawners should result in good numbers of juvenile salmon in 2021.

KEY FINDINGS

- Good teamwork and lots of help enabled the fisheries team to continue their data collection in a challenging 2020.
- The 2020 salmon smolt estimate was 40% higher than the 10-year average and the mean size of the 2020 smolts was large, boding well for their return rate.
- The juvenile life stage was the only one with disappointing results in 2020. Poor recruitment, particularly in the upper part of the River Frome catchment from last winter's spawning, resulted in fewer juvenile salmon than normal available for tagging.
- A good number of spawners was recorded in 2020, which is promising for the recruitment of juvenile salmon in 2021.

Rasmus Lauridsen

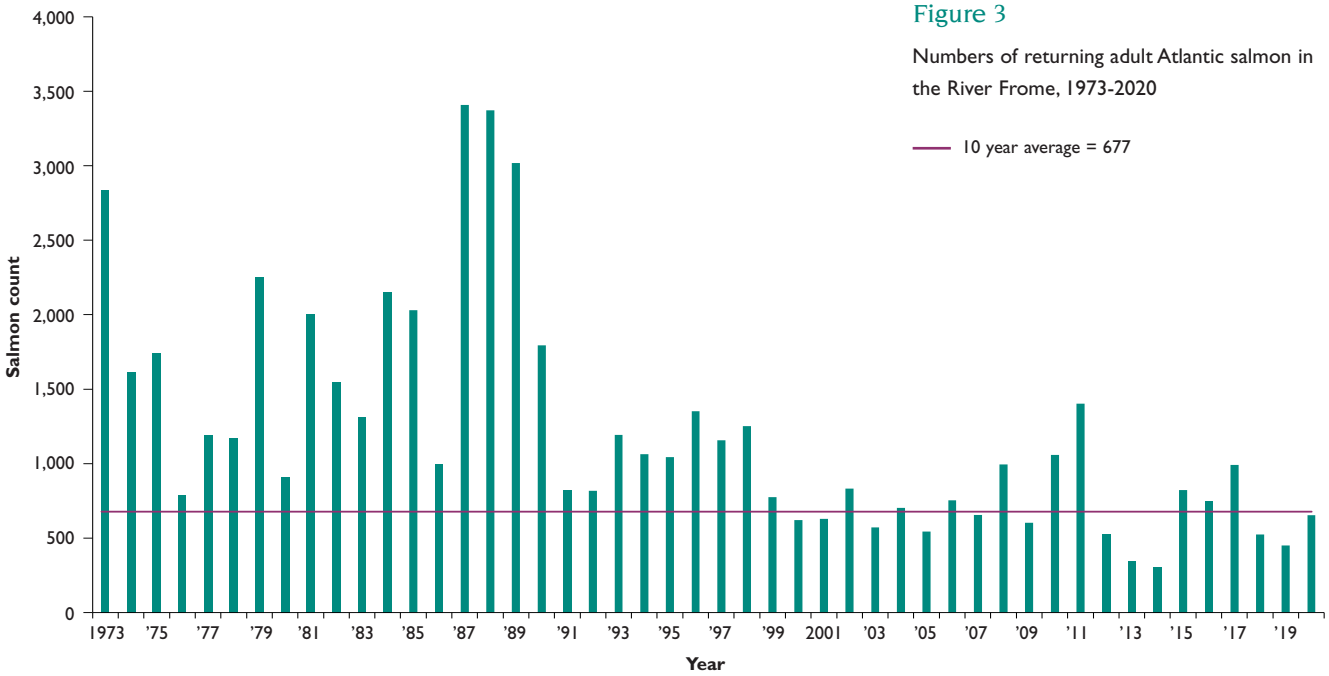


Figure 3

Numbers of returning adult Atlantic salmon in the River Frome, 1973-2020

10 year average = 677

SAMARCH overview and progress

We caught adult sea trout at sea within six miles of the English coast in the Channel. © Luke J Scott/GWCT

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BACKGROUND

The English Channel is one of the busiest parts of the ocean for shipping, commercial fishing, especially with gill nets, and marine developments. This poses several challenges for the salmon and sea trout that spawn in the 80 or so rivers in the south of England and northern France which flow directly into the Channel.

Aims and objectives of the project

The SAlmonid MAnagement Round the CHannel project 2017-2023 (SAMARCH) is led by the GWCT and includes 10 partners from France and England who are a blend of research and regulatory organisations, and key stakeholders. It has four themed technical work packages:

1. Fish tracking. This package is using acoustic tracking and data collection technology to follow sea trout and salmon through four estuaries and at sea.
2. Genetics. A genetic database of trout from rivers flowing into the Channel is being developed so that fish caught at sea can be assigned back to their river. Evidence is also being collected on the risk of bycatch of salmon and sea trout in gill nets.
3. Data collection and modelling. This package is updating existing data and using them together with novel data generated by work packages 1 and 2 to improve existing, and develop new, salmon stock assessment methods.

We recaptured 14 tagged sea trout and received a further 20 tags that were recovered from beaches all over Europe. © GWCT

4. Policy development and stakeholder engagement. This will ensure the results produced by the project inform, improve and develop new policies for the management of salmonids in estuaries and coastal waters.

For further information please go to **www.samarch.org**.

Tracking salmon and sea trout

In 2020, the tracking work package focused on three rivers: the Tamar and Frome in the UK and the Bresle in France. From December 2019 to February 2020, we tagged 143 sea trout kelts with data storage and acoustic tags. The acoustic receivers deployed in the estuaries recorded at least 105 (73%) sea trout re-entering the coastal environment and 39 of them survived their marine migration and were detected back in the estuaries five to seven months later. Of these fish, we managed to recapture 14. Others died at sea and their data storage tag, encapsulated by a float, drifted with the current onto beaches in France, England, Belgium, Germany and the Netherlands where they were found by walkers who returned some 20 tags.

Temperature and pressure parameters recorded by the tags give us clues to the reasons for the mortality of sea trout at sea. A sudden temperature rise signifies that the tag was inside a warmer organism and in the same way, a change in the pressure pattern reflects the behaviour of another species. Of the tags collected in 2020, we identified four main mortality reasons: predation by birds (5%) and marine animals (33%), other causes of natural mortality (17%) and non-natural mortality, likely fishing (17%). The pressure data showed diving activity to depths of 80 metres, with patterns that differed between tagged populations as well as migration routes. Analyses are ongoing, but we already have evidence that some sea trout from England travel towards the French coast and vice versa.

Genetics

As part of the genetic database development work, more than 4,600 fin-clip samples have been collected from trout in some 80 rivers all along the English and French sides of the Channel. This has resulted in the development of a panel of 431 Single-Nucleotide Polymorphism or SNP genetic markers and revealed six genetically distinct UK and French populations. Genotyping for the database is ongoing but will include some 3,000 trout samples.

KEY FINDINGS

- Thirty-eight percent of sea trout mortality at sea is due to predation.
- Sea trout migration behaviour seems to differ between populations. Sea trout swim to a depth up to 80 metres.
- Twenty-three percent of the data storage tags deployed in adult sea trout have been recovered.
- River Frome juvenile salmon grow best overwinter when it is warm and wet.
- River Frome smolts are migrating to sea earlier and following warmer winters.
- River Sélune adult salmon sea ages appear related to sex-specific post-smolt growth in their first-sea winter.

Céline Artero
Stephen Gregory
Dylan Roberts

Over 23 days, 27 adult and seven post-smolt trout, five grilse and one salmon were captured in gill nets, which represents 1.7 salmonids captured per day from the near coast. © Dylan Roberts/GWCT

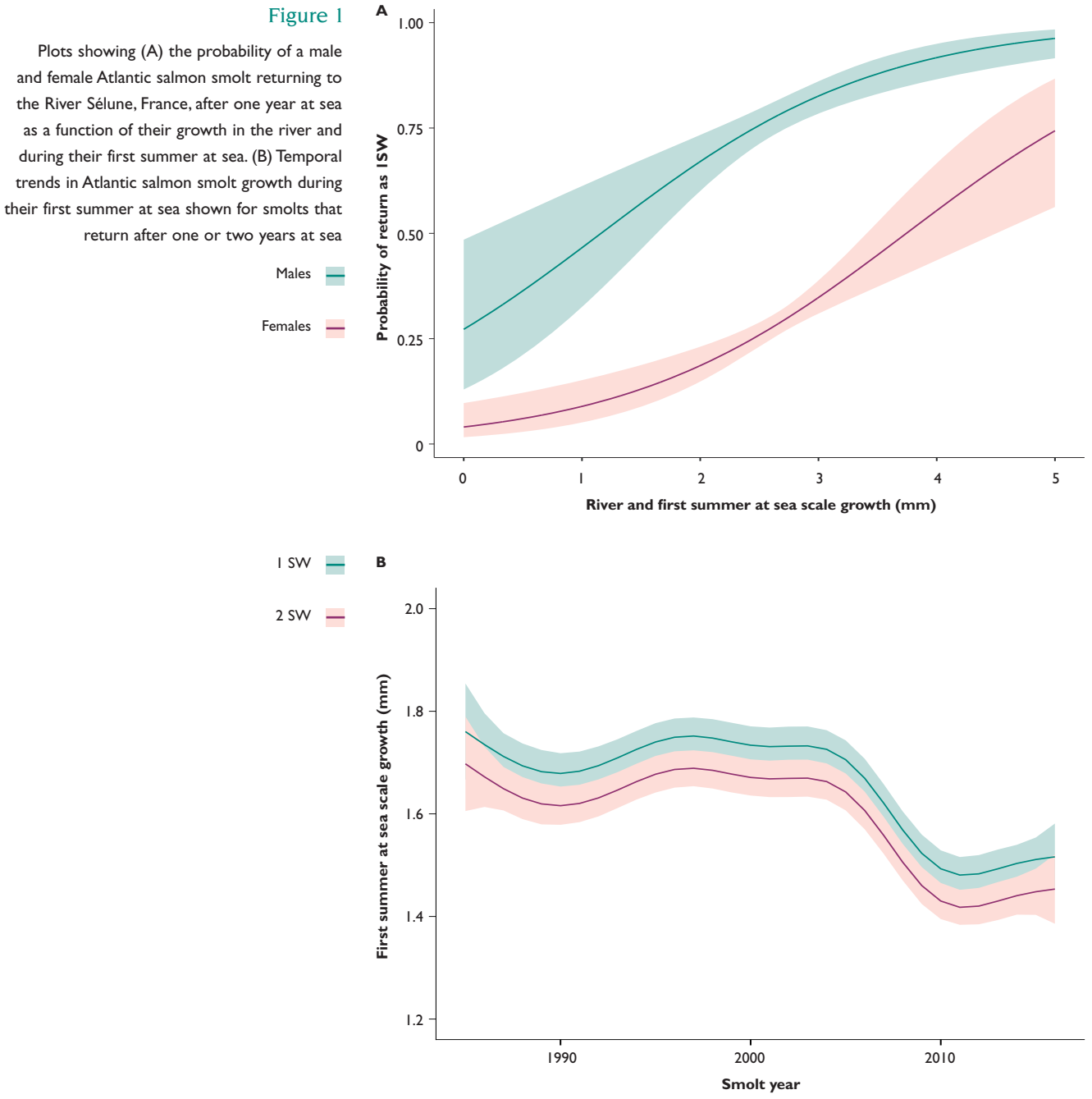
Genetic samples from sea trout caught within six miles of the English side of the Channel have been obtained to determine where these fish go at sea and to investigate the potential impact of coastal nets on sea trout. In the spring and summer of 2019, two commercial fishermen were hired to set gill nets off the Channel coast. The fishermen fished for 23 days using a total of 600 metres of gill net each day. In total, 27 adult and seven post-smolt trout, five grilse and one salmon were captured, which represents 1.7 salmonids captured per day from the near coast. This work was delayed in 2020 due to the Covid pandemic, but will be repeated and extended to other parts of the coast in 2021.

Data collection and modelling

Ludivine Lamireau and Benjamin Bagot joined the work package 3 team in 2017 to collate and extract data from more than 9,000 salmon scales, representing different life stages from smolts to adult returns, collected on the five SAMARCH rivers: Bresle, Oir, Scorff, Frome and Tamar. The new data they have generated, and the database they have designed to store it, has facilitated the work of our PhD students, Olivia Simmons

Figure 1

Plots showing (A) the probability of a male and female Atlantic salmon smolt returning to the River Sélune, France, after one year at sea as a function of their growth in the river and during their first summer at sea. (B) Temporal trends in Atlantic salmon smolt growth during their first summer at sea shown for smolts that return after one or two years at sea



Our research has shown that smolts that grew well in the river and their first summer at sea were more likely to return to spawn after only one year at sea. © Olly Dean/GWCT

and Cécile Tréhin. Olivia and Cécile joined the work package 3 team in 2018 to complete studies exploring salmon smolt growth, migration and survival in their freshwater and early marine periods. Olivia has completed studies describing River Frome salmon overwinter juvenile growth and in-river smolt migrations and how they relate to the characteristics of individual fish, including their length and prevailing environmental conditions (see pages 60-61). Cécile has completed studies describing post-smolt growth during their first year at sea and how it relates to their sex and ultimately the amount of time they spend at sea. Specifically, she has shown that smolts that grew well in the river and their first summer at sea were more likely to return to spawn after only one year at sea, and this effect was greatest in males; females were more likely to stay at sea longer than males irrespective of growth, presumably to gain body condition that is directly related to fecundity (see Figure 1a). Understanding the effects of river and first summer at sea growth on sex-specific maturation rate has important implications for salmon stock assessment models, particularly if recent declines in summer growth (see Figure 1b) cause changes in stock sex ratios and sea-age compositions.

Marie Nevoux and Etienne Rivot have led the development of a new methodology to reconstruct changes in salmon stocks across the Atlantic Basin and linking them to environmental conditions, including sea-surface temperature and primary productivity. The International Council for the Exploration of the Seas (ICES) Working Group on North Atlantic Salmon (WGNAS) plans to adopt this methodology for future salmon stock assessments. Stephen Gregory has been working with agencies involved in local and national salmon stock assessments to review, and where possible improve, current methods, such as those used to estimate salmon rod exploitation rates.

Policy development and stakeholder engagement

Work package 4 brings together all the new data, information and results to work with regulators and stakeholders to see where current policies to manage salmon and sea trout can be improved or new ones can be developed. The research element of the project is still ongoing, and we await the final conclusions. However, to encourage engagement, there have been several meetings, workshops and events at local, regional and international level. For example, meetings have been held with the ICES salmon and trout working groups, NASCO, Environment Agency and the regional IFCAs.

ACKNOWLEDGEMENTS

We are grateful to the Environment Agency and the French Office for Biodiversity for providing funding and human resources support to recapture sea trout in England and France. We are also grateful to the EU's Interreg Channel Programme and the Missing Salmon Alliance for funding the SAMARCH project.

THE MISSING SALMON ALLIANCE

What is causing River Wylye grayling to decline?

Grayling migrate within fresh water only and it is thought that they are less tolerant to changes in water temperature and quality. © Rostislav Stefanek

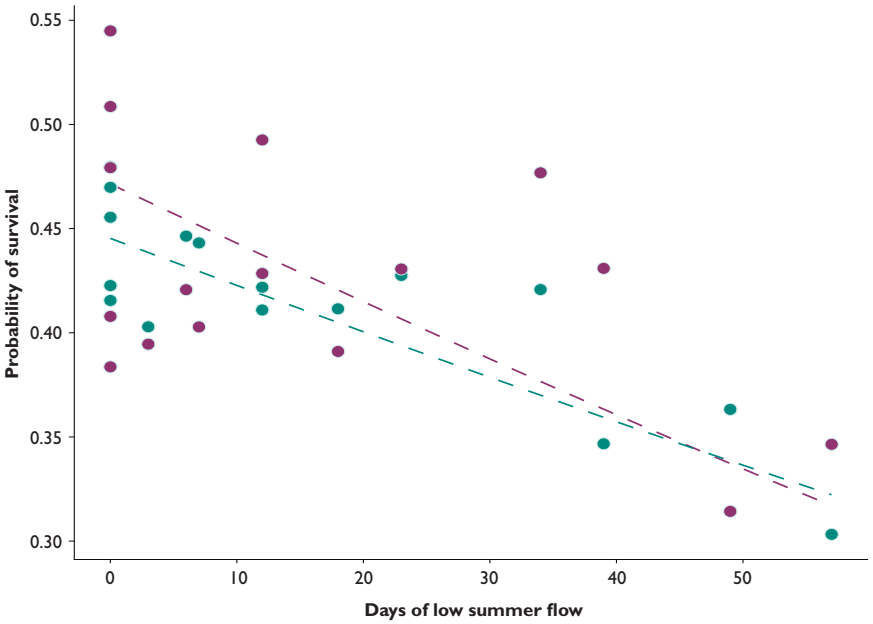
The European grayling is a member of the family *Salmonidae*. It has received less research attention compared with other salmonid species and less is known about its ecology. Unlike the anadromous Atlantic salmon and sea trout, which migrate from sea to the river to spawn, the grayling is generally potamodromous, which means that it migrates within fresh water only. It is less tolerant to changes in water temperature and quality and could be an indicator species for negative effects of environmental change on other salmonids.

Recently, the Wylye Grayling and Trout Study (WGTS) observed an apparent decline in grayling abundance, yet numbers of trout were stable or even increasing. Changing environmental conditions in the River Wylye were also noticed with frequent low summer flows and infrequent winter high flow 'recharge' events. Consequently, a new project, funded by The Grayling Research Trust, The Piscatorial Society and Wessex Water, aimed to identify biological and environmental variables that influenced grayling survival at different life-stages: juvenile (age 0+), sub-adult (age 1+) and mature adults (ages 2+ to 5+).

A previous GWCT study (see *Review of 2018*) showed that low-flow events and water temperatures above 13.5°C during summer had a negative influence on juvenile recruitment (successful production of juveniles). Our work extended that study to older age-classes and additional, potentially important, explanatory variables to test

Figure 1

Sub-adult and mature adult grayling survival decreases with increasing number of days of low summer flow, after taking into account the effects of other variables. The dashed line shows the partial effect of low summer flow on probability of survival and the points represent the estimated mean probability of survival in each year of the study



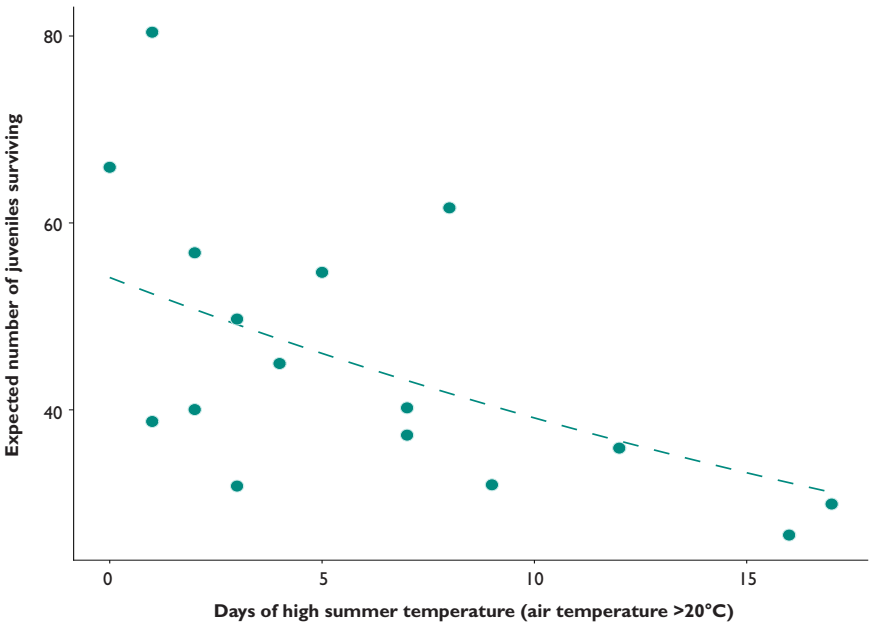


Figure 2

Expected number of juveniles surviving from eggs decreases with increasing number of days with high summer temperature, after taking into account the effects of other variables. The dashed line shows the partial effect of high summer temperature on expected number of juveniles and the points represent the estimated mean expected number of juveniles in each year of the study

broader and stage-specific hypotheses. For example, low flows can reduce habitat, such as deep pools, which are utilised by larger grayling and might offer refuge from high summer temperatures. Higher winter flows are thought to help clean out silt from spawning gravels, reduce vegetation cover and promote juvenile recruitment.

We tested a range of explanatory variables that were hypothesised to affect grayling survival at each life-stage, which also represented the changing habitat conditions observed in the Wylye. We found that the frequency of low-flow events (days where the flow was equalled or exceeded for 90% of the flow record) and high temperatures (>20°C air temperature) during summer has been above the 16-year average in the last three and four years, respectively, and that average winter discharge has been below the 16-year average in the last five years. We thought that these changing conditions would have negative impacts on grayling and could explain the decline in abundance over time.

Using WGTS data from 2003-2019, during which trout data were the most complete, we found that by 2019, abundances of all grayling age-classes had declined by over 75% from 2003 levels, and that this decline was particularly pronounced in mature adults. Sub-adult and mature adult survival in each year was estimated as a probability of surviving based on the explanatory variables measured in that year. Juvenile survival was estimated as the number of expected juveniles surviving in each year based on the estimated number of eggs and explanatory variables measured in that year.

Low summer flow had negative impacts on sub-adult and mature adult survival, with survival declining from an average of 47% and 45% in years with no low-flow events, to 32% and 37% in years with 50 days of low summer flow for sub-adult and mature adults respectively (see Figure 1). High summer temperatures had a negative impact on juvenile survival, with expected numbers of juveniles surviving from eggs declining from an average of 51 in years with < five days of high summer temperatures to an average of 28 in years with > 15 days of high summer temperatures (see Figure 2). Higher winter discharge had a positive impact on juvenile survival, with the expected number of juveniles surviving from eggs increasing from an average of 33 in years with mean winter discharge < 2m³/s to an average of 66 in years with mean winter discharge > 6m³/s.

These conditions, ie. more low-flow events and high temperatures during summer and lower discharge during winter, appear to be becoming more frequent in the Wylye, suggesting that its grayling population might be vulnerable to climate change. As this population is situated near the species' southern range limit, these findings also have future implications for local populations of more tolerant salmonid species, as well as grayling populations at higher latitudes. We found no negative impact of trout abundance on grayling survival, suggesting that the two species are well adapted to living in the same geographic area. Our findings will inform management strategies to improve habitat conditions for the grayling in the Wylye (and beyond), thereby helping to conserve this iconic fish.

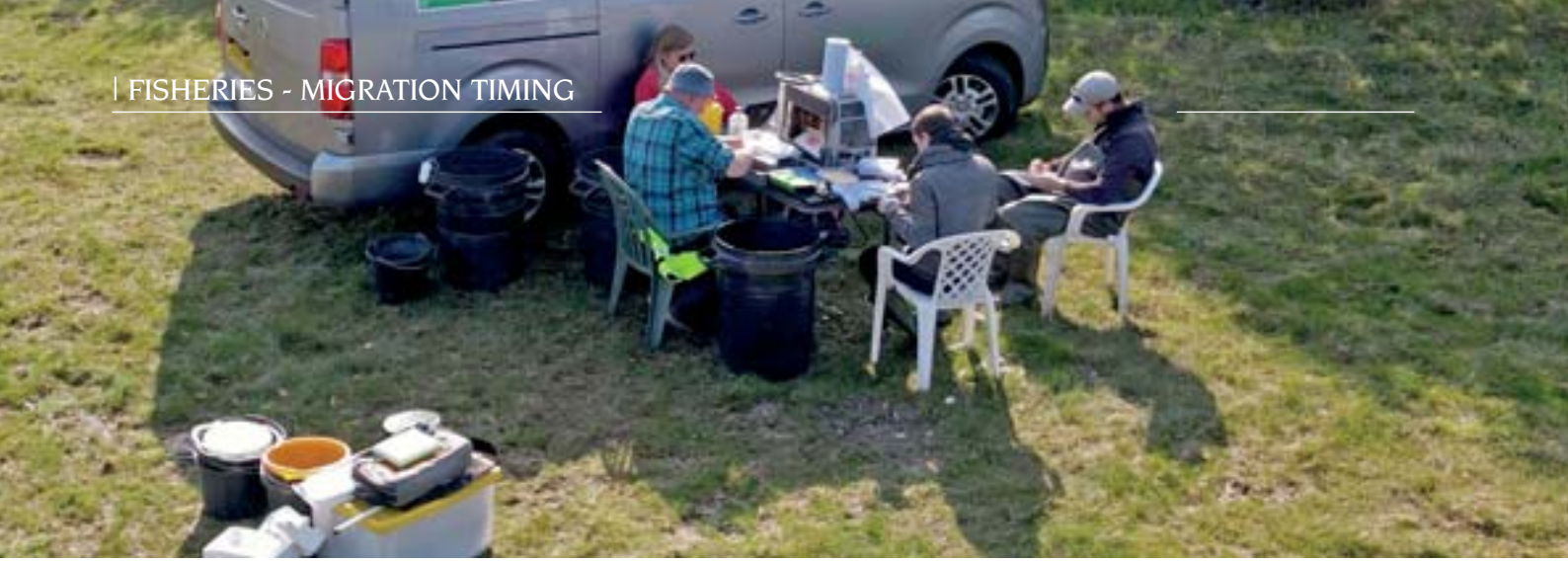
BACKGROUND

The Wylye Grayling and Trout Study (WGTS) has been surveying grayling and brown trout in the River Wylye, a tributary of the Hampshire Avon, since 1996, making it the longest consistent grayling population survey in Europe. The annual electrofishing survey, which is supported by the GWCT, The Piscatorial Society and Natural Resources Wales, is carried out in autumn. Six long-term sites are fished quantitatively to record abundance of grayling and trout. Individual length and weight measurements are recorded, and a scale sample is taken to age the fish. Grayling are tagged with PIT tags or visual implant tags to track recaptured individuals over time.

KEY FINDINGS

- Abundances of all age-classes of grayling (age 0+ to 5+) were > 75% lower in 2019, relative to the beginning of the study in 2003.
- Changes to seasonal flow regimes influenced grayling survival.
- Low summer flows negatively impacted sub-adult and mature adult survival and high winter discharge was positively linked to greater juvenile survival.
- Large trout abundance was positively associated with sub-adult grayling survival, suggesting that the two species utilise similar habitat.

Jessica Marsh



Timing of migration by juvenile Atlantic salmon

Every autumn we catch and tag 10,000 juvenile salmon. © Olly Dean/GWCT

BACKGROUND

The Atlantic salmon is an anadromous fish species, meaning it spends part of its life in freshwater and part at sea. During one part of its life cycle the Atlantic salmon is known as a smolt, a key life stage during which the juvenile undergoes big physiological, morphological and behavioural changes as it leaves fresh water and enters the sea. This migration period, known colloquially as the smolt run, is often fraught with danger from novel environmental conditions and elevated predation risk. Understanding what factors affect the timing of the smolt run has important conservation implications.

Every spring juvenile Atlantic salmon in the River Frome undergo physical and behavioural changes: they become sleeker, more silver in colour and start to abandon a previously solitary life in favour of joining their conspecifics in small shoals. The time has come for the annual smolt run, where the young salmon get the urge to leave the river that they have resided in since hatching. They head down the River Frome, pass rapidly through Poole Harbour and travel towards their oceanic feeding grounds, where they will feed and mature into adult Atlantic salmon. This migration is crucial for Atlantic salmon, as they can access far greater feeding resources at sea than in fresh water, enabling them to grow into mighty adults. It is not, however, without substantial risks. Salmon smolts face environmental conditions novel to them as they enter the estuary for the first time, including saline waters and different temperature regimes. They also face new predators, such as large piscivorous fish and seabirds. Previous research has shown that the timing of the smolt run is crucial for ensuring that smolts entering the estuary have the best chance to survive the journey to their feeding grounds in the North Atlantic. Knowing that the smolt migration bears great rewards to successful returners means that understanding factors that affect the timing of the smolt run is extremely important. As such, we have tested statistically how various environmental and biological variables affect the timing of Atlantic salmon smolt migrations in the River Frome, and how the effect of some of these variables may alter during the smolt run.

Every autumn since 2005, approximately 10,000 juvenile Atlantic salmon are marked with a 'PIT'-tag enabling us to detect these individuals as they leave the river as smolts (see page 52). A sample of smolts is recaptured in a rotary screw trap at East Stoke, scanned for tags and measured so that we have a record of their body size. The fish are then gently released back into the Frome to continue their migration.

We hypothesised that water temperature, river discharge, moon phase, smolt body length, schooling behaviour, in-river migration distance and year influenced the timing of the smolt run. We tested statistically how each variable affected the cumulative probability of each smolt migrating on any given day of the smolt run, for 15 smolt runs (from 2006 up to and including 2020). We also divided the number of days in the smolt run into three equal periods (early, middle and late) to assess how the effect of water temperature, discharge and schooling behaviour varied for smolts migrating at different times during the run. Finally, we hypothesised that the effect of smolt body size and schooling behaviour varied depending on whether the smolts were migrating

Early migrants were generally large individuals and from sites lower in the catchment. © James Long/GWCT

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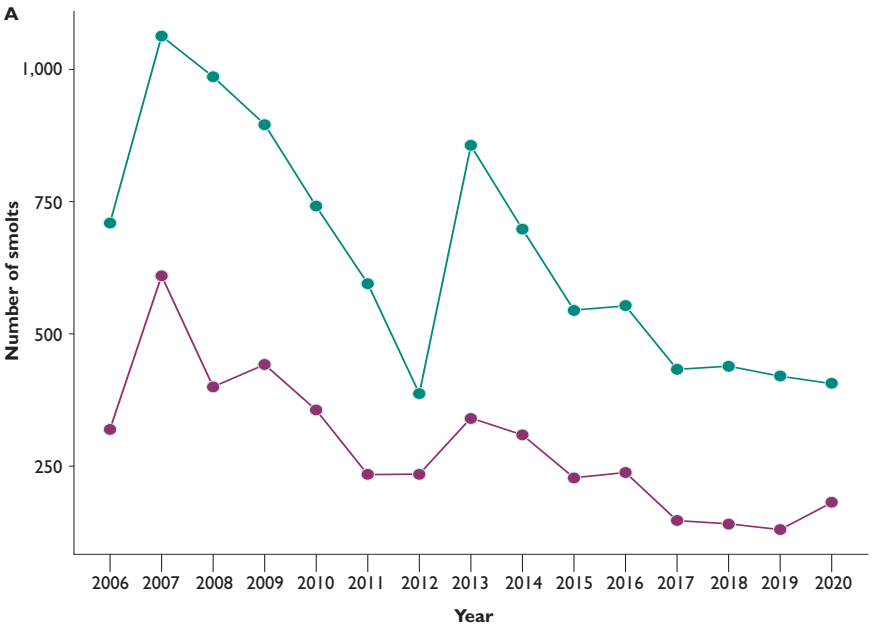


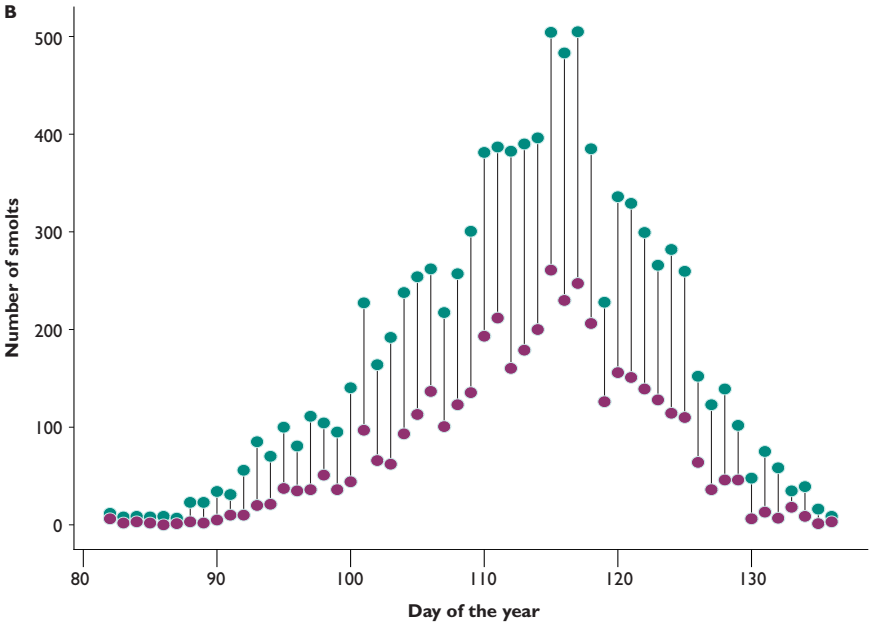


Figure 1

The number of Atlantic salmon smolts detected by PIT-tag detectors in the Fluvarium at East Stoke (green) and captured in the rotary screw trap (purple) for each (A) year and (B) the day of year (summed total for all years), where day 80 = 21 March and 130 = 10 May

during the daytime or at night, so we tested these interactions as well. These hypotheses are based largely on observations made by staff during the last 15 years.

Preliminary results suggest that the probability of smolts arriving earlier at East Stoke was elevated following warm winters, and when there were larger positive daily changes in water temperature and discharge during the smolt run. Early migrants were generally large individuals and from sites lower in the catchment. Likewise, later migrants were more likely to migrate in schools, but with schooling behaviour also more likely to occur during daylight than at night. Relative changes in daily water temperature were most important during the early and late run. Relative changes in daily discharge were most influential for the late run, when even relatively small changes in discharge had a strong influence on migration. Further statistical modelling will tease out the nuances of these hypotheses and observations.

Biological and environmental variables are important for the phenology of smolt migrations, and their influence can alter throughout the run. With climate change, predictions of annually increasing river temperatures, more frequent and intense discharge events, and associated shifts to earlier migration, these results imply that such changes in climate are likely to have substantial consequences on the future success of smolt migrations and thereby on future numbers of returning adult spawners.

KEY FINDINGS

- Increases in water temperature and discharge encourage smolts to migrate past our facility at East Stoke.
- Large smolts migrate earlier than small smolts, usually in isolation and not in a school.
- Observations suggest that schooling behaviour changed during the smolt run.

Olivia Simmons

ACKNOWLEDGEMENTS

We would like to thank John Davy-Bowker for access to the River Lab long-term monitoring project temperature data. This study is part of the SAMARCH project, and the studentship was part-funded by Bournemouth University.

Low summer discharge and salmonid ecosystems

We collected samples to look at macroinvertebrate prey availability for salmonids before, during and after discharge reduction. © GWCT

BACKGROUND

Increased abstraction and climate change will likely reduce summer flow in southern chalk streams in the future. The resultant change in discharge is considered one of the biggest future threats to chalk stream ecosystems.

The chalk streams of England are predominantly groundwater fed and consequently have a high base-flow index. Increasing water demand and resulting abstraction from the groundwater aquifers, coupled with reduced recharge of aquifers as a result of projected climate change, are among the biggest threats to chalk stream ecosystems. Despite this, the ecological implications of the potential changes in river discharge have received limited attention at river level. This PhD research used a stream-scale, discharge manipulation experiment in three chalk streams within the River Itchen catchment (Hampshire), where sluice gates at the top of each stream enabled complete control of discharge, to investigate the ecosystem-level response to simulated drought (reduced summer discharge). Experimental summer discharge reductions of 50% and 90% were selected based on long-term records of summer discharge (1975-2018) on the River Itchen and River Test, and implemented on each of the three streams over three consecutive years using a temporal block design (see Table 1).

Physical characteristics, basal resources (detritus and benthic algae) and macroinvertebrates in the streams were monitored, as well as the diet, habitat use, growth, movement and population size of the salmonids present. Sampling occurred before, during and after a 30-day long reduction in discharge each summer. Changes in the physical habitat were quantified by repeated recordings of water depth, velocity, wetted width and temperature, and samples of basal resources were taken. The response of macroinvertebrates and prey availability for salmonids was determined by collect-

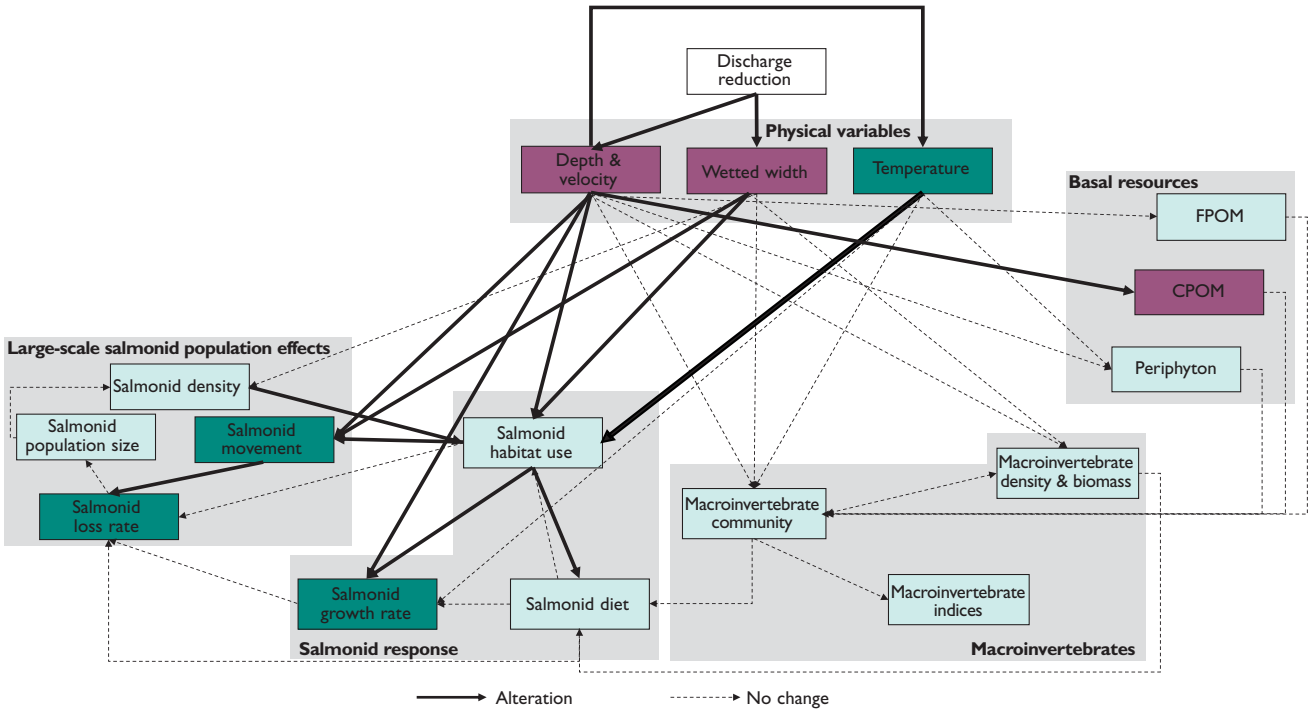
TABLE 1

Study design, showing distribution of treatments (% reduction in discharge) in the study streams over three years

Stream	Year 2015	2016	2017
Fallodon	Control	90%	50%
Blackbridge	50%	Control	90%
Brandy	90%	50%	Control

ACKNOWLEDGEMENTS

Jessica Picken successfully defended this PhD, funded by Queen Mary University of London, Cefas and GWCT, in 2020.



ing Surber and drift-net samples. Salmonid numbers and population age structure were monitored using electric-fishing and we quantified salmonid diet by analysing stomach contents collected by non-destructive stomach flushing a subsample of the electric-fished individuals. We monitored salmonid movements using Passive Integrated Transponder (PIT) tag technology.

Figure 1 represents the hypothesised and realised effects of reduced discharge on the salmonid ecosystem. Despite substantial reductions in water depth, velocity and wetted width, and an increase in mean and variation of water temperature, there were limited changes in basal resources and no effect on macroinvertebrate density resulting from the discharge reduction. Reduced discharge resulted in a significant change in macroinvertebrate community composition, but the size of the effect was small in comparison with the variation between sampling occasions (seasonal response). In addition to a limited response by invertebrates, salmonids displayed high dietary plasticity. For example, 0+ trout consumed larger prey items, primarily *Gammarus*, within the discharge reduction treatments then within the control.

Site loyalty decreased for salmon, 0+ and ≥2+ trout during the 90% discharge reduction. Older (≥2+) trout were more likely to move out of the affected area during a 90% discharge reduction with 31% of tagged individuals moving out of the area affected by 90% discharge reduction compared with 2% leaving the control area, which corresponded with reduced site loyalty. Salmon were the only species to move back into the study area after the reinstatement of pre-manipulation discharge, potentially due to reduced competition by older (≥2+) trout.

There were no lasting effects of discharge reduction on site loyalty, which indicates that these salmonids were resilient to reduced discharge conditions. Yearling (1+) trout adopted a 'sit it out' strategy during reduced discharge conditions. Adopting this strategy increased growth rate and allowed for the expansion of area used once discharge was reinstated to pre-manipulation levels. There were no effects of discharge reduction on population size, although there was a slight (but not significant) effect on salmonid population density after the streams had experienced a 90% discharge reduction. This research highlights that, despite a marked response in the recorded physical characteristics of the streams, macroinvertebrates and salmonids within these chalk streams display a remarkable resistance/resilience to short-term summer discharge reduction. This suggests that they are highly adaptable species and during short-term summer discharge reduction it may be better for river managers not to intervene, even under severe discharge reductions. However, the discharge reductions were limited to 30 days and hence this study does not inform on the effect of prolonged or increased frequency of drought periods.

Figure 1

Effects of experimental discharge reduction on salmonid ecosystems. The links are based on hypothesised effects and solid lines indicate confirmed effects. Coloured boxes indicate increase (green), decrease (purple) and no-directional change (pale green) as a result of experimental discharge reduction. FPOM: fine particulate matter; CPOM: coarse particulate matter

KEY FINDINGS

- A 30-day experimental discharge reduction in three streams within the River Itchen catchment significantly impacted depth, velocity and wetted width of the streams.
- Despite changing the physical characteristics of the streams, we observed limited impact on detritus and algae, macroinvertebrates and the fish community composition.
- Fish behaviour was impacted by discharge reduction with site loyalty reduced for many groups and evidence for older trout leaving the affected streams during discharge reduction.

Jess Picken
Rasmus Lauridsen

Ecological effects of releasing for shooting

There is considerable scope to reduce the negative effects of pheasant releasing and enhance positive ones by adhering to sustainable releasing practices.
© Peter Thompson

BACKGROUND

Releasing pheasants and red-legged partridges for shooting has steadily increased over the last six and four decades respectively. Today, around 42 million pheasants and 11 million partridges are normally released each year in late summer (not in 2020). Pheasants are released into large woodland-based open-topped pens and partridges usually into smaller, initially closed, pens on farmland. The basic aim of their management in and around release sites is to keep them healthy, protect them from predators and provide attractive habitat that holds birds to facilitate driving and shooting during the winter.

Released gamebirds and their management have a range of potential effects on habitats and other wildlife, many of which have been looked at scientifically by the GWCT and others. In 2020, we systematically accessed and reviewed this literature and published a paper in the scientific journal *Wildlife Biology*. This article provides an overview of its main findings (see page 66). In the paper, we used the literature to define relevant topics which, in turn, were used to produce the summary synthesis illustrated in Figure 1.

In general, negative effects are caused by the birds themselves while positive effects are usually a consequence of management activities. Some of the negative effects, such as damage to woodland plants or insects, are spatially confined (eg. at the release site) while others, in particular disease issues and the effect of releasing on generalist predators, may occur at a landscape scale.

Many of the positive effects of woodland planting or woodland management, hedge management and game crops occur at the scale of a whole woodland, estate or farm. Woodlands are the most widespread semi-natural habitat in lowland Britain. The review identifies a range of benefits of habitat management for pheasants in and around woodlands which arguably outweigh the negative impacts, which mainly occur at release points.

Some negative effects have relatively straightforward management solutions. In particular, most local effects reduce with lower densities of birds at release sites. There is also scope for shoots to identify sensitive sites and avoid conflicts with, for example, reptile colonies or woodland areas with valuable ground vegetation. GWCT radio-tracking work at many sites over the last 30 years indicates that at least 90% of surviving pheasants and partridges remain well within one kilometre of the release point even on very large shoots where birds can move between different release pen and game crop areas. Some positive management activities, such as game crop plantings or predator control, are more effectively implemented at larger releases.

Overall, the work suggests that there is an approximate balance of positive, neutral and negative effects of releasing. Another finding from the review is that more work is needed. For example, the effect of releases on predator abundance has not been properly explored and there will be other specific conflicts between gamebirds, other animals and plants. A key aim of future GWCT research in this area is to look at areas where gains can be made and to encourage practices that enhance the benefits, reduce the negatives and hence ensure a net overall gain in biodiversity.

Using this information in a programme of widespread engagement with best practice, we expect to be able to point to an overall positive ecological effect of releasing in the future. Negative effects will, however, remain. When assessing these it is

Figure 1

Twenty-five ecological consequences of gamebird releasing for shooting as identified by the scientific literature in the reviews. There are 10 potentially positive, three neutral and 12 potentially negative effects that occur at one of three spatial scales as indicated. Neutral effects are where negative effects were suggested but not found or no longer occur. Patch scale is whole woodland or farm. Density component shown means there is evidence that negative effects appear or get larger as the numbers released goes up

- Positive
- Neutral
- Negative

worth remembering that there is no such thing as an economic land-use activity that does not have negative ecological consequences. In practice, where shoots over-stock release pens located in sensitive areas and do not provide good habitat elsewhere, negative effects will become more prominent. Where shoots follow best practice guidelines on release pens and sites, plant game crops and manage woodland edges, the positives will outweigh the negatives.

Negative effects are caused by the birds themselves, while positive effects are usually a consequence of management activities. © Peter Thompson

KEY FINDINGS

- Releasing pheasants and red-legged partridges has a range of ecological consequences. Many have been studied by the GWCT and others over recent decades. In 2020 the subject became very topical and several scientific reviews were undertaken, including a peer-reviewed paper by GWCT which condensed and summarised the evidence. We found 10 distinct positive effects of releasing, many of which were caused by management for releases, 12 negative effects, most of which were caused by the birds themselves, and three neutral effects. There is considerable scope to reduce negative effects and enhance positive ones by adhering to sustainable releasing practices.

Rufus Sage

Feeders for gamebirds have been shown to be used by a wide range of birds and some mammal species and can have benefits for bird populations. © Francis Buner/GWCT

Review key findings

- Released pheasants affect soil and ground vegetation inside release pens and in other places where they congregate. Away from these places there is no evidence of an effect. Bryophytes and lichens growing on trees in especially sensitive woodlands may be affected away from release sites because of atmospheric enrichment or changes in microclimate.

- Outside woodlands, when pheasants congregate at feed points or in game crops on farmland, the soil and flora might be changed but on improved grasslands or cultivated ground this is of little consequence. Near to release points in woodland or on farmland, the base of hedges can be degraded by congregations of released birds. Hedgerows on farmland are improved and retained for game management purposes.

- Several studies have found little evidence that released pheasants and partridges have a significant effect on insect communities away from release sites. Pheasants and partridges become very thinly distributed away from release pens and game crops. Within release pens, where pheasant densities are at their highest, there is evidence of a direct effect on some insect groups. Reptile colonies near release pens might be affected but there is no direct evidence.

- Supplementary feeding of released gamebirds is usually undertaken using feeders designed to prevent grain accumulating on the ground. These feeders have been shown to be used by a wide range of birds and some mammal species and can have benefits for bird populations. Where unwanted mammals such as rats are a problem, there are guidelines on how to tackle the issue.

- Game crops are widely planted on release-based shoots and they attract a wide range of farmland and woodland-edge bird species. Larger plots have more benefit to birds and better seed-bearing crop types include kale or quinoa. There is also evidence that game crops can play a significant role in maintaining breeding farmland birds in improved grasslands.

- There is evidence that some parasites and diseases acquired by released gamebirds are also found in other wildlife, especially birds. It may be that released gamebirds cause local infections in other wildlife; there is some evidence to suggest this, but more research is required.

The evidence reviewed suggests negative effects of releases on woodland ground floras and changes to invertebrate communities occur at release pens and feed points but not elsewhere. © GWCT

Game crops are widely planted on release-based shoots and they attract a wide range of farmland and woodland-edge bird species. © Peter Thompson

- Wildlife abundance can be negatively affected by predators and there is clear evidence that the abundance of many wild birds can be suppressed by, for example, foxes and crows. Releasing shoots that undertake effective predator control will benefit these species.

- Illegal killing of raptors was relatively common in past decades, as a hangover from the intensive game management systems of the early 20th century. More recently sporadic cases continue to be identified alongside releasing, but evidence in this area suggests that it is declining.

- How gamebird releases influence the local abundance of generalist predators is a key issue for many conservationists and researchers. There is some research to suggest that predators are attracted to release sites, but there is no evidence that they then cause problems for other wildlife.

A good shrub layer in a well-managed woodland for pheasants. © Peter Thompson

Breeding woodcock outcomes

To find out more about the roding behaviour of woodcock at dusk (above) we caught and tagged them with GPS tags (see below far right).
© Roger Tidman (rspb-images.com)/Freya Stacey

BACKGROUND

In 2013, I began a part-time PhD co-supervised by the GWCT and the University of Nottingham. My thesis focused on the status, ecology and display behaviour of breeding woodcock in Britain. This involved analysing data from the 2013 GWCT/BTO Breeding Woodcock Survey and tracking the roding displays of male woodcock using GPS loggers. I submitted my thesis in 2019 and graduated in absentia in 2020.

My PhD began in 2013 to coincide with the GWCT/BTO Breeding Woodcock Survey, the analysis of which was a major part of my thesis. The survey revealed a decline in the British woodcock population from an estimated 78,346 males (95% confidence interval: 61,717-96,493) in 2003, to 55,241 males (95% CI 41,806-69,004) by 2013. Regional declines have exaggerated the British population's uneven distribution with more than two-fifths of the population breeding in northern Scotland in 2013. Widespread losses in the English Midlands and Wales have left a sizeable but isolated 'southern stronghold' centred on Surrey, Sussex and Hampshire, that supports around 11.6% of the national population estimate.

The method used to gather these data relies on counts of passes of 'roding' woodcock: males performing display flights at dusk. There are still several aspects of the roding display that are poorly understood, and the second main strand of my PhD study was to improve our knowledge of this behaviour. To do this, I caught a sample of male woodcock between 2015 and 2017 and tagged them with small GPS logging devices that recorded their movements during the display period (see *Review of 2018* for more about GPS tags).

GPS loggers revealed that roding flights averaged 13.3km in length per evening and, on average, covered an area of 111 hectares (ha) (see Figure 1). Two of the 16 males for which roding movements were recorded covered daily roding areas greater than 200ha. All tagged males included multiple woodland clearings within their roding areas, and those with the largest ranges crossed to neighbouring woods using connecting features such as shelter belts and small copses.

Figure 1

A male woodcock displaying over three consecutive days in June. Each colour represents a separate 90-minute roding period, beginning 15 minutes before sunset. Coloured circles showing the daytime roost location at which the bird started. The blue star shows the site at which we caught and tagged the woodcock five days prior to recording. Mixed woodlands surround a grassy colliery spoil site, with farmland and urban areas beyond

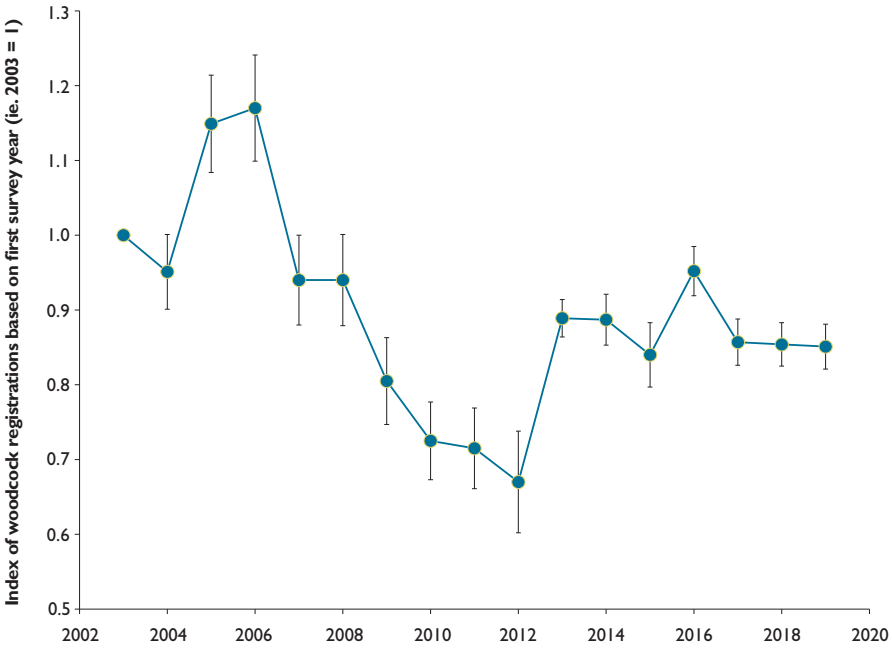


Figure 2

Annual variation in the number of woodcock registrations recorded at 'repeat' survey sites. A subsample of surveyors continued to visit their Breeding Woodcock Survey sites following the national surveys of 2003 and 2013. A much larger sample of repeat sites have been visited since 2013, hence the lower degree of annual variation and smaller error bars thereafter. Values are provided as an index based on the first year (2003=1)

Several of my findings have practical implications for our woodcock survey methods. We already knew that woodcock are less likely to rode in strong wind and rain, but the activity of tagged males showed that even subtle variations in weather can influence how long each individual spends roding. This included the conditions experienced during the preceding fortnight, with protracted dry spells resulting in a reduction in display behaviour. This may mean that variation in woodcock survey results could reflect woodcock activity as well as woodcock numbers.

Some of the measures required to reduce this error are already in place. The national woodcock surveys of 2003 and 2013 have been supplemented by a smaller sample of annual counts that help us capture yearly fluctuations according to weather and allow us to visualise more general trends. The breeding woodcock survey methods stipulate that three visits should be made to each survey site, separated by at least a week, and taking the maximum count from the three visits provides some buffer against counts made in sub-optimal conditions.

We hope that a third national survey will be conducted in 2023. Annual monitoring conducted since 2013 suggests that numbers may have stabilised, but there are few signs of a recovery yet (see Figure 2). A full-scale national survey, based on counts at a randomly selected sample of grid squares, provides a more representative assessment of population status and is the best way of providing an accurate estimate of British population size. The improved understanding of roding behaviour granted by our GPS tracking study will aid the design and interpretation of future surveys.

KEY FINDINGS

- Britain's breeding woodcock population declined by 29% between 2003 and 2013.
- Woodcock are now largely restricted to the most heavily-wooded areas of Britain, despite previously having occurred more widely.
- GPS loggers have contributed new information to our understanding of 'roding', the display performed by males that underpins our current survey method.
- This provides us with more in-depth background knowledge ahead of a repeat of the national survey proposed for 2023.

Chris Heward

ACKNOWLEDGEMENTS

Thanks to my supervisors, Dr Andrew Hoodless and Professor Andrew MacColl (University of Nottingham), to all the volunteers and landowners involved in the 2003 and 2013 GWCT/BTO Breeding Woodcock Surveys, and to Dr Greg Conway (BTO) and Dr Nicholas Aebischer for help with data collation and analysis. I'm grateful to Dr Andrew Lowe, Ann Ward and other members of Birklands Ringing Group for help catching woodcock, and the landowners that permitted my tracking work (including Forestry England). Thank you to all the funders, especially The de Laszlo Foundation.

ACKNOWLEDGEMENTS

We are grateful to our students Elizabeth Ogilvie and Max Wright for monitoring waders and downloading lapwing data at GWSDF under testing circumstances in 2020, and to Lucy Capstick, Pete Potts and Andy Page for assistance with tagging. We thank EU LIFE+ for part-funding the tags used in the Avon Valley and Hampshire Ornithological Society for funding curlew tags deployed in the New Forest. We are grateful to everyone who donated to our wader tracking appeal.

Wandering waders – using tracking technology

Wetland ecologist Lizzie Grayshon deploying a base station in the Avon Valley and looking for tagged lapwings. © GWCT

Waders are in serious decline throughout most of Europe owing to low breeding success. Land use change and increasing rates of predation are important drivers in Britain and Ireland, and we have conducted research in the uplands and lowlands demonstrating how these factors can be effectively addressed. Tracking of individuals helps us complete the picture of species' requirements and assess the scale of management needed across the landscape for sustainable populations. This is illustrated by our ongoing work on connections between breeding and wintering sites of lapwing and breeding season habitat use by curlew.

Case study 1: Lapwing migration

Information from bird ringing suggests that lapwings breeding in northern England and Scotland tend to move south and west to winter in Ireland, whereas lapwings breeding in southern England are more likely to winter in France and Iberia. Movements are thought to be linked to colder weather, though evidence for this is limited. Lapwings face different pressures away from the breeding grounds and depending on where they spend the winter, so it is important that we gain a better understanding of the resources that they require when moving between breeding and wintering grounds, the pressures at wintering sites and where conservation efforts could be improved.

Figure 1

Movements of an adult male lapwing, tagged in the Avon Valley, between May 2019 and February 2020

This bird bred on arable fields inside our study area (1), left on 29 May but remained on wet grassland in the Avon Valley until 16 June. It then flew 30km to near Stockbridge (2) until 16 October, when it was recorded at another LIFE Waders for Real hotspot site in the Avon Valley (3). There it used the wet grassland, adjacent arable land and visited outdoor pig fields (3). After 10 days, it moved to Southampton Water via Christchurch Harbour, utilising pasture at Dibden and adjacent coastal sites (4). It left the estuary 26 January 2020 for an arable area near Warminster (5), moving on 6 February to another arable area (6), moving back towards the Avon Valley a couple of weeks later and returning to the same arable field to breed where it was tagged (7). This bird used wet grassland, arable farmland and coastal designated areas after leaving its breeding site (orange cross), providing the first evidence for a link between breeding sites in the Avon Valley and designated coastal sites for wintering and the need to consider habitats used during both periods for effective wader conservation. Map data copyrighted ESRI 2021

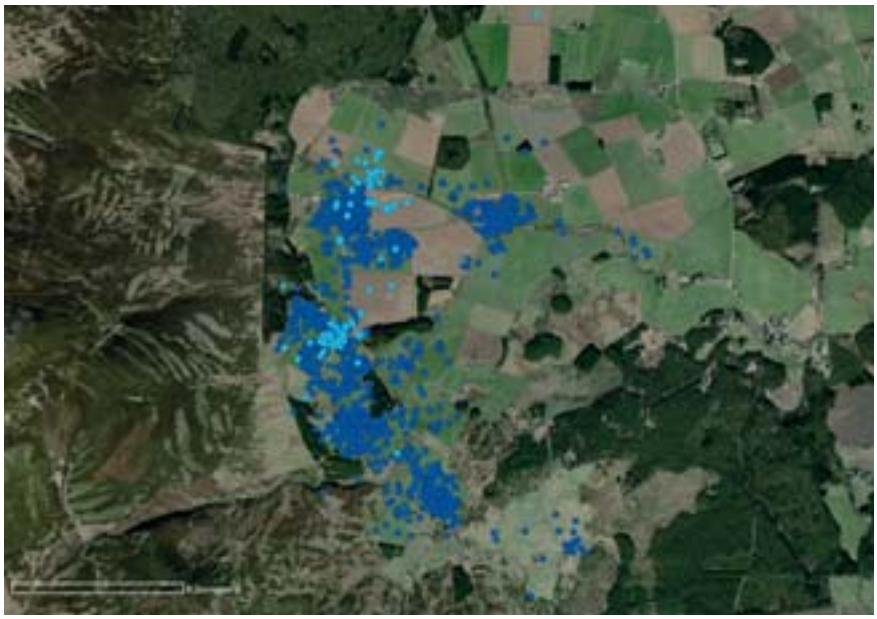


Figure 2

Over 1,500 positions collected from a breeding male curlew at GWSDF between late May and July 2018

This period encompasses the last days of the bird's nesting period (light blue dots) then until the end of brood rearing (dark blue). The bird primarily used areas of pastoral land within the farm, with very few positions on the adjacent moorland.
Map data copyrighted ESRI 2021

In 2019, 21 breeding adult lapwings were fitted with GPS tags at the GWCT's Game & Wildlife Scottish Demonstration Farm (GWSDF), in the Avon Valley and on the South Downs in Sussex. Unlike our woodcock tags, these devices do not transmit GPS positions live, but transmit the data to a remote base station when they return to breeding sites the following season. These devices record their position every 12 hours and will do so for the next two to three years.

Plans for gathering these data in 2020 had to change, but with support from gamekeepers, farmers and students on our sites and the kind loan of further equipment by Natural England, we were able to deploy base-stations across all sites. Amazingly, in a year with very limited field access, overwinter and migration data were gathered from 11 of the tagged lapwings across all three sites, representing over 6,000 locations. The routes taken by each lapwing varied greatly. Birds from GWSDF wintered in other areas of Scotland, Ireland and Northern Ireland. The single bird downloaded from the Avon Valley wintered locally, suggesting that it is important to have a local network of areas designated for breeding and wintering waders (see Figure 1). Further birds were to be tagged in 2020, but owing to Covid-19 this project will continue in 2021.

Case study 2: Curlew breeding ecology

Owing to their rapid decline and low breeding success, curlews are, arguably, the wader of highest conservation priority in the UK. The GWCT plays an important part in shaping curlew conservation, through research, education and conservation interventions. Restoring curlew breeding success is crucial to curlew recovery and although there are measures that we can implement now, there are still many aspects of curlew ecology that we need to understand better. GPS tracking is a key method in our research.

The main emphasis of our curlew work is the activity of birds during the breeding season. Before 2020, eight adult breeding curlews had been fitted with a GPS-tag and are providing important insights into curlew ecology. This work currently focuses on curlews breeding on GWSDF and in the New Forest National Park. Birds breeding in the latter regularly use feeding sites within our Avon Valley wader recovery area. The tags provide hourly locations for two to three years, enabling us to identify key adult feeding areas and monitor brood movements during chick-rearing (see Figure 2). The birds at GWSDF have so far shown that they move only short distances to forage when not incubating, meaning that off-duty birds are always close enough to help with nest defence. This contrasts with some studies that show large movements between nests and foraging habitat, highlighting the excellent habitat at GWSDF.

In the coming years, GPS-tracking data will be combined with field data on invertebrate abundance and habitat characteristics to reveal the drivers of curlew habitat use. Conclusions from this work will feed directly into the work of the GWCT advisory team on curlew conservation and management at study sites.

BACKGROUND

Wildlife tracking devices can provide detailed data on the movements of animals over extended periods, often providing information that would be impossible to gather without this technology. A host of questions can be explored, from international migrations to the fine-scale use of specific habitats within a territory. Our novel Woodcock Watch project utilised satellite tracking to reveal fascinating and otherwise unknown insights on the migration routes and breeding sites of our wintering woodcock. We are now using GPS technology to examine questions concerning habitat use, winter movements and survival of several wader and duck species.

KEY FINDINGS

- Great progress was made in 2020 with our lapwing project with 11 GPS-tracked birds providing year-round movement data.
- Lapwings fitted with tags at GWSDF wintered in Scotland and Ireland, while a bird tagged in the Avon Valley stayed local.
- Our tracked curlew at GWSDF stayed mostly on and around the farm throughout the breeding season, suggesting the required resources were all within easy reach.

Ryan Burrell
Lizzie Grayshon
Marlies Nicolai
Dave Parish
Andrew Hoodless

Partridge & Biometrics

JOIN THE PCS

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

Partridge Count Scheme

Effective partridge-friendly management helps support partridge populations and advances recovery.
© Kalina Georgieva

KEY FINDINGS

- More than 6,600 grey partridge pairs were recorded in 2020.
- National productivity, recorded as Young-to-Old ratio, increased by 24% to 2.6 young birds per adult.
- National autumn density averaged 20.2 birds per 100ha, an increase of 7% from 2019.

Neville Kingdon
Julie Ewald

The results of the 2020 spring and autumn grey partridge counts from the PCS are summarised in Table 1. A total of 530 spring counts were received, 6% (31) fewer counts than for spring 2019. Although disappointing it is not wholly unexpected, with delays in counting due to the wet start to the year, followed by the Covid-19 lockdown that prevented access to count areas for those not living on-site.

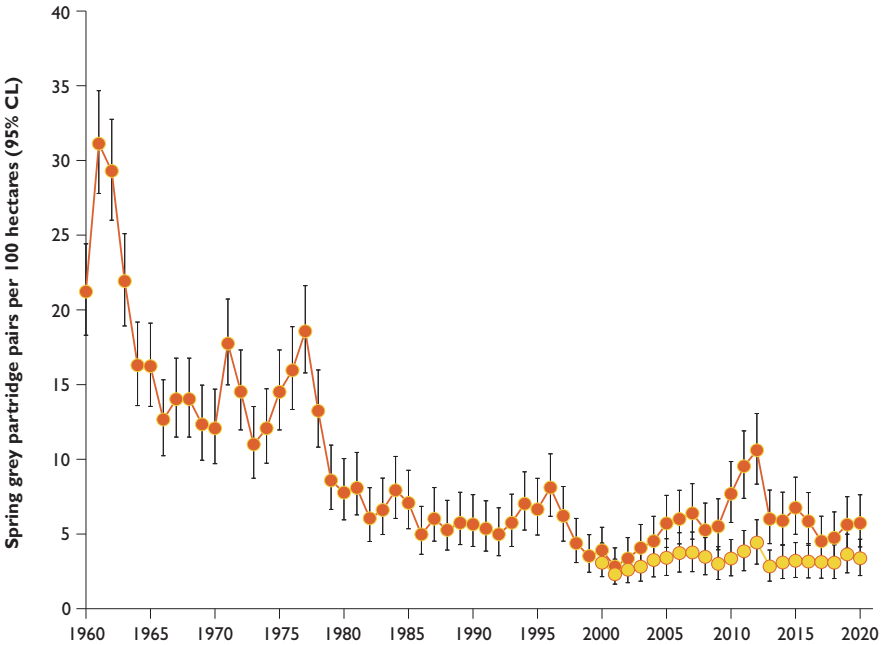
Despite this, PCS participants were still able to count 6,654 grey partridge pairs over an area of 171,900 hectares (ha) (424,800 acres). This was a 10% decline from the 7,406 pairs recorded in 2019, due mainly to the decline in the area counted. Average pair density across all PCS sites nationally remained stable at four pairs per 100ha (250 acres), but eastern England, Midlands and Scotland recorded regional declines of 13-19% from their 2019 densities.

The long-term trend in spring pair density on long-term sites (those participating before 1999) remained stable at an average of 5.7 pairs per 100ha (see Figure 1). This analysis adjusted for site turnover and missing counts, as not all sites managed to return counts in every year. Meanwhile, 'new' sites recorded a 7% decline in pair density, with an average of 3.4 pairs per 100ha.

In autumn 2020, 500 counts were received, an encouraging increase from the 476 of 2019 (see Table 1), especially as it is the first rise in autumn counts returned

Figure 1

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



ACKNOWLEDGEMENTS

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

TABLE 1

Grey partridge counts

Densities of grey partridge pairs in spring and autumn 2019 and 2020, 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	*2019*	**2020**	*2019*	**2020**	**Change (%)**	*2019*	**2020**	*2019*	**2020**	*2019*	**2020**	**Change (%)**
South	81	79	1.5	2.4	60	74	84	1.8	2.3	8.8	12.5	42
East	175	151	5.3	5.2	-2	129	145	2.1	2.4	25.5	19.9	-22
Midlands	103	92	2.6	3.1	19	87	84	1.8	2.2	11.7	14.7	26
Wales	2	2	1.5	1.5	0	2	2	0	1.5	0	7.3	730*
North	123	127	6.0	5.1	-15	113	117	2.2	3.0	28.4	34.0	20
Scotland	76	79	2.7	2.4	-11	70	68	2.2	2.9	10.9	14.2	30
N Ireland	1	0	9.9	0	-	1	0	0.8	-	22.0	-	-
Overall	**561**	**530**	**4.1**	**4.0**	**-2**	**476**	**500**	**2.1**	**2.6**	**18.8**	**20.2**	**7**

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

for over a decade and looks to have been due to the expectations of it being a good partridge year. Indeed, the number of grey partridges recorded nationally was 26,163, a 36% increase (over 6,900 birds) from 2019. This was from a total area counted covering 161,600ha, 5,200ha more than in 2019. Eastern England continued to report the greatest share of national grey partridges, with 11,889 birds recorded (45%), and northern England saw 6,594 birds (25%). Sadly, with the retirement of our one remaining participant site in Northern Ireland, that was re-establishing a sustainable population of wild grey partridges, we no longer have insight into partridge numbers from across the Irish Sea.

UK productivity, measured by the average Young-to-Old ratio (YtO), increased from 2.1 in 2019 to 2.6 in 2020 (+24%); this was one of the highest national YtO ratios in the past 10 years. This is positive news and raises expectations of an increased potential for breeding pairs in spring 2021, although regionally Wales did not achieve the YtO threshold level of 1.6 necessary to cover adult losses into next year.

The average national autumn density was 20.2 birds per 100ha, an increase of 7% from 2019. Southern England saw a 42% increase to 12.5 birds per 100ha, but other than Wales it still remains the region recording the lowest autumn density. The Midlands and Scotland reported increases (26% and 30% respectively) each with over 14 birds per 100ha. Grey partridge densities in northern England also saw a large increase (20%) to achieve the highest regional autumn density of 34 birds per 100ha. Although eastern England recorded a density decline (-22%) it still recorded the second-highest regional density with 19.9 birds per 100ha.

The 2020 partridge counts witnessed the full gamut of conditions and consequences of the spring and summer weather. Many sites benefited from local conditions and their habitats provided them with one of their best years for grey partridge chicks in a long while. But for others the conditions were just too much, and they lost all their broods, the combined effect of poor crop and habitat germination, lack of chick-food insects and even flooding from heavy downpours onto parched ground. Retaining as many birds as possible through to spring, and ensuring partridge-friendly management for 2021, is the best way to address this.

The Partridge Count Scheme is our primary method of collecting information about grey partridge numbers across the country. It relies on the continued interest and enthusiasm of farmers, gamekeepers and land managers to count their ground. We encourage all readers who have wild grey partridges on their land to join. When it comes to grey partridge conservation and recovery – 'Every one Counts'. Go to **gwct.org.uk/pcs** to find out more.

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:

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

www.gwct.org.uk/pcs.

The Rotherfield Demonstration Project

The amount of grey-partridge-friendly habitat increased from 10.4 hectares (5%) to 43.3 hectares (20%) in the 217ha project core area. © Francis Buner/GWCT

BACKGROUND

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

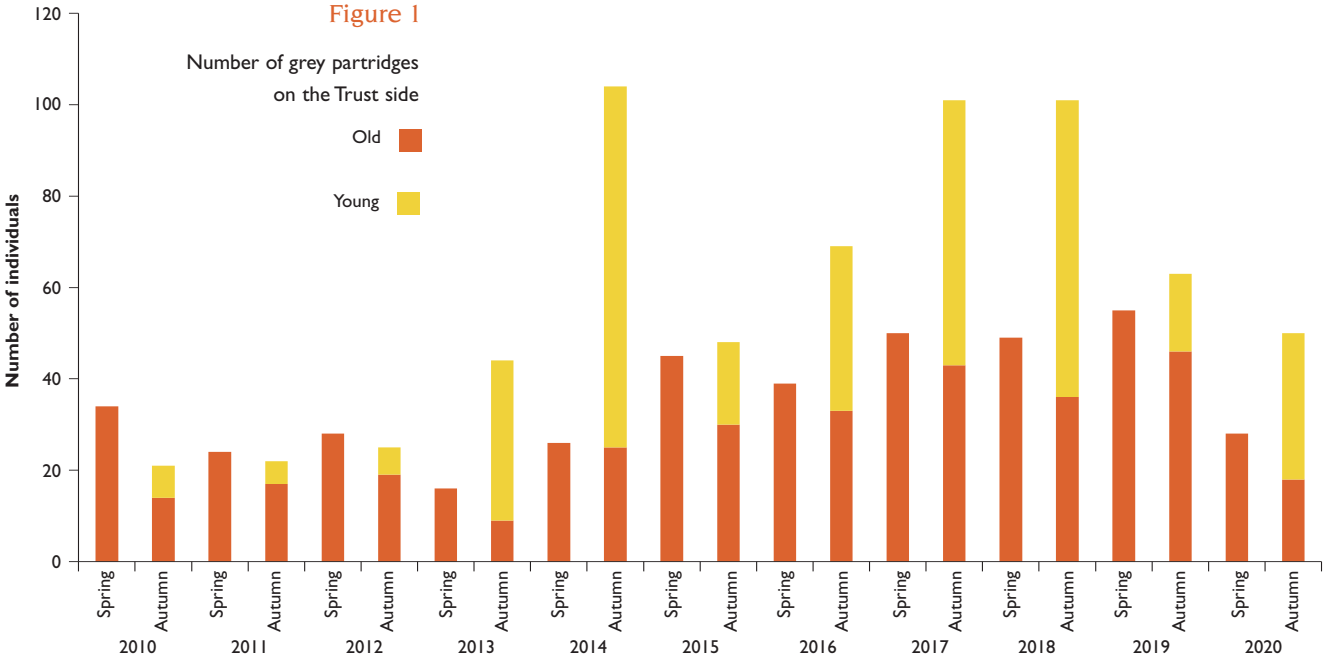
The Rotherfield demonstration project in east Hampshire was launched in 2010 to demonstrate how to recover grey partridges in an area where they disappeared in the early 1990s, and to showcase how grey partridge conservation management benefits farmland wildlife more generally. The Rotherfield Estate invited the Trust's own gamekeeper, Malcolm Brockless, to manage an area of 700 hectares (ha) (Trust side) to build a wild-bird shoot. GWCT researchers provided habitat improvement advice to the farm and managed the wildlife monitoring protocols agreed at the beginning of the project. Between 2011 and 2020, 600 wing-tagged cock pheasants were released annually, demonstrating a workable way to provide moderate but high-quality shooting during the grey partridge recovery period when any partridge shooting should be avoided.

In February 2020, Malcolm Brockless retired from the GWCT handing back predation and shoot management to the Rotherfield Estate, bringing a natural end to the project. Nevertheless, the long-term wildlife monitoring protocols remain in place until 2023 as part of the PARTRIDGE project, alongside habitat management advice where required (see page 76).

During the 11-year period, the amount of high-quality grey-partridge-friendly habitat within the 217ha core grey partridge recovery area, mostly part of an HLS Agri-Environment Scheme (wild bird seed mixes, cultivated uncropped margins, beetle banks, floristically enhanced grass margins and field corners, pollen and nectar mixes and extended overwintered stubbles) increased from 10.4ha (5%) to 43.3ha (20%). During the same period, the cropping plan was diversified, and fields made smaller, resulting in a mixed arable crop pattern. Meanwhile, gamekeeping management was intensified, focusing on predation management during the breeding season from early May until mid-July and supplementary winter feeding from September to the end of April, with an average of 24 tonnes of wheat grain fed per winter.

On the Trust side, the number of grey partridge pairs remained unchanged (17 pairs in 2010 vs 16 pairs in 2020), with a peak of 27 pairs in 2019 (see Figure 1).

Figure 1



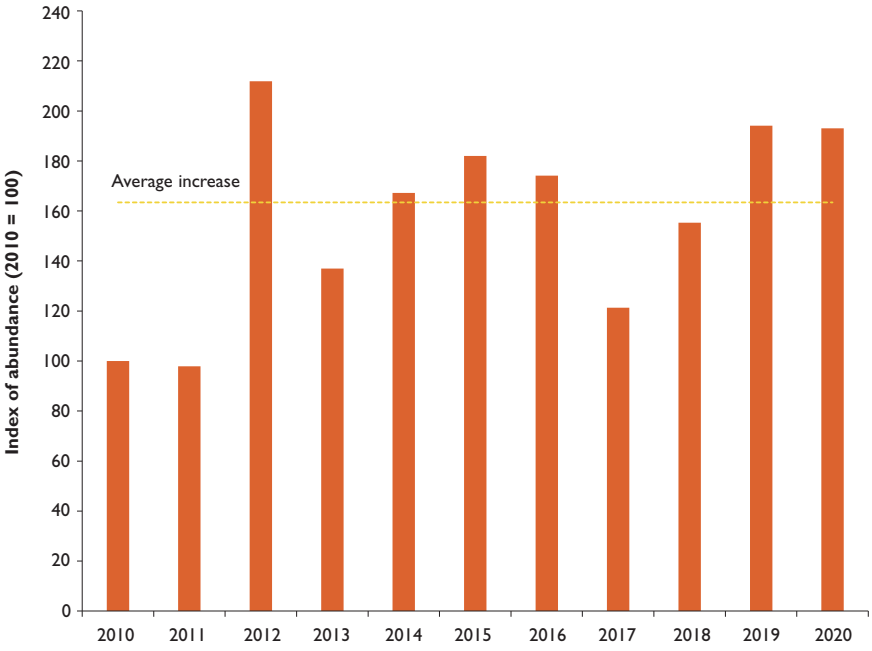


Figure 2

Abundance index of farmland songbirds of conservation concern during the breeding season (April-June) on the Trust side of Rotherfield Estate, based on counts along a 10-km transect. The index of the baseline year 2010 is set at 100. The index of 193 in 2020, for example, means that numbers have increased by 93% compared with the baseline year

However, in 2010 almost all birds were released (17 pairs produced only seven young; a young-to-old-ratio of 0.5), whereas from 2014 onwards all were wild. With 36 young recorded in autumn 2020 (young-to-old ratio of 1.8), the ratio was slightly higher than the 11-year average of 1.4. The peak year for productivity was 2014 with 79 young produced by 13 pairs (young-to-old-ratio of 3.2). The autumn stock of the re-established wild grey partridge population (no release of reared or wild birds since 2014, see *Review of 2014*) was 56 in 2020, with the highest autumn numbers of around 100 birds recorded in 2014, 2017 and 2018. Clearly, the disastrous breeding season of 2019 (27 spring pairs produced only 17 young, resulting in an autumn young-to-old ratio of 0.4) affected the situation in 2020.

In 2020, the abundance of red- and amber-listed farmland songbirds recorded during the breeding season (yellowhammer, skylark, linnet, dunnock, song thrush, bullfinch and tree pipit) was similar to 2019, and 93% higher than in 2010 in the project area (see Figure 2), whereas nationally they increased by only 1% during almost the same 10-year period (see BTO BirdTrends for England). Similarly, brown hare numbers increased 1.8-fold, from an average of 23.5 hares/100ha in 2017, to 42.0 hares/100ha in 2020 (11.2 fewer per 100ha than in 2019). Monitoring of hares began only with the start of the PARTRIDGE project (see page 77).

Between 2011 and 2020, the number of shoot days per season averaged 12 (six driven days including walk-stand days for 16 guns, and six mixed walked-up days including spaniel and pointer trial days), with an average annual mixed bag of 382 head of feathered game (SE 38.6), of which 290 (SE 24.6) were cock pheasants. Of the 600 wing-tagged cocks that were released annually, 153 (SE 18.4) were shot per season. Hence, the known recovery rate of released cocks in the bag was 25.5% (SE 1.1), whereas the recovery rate based on the total cock bag (the way recovery is typically calculated on UK shoots because released birds remain untagged), was 47% (SE 4.5).

Young grey partridges. © Markus Jenny

KEY FINDINGS

- After 11 years at Rotherfield, and 36 working for the GWCT, Malcolm Brockless retired from his gamekeeper position handing predation management back to the Rotherfield Estate.
- In 2020, the number of grey partridge spring pairs on the Trust's demonstration area was 16 pairs, 11 fewer than in the previous year and one less than when the project started in 2010.
- On the Trust's area, the grey partridge autumn stock was 50 birds, 13 less than in 2019. During the project period, autumn numbers exceeded 100 birds three times.
- Farmland birds of conservation concern were up 93% compared with the baseline year in 2010, with an average increase of 63% since the project began.
- During the 10-year shooting period, an average of 12 shoot days were held per season, with mixed bags of 382 feathered game per season.

Francis Buner
Nicholas Aebischer

ACKNOWLEDGEMENTS

We are extremely grateful to the Rotherfield Estate, including all the farm staff, for allowing the GWCT to demonstrate how to successfully recover grey partridges from initial extirpation to an autumn stock of just over 100 wild birds on three occasions during our 11-year involvement. This has not been achieved anywhere else in Europe.

BACKGROUND

Since November 2016, the GWCT has been the lead partner of a pioneering cross-border North Sea Region Interreg programme project called PARTRIDGE that runs till 2023. Comprising 12 partner organisations from the Netherlands, Belgium, Germany, Denmark, Scotland and England, PARTRIDGE showcases how the abundance of farmland wildlife can be increased by 30% at ten 500-ha demonstration sites (two in each country, except in Denmark). In the UK, the four PARTRIDGE demonstration sites (Rotherfield and the Allerton Project in England, and Whitburgh and Balgonie in Scotland) all have GWCT involvement in partnership with the estate owners and staff.

Interreg North Sea project PARTRIDGE

The PARTRIDGE mix has been developed to benefit biodiversity overall. © Molly Crookshank/GWCT

PROJECT AIMS

- GWCT-led North Sea Region (NSR) cross-border Interreg project involving England, Scotland, the Netherlands, Belgium, Germany and Denmark.
- Demonstrate how to reverse farmland biodiversity loss at ten 500ha sites by 2023.
- Use the grey partridge as a flagship species for management plans at the demonstration sites.
- Influence agri-environment policy and showcase how to enthuse local stakeholders to conserve farmland wildlife.

Francis Buner
Fiona Torrance
Paul Stephens
Ellie Raynor

PARTRIDGE is a cross-border North Sea Interreg project that demonstrates how to reverse the ongoing Europe-wide decline of farmland wildlife using science-based management plans based on a bottom-up approach. The project is led by the GWCT in partnership with 11 other organisations from six countries. These work with more than 70 farmers organised in Farmer Clusters at 10 demonstration sites, assisted by around 40 hunters and several hundred volunteers.

The project's locally adapted management plans are tailored to the grey partridge, because existing evidence shows that partridge-friendly measures, in particular wild bird seed mixes and wild-flower blocks, benefit farmland biodiversity in general. In 2020 we published a booklet that summarises the evidence upon which our project approach is based: *Farming with Nature – promoting biodiversity across Europe through partridge conservation.* The beautifully illustrated publication includes a foreword by NFU President Minette Batters (English version), and by Fergus Ewing (Scottish Government's Cabinet Secretary for Rural Economy and Tourism (Scottish version)), followed by a brief overview of the current challenges facing farmland biodiversity across Europe. The publication then briefly describes the life cycle of the grey partridge, before delving into the habitat requirements that are key for grey partridge conservation. We then cover supplementary winter feeding and predation management, considering both lethal and non-lethal methods. Each chapter ends with an overview of which other types of farmland wildlife benefit from the partridge-tailored measures implemented. The booklet concludes by highlighting the importance of all stakeholders working together for a common goal. *Farming with Nature* is available from the GWCT online shop and is a must-read for anyone interested in how to make their farm more partridge- and wildlife-friendly. We also produced a beautiful flying partridge pin in this reporting period, with a limited few still available from the GWCT shop.

In the UK, we continued to trial our new PARTRIDGE wild bird seed mixes, developed by Oakbank and Kings Crops in collaboration with the GWCT, at Balgonie,

The Farming with Nature *booklet summarises the most relevant scientific evidence regarding grey partridge management and the biodiversity benefits associated with it. © Francis Buner/GWCT*

the Allerton Project and Rotherfield, whereas at Whitburgh the farm started to revert to the more conventional cover mixes. At Rotherfield, even more species-rich spring- and autumn-sown mixes were planted, containing more perennial flowering plants than the currently available wild bird seed mixes in the UK. The aim is to provide multi-annual cover containing varied vegetational structure, which will benefit wild game, a wide range of farmland birds and other wildlife all year round for up to 10 years. This new mix has already been put forward as one of the options potentially available in the future Agri-environment Scheme (ELM) for England.

Despite the nationwide Covid-19 restrictions that were in place in all project countries for most of 2020, we successfully continued to promote the PARTRIDGE approach more widely across the North Sea Region and Europe, notably by taking part in the EU Green Week with a virtual stand, by increasing social media and printed press output, and by holding demonstration-site farm walks, although the latter at a much-reduced number than in previous years. Our official PARTRIDGE webpage (**www.northsearegion.eu/partridge/**) has had 50,000 unique page views since the project began, more than any other Interreg North Sea Region project. Through our strategic communication activities including social media, TV and radio, conferences and symposia, we have reached an estimated five million people to date.

Farm walks across our UK and European demonstration sites continued to help us promote our bottom-up approach to a wide range of stakeholders, including two special advisors to the English Minister of State. © Francis Buner/GWCT

ACKNOWLEDGEMENTS

This project would not be possible without the help of hundreds of supporters. We thank all participating GWCT members of staff (in particular Dave Parish, Julie Ewald, Chris Stoate, John Szczur, Austin Weldon, Steve Moreby and Lucy Robertson), the PARTRIDGE co-ordinating partner organisations BirdLife NL, the Flemish Land Agency (VLM), INBO, the University of Göttingen and the Danish Hunters Association together with their local PARTRIDGE partner organisations, all the participating farmers, hunters, volunteers, NGOs and Government agencies, the Steering Committee members, and, last but not least, the NSR Interreg Secretariat in Denmark.

Grouse, snipe and hares in England and Scotland

Milder winters in recent years may have meant that fewer continental snipe overwintered in Britain. © Simonas Minkevicius

BACKGROUND

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

The Trust's National Gamebag Census (NGC) collates numbers shot or culled of a large range of game and other species, and has done so since 1961. We collect the data by mailing questionnaires to some 700 shoots each year, and treat all information received as confidential. Participation is voluntary, and we are always immensely grateful to all our contributors for sending in their returns. Over time, the accumulated bag records provide an insight into changes in underlying species abundance and shooting practices that we use to inform policymakers, advise statutory agencies and feed into statutory reports.

This article focuses on two species of upland game, red grouse and mountain hare, the latter's lowland cousin the brown hare, and the mainly upland-breeding snipe whose winter numbers are bolstered by the arrival of birds from the continent. We compare England and Scotland where appropriate. Using sites that have returned bags of a given species for at least two years, analysis converts bags to numbers per unit area to account for differences in shoot size, then summarises the year-to-year changes within sites relative to 1961, the start year. This means that 1961 has a value of 1, and subsequent bag indices measure relative change over time. For example, index values of 2 and 0.5 indicate that bag sizes doubled and halved respectively since 1961.

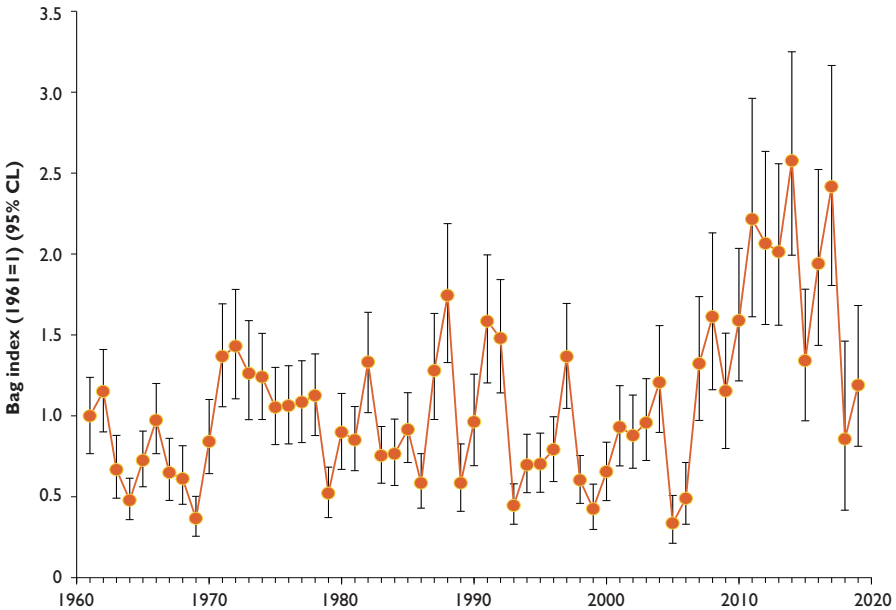
Red grouse (Figure 1, 2)

The English bag indices from 1961 to 2019 (see Figure 1) are based on returns from 152 shoots, the Scottish ones (see Figure 2) from 333 shoots. Up to 2007, bags in England displayed a 'quasi-cyclical' pattern, with alternating highs and lows over periods of four to six years, caused by the interaction between the bird and its gut parasite *Trichostrongylus tenuis*. To combat the disease, the GWCT developed medicated grit (a quartz grit coated in fat containing an anthelmintic drug) and a delivery method using grit boxes. The first

Figure 1

Red grouse index, England, from NGC bags 1961-2019

Heather beetle outbreaks are thought to have contributed to a drop in grouse bags. © GWCT



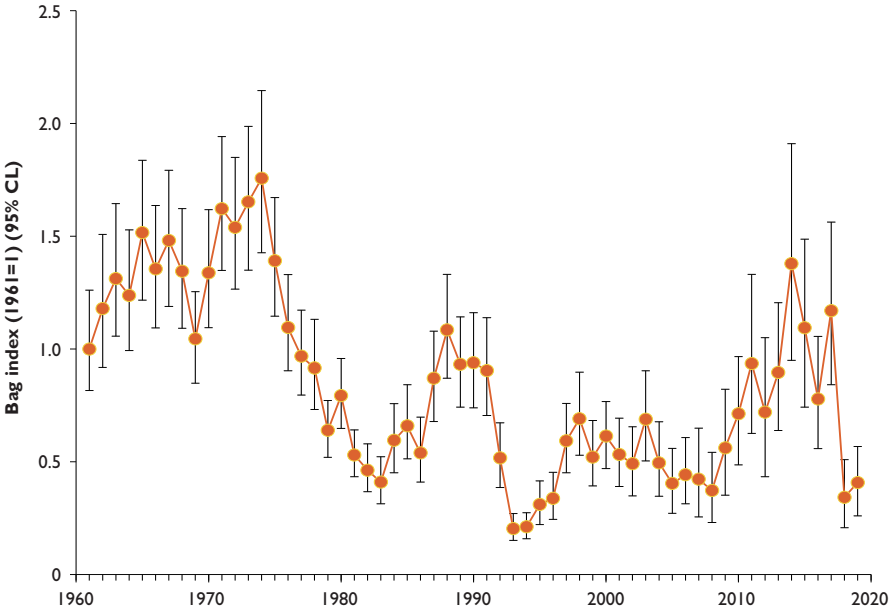


Figure 2

Red grouse index, Scotland, from NGC bags 1961-2019

version of medicated grit lost its effectiveness through weathering, but a revised formulation with a more persistent coating became available in 2007. It was rapidly adopted by grouse moor managers, resulting in record bags between 2011 and 2017. A drop in bags in the last two years has been attributed to strongylosis in early spring, heather beetle outbreaks and unfavourable weather. In Scotland, where grouse densities (and bags) are lower than in England, the impact of strongylosis is less marked, leading to less year-to-year variation in the bags. Since 2007, as in England, the use of the new medicated grit led to a rapid and sustained improvement in bags until the last two years, which have been poor.

Common snipe (Figure 3, 4)

The number of shoots contributing snipe records from 1961 to 2019 was 735 in England and 344 in Scotland. Most snipe shot in the UK are wintering birds from northern and eastern continental Europe rather than local breeders. In England, snipe bags fell by more than half after 1962; they remained broadly stable at a low level until the late 2000s, but have since fallen by a third (see Figure 3). The graph shows the final part of a decline that began at the end of the 1930s, and reflects a permanent loss of suitable habitat as wetlands and damp meadows were drained for cultivation during and after the Second World War. In Scotland, where much greater areas of suitable habitat remain, bags show large fluctuations but held up well as late as 2005 (see Figure 4). Since then, however, bags have approximately halved. It is possible

KEY FINDINGS

- Red grouse bags peaked in England and Scotland in 2011-2017 thanks to medicated grit, but 2018 and 2019 were both poor.
- After 1962, common snipe bags have been low in England. In Scotland, numbers fluctuated but stayed high to 2005. Since then, declines are apparent in both countries.
- Scottish mountain hare bags show long-term cycles of seven to 10 years, with 2019 marking the trough of the latest cycle
- Brown hare bags declined 15 years later in Scotland than in England. A slow recovery in England from the mid-1980s to 2011 has reversed, with numbers in both countries hitting new lows in recent years.

Nicholas Aebischer

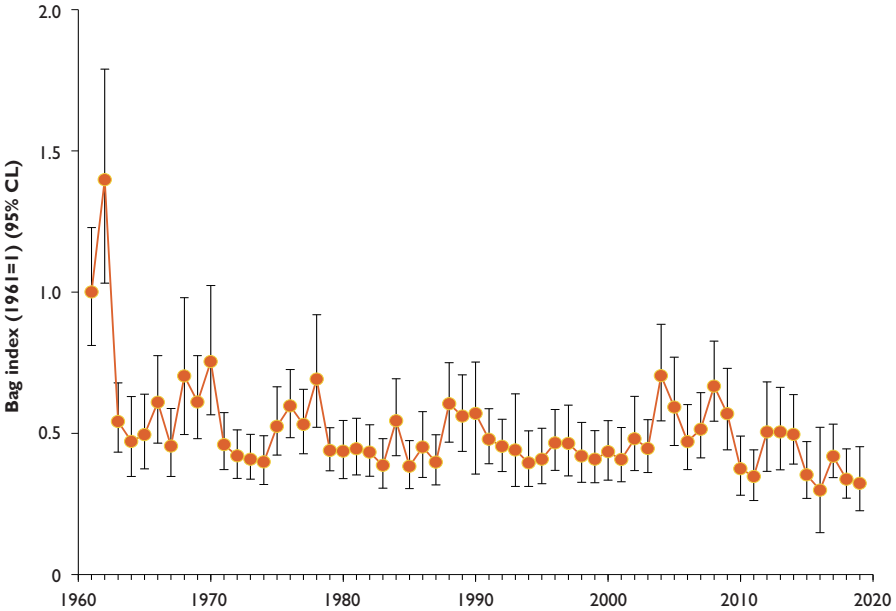
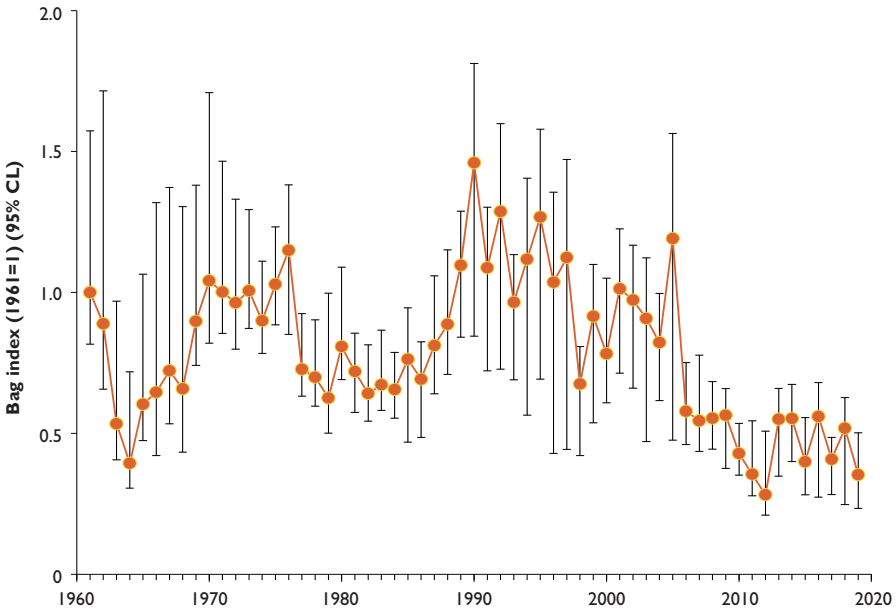


Figure 3

Common snipe index, England, from NGC bags 1961-2019

Figure 4

Common snipe index, Scotland, from NGC bags 1961-2019



that milder winters in recent years have meant that fewer continental snipe overwintered in Britain, causing declines in both England and Scotland. A recent emphasis on re-afforesting the Scottish uplands may also have reduced areas of suitable habitat.

NATIONAL GAMEBAG CENSUS PARTICIPANTS

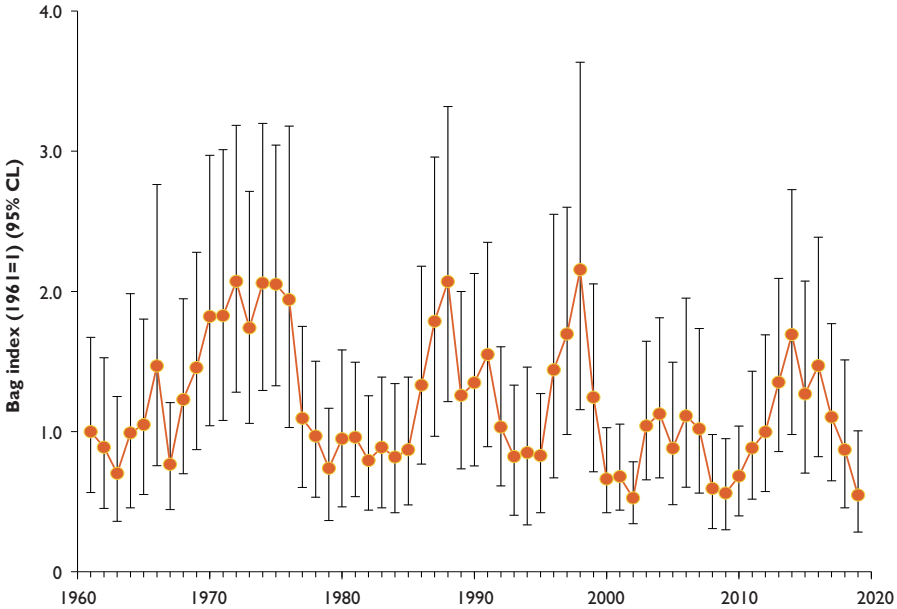
We are always seeking new participants in our National Gamebag Census. If you manage a shoot and do not already contribute to our scheme, please contact Corinne Duggins on 01425 651019 or email ngc@gwct.org.uk.

Mountain hare (Figure 5)

Scotland is the UK stronghold for mountain hares, and we consider only Scottish returns (from 209 shoots) as data from outside Scotland are too sparse for analysis. Over the last 59 years, Scottish bags have risen and fallen periodically over the space of seven to 10 years, most recently over the period 2009-2019. It is thought that this cyclical pattern reflects underlying changes in abundance caused by the gut parasite *Trichostrongylus retortaeformis,* in a similar way to which *T. tenuis* affects red grouse. The shooting of mountain hares has lately become controversial as a result of a study published in 2018 describing a 99% decline in mountain hare abundance on moorland since the 1950s. Neither NGC bag data (see Figure 5), GWCT data on hare abundance collected during grouse counts nor data from surveys of mountain hare distribution were able to corroborate the existence of such a generalised decline. Instead, the GWCT studies found that abundance was high and increasing on driven grouse moors in Grampian and Highland; it was declining in Tayside, especially on moors with no shooting, probably because of moorland fragmentation associated with afforestation. On 17 June 2020, the Scottish Parliament voted to give the species year-round protection under the Wildlife and Countryside Act, with shooting permitted only by licence.

Figure 5

Mountain hare index, Scotland, from NGC bags 1961-2019



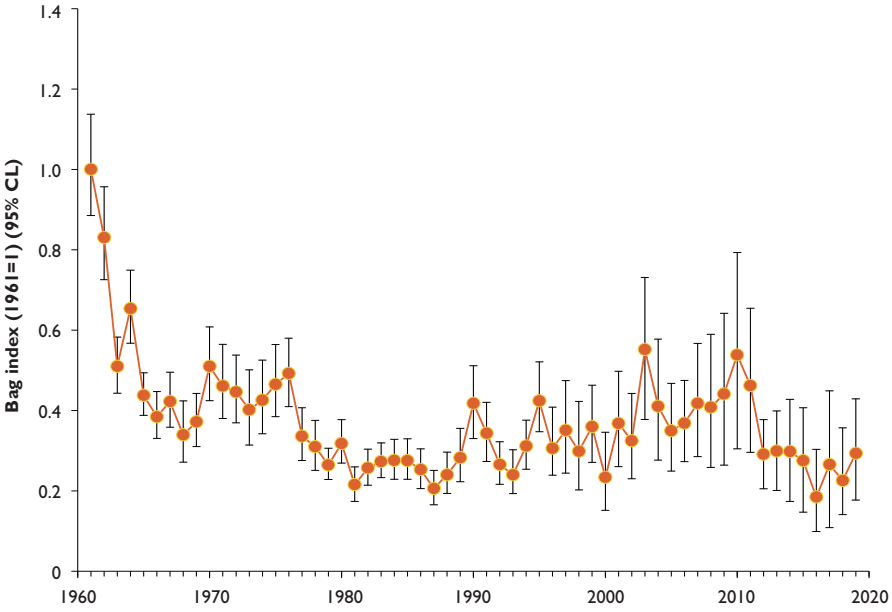


Figure 6

Brown hare index, England, from NGC bags 1961-2019

Brown hare (Figure 6, 7)

The brown hare was listed as a priority species in the 1995 UK Biodiversity Plan because of a perceived long-term decline in abundance. That decline is apparent in shoot bags, which have declined by 70% in England (see Figure 6, data from 981 shoots) and, starting around 15 years later, by 88% in Scotland (see Figure 7, data from 270 shoots). Since the mid-1980s, increasing English bags suggested a gradual recovery until 2010, coinciding with the implementation of set-aside and agri-environment schemes. Since the very wet summer of 2012, however, bags dropped back to those seen in the 1980s. In Scotland, although bags stabilised after the mid-1980s, they dropped to their lowest recorded level after 2010. This may be because Scottish agri-environment schemes are geared more towards grassland than arable management. In the last five years, disease may have played a part in recent declines, with Rabbit Viral Haemorrhagic Disease type 2 and even myxomatosis suggested as possible causes. However, nationwide appeals for dead or dying hares to be sent for veterinary examination have not uncovered evidence of epidemic disease. Given that hare bags reflect both local population density and concern to conserve the species, trends in bag numbers may exaggerate actual population trends. We outline practical conservation measures to help brown hares in our leaflet *Conserving the brown hare,* available online at gwct.org.uk/brownhare.

Brown hare bags show recent declines in both England and Scotland. © Peter Thompson

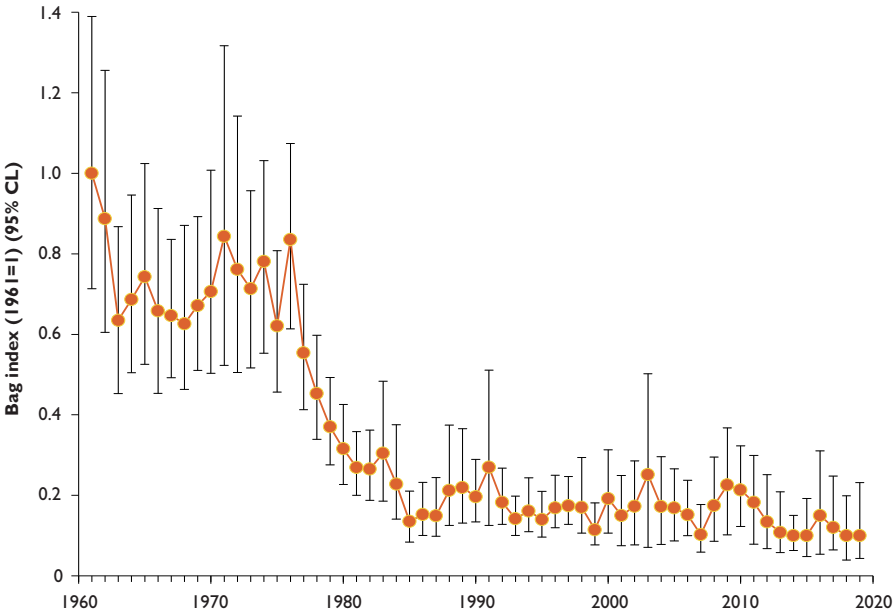


Figure 7

Brown hare index, Scotland, from NGC bags 1961-2019

Research projects

by the Game & Wildlife Conservation Trust in 2020

UPLANDS RESEARCH IN 2020

Project title	Description	Staff	Funding source	Date
Grouse Count Scheme (see p16)	*Annual grouse and parasitic worm counts in relation to moorland management indices and biodiversity*	*David Baines, David Newborn, Mike Richardson, Kathy Fletcher, Sonja Ludwig*	*Core funds, Gunnerside Estate*	*1980- ongoing*
Long-term monitoring of breeding ecology of waders in the Pennine uplands	*Annual measures of wader density, lapwing productivity, recruitment and survival*	*David Baines*	*Core funds*	*1985- ongoing*
Black grouse monitoring (see p22)	*Annual lek counts and brood counts*	*Philip Warren, David Baines, David Newborn, Kathy Fletcher*	*Core funds*	*1989- ongoing*
Capercaillie brood surveys	*Surveys of capercaillie and their broods in Scottish forests*	*Kathy Fletcher, Sonja Ludwig, David Baines, Phil Warren*	*Cairngorms National Park Authority, Seafield Estates*	*1991- ongoing*
Impacts of ticks on red grouse chick survival	*Use of acaricide-treated sheep to suppress ticks in a multi-host system*	*Kathy Fletcher, David Baines*	*The Samuels Trust*	*1995- ongoing*
Grey partridge (see p26)	*Using call-back surveys to estimate spring densities*	*David Baines, Madeleine Benton*	*Core funds*	*2018- ongoing*
Post-burning vegetation recovery on blanket peat at Langholm	*Using aerial images and field surveys to assess chrono-sequences of vegetation responses to heather burning*	*Sian Whitehead, Hannah Weald*	*Core funds*	*2019-2020*
Measuring rises in strongyle worms	*Fortnightly grouse faecal egg counts Dec'-May in relation to weather and medication*	*David Newborn*	*Core funds*	*2019-2020*
Repeat moorland bird surveys	*Repeat of bird and vegetation surveys conducted on circa 90 UK moors 2007-2012*	*David Baines, David Newborn, Mike Richardson, Madeleine Benton, Kathy Fletcher, Sonja Ludwig*	*Core funds*	*2019-2021*
Development of Black Grouse Study Groups in Scotland	*Co-ordinating volunteer inputs into annual lek monitoring across several regions of Scotland*	*Philip Warren*	*Heritage Lottery Fund*	*2019-2021*
Development of long-term heather burning experiments on blanket peat (see p24)	*Are burning and cutting useful management tools for blanket bog restoration? Does the structure and composition of pre-burn vegetation influence post-burn vegetation recovery?*	*Sian Whitehead, Madeleine Benton*	*Core funds*	*2019-2028*
Rush management for breeding waders	*Experimental rush cutting to improve habitat for breeding lapwing*	*David Baines, Madeleine Benton, Sian Whitehead*	*Philip Wayre Uplands Trust*	*2020-2021*
Mammalian predator indices in Strathspey	*Measuring marten and fox indices using trail cameras in forests used by breeding capercaillie*	*Kathy Fletcher*	*Cairngorms National Park Authority*	*2020-2021*

FARMLAND RESEARCH IN 2020

Project title	Description	Staff	Funding source	Date
Chick-food and farming systems	*A comparison of grey partridge chick-food in conventional and organically farmed crops and habitats*	*John Holland, Steve Moreby, Niamh McHugh, Ellie Ness, Inca Johnson, Ben Prego*	*Private funds*	*2015- ongoing*
Long-term monitoring	*Monitoring of wildlife on BASF demonstration farms*	*John Holland, Lucy Capstick, Jade Hemsley, Jayna Connelly, Ellie Jackson-Smith, Ben Prego, Inca Johnson*	*BASF*	*2017- ongoing*
Chick-food invertebrate levels	*Chick-food invertebrate levels in crops and non-crop habitats on three estates*	*John Holland, Steve Moreby, Jayna Connelly, Ellie Jackson-Smith, Inca Johnson, Ben Prego, Adam McVeigh*	*Private funds, The Millichope Foundation*	*2017- ongoing*
Evaluation of cultivated margin option effectiveness & exploration of their natural capital (see p30)	*Evaluation of invertebrate and botanical composition of annually cultivated and floristically-enhanced margins*	*John Holland, Niamh McHugh*	*NE*	*2018-2020*
Acoustic detectors for monitoring woodcock	*Evaluation of acoustic detectors for monitoring woodcock*	*Niamh McHugh, Chris Heward, Andrew Hoodless, Thomas Bristow*	*Core funds*	*2018- ongoing*
Invertebrate sampling methods	*Comparison of Dvac, sweep net and vortis suction sampling techniques*	*Steve Moreby*	*Core funds*	*2018- ongoing*
BEESPOKE (see p28)	*Increasing the area of pollinator habitat and pollination*	*John Holland, Niamh McHugh, Jade Hemsley, Jayna Connelly, Ellie Jackson-Smith, Lucy Capstick*	*EU Interreg North Sea Region*	*2019-2023*
Bat monitoring in Devon	*Identification of bat species on a Devon demonstration farm*	*Niamh McHugh, Chris Heward*	*Private funds*	*2020*
The Owl Box Initiative	*Barn Owl conservation, research and engagement project*	*Niamh McHugh, Chris Heward, Ellie Ness*	*Green Recovery Challenge Fund*	*2020-2021*
FRAMEwork	*Evaluation and development of Farmer Cluster approach across Europe*	*John Holland, Niamh McHugh, Ellie Ness*	*EU Horizon 2020*	*2020-2025*
Farmland birds and farming systems	*Comparison of farmland bird abundance relative to conventional and organically farmed crops and agri-environment habitats*	*Niamh McHugh*	*Private funds*	*2020- ongoing*
PhD: Solitary bees	*Seed mixes for solitary bees*	*Rachel Nichols. Supervisors: John Holland, Prof Dave Goulson (University of Sussex)*	*NERC/GWCT*	*2018- ongoing*
PhD: Biodiversity footprint of foods	*Creating an index of crop-farming traits to assess the biodiversity footprint of foods*	*Helen Waters. Supervisors: John Holland, Alfred Gathorne-Hardy (University of Edinburgh), Barbara Smith (Coventry University)*	*NERC/GWCT*	*2019- ongoing*

ALLERTON PROJECT RESEARCH IN 2020

Project title	Description	Staff	Funding source	Date
Monitoring wildlife at Loddington (see p34)	*Annual monitoring of game species, songbirds, invertebrates, plants and habitat*	*Chris Stoate, John Szczur, Alastair Leake, Steve Moreby, John Holland*	*Allerton Project funds*	*1992- ongoing*
Effect of game management at Loddington	*Effect of ceasing predator control and winter feeding on nesting success and breeding numbers of songbirds*	*Chris Stoate, Alastair Leake, John Szczur*	*Allerton Project funds*	*2001- ongoing*
Water Friendly Farming (see p40)	*A landscape-scale experiment testing integration of resource protection and flood risk management with farming in the upper Welland*	*Chris Stoate, John Szczur, Jeremy Biggs, Penny Williams, (Freshwater Habitats Trust), Professor Colin Brown (University of York)*	*EA, Regional Flood and Coastal Committee*	*2011-2027*
School farm catchment	*Practical demonstration of ecosystem services*	*Chris Stoate, John Szczur*	*Allerton Project, EA, Anglian Water, Agrii*	*2012- ongoing*
Soil monitoring	*Survey of soil biological, physical and chemical properties*	*Chris Stoate, Jenny Bussell, Alastair Leake, Phil Jarvis, Gemma Fox*	*Allerton Project*	*2014- ongoing*
SoilCare	*Soil management to meet economic and environmental objectives across Europe*	*Chris Stoate, Jenny Bussell, Gemma Fox John Szczur*	*EU H2020*	*2016-2021*
Soil Biology and Soil Health	*The role of soil biology in crop production systems*	*Chris Stoate, Jenny Bussell, Gemma Fox*	*AHDB*	*2016-2021*
Conservation Agriculture (see p44)	*Economic and environmental impacts of three contrasting crop production approaches*	*Alastair Leake, Phil Jarvis, Chris Stoate, Jenny Bussell, Gemma Fox*	*Syngenta*	*2017-2022*
RePhoKUs	*Understanding food system phosphorus balance at a range of scales*	*Chris Stoate, Paul Withers and partners*	*Research Councils*	*2018-2021*
Agroforestry	*Optimising tree densities to meet multiple objectives in grazed pasture*	*Chris Stoate, Jenny Bussell, Gemma Fox, Alastair Leake*	*Woodland Trust*	*2018- ongoing*
Tree leaves as ruminant fodder (see 42)	*Assessing the nutritional value of tree leaves for ruminants*	*Chris Stoate, Jenny Bussell, Gemma Fox, Nigel Kendall (Nottingham University)*	*Woodland Trust*	*2019-2022*
Green headlands	*Evaluation of green and flowering headland seed mixes on a range of soil indicators.*	*Phil Jarvis, Alastair Leake, Oliver Carrick, Lucy Baker*	*Asda, Syngenta*	*2020*
Compaction and infiltration	*Exploring the relationship between soil compaction and infiltration in the Eye Brook catchment*	*Chris Stoate, Gemma Fox, Jenny Bussell*	*EA*	*2020-2021*
PhD: Mapping ecosystem services	*Mapping ecosystem services across the Welland river basin*	*Max Rayner. Supervisors: Chris Stoate, Dr Heiko Balzter (Leicester University)*	*NERC*	*2017-2021*

AUCHNERRAN PROJECT RESEARCH IN 2020

Project title	Description	Staff	Funding source	Date
Core biodiversity monitoring (see p46)	*Monitoring of key groups to assess impacts of farming changes*	*Dave Parish, Marlies Nicolai, Elizabeth Ogilvie, Max Wright, Sophie McPeake, Olivia Stubbington*	*Core funds*	*2015- ongoing*
Rabbit population monitoring	*Assessing rabbit numbers in relation to control methods and impacts on grass and other species*	*Dave Parish, Marlies Nicolai, Elizabeth Ogilvie, Max Wright, Sophie McPeake, Olivia Stubbington*	*Core funds*	*2016- ongoing*
GWSDF Cromar Farmer Cluster	*Developing the Cromar Farmer Cluster*	*Dave Parish, Marlies Nicolai, Ross MacLeod*	*Core funds, Working for Waders*	*2016- ongoing*
LIFE Laser Fence (see p50)	*Experimental trials of laser technology as a deterrent for various mammals*	*Dave Parish, Marlies Nicolai, Elizabeth Ogilvie, Max Wright*	*LIFE+, Core funds*	*2016-2020*
Liming experiment	*Split-field experiment investigating impacts of liming on invertebrates, including mud snails*	*Dave Parish, Marlies Nicolai, Elizabeth Ogilvie, Max Wright*	*James Hutton Institute, Core funds*	*2016-2021*
Thrush population monitoring	*Detailed investigation of thrush habitat use, distribution and productivity*	*Dave Parish, Marlies Nicolai, Elizabeth Ogilvie, Max Wright*	*Core funds*	*2017-2020*
Wader population monitoring	*Surveying of wader numbers, distribution and productivity, radio-tagging lapwing chicks, GPS tagging curlew and lapwing*	*Dave Parish, Marlies Nicolai, Andrew Hoodless, Elizabeth Ogilvie, Max Wright*	*Core funds, Working for Waders, Perdix Wildlife Supplies*	*2017- ongoing*
Mud snail and liver fluke interactions	*Investigating the importance of intermediate/ alternative fluke hosts and land-use*	*Dave Parish, Marlies Nicolai*	*Core funds, Moredun Research Institute*	*2017- ongoing*

PREDATION RESEARCH IN 2020

Project title	Description	Staff	Funding source	Date
Diet of foxes in the Avon Valley	*Analysis of stomach and faecal analysis to determine main dietary components supporting foxes in the Avon Valley*	*Mike Short, Jodie Case*	*Core funds*	*2019-2021*
Foxes in the Avon Valley	*Analysis of GPS tracking data and DNA evidence to determine resident density, activity patterns and habitat use of foxes in the Avon Valley, in the context of declining wading bird populations*	*Mike Short, Tom Porteus, Jonathan Reynolds*	*Core funds*	*2020-2021*
Use of tunnels by small mustelids in a river meadow habitat	*Revision of scientific write-up following peer review*	*Jonathan Reynolds, Mike Short, Tom Porteus*	*Core funds*	*2020-2021*

FISHERIES RESEARCH IN 2020

Project title	Description	Staff	Funding source	Date
Fisheries research	*Develop wild trout fishery management methods including completion of write-up/reports of all historic fishery activity*	*Dylan Roberts*	*Core funds*	*1997- ongoing*
Salmonid life-history strategies in freshwater (see p52)	*Understanding the population declines in salmon and sea trout*	*Rasmus Lauridsen, Dylan Roberts, William Beaumont, Luke Scott, Stephen Gregory*	*EA, Cefas, The Missing Salmon Alliance*	*2009- ongoing*
Grayling ecology (see p58)	*Long-term study of the ecology of River Wylye grayling*	*Stephen Gregory, Luke Scott, Jessica Marsh*	*NRW, Core funds, Grayling Research Trust, Piscatorial Society*	*2009- ongoing*
Headwaters and salmonids	*Contribution of headwaters to migratory salmonid populations and the impacts of extreme events*	*Rasmus Lauridsen, William Beaumont, Luke Scott, Dylan Roberts, Stephen Gregory, Will Beaumont, Bill Riley*	*Cefas/Defra, The Missing Salmon Alliance*	*2015- ongoing*
Salmon and trout smolt tracking (see p54)	*Movements and survival of salmon and sea trout smolts through four estuaries in the English Channel as part of the SAMARCH project*	*Céline Artero, Rasmus Lauridsen, William Beaumont, Luke Scott, Dylan Roberts, Stephen Gregory, Elodie Reveillac (Agrocampus Ouest), Will Beaumont*	*EU Interreg The Missing Salmon Alliance*	*2017-2022*
Sea trout kelt tracking	*Movements and survival of sea trout kelts at sea from three rivers in the English Channel as part of the SAMARCH project*	*Céline Artero, Rasmus Lauridsen, William Beaumont, Luke Scott, Dylan Roberts, Elodie Reveillac, Will Beaumont*	*EU Interreg The Missing Salmon Alliance*	*2017-2022*
Genetic tools for trout management	*Creation of a genetic database for trout in the Channel rivers (ca. 100 rivers) and a tool for identifying areas at sea important for sea trout*	*Jamie Stevens, Andy King (Exeter University), Sophie Launey (INRA), Dylan Roberts, Rasmus Lauridsen*	*EU Interreg The Missing Salmon Alliance*	*2017-2022*
New salmon stock assessment tools (see p54)	*Providing new information for stock assessment models and new stock assessment tools in England and France as part of the SAMARCH project*	*Stephen Gregory, Marie Nevoux (INRA), Etienne Rivot (Agrocampus Ouest), Rasmus Lauridsen, William Beaumont, Luke Scott, Dylan Roberts, Will Beaumont*	*EU Interreg The Missing Salmon Alliance*	*2017-2022*
New policies for salmon and sea trout in coastal and transitional waters (see p54)	*Developing new policies for the better management of salmon and sea trout in coastal and transitional waters based on the outputs of SAMARCH*	*Dylan Roberts, Will Beaumont, Lawrence Talks and Simon Toms (EA), Laurent Beaulaton (Association of French Biodiversity), Gaelle Germis (Bretagne Grands Migrateurs), Paul Knight, Lauren Mattingley (S&TC, UK), Jerremy Corr (Normandie Grands Migrateurs)*	*EU Interreg The Missing Salmon Alliance*	*2017-2022*
Pink salmon	*Use new eDNA methods to determine distribution of non-native pink salmon in the UK and to use stable isotopes to study the ecosystem effect of pink salmon where present.*	*Rasmus Lauridsen, Gordon Copp (Cefas), Iwan Jones (QMUL) , Phil Davidson (Cefas), Michał Skóra, Hui Wei*	*Cefas, The Missing Salmon Alliance*	*2019-2021*
PhD: Beavers and salmonids	*Impacts of beaver dams on salmonids*	*Robert Needham. Supervisors: Dylan Roberts, Paul Kemp (Southampton University)*	*Core funds, Southampton University, SNH, S&TC, UK*	*2014-2020*
PhD: Impact of low flows on salmonid river ecosystems (see p62)	*Investigate fish prey availability, the diet of trout and salmon, stream food webs and ecosystem dynamics under differing, experimentally manipulated flow conditions*	*Jessica Picken. Supervisors: Rasmus Lauridsen, Dr Iwan Jones, Pavel Kratina (QMUL), Bill Riley (Cefas), Sian Griffiths (Cardiff University)*	*QMUL, Cefas, Core funds*	*2015-2020*
PhD: Effects of smolt-characteristics on their migration and survival (see p60)	*Quantify the effects of smolt characteristics, among other factors, on their migration and marine survival in the Frome and elsewhere*	*Olivia Simmons. Supervisors: Robert Britton & Phillipa Gillingham (Bournemouth University) Stephen Gregory*	*EU Interreg, Bournemouth University*	*2018-2021*
PhD: Trout metal tolerance	*Disentangling the three main factors affecting trout ability to tolerate metals: evolution, local adaption and pollution*	*Daniel Osmond. Supervisors: Rasmus Lauridsen, Jamie Stephens (Exeter University), Mike Bruford (Cardiff University), Bruce Stockley (WRT)*	*GW4 FRESH CDT, Core funds*	*2019-2023*

LOWLAND GAME RESEARCH IN 2020

Project title	Description	Staff	Funding source	Date
Pheasant population studies	*Long-term monitoring of breeding pheasant populations on releasing and wild bird estates*	*Roger Draycott, Maureen Woodburn, Rufus Sage*	*Core funds*	*1996- ongoing*
Game marking scheme and enhanced pheasants	*Study of factors affecting return rates of enhanced pheasants and effect of release pens*	*Rufus Sage, Maureen Woodburn*	*Core funds*	*2008- ongoing*
Consequences of releasing (see p64)	*Literature review and synthesis on ecological consequence of releasing for shooting*	*Rufus Sage, Dr Joah Madden, (Exeter University)*	*Core funds, NE*	*2019-2021*
Predators of woodland birds	*Using trail cameras to monitor squirrels and bird nests to assess predator effect on nest outcome*	*Rufus Sage, Jonathan Reynolds, Matthew Beedle*	*Songbird Survival*	*2019-2020*
PhD: Improving released pheasants	*Using improved hand-reared pheasants to increase survival and wild breeding post-release*	*Andy Hall. Supervisors: Rufus Sage, Dr Joah Madden (Exeter University)*	*Exeter University, Core funds*	*2015-2020*

WETLAND RESEARCH IN 2020

Project title	Description	Staff	Funding source	Date
Woodcock monitoring	*Examination of annual variation in breeding woodcock abundance*	*Chris Heward, Andrew Hoodless, collaboration with BTO*	*Shooting Times Woodcock Club*	*2003- ongoing*
Woodcock survival and site fidelity	*Intensive ringing and recapture of woodcock at three winter sites*	*Andrew Hoodless, Chris Heward, collaboration with the Woodcock Network*	*Core funds*	*2012- ongoing*
Woodcock migration and breeding site habitat use (see p68)	*Use of GPS tags to understand autumn migration and breeding site habitat use*	*Andrew Hoodless, Chris Heward, collaboration with ONCFS*	*Shooting Times Woodcock Club, private donors, Woodcock Appeal*	*2017-2020*

Habitat use by breeding woodcock	*Use of GPS tags to examine fine-scale habitat use by breeding woodcock and the value of habitat management*	*Chris Heward, Andrew Hoodless*	*Private donors, Core funds*	*2018-2021*
Lapwing on the South Downs	*Monitoring of lapwing breeding success on the South Downs*	*Lucy Capstick, Andrew Hoodless, collaboration with RSPB and South Downs National Park*	*Core funds*	*2018-2022*
Use of Special Protection Area habitats by waders	*GPS tracking of oystercatchers and curlews on the Exe Estuary*	*Ryan Burrell, Andrew Hoodless, collaboration with NE and University of Exeter*	*NE*	*2018-2022*
Use of Southampton Water by waders, ducks and geese	*Winter GPS tracking of curlew, oystercatcher, wigeon, teal, brent goose to examine use of shore and field habitats*	*Lizzie Grayshon, Ryan Burrell, Chris Heward, Jodie Case, collaboration with Farlington Ringing Group and ABPmer*	*Associated British Ports*	*2019-2021*
Winter movements of lapwings (see p70)	*Comparison of lapwings breeding in Scotland and southern England using GPS tracking*	*Andrew Hoodless, Dave Parish, Marlies Nicolai, Lizzie Grayshon, Ryan Burrell, Lucy Capstick, Elizabeth Ogilvie, Max Wright*	*EU LIFE, Associated British Ports, Core funds*	*2019-2022*
Avon Valley Farmer Cluster	*Farmer-led habitat restoration and wader recovery in the Avon Valley*	*Lizzie Grayshon*	*NE Facilitation Fund, Core funds*	*2020-2022*
PhD: Woodcock in Ireland	*Breeding woodcock distribution and habitat relationships. Effect of shooting on winter woodcock behaviour and mortality rate*	*James O'Neill. Supervisors: Andrew Hoodless, Prof John Quinn (UCC)*	*Irish Research Council, NARGC, NPWS, Core funds*	*2019-2022*
PhD: Role of camouflage in the survival and conservation of ground-nesting birds	*Influence of nest and chick crypsis on lapwing breeding success and possible modifications to field and sward management*	*George Hancock. Supervisors: Andrew Hoodless, Dr Jolyon Troscianto, Dr Martin Stevens (University of Exeter), Dr Innes Cuthill (University of Bristol)*	*NERC*	*2019-2022*
PhD: Landscapes for curlews	*Monitoring breeding success and use of GPS tracking to determine foraging areas of adult curlews and brood ranges*	*Elli Rivers. Supervisors: Andrew Hoodless, Prof Richard Stillman, Dr Kathy Hodder (Bournemouth University), Andy Page (FC)*	*Hampshire Ornithological Society, Forestry England, private donors*	*2020-2022*
PhD: Lapwings and avian predators	*Quantifying lapwing chick survival in arable habitats and the effects of disturbance by corvids and raptors*	*Ryan Burrell. Supervisors: Andrew Hoodless, Prof Richard Stillman, Dr Kathy Hodder (Bournemouth University)*	*Core funds*	*2020-2022*

PARTRIDGE AND BIOMETRICS RESEARCH IN 2020

Project title	Description	Staff	Funding source	Date
Partridge Count Scheme (see p72)	*Nationwide monitoring of grey and red-legged partridge abundance and breeding success*	*Neville Kingdon, Nicholas Aebischer, Julie Ewald, Thomas Bristow, Jemma Gibson, Rachel Cook, George Scarisbrick*	*Core funds, GCUSA*	*1933- ongoing*
National Gamebag Census (see p78)	*Monitoring game and predator numbers with annual bag records*	*Nicholas Aebischer, Corinne Duggins, Cameron Hubbard, Thomas Bristow, Jemma Gibson, Rachel Cook, George Scarisbrick*	*Core funds*	*1961- ongoing*
Sussex study	*Long-term monitoring of partridges, weeds, invertebrates, pesticides and land use on the South Downs in Sussex*	*Julie Ewald, Nicholas Aebischer, Steve Moreby, Cameron Hubbard*	*Core funds, Ernest Kleinwort Charitable Trust*	*1968- ongoing*
Wildlife monitoring at Rotherfield Park (see p74)	*Monitoring of land use, game and songbirds for the Rotherfield Demonstration Project*	*Francis Buner, Malcolm Brockless, Julie Ewald Lucy Robertson, Ellie Raynor*	*Core funds, Interreg (EU North Sea Region)*	*2010-2023*
Grey partridge management	*Researching and demonstrating grey partridge management at Whitburgh Farms*	*Dave Parish, Hugo Straker, Adam Smith, Merlin Becker, Fiona Torrance, Hannah Brunsden, Markos Nicolaou, Molly Crookshank, Tamara Spivey, Elizabeth Fitzpatrick*	*Whitburgh Farms, Core funds*	*2011-2021*
Capacity building in Himachal Pradesh, India	*Bird ringing, monitoring and Galliform re-introduction capacity building for Himachal Pradesh Wildlife Department*	*Francis Buner*	*Forest and Wildlife Department of Himachal Pradesh*	*2013- ongoing*
Cluster Farm mapping	*Generating cluster-scale landscape maps for use by the Advisory Service and the Farm Clusters*	*Julie Ewald, Neville Kingdon, Cameron Hubbard, Thomas Bristow, Jemma Gibson, Rachel Cook, George Scarisbrick*	*Core funds*	*2014- ongoing*
Developing novel game crops	*Developing perennial game cover mixes*	*Dave Parish, Fiona Torrance, Hugo Straker, Hannah Brunsden, Markos Nicolaou, Molly Crookshank, Tamara Spivey, Elizabeth Fitzpatrick*	*Balgonie Estates Ltd, Core funds, Kingdom Farming, Kings Crops Scottish Agronomy*	*2014-2021*
Grey partridge recovery	*Monitoring grey partridge recovery at Balgonie Estate and impacts on associated wildlife*	*Dave Parish, Hugo Straker, Fiona Torrance, Hannah Brunsden, Markos Nicolaou, Molly Crookshank, Tamara Spivey, Elizabeth Fitzpatrick*	*Balgonie Estates Ltd, Core funds, Kingdom Farming, Kings Crops Scottish Agronomy*	*2014-2021*
PARTRIDGE (see p76)	*Co-ordinated demonstration of management for partridge recovery and biodiversity in the UK, the Netherlands, Belgium, Germany and Denmark*	*Francis Buner, Fiona Torrance, Julie Ewald, Dave Parish, Paul Stephens, Ben Stephens, Lucy Robertson, Ellie Raynor, Molly Crookshank, Hannah Brunsden, Markos Nicolaou, Tamara Spivey, Elisabeth Fitzpatrick Cameron Hubbard, John Szczur, Chris Stoate, Austin Weldon, Roger Draycott, Francesca Pella, Nicholas Aebischer*	*Interreg (EU North Sea Region) Core funds*	*2016-2023*
Recovery of grey partridge populations in Scotland	*Encouraging grey partridge management and monitoring across Scotland*	*Dave Parish, Fiona Torrance*	*Core funds*	*2017- ongoing*
Lowland Gamebird Impact Study	*Compare land holdings with released gamebird shooting to geographically matched land holdings without such management*	*Neville Kingdon, Cameron Hubbard, Julie Ewald, Nicholas Aebischer, Rachel Cook, George Scarisbrick*	*The Wates Family Charities*	*2019-2024*

Key to abbreviations: AHDB = Agriculture and Horticulture Development Board; BEESPOKE = Benefiting Ecosystems through Evaluation of food Supplies for Pollination to Open up Knowledge for End users; BTO = British Trust for Ornithology; CEFAS = Centre for Environment, Fisheries & Aquaculture Science; Defra = Department for Environment, Food and Rural Affairs; EA = Environment Agency; EU = European Union; FC = Forestry Commission; FRAMEwork = Farmer clusters for Realising Agrobiodiversity Management across Ecosystems; GCUSA = Game Conservancy USA; GWSDF = Game & Wildlife Scottish Demonstration Farm; H2020 = Horizon 20:20; INRA = Institut National de la Recherche Agronomique; Interreg = European Regional Development Board; LIFE = L'Instrument Financier pour l'Environnement; NARGC = National Association of Regional Game Councils; NE = Natural England; NERC = Natural Environment Research Council; NRW = Natural Resources Wales; ONCFS = Office National de la Chasse et de la Faune Sauvage; PARTRIDGE = Protecting the Area's Resources Through Researched Innovative Demonstration of Good Examples; QMUL = Queen Mary University of London; RePhoKUs = Role of Phosphorus in the Resilience and Sustainability of the UK Food System; RSPB = Royal Society for the Protection of Birds; SAMARCH = SAlmonid MAnagement Round the CHannel; SNH = Scottish Natural Heritage; S&TC, UK = Salmon & Trout Conservation UK; UCC = University College Cork; WRT = Westcountry Rivers Trust.

Scientific publications

by staff of the Game & Wildlife Conservation Trust in 2020

Arroyo, B, Souchay, G & **Aebischer, NJ (2020)** Red-legged partridge *Alectoris rufa*. In: Keller, V, Herrando, S, Voříšek, P, Franch, M, Kipson, M, Milanesi, P, Martí, D, Anton, M, Klvaňová, A, Kalyakin, MV, Bauer H-G & Foppen RPB (eds). *European Breeding Bird Atlas 2: Distribution, Abundance and Change:* 76-77. European Bird Census Council & Lynx Edicions, Barcelona.

Baines, D, Newborn, D & Richardson, M (2020) Correlates of pathological lesions associated with respiratory cryptosporidiosis prevalence in shot red grouse *Lagopus scotica* from moors in northern England. *Avian Pathology,* 49: 74-79.

Bates, LJ, Pope, TW & **Holland, JM** (2020) Can a PCR assay of aphids caught in-crop on yellow sticky traps inform field level barley yellow dwarf virus risk assessment? *Annals of Applied Biology*, 177: 178-183.

Buner, FD & Gottschalk, E (2020) Grey partridge *Perdix perdix*. In: Keller, V, Herrando, S, Voříšek, P, Franch, M, Kipson, M, Milanesi, P, Martí, D, Anton, M, Klvaňová, A, Kalyakin, MV, Bauer, H-G. & Foppen, RPB (eds). *European Breeding Bird Atlas 2: Distribution, abundance and change*: 84-85. European Bird Census Council & Lynx Edicions, Barcelona.

Cabodevilla, X, **Aebischer, NJ**, Mougeot, F, Morales, MB & Arroyo, BE (2020) Are population changes of endangered little bustards associated with releases of red-legged partridges for hunting? A large-scale study from central Spain. *European Journal of Wildlife Research*, 66 (30): 1-10.

Cole, LJ, Kleijn, D, Dicks, LV, Stout, JC, Potts, SG, Albrecht, M, Balzan, MV, Bartomeus, I, Bebeli, PJ, Bevk, D, Biesmeijer, JC, Chlebo, R, Dautartè, A, Emmanouil, N, Hartfield, C, **Holland, JM**, Holzschuh, A, Knoben, NTJ, Kovács-Hostyánski, A, Mandelik, Y, Panou, H, Paxton, RJ, Petanidou, T, Pinheiro de Carvalho, MAA, Rundlöf, M, Sarthou, J-P, Stavrinides, MC, Suso, MJ, Szentgyörgyi, H, Vaissière, BE, Varnava, A, Vilà, M, Zemeckis, R & Scheper, J (2020) A critical analysis of the potential for EU Common Agricultural Policy measures to support wild pollinators on farmland. *Journal of Applied Ecology,* 57: 681-694.

Dobson, ADM, Milner-Gulland, EJ, **Aebischer, NJ**, Beale, CM, Brozovic, R, Coals, P, Critchlow, R, Dancer, A, Greve, M, Hinsley, A, Ibbett, H, Johnston, A, Kuiper, T, Le Comber, S, Mahood, SP, Moore, JF, Nilsen, EB, Pocock, MJO, Quinn, A, Travers, H, Wilfred, P, Wright, J & Keane, A (2020) Making messy data work for conservation. *One Earth,* 2: 455-465.

Ewald, JA, Sotherton, NW & Aebischer, NJ (2020) Invertebrate trends in an arable environment: long-term changes from the Sussex Study in southern England. In: Hurford, C, Wilson, PJ & Storkey, J (eds) *The Changing Status of Arable Habitats in Europe – a Nature Conservation Review: 157-172.* Springer, London.

Ewald JA, Sotherton NW & Aebischer NJ (2020) Research into practice: gray partridge *(Perdix perdix)* restoration in southern England. *Frontiers in Ecology and Evolution* 8:517500. doi: 10.3389/fevo.2020.517500 1-13.

Fletcher, K & Baines, D (2020) Observations on breeding and dispersal by capercaillie in Strathspey. *Scottish Birds*, 40: 27-34.

Gillson, JP, Maxwell, DL, **Gregory, SD**, Posen, PE, Riley, WD, **Picken, JL** & Assunção, MGL (2020) Can aspects of the discharge regime associated with juvenile Atlantic salmon *(Salmo salar L.)* and trout *(S. trutta L.)* densities be identified using historical monitoring data from five UK rivers? *Fisheries Management and Ecology*, 27: 567-579.

Gregory, SD, Bewes, VE, Davey, AJH, Roberts, DE, Gough, P & Davidson, IC (2020) Environmental conditions modify density-dependent salmonid recruitment: insights into the 2016 recruitment crash in Wales. *Freshwater Biology,* 65: 2135-2153.

Hayward, N, **Parish, DMB, & Smith, AA** (2020) Quail *Coturnix coturnix* numbers and habitat use on an Angus farm, 1985-2017. *Scottish Birds*, 40: 232-237.

Hesford, N, Baines, D, Smith, AA & Ewald, JA (2020) Distribution of mountain hares *Lepus timidus* in Scotland in 2016/2017 and changes relative to earlier surveys in 1995/1996 and 2006/2007. *Wildlife Biology,* 40: 313-326.

Holland, JM, Sutter, L, Albrecht, M, Jeanneret, P, Pfister, SC, Schirmel, J, Entling, MH, Kaasik, R, Kovács, G, Veromann, E, Bartual, AM, Marini, S, Moonen, A-C, Szalai, M, Helsen, H, Winkler, K, Lof, ME, van der Werf, W, **McHugh, NM, Smith, BM**, Wallis, DW & Cresswell, JE **(2020)** Moderate pollination limitations in some entomophilous crops of Europe. *Agriculture, Ecosystems and Environment*, 302(107002): 1-5.

Holland, JM, Jeanneret, P, Moonen, A-C, van der Werf, W, Rossing, WAH, Antichi, D, Entling, MH, Giffard, B, Helsen, H, Szalai, M, Rega, C, Gilbert, C & Veromann, E **(2020)** Approaches to identify the value of semi-natural habitats for conservation biological control. *Insects,* 11 (195): 1-11.

Hoodless, A, Heward, CJ & Williams, O **(2020)** Migration and movements of woodcock wintering in Britain & Ireland. *British Birds,* 113: 256-278.

Ludwig, SC, Aebischer, NJ, Richardson, M, Roos, S, Thompson, DBA, Wilson, JD & **Baines, D (2020)** Differential responses of heather and red grouse to long-term spatio-temporal variation in sheep grazing. *Biodiversity and Conservation*, 29: 2689-2710.

Ludwig, SC, Roos, S & **Baines, D (2020)** Fluctuations in field vole abundance indirectly influence red grouse productivity via a shared predator guild. *Wildlife Biology,* 2020 (wlb.00642): 1-11.

Ludwig, SC, Roos, S, Rollie, CJ & **Baines, D (2020)** Long-term changes in the abundance and breeding success of raptors and ravens in periods of varying management of a Scottish grouse moor. *Avian Conservation & Ecology,* 15 (21): 1-17.

Marsh, JE, Lauridsen, RB, Gregory, SD, Beaumont, WRC, Scott, LJ, Kratina, P & Jones, JI **(2020)** Above parr: lowland river habitat characteristics associated with higher juvenile Atlantic salmon *(Salmo salar)* and brown trout *(Salmo trutta)* densities. *Ecology of Freshwater Fish*, 291: 542-556.

McHugh, NM, Moreby, SJ, Lof, ME, van der Werf, W & **Holland, JM (2020)** The contribution of semi-natural habitats to biological control is dependent on sentinel prey type. *Journal of Applied Ecology,* 57: 914-925.

Newey, S, Potts, JM, **Aebischer, NJ**, Wilson, MW & Newson, SE **(2020)** *Designing a monitoring scheme for mountain hare* (Lepus timidus) *in Scotland.* Research Report No. 1076. Scottish Natural Heritage, Inverness.

Nichols, RN, Holland, JM & Goulson, D **(2020)** Methods for creating bare ground on farmland in Hampshire, UK, and their effectiveness at recruiting ground-nesting solitary bees. *Conservation Evidence,* 17: 15-18.

Nyqvist, MJ, Cucherousset, J, Gozlan, RE, **Beaumont, WRC** & Britton, JR **(2020)** Dispersal strategies of juvenile pike *(Esox lucius L.)*: Influences and consequences for body size, somatic growth and trophic position. *Ecology of Freshwater Fish,* 29: 377-383.

Picken, JL (2020) *The effects of low summer discharge on salmonid ecosystems.* Unpublished PhD thesis. Queen Mary University, London.

Pottier, G, **Beaumont, WRC**, Marchand, F, Le Bail, P-Y, Azam, D, Rives, J, Vigouroux, R & Roussel, J-M **(2020)** Electrofishing in streams of low water conductivity but high biodiversity value: challenges, limits and perspectives. *Fisheries Management and Ecology,* 27: 52-63.

Sage, RB, Hoodless, AN, Woodburn, MIA, Draycott, RAH, Madden, JR & **Sotherton, NW (2020)** Summary review and synthesis – Effects on habitats and wildlife of the release and management of pheasants and red-legged partridges on UK lowland shoots. *Wildlife Biology*, 2020(wlb.00766): 1-12.

Simmons, OM, Britton, JR, Gillingham, PK & **Gregory, SD (2020)** Influence of environmental and biological factors on the over-winter growth rate of Atlantic salmon *Salmo salar* parr in a UK chalk stream. *Ecology of Freshwater Fish*, 29: 665-678.

Smith BM, Aebischer NJ, Ewald J, Moreby S, Potter C & Holland JM (2020) The potential of arable weeds to reverse invertebrate declines and associated ecosystem services in cereal crops. *Frontiers in Sustainable Food Systems,* 3 (118): 1-13.

Sotherton, NW, Aebischer, NJ & Ewald, JA (2020) The conservation of the grey partridge *(Perdix perdix)* on farmland in southern England. In: Hurford, C, Wilson, PJ & Storkey, J (eds) *The Changing Status of Arable Habitats in Europe – a Nature Conservation Review: 279-290. Springer, London.*

Stoate, C & Wilson, P **(2020)** Historical and ecological background to the arable habitats of Europe. In: Hurford, C, Wilson, P & Storkey, J (eds) *The Changing Status of Arable Habitats in Europe – a Nature Conservation Review*: 3-13. Springer, London.

Villamizar, ML, **Stoate, C**, Biggs, J, Morris, C, **Szczur, J** & Brown, CD **(2020)** Comparison of technical and systems-based approaches to managing pesticide contamination in surface water catchments. *Journal of Environmental Management,* 260 (110027): 1-10.

Warren, P, Land, C, **Hesford, N & Baines D** (2020) Conserving black grouse *Lyrurus tetrix* in southern Scotland: evidence for the need to retain large contiguous moorland habitat within a forest-moorland landscape. *Bird Study,* DOI: 10.1080/00063657.2020.1726875.

Williams, P, Biggs, J, **Stoate, C, Szczur, J,** Brown, C & **Bonney, S (2020)** Nature based measures increase freshwater biodiversity in agricultural catchments. *Biological Conservation,* 244 (108515): 1-14.

Woodward, ID, **Aebischer, NJ**, Burnell, D, Eaton, MA, Frost, T, Hall, C, Stroud, DA & Noble, DG **(2020)** Population estimates of birds in Great Britain and the United Kingdom. *British Birds,* 113: 69-104.

GWCT staff in bold.

Financial report
for 2020

The summary report and financial statement for the year ended 31 December 2020, set out below and on pages 90 to 91, consist of information extracted from the full statutory Trustees' report and consolidated accounts of the Game & Wildlife Conservation Trust and its wholly-owned subsidiaries Game & Wildlife Conservation Trading Limited, Game & Wildlife Scottish Demonstration Farm and GWCT Events Limited. They do not comprise the full statutory Trustees' report and accounts, which were approved by the Trustees on 13 April 2021 and which may be obtained from the Trust's Headquarters. The auditors have issued unqualified reports on the full annual accounts and on the consistency of the Trustees' report with those accounts, and their report on the full accounts contained no statement under sections 498(2) or 498(3) of the Companies Act 2006.

KEY POINTS

- Income was £7.7 million, a 14.9% decrease compared with 2019.
- Expenditure on charitable activities was £5.13 million (a decrease of 12.1%).
- There was a surplus of £226,491 on unrestricted funds.
- The Trust's net assets were £9.5 million at the end of the year.

The Trust showed a small surplus on unrestricted funds in 2020 due once again to the generosity of our supporters and effective cost management by our staff. The increase in net assets was due to gains and losses on the Trust's investments, which performed well during a difficult year, and timing differences on restricted funds income and expenditure.

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 2020 the Trust's reserves (according to this definition) were £1.7 million, compared with £1.3 million at the end of 2019.

Plans for future periods

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

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

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

Sir Jim Paice
Chairman of the Trustees

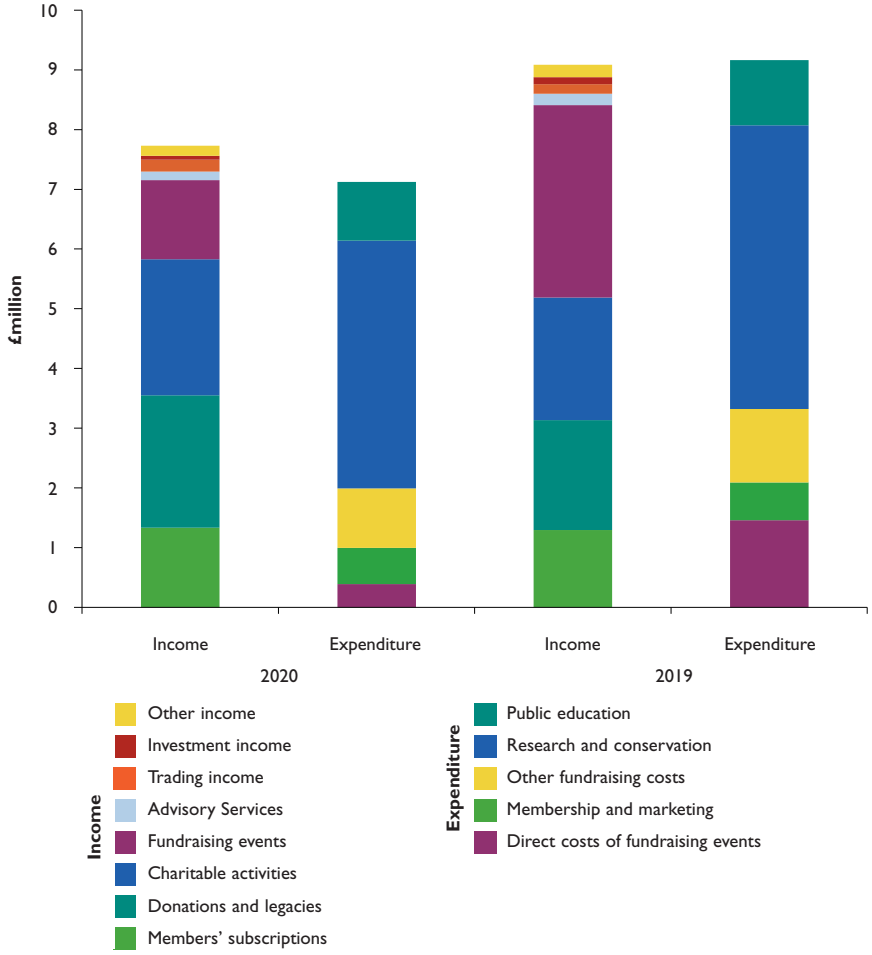


Figure 1

Total incoming and outgoing resources in 2020 (and 2019) 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 2020 which is set out on pages 90 and 91.

Opinion

In our opinion the summary financial statement is consistent with the full annual financial statements of the Game & Wildlife Conservation Trust for the year ended 31 December 2020 and complies with the applicable requirements of Section 427 of the Companies Act 2006 and the regulations made thereunder.

Respective responsibilities of Trustees and Auditors

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

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

FLETCHER & PARTNERS
Chartered Accountants and Statutory Auditors
Salisbury, 30 April 2021

Consolidated

Statement of financial activities

	General Fund £	Designated Funds £	Restricted Funds £	Endowed Funds £	**Total 2020 £**	Total 2019 £
INCOME AND ENDOWMENTS FROM:						
Donations and legacies						
Members' subscriptions	1,332,661	-	-	-	**1,332,661**	1,294,025
Donations and legacies	1,372,623	-	845,432	-	**2,218,055**	1,842,656
	2,705,284	-	845,432	-	**3,550,716**	3,136,681
Charitable activities	-	-	2,277,295	-	**2,277,295**	2,049,168
Other trading activities						
Fundraising events	1,324,000	-	-	-	**1,324,000**	3,225,082
Advisory Service	145,628	-	-	-	**145,628**	190,836
Trading income	200,239	-	-	-	**200,239**	158,111
Investment income	3,644	-	58,464		**62,108**	115,721
Other	85,867	-	82,790	-	**168,657**	209,204
TOTAL	4,464,662	-	3,263,981	-	**7,728,643**	9,084,803
EXPENDITURE ON:						
Raising funds						
Direct costs of fundraising events	391,559	-	-	-	**391,559**	1,457,737
Membership and marketing	604,671	-	-	-	**604,671**	634,562
Other fundraising costs	995,157	-	-		**995,157**	1,228,297
	1,991,387	-	-	-	**1,991,387**	3,320,596
Charitable activities						
Research and conservation						
Lowlands	884,179	-	681,132	-	**1,565,311**	2,101,686
Uplands	269,323	-	378,267	-	**647,590**	536,601
Demonstration	219,910	-	1,115,071	4,150	**1,339,131**	1,297,171
Fisheries	76,042	-	523,230	-	**599,272**	816,258
	1,449,454	-	2,697,700	4,150	**4,151,304**	4,751,716
Public education	797,330	-	183,743	-	**981,073**	1,092,299
	2,246,784	-	2,881,443	4,150	**5,132,377**	5,844,015
TOTAL	4,238,171	-	2,881,443	4,150	**7,123,764**	9,164,611
Income/(expenditure) before investment gains	226,491	-	382,538	(4,150)	**604,879**	(79,808)
Net gains/(losses) on investments:						
Realised	(12,081)	-	-	(58,259)	**(70,340)**	47,141
Unrealised	87,406	-	-	138,815	**226,221**	202,500
NET INCOME/(EXPENDITURE)	301,816	-	382,538	76,406	**760,760** -	169,833
Transfers between funds	3,447	(3,447)	-	-	-	-
NET MOVEMENT IN FUNDS	305,263	(3,447)	382,538	76,406	**760,760**	169,833
RECONCILIATION OF FUNDS						
Total funds brought forward	3,187,305	11,492	800,552	4,805,950	**8,805,299**	8,635,466
TOTAL FUNDS CARRIED FORWARD	£3,492,568	£8,045	£1,183,090	£4,882,356	**£9,566,059**	£8,805,299

Consolidated

Balance sheet

as at 31 December 2020

	2020		2019	
	£	£	£	£
FIXED ASSETS				
Tangible assets		3,615,810		3,658,675
Investments		3,078,851		2,931,480
		6,694,661		6,590,155
CURRENT ASSETS				
Stock	376,596		424,001	
Debtors	1,337,808		2,057,030	
Cash at bank and in hand	2,748,753		1,177,934	
	4,463,157		3,658,965	
CREDITORS:				
Amounts falling due within one year	1,023,967		843,497	
NET CURRENT ASSETS		3,439,190		2,815,468
TOTAL ASSETS LESS CURRENT LIABILITIES		10,133,851		9,405,623
CREDITORS:				
Amounts falling due after more than one year		567,792		600,324
NET ASSETS		£9,566,059		£8,805,299
Representing:				
CAPITAL FUNDS				
Endowment funds		4,882,356		4,805,950
INCOME FUNDS				
Restricted funds		1,183,090		800,552
Unrestricted funds:				
Designated funds	8,045		11,492	
Revaluation reserve	218,647		210,978	
General fund	3,241,602		2,940,558	
Non-charitable trading fund	32,319		35,769	
		3,500,613		3,198,797
TOTAL FUNDS		£9,566,059		£8,805,299

Approved by the Trustees on 13 April 2021 and signed on their behalf

J PAICE

Chairman of the Trustees

Staff

of the Game & Wildlife Conservation Trust in 2020

CHIEF EXECUTIVE	Teresa Dent BSc, FRAgS, CBE
Personal Assistant	Laura Gell
Chief Finance Officer	Nick Sheeran BSc, ACMA, CGMA
Accountant	Leigh Goodger
Finance Senior	Hilary Clewer BA
Finance Assistant	Lindsey Chappé De Leonval
Accounts Assistant	Jean Porter *(until January)*; Amy Cheese *(from March)*
Head of Administration & Personnel	Alastair King Chartered MCIPD, MAHRM
Head Groundsman (p/t)	Craig Morris
Headquarters Site Maintenance	Steve Fish
Cleaner	Theresa Fish
Head of Information Technology	James Long BSc
IT Assistant	Dean Jervis HNC, BA
DIRECTOR OF RESEARCH	Prof. Nick Sotherton BSc, PhD, ARAgS *(until June)*
INTERIM DIRECTOR OF RESEARCH	Andrew Hoodless BSc, PhD *(from July)*
Personal Assistant (p/t)	Lynn Field
Public Sector Fundraiser	Paul Stephens BApp.Sc
Public Sector Fundraiser Administrator	Ben Stephens MAAT
Head of Fisheries	Dylan Roberts BSc
Head of Fisheries – Research	Rasmus Lauridsen BSc, MSc, PhD
Senior Fisheries Scientist (p/t)	William Beaumont MIFM
Fisheries Scientist	Stephen Gregory BSc, MPhil, PhD
Fisheries Ecologist	Luke Scott
Project Scientist	Céline Artero BSc, MSc, PhD
Fisheries Project Officer	Will Beaumont BSc
Research Assistant	Thomas Lecointre
Wylye Grayling Project	Jessica Marsh BSc, MSc, PhD
PhD Student *(University of Southampton)* - beavers and salmonids	Robert Needham BSc
PhD Student *(Queen Mary University of London)* - low flows on salmonids and river ecosystems	Jessica Picken BSc, MSc
PhD Student *(Bournemouth University)* - smolt migration and survival	Olivia Simmons BSc, MSc
PhD Student *(University of Exeter)* - adaption of trout to metal polluted rivers	Daniel Osmond BSc, MSc
Head of Lowland Gamebird Research	Rufus Sage BSc, MSc, PhD
Ecologist - Pheasants, Wildlife (p/t)	Maureen Woodburn BSc, MSc, PhD
PhD Student *(Exeter University)* - pheasant release pens	Andy Hall MSc
Placement Student *(Brighton University)*	Matthew Beedle *(until August)*
Placement Student	Samuel McCready *(from October)*
Head of Wetland Research	Andrew Hoodless BSc, PhD
Research Ecologist	Lucy Capstick BSc, PhD *(until November)*
Ecologist – LIFE Waders for Real	Lizzie Grayshon BSc
Research Assistant – woodcock	Chris Heward BSc, PhD
Research Assistant	Ryan Burrell BSc *(until January)*
Research Assistant	Jodie Case BSc
PhD student *(University College Cork)* - woodcock	James O'Neill BSc
PhD student *(University of Exeter)* - lapwing nest crypsis	George Hancock BSc, MSc
PhD student *(Bournemouth University)* - curlew	Elli Rivers BSc, MSc
PhD student *(Bournemouth University)* - lapwings and avian predators	Ryan Burrell BSc
Placement Student *(Bournemouth University)*	Thomas Weston *(until August)*
Placement Student	Daisy Gillman *(from November)*
Head of Predation Control Studies	Jonathan Reynolds BSc, PhD
Senior Field Ecologist	Mike Short HND
Research Ecologist	Tom Porteus BSc, MSc, PhD *(until August)*
Head of Farmland Ecology	Prof. John Holland BSc, MSc, PhD
Senior Entomologist	Steve Moreby BSc, MPhil
Postdoctoral Scientist	Niamh McHugh BSc, MSc, PhD
Postdoctoral scientist	Lucy Capstick BSc, PhD *(from November)*
Research Assistant	Jade Hemsley BSc *(until September)*
Research Assistant	Adam McVeigh *(until June)*
Research Assistant	Eleanor Ness BSc *(from October)*
PhD Student *(University of Sussex)* - solitary bees	Rachel Nichols BSc, MSc
PhD Student *(University of Edinburgh)* - biodiversity footprint of foods	Helen Waters BSc
Placement Student *(University of Reading)*	Jayna Connelly *(until August)*
Placement Student *(University of Bath)*	Ellie Jackson-Smith *(until August)*
Placement Student *(Plymouth University)*	Inca Johnson *(from September)*
Placement Student *(Durham University)*	Benjamin Prego *(from September)*
Director of Upland Research	David Baines BSc, PhD
Office Manager, Uplands	Sarah Grondowski
Senior Research Assistant - Scotland	Nick Hesford BSc, PhD *(until April)*
Senior Scientist - Scottish Upland Research	Sonja Ludwig MSc, PhD
Senior Scientist - North of England Grouse Research	David Newborn HND *(until September)*
Senior Research Assistant - Scottish Upland Research	Kathy Fletcher BSc, MSc, PhD
Research Assistant	Michael Richardson BSc
Senior Scientist	Phil Warren BSc, PhD
Placement Student *(University of Leeds)*	Alexander Donovan *(from August)*
Research Assistant *(University of York)*	Madeleine Benton BSc
Senior Scientist	Sian Whitehead BSc, DPhil
Placement Student	Kimberley Holmes *(from August)*
Placement Student *(Anglia Ruskin University)*	Sandy Jasper *(until July)*
Head of Scottish Lowland Research	David Parish BSc, PhD
Research Assistant - GWSDF Auchnerran	Marlies Nicolai BSc
Research Assistant - Scottish Grey Partridge Recovery Project	Fiona Torrance BSc
Research Assistant	Molly Crookshank BSc, MSc *(March-August)*
Placement Student *(Leeds University)*	Hannah Brunsden *(until March)*
Placement Student *(University of Leicester)*	Markos Nikolaou *(until August)*
Placement Student *(University of Brighton)*	Max Wright *(until August)*
Placement Student *(University of Birmingham)*	Elizabeth Ogilvie *(until August)*
Placement Student *(Queens University Belfast)*	Sophie McPeake *(from September)*
Placement Student *(Reading University)*	Tamara Spivey *(from September)*

Placement Student *(Plymouth University)*	Olivia Stubbington *(from September)*
Placement Student *(Leeds University)*	Elizabeth Fitzpatrick *(from September)*
INTERIM DIRECTOR OF ADVISORY & EDUCATION	Roger Draycott HND, MSc, PhD[2]
Co-ordinator Advisory Services (p/t)	Lizzie Herring
Biodiversity Advisor – Farmland Ecology	Jessica Brooks BSc, MSc, ACIEEM
Trainee Advisor	Amber Lole BSc, MSc *(from February)*
Head of Education	Mike Swan BSc, PhD[3]
Regional Advisor – central England	Austin Weldon BSc, MSc[4] *(until November)*
Game Manager (p/t) – Allerton Project	Matthew Coupe
Biodiversity Advisor – northern England (p/t)	Jennie Stafford BSc
Game Manager – Rotherfield Park	Malcolm Brockless *(until February)*
DIRECTOR OF POLICY, PARLIAMENTARY AFFAIRS & THE ALLERTON PROJECT	Alastair Leake BSc (Hons), MBPR (Agric), PhD, FRAgS, FIAgrM, CEnv
Secretary (p/t)	Sarah Large/Katy Machin *(until October)*
Policy Officer (England) (p/t)	Henrietta Appleton BA, MSc
Head of Research for the Allerton Project	Prof. Chris Stoate BA, PhD
Ecologist	John Szczur BSc
Soil Scientist (p/t)	Jennifer Bussell BSc, PhD
Research Assistant (p/t)	Gemma Fox
Welland Project Officer	Chris French
Welland Community Engagement Officer	Perry Burns *(from September)*
PhD student *(Leicester University)* - ecosystem services mapping	Max Rayner BSc
Head of Farming, Training & Partnerships	Philip Jarvis MSc
Assistant Farm Manager	Oliver Carrick BSc
Farm Assistant	Michael Berg
Research Assistant	Lucy Baker *(July-September)*
DEPUTY DIRECTOR OF RESEARCH	Nicholas Aebischer Lic ès Sc Math, PhD, DSc
Librarian, National Gamebag Census Co-ordinator & Head of CRM	Corinne Duggins Lic ès Lettres
Placement student *(CESI École d'Ingénieurs)*	Clément Boutin *(March-September)*
Senior Conservation Scientist & Head of PARTRIDGE	Francis Buner Dipl Biol, PhD
PARTRIDGE placement student *(Manchester Metropolitan University)*	Ellie Raynor *(from September)*
PARTRIDGE placement student *(University of Swansea)*	Lucy Robertson *(until August)*
Erasmus Student *(University of Osnabrück, Germany)*	Florian Schröer *(until April)*
Head of Geographical Information Systems	Julie Ewald BS, MS, PhD
Partridge Count Scheme Co-ordinator	Neville Kingdon BSc
Biometrics/GIS Assistant	Cameron Hubbard BSc, MSc
Placement Student shared with Wetland *(University of Southampton)*	Thomas Bristow *(until September)*
Placement Student shared with Wetland *(University of Plymouth)*	Jemma Gibson *(until September)*
Computer Science Placement Student *(Bournemouth University)*	Sophie Walker *(until August)*
Placement Student shared with Wetland *(Bangor University)*	George Scarisbrick *(from September)*
Placement Student shared with Wetland *(Bangor University)*	Rachel Cook *(from September)*
DIRECTOR OF FUNDRAISING	Jeremy Payne MA, MCIOF
Prospect Researcher	Tara Ghai
Events and Engagement Manager London	Vanessa Steel *(from November)*
London Events Manager	Jo Langer *(until February)*
London Events Co-ordinator	Eleanor Usborne *(until August)*
Northern Regional Fundraiser (p/t)	Sophie Dingwall
Southern Regional Fundraiser	Max Kendry
Eastern Regional Fundraiser (p/t)	Lizzie Herring
Regional Organiser (p/t)	Gay Wilmot-Smith BSc
Regional Organiser (p/t)	Charlotte Meeson BSc
Regional Organiser (p/t)	David Thurgood
Regional Organiser (p/t)	Pippa Hackett
Regional Organiser (p/t)	Fleur Fillingham
Administration Assistant	Daniel O'Mahony
DIRECTOR OF COMMUNICATIONS, MARKETING & MEMBERSHIP	Andrew Gilruth BSc
Team Assistant	Helen Smith
Membership & Shop Manager	Beverley Mansbridge
Membership Administrator	Heather Acors
Shop & Database Administrator	Emily Norris
Press & Publications Manager	James Swyer
Publications Officer (p/t)	Louise Shervington
Communications Officer	Katherine Williams *(from April)*
Graphic Designer	Chloe Stevens
Online Marketing Manager	Rob Beeson
Website Editor	Oliver Dean
Online Marketing Officer	Danny Sheppard
National Recruitment Manager	Les Fisher
Writer & Research Scientist (p/t)	Jen Brewin BSc, MSc, PhD
Science Writer	Emily Horrocks *(from April)*
Specialist Writer	Joe Dimbleby
DIRECTOR SCOTLAND	Bruce Russell BSc, MBE, DL
Scottish HQ Administrator (p/t)	Irene Johnston BA
Director of Policy (Scotland) (p/t)	Adam Smith BSc, MSc, DPhil
Head of Policy (Scotland)	Ross Macleod MA, MBA
Head of Events (Scotland)	Sarah Ballantyne BSc *(until October)*
Regional Organiser	Rory Donaldson
Senior Scottish Advisor & Scottish Game Fair Chairman	Hugo Straker NDA[1]
Trainee Advisor (Scotland)	Merlin Becker BSc *(until February)*
Advisor Scotland	Nick Hesford *(from May)*
Shepherd Manager GWSDF Auchnerran	Allan Wright
DIRECTOR WALES	Sue Evans
Curlew Country	Amanda Perkins
Advisor	Matthew Goodall[5]
Project Officer	Lee Oliver *(from April)*

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

External committees with GWCT representation

© GWCT

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

63.	Joint Hampshire Bird Group	Peter Thompson
64.	LEAF Policy and Communications Advisory Committee	Alastair Leake
65.	Mammal Expert Group of the England Biodiversity Strategy	Jonathan Reynolds
66.	Missing Salmon Alliance Steering Group	Teresa Dent/ Dylan Roberts
67.	Missing Salmon Alliance Technical Group	Rasmus Lauridsen
68.	Moorland Gamekeepers' Association	David Newborn
69.	Mountain Hare Monitoring Group	Ross Macleod
70.	National Trust for Scotland, Natural Heritage Advisory Group	Adam Smith
71.	Natural Resources Wales Fish Eating Birds Review Group	Dylan Roberts
72.	Natural Resources Wales Fisheries Forum	Dylan Roberts
73.	Natural Resources Wales Wild Bird Review - Stakeholder Meeting - Land Management and Shooting Sector Group	Matt Goodall/Sue Evans
74.	Natural England – Main Board	Teresa Dent
75.	New Forest Consultative Panel (Chair)	Andrew Gilruth
76.	NFU East Midlands Combinable Crops Board	Phil Jarvis
77.	NFU National Crops Board	Phil Jarvis
78.	NFU National Environment Forum	Phil Jarvis
79.	NGO Committee	Mike Swan
80.	North Wales Moors Partnership	David Baines
81.	Northern Uplands Local Nature Partnership	Sian Whitehead
82.	Oriental Bird Club Conservation manager for Pakistan and Northern India	Francis Buner
83.	Perthshire Black Grouse Group	Kathy Fletcher
84.	Pesticides Forum Indicators Group of the Chemicals Regulation Directorate	Julie Ewald
85.	Poole Harbour Catchment Initiative	Stephen Gregory
86.	Principles of Moorland Management Steering Group	Adam Smith/ Ross Macleod
87.	Purdey Awards	Mike Swan
88.	RASE Awards Panel	Alastair Leake
89.	Resilient Dairy Landscapes Stakeholder Advisory Group	Alastair Leake
90.	River Deveron Fisheries Science	Dylan Roberts
91.	River Otter Beaver Trial	Dylan Roberts/Mike Swan
92.	Rothamsted Research	Alastair Leake
93.	Rural Environment and Land Management Group	Adam Smith/Ross Macleod/Bruce Russell
94.	Rutland Agricultural Society	Alastair Leake
95.	Scientific Advisory Committee of the World Pheasant Association	Nick Sotherton
96.	Scotland's Moorland Forum and sub-groups	Adam Smith/Ross Macleod
97.	Scottish Black Grouse BAP Group	Phil Warren/David Baines
98.	Scottish Capercaillie Group	David Baines/Adam Smith/Kathy Fletcher
99.	Scottish Farmed Environment Forum	Ross Macleod
100.	Scottish Government Technical Assessment Group (Snares and traps)	Hugo Straker
101.	Scottish Land & Estates Moorland Working Group	Adam Smith
102.	Scottish Moorland Groups	Adam Smith/Hugo Straker/Nick Hesford
103.	Scottish Muirburn Code Review Group	Nick Hesford
104.	Scottish PAW Executive, Raptor and Science sub-groups	Adam Smith
105.	Scottish Principles of Moorland Management Group	Adam Smith/Nick Hesford/Ross Macleod
106.	SGR Monitoring Group	Alastair Leake
107.	Shoot Liaison Committee Wales	Matt Goodall/Sue Evans
108.	SNH Deer Management Round Table	Adam Smith
109.	SNH National Species Reintroduction Forum	Adam Smith
110.	SNH Scientific Advisory Committee Expert Panel	Nicholas Aebischer
111.	SNH South of Scotland Golden Eagle Reintroduction Project Scientific Steering Group	Adam Smith
112.	South Coast White-tailed Eagle Reintroduction project steering group	Mike Short
113.	South Downs Farmland Bird Initiative	Julie Ewald
114.	Southern Curlew Forum	Andrew Hoodless/ Amanda Perkins
115.	Species Survival Commission Galliformes Specialist Group	Francis Buner
116.	Speyside Black Grouse Study Group	Kathy Fletcher
117.	Strathbraan Wader Conservation Group	Adam Smith/Ross Macleod
118.	The Bracken Control Group	Alastair Leake
119.	The CAAV Agriculture and Environment Group	Alastair Leake
120.	The Curlew Country Board	Amanda Perkins/Sue Evans
121.	Tree Charter Steering Group	Austin Weldon
122.	UK & Ireland Curlew Action Group	Sian Whitehead
123.	UK Avian Population Estimates Panel (JNCC-led)	Nicholas Aebischer
124.	UK Upland Shoot Liaison Committee	Adam Smith
125.	Uplands Management Group	Sian Whitehead
126.	Voluntary Initiative National Steering Group	Alastair Leake
127.	Voluntary Initiative Water sub-Group	Chris Stoate
128.	Waitrose Responsible Efficient Production Expert Panel	Alastair Leake
129.	Welland Rivers Trust	Chris Stoate
130.	Welland Resource Protection Group (Chair)	Chris Stoate
131.	Welsh Government Fox Snaring Advisory Group	Matt Goodall
132.	Wild Purbeck Group	Dylan Roberts
133.	Wildlife Estates England Scientific Committee	Andrew Hoodless
134.	Wildlife Estates England Steering Group	Roger Draycott
135.	Wildlife Estates, European Scientific Committee	Alastair Leake
136.	Wildlife Estates Scotland Board & Sub Groups	Adam Smith/Ross Macleod
137.	World Pheasant Association Scientific Advisory Committee	David Baines
138.	Working for Waders	Adam Smith/Ross Macleod

Key to abbreviations: AIHTS = Agreement on International Humane Trapping Standards; BAP = Biodiversity Action Plan; BASC = British Association for Shooting and Conservation; BBSRC = Biotechnology and Biological Sciences Research Council; CAAV = Central Association of Agricultural Valuers; CFE = Campaign for the Farmed Environment; CIC = International Council for Game and Wildlife Conservation; CNPA = Cairngorms National Park Authority; EA = Environment Agency; FWAG = Farming & Wildlife Advisory Groups; ICES = International Council for the Exploration of the Sea; IOBC-WPRS = International Organisation for Biological and Integrated Control of Noxious Animals and Plants-West Palearctic Regional Section; IUCN = International Union for Conservation of Nature, JNCC = Joint Nature Conservation Committee; LEAF = Linking Environment And Farming; NE = Natural England; NFU =National Farmers' Union; NGO = National Gamekeepers' Organisation; NIA = National Improvement Area; PAW = Partnership for Action Against Wildlife Crime; RASE = Royal Agricultural Society of England; SGR = Second Generation Rodenticide; SNH = Scottish Natural Heritage.

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