Review
of 2006

A full report of the activities of
The Game Conservancy Trust
and Game Conservancy Limited

www.gct.org.uk

THE GAME CONSERVANCY TRUST

Supported by

HISCOX

OVAL

Review of 2006

Issue 38

A full report of the activities of The Game Conservancy Trust Limited (Registered Charity No. 1112023) during the year

The Game Conservancy Trust Limited's 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.

Produced by: Natterjack Publications Limited
3 Nether Cerne, Dorchester, DT2 7AJ
Tel: 01300 341833 or 07740 760771
smiles@natterjackpublications.co.uk

Editing, design, layout: Sophia Gallia

Printing and binding: Friary Press, Dorchester

Front cover pictures: Hare by Laurie Campbell;
Inset picture by Sophia Gallia

Photography: The Game Conservancy Trust wishes to thank the photographers who have contributed to this publication. Their details can be obtained from Sophia Gallia.

The Game Conservancy Trust, Fordingbridge, Hampshire, SP6 1EF
Tel: 01425 652381 Fax: 01425 651026/7 Email: info@gct.org.uk
Ref: PAR1010607
Printed on elemental chlorine-free paper from sustainable forests

Corporate sponsorship

The Game Conservancy Trust acknowledges the exceptional support of its Corporate Sponsors in 2006, Hiscox (with Oval), Subaru and Isuzu, in assisting vital research and educational work to conserve game, wildlife and their habitats in Britain.

HISCOX

OVAL

www.gct.org.uk

THE GAME CONSERVANCY TRUST

Sound advice

through scientific understanding

- **Professional conservation advice**
- **Training courses**
- **Demonstration days**

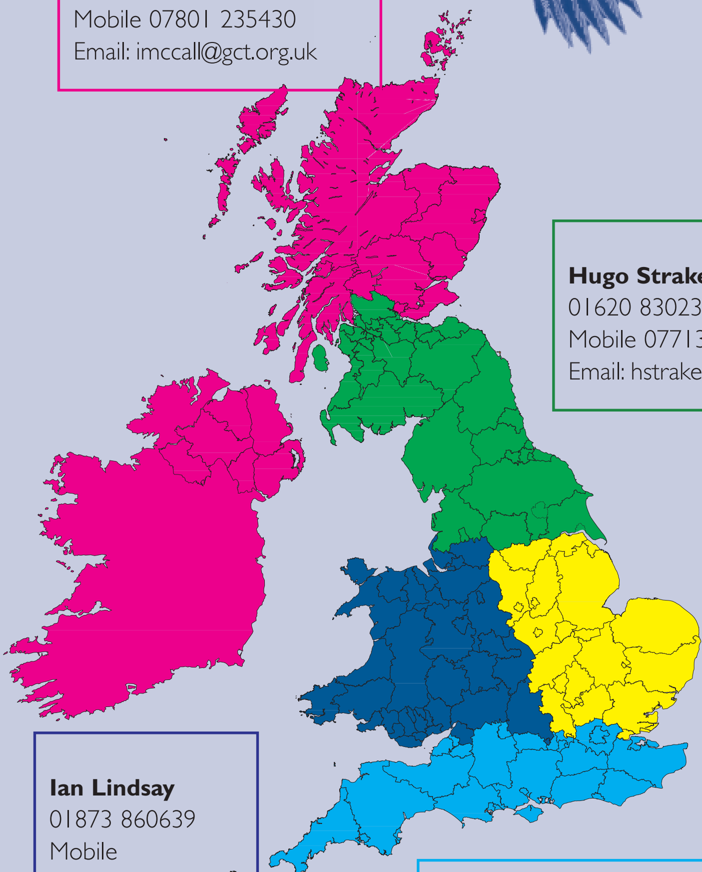
- **Game population counts**
- **Harvesting suggestions**
- **Grouse worm counts and louping ill tests**

Your GCL advisor provides professional advice to help you with:

Grants, stewardship, biodiversity.
Woodland siting, establishment and improvement.
Pond creation and wetland management.
Fishery management.
Woodland deer management.
Game crop selection, siting and establishment.
Maximising agri-environment schemes for game and wildlife.

Grouse and moorland management.
Strongyle worm counting.
Grouse counting.
Louping ill testing.

Game and wildlife management courses.



Ian McCall
01828 650543
Mobile 07801 235430
Email: imccall@gct.org.uk

Hugo Straker
01620 830230
Mobile 07713 074147
Email: hstraker@gct.org.uk

Martin Tickler
01379 586551
Mobile 07730 065935
Email: mtickler@gct.org.uk

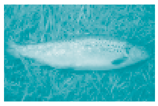
Ian Lindsay
01873 860639
Mobile 07968 327630
Email: ilindsay@gct.org.uk

Mike Swan
01425 651020
Mobile 07801 413209
Email: mswan@gct.org.uk

Advisory Services,
Game Conservancy Limited
Fordingbridge,
Hampshire SP6 1EF
Tel: 01425 651013
Email: advice@gct.org.uk

GAME CONSERVANCY LIMITED

Contents



The Game Conservancy Trust Council

as at 1 January 2007

Chairman's report

It is an honour to be penning my contribution to the *Review of 2006* as the new Chairman of Trustees. First, I wish to acknowledge the very great debt The Game Conservancy Trust (GCT) owes to my predecessor Andrew Christie-Miller. In Andrew, the Trust found a hugely beneficial combination of commitment and skills. He was, and is, utterly committed to our science and the "brand" of conservation that emerges from that; his intimate knowledge of farming, wildlife and game management enabled him to help form the GCT's wildlife management policies, and his business skills have helped re-shape it into an organisation fit for purpose in the 21st century. I'm delighted that Andrew remains involved as a trustee helping in particular with fundraising.

Mark Hudson is an organic dairy, beef and arable farmer from North Wales. He is a farm business consultant and past President of the Country Land and Business Association. (Tom Hudson)

As mentioned in the report to the accounts at the back of this *Review*, this year we merged fully with the Allerton Research and Educational Trust (ARET). It was in many ways a formality as ARET's farm at Loddington in Leicestershire has been the GCT's demonstration farm ever since it was gifted by Lord and Lady Allerton's executors in 1992: for various reasons it was set up as a separate, but linked charity, which we have now merged with GCT. I'm delighted that both Mike Barnes and Joe Cowen (ARET trustees) are now part of the GCT trustee team, and that Mrs Sue Treadwell (the Allertons' granddaughter) is a Vice-president.

I am very pleased to have the opportunity to thank the many people that make the work of the GCT possible: the trustees themselves who donate considerable time and expertise; our army of volunteers around the country who help magnificently with fundraising – highlights being the Scottish auction which raised £177,000, and the GCUSA auction £225,000. Thanks, too, to our members who demonstrate their commitment year after year; the many individuals and charitable trusts that support our work, and all our corporate sponsors for their support during 2006 – especially our main sponsors Hiscox and Oval Insurance Broking Group. I would also like to thank Subaru and Isuzu for many years of sponsorship.

We are very fortunate in having highly professional staff, ably led by our Chief Executive, Teresa Dent. During my first year as chairman, I have tried to meet as many of them as possible and visit our research and demonstration sites as time allowed. During those visits, I have been struck by the dedication of the staff and their true commitment to sound science.

Research is and must remain the heart of what we do, but the challenge I believe we face during my term as chairman is to ensure that we deliver that research effectively into policy, practice and public awareness; the message is simple – game and wildlife management is a vital part of nature conservation.

Chief Executive's report

Chief Executive, Teresa Dent. (Louise Shervington)

As befitting a charity that celebrated a "double jubilee" in 2005, 2006 has been a year in which we have invested for the future – the next 25 years.

We have focused on four initiatives all centred around using our science to greater effect and ensuring better understanding of the contribution game management makes to nature conservation. These four are policy, profile, education and practice.

We are putting more resources into ensuring our science, and conservation message, is understood by policy makers and politicians. And not just the existing generation (those "in-post"), we'll also be seeking to educate the next generation currently in university or college; those who will be making their careers in government and organisations such as Natural England, or in the practical world of land management. In this world of increasing legislation and regulation there needs to be a real understanding among policy makers of the multi-functionality of land use, and how we can effectively juggle the sometimes competing demands of wildlife conservation with farming, forestry, landscape and recreation.

An organisation that is well-known will have its opinions listened to more carefully and taken more seriously. Outside the world of game management and farming the GCT is not well known. To improve our profile we will be investing in a marketing campaign to enhance awareness, and have recruited a new Director for Marketing & Membership.

If we want to deliver our strong and relevant message better about how game management is essential to nature conservation, we need to attract more members and supporters. By broadening our appeal and relevance to new audiences, we will be striving to ensure that our charitable objects are delivered as effectively as possible.

Good practice in any aspect of land and wildlife management is vital, and never

Science remains the backbone of what our organisation is and does. (Des Purdy)

We are expanding our training and education programme to all those managing the countryside. (Sophia Gallia/Natterjack Publications)

more so than in game management. We are expanding and strengthening our training and practitioner education programme. We'll also be looking to work with all those involved in managing the countryside and the wildlife in it.

But none of this must be at the expense of the science from which this all emanates. By way of example, in 2006 we launched the results of our four-year study into the environmental impact of released pheasants. This study allowed us to prepare releasing guidelines which allow individual shoot managers to ensure that there are conservation gains from their released pheasant shoot. The guidelines have also been incorporated into the new shoot assurance scheme. This is a good example of science providing conservation solutions which inform good practice; science that promotes the conservation benefits of woodland management for pheasants; and science that shows policy makers that banning released pheasants would probably not be in the interests of conservation.

We have hit our financial targets this year, which is very satisfactory (the accounts report is on page 90). Our research programme continues apace as illustrated by the many reports in this *Review*. As always they make fascinating reading.

Finally, I'd like to add my thanks to those of our Chairman to all those members, volunteers, trustees and funders who have helped make our work in 2006 possible. The directors and staff have worked incredibly hard and I am proud of and grateful to all of them.

Delivering our message

by Ian Lindsay,
Director of Advisory & Education

Since the inception of our organisation in the 1930s, it has embodied a unique partnership between its research and advisory departments providing farmers, game and wildlife managers with up-to-date, science-based wildlife management prescriptions. Although historically game species, their habitats and management were the principal focus of activity, today, our work increasingly covers a much wider range of species and habitats, advising Governments on agri-environment schemes and providing leadership in the recovery of species from grey partridges, brown hares and water voles to farmland birds and rare arable flora. Our continuing priority is to increase the profile, number and breadth of training available to game, land and wildlife managers and to provide the leadership and encouragement for the wider adoption of our management prescriptions.

Mike Swan, one of our team of advisors, demonstrating how to construct and use a GCT Mink Raft. (Sophia Gallia/Natterjack Publications)

During 2006, we established 11 highly successful regional grey partridge groups. Funded by the Vocational Training Scheme and made possible by initial funding from Saffrey Champness, these provide detailed, practical advice for farmers, conservation groups and others on the restoration and management of wild grey partridges, brown hares and a wide range of other farmland wildlife. These groups ran over 20 training events in 2006 and are closely linked to our Partridge Count Scheme (see page 72), what we believe is the biggest farmer-led wildlife monitoring scheme in Europe.

Both regionally, at Fordingbridge, and at our demonstration projects we launched other training initiatives in 2006 including a fisheries management course, training for conservation agencies covering the management of water voles, brown hares, black grouse, together with "best practice" demonstrations on predator control, gamebird releasing and management. Collectively, these provided a total of 89 group events attracting over 3,200 attendees.

Among our demonstration projects, the Allerton Project at Loddington continues to provide one of the most important and persuasive demonstrations of crop, soil and habitat management in the UK. As well our own continuing studies on the impacts of game management on farmland wildlife, the estate now hosts research to support the EU Water Framework Directive aimed at reducing the effect of soil and crop management on water catchments (see page 56). During 2006, we welcomed over 2,400 visitors to Loddington.

Through this expanding programme of training and demonstrations, we significantly increased the direct "delivery" of our game and wildlife management prescriptions in 2006. To coincide with this activity, we produced a comprehensive prospectus of all our training and demonstration events, and will produce a similar publication annually. The increasing number and breadth of opportunities we provide to those managing game and wildlife is a reflection of our unique position as a research-based organisation able to impart practical advice.

The new fisheries course in June included a visit to the River Ebble where our practical management prescriptions are being used to boost wild trout numbers. Here Dylan Roberts explains what has been done. (Sophia Gallia/Natterjack Publications)

Broadening our appeal

by Chris Washington-Sare,
Director of Marketing & Membership

As a long-established conservation charity, The Game Conservancy Trust uses science to promote game and wildlife management as an essential part of nature conservation. Members support us because they believe in the principle of *conservation through wise use*. However, a recent survey we conducted showed that 81% of UK adults do not understand the term. To promote game and wildlife management effectively to as wide an audience as possible, we need to broaden our appeal to those who love the British countryside – whether they live in it, walk, work, farm, shoot or fish it.

It must be stressed that we are not trying to change our core values, principles or beliefs. We are simply trying to communicate them more effectively.

Recently we conducted research to get a better understanding of people's attitudes to the countryside and our work. The research project solicited the views of members, staff, trustees and the general public – over 2,500 people responded to questioning. The results provide a fascinating insight into what we need to do to put game and wildlife management at the centre of the conservation debate.

- Currently 7% of UK adults recognise The Game Conservancy Trust logo – when prompted. Unprompted, recognition is non-existent, indicating that we need to focus on raising our profile with key target audiences.
- 23% of UK adults wouldn't support us because they do not shoot. Of this group, 25% have no objection to eating venison, pheasant or hare. We have an opportunity to show that shooting is part of game and wildlife management, which in turn is part of good nature conservation. And we need to re-connect the food on the plate with how it gets there.
- When shown a range of draft logo designs, 71% of members (and 83% of non-members) preferred their new logo choice over our existing logo. It is clear that we have an opportunity to evolve the way in which we present The Game Conservancy Trust.

The findings of this research are being incorporated into a communications and marketing plan which will be launched in the latter part of 2007.

A leaflet introducing our organisation – we have used a wide range of photographic resources to communicate the depth and breadth of our work.

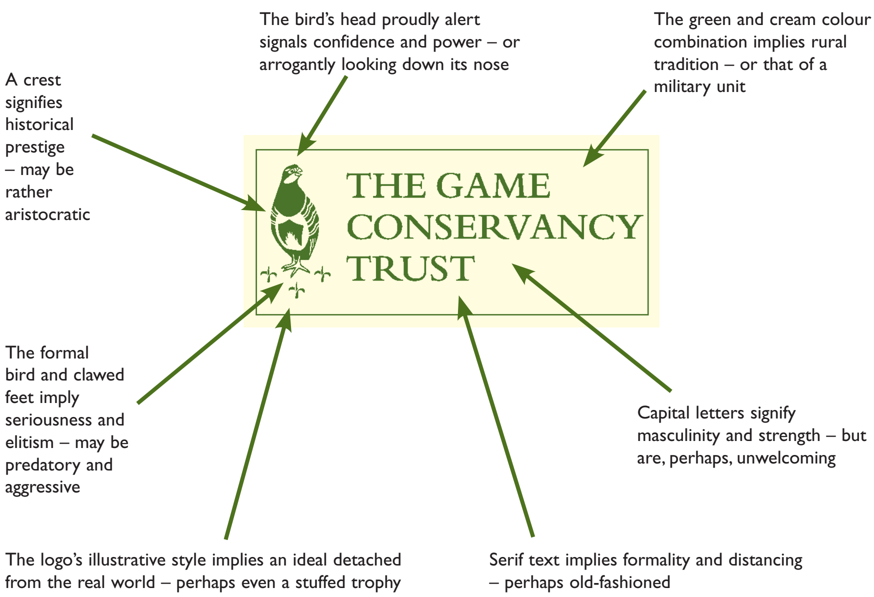


Figure 1

Hidden codes and meanings in our current logo that may influence how people perceive the Trust, as analysed from a semiotic study

River ecology summary for 2006

Key achievements

- Completion of long-term monitoring on the Clywedog Brook.
- Restoration on River Monnow Project completed, monitoring continued.
- Study of effects of stocking trout on wild fish neared completion.
- Study of effect of siltation on fly-life and salmonid egg survival entered third year.

Dylan Roberts

A typical chalk stream of southern England. (Sophia Gallia/Natterjack Publications)

We completed the long-term monitoring of the effects of upland stream fencing and coppicing on brown trout and juvenile salmon on the Clywedog Brook that we started in 1998. The results of this work are due to be published in 2007. We also continued monitoring the habitat restoration work on the River Monnow (see page 14).

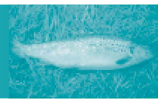
Our research on stocked brown trout continued with a repeat of the mark-recapture and the radio-tracking elements of this work. This project, in partnership with the Environment Agency, aims to compare the survival of fertile diploid with infertile triploid brown trout in both upland and lowland rivers, and also to assess their effects on wild fish. We are due to complete this work in late 2007.

Our study to measure the effectiveness of farm management in reducing siltation in rivers entered its third year in 2006. Siltation can reduce fly life and the survival of trout and salmon eggs, so this work compares egg survival and fly-life in managed and unmanaged catchments in North Cornwall and forms Dominic Stubbing's PhD. Initial trials tested putting well-developed trout eggs (which are reasonably hardy and safe to move) into artificial redds made from plastic pots used to collect and measure silt. Early results show that permeability of the river substrate affects egg survival, whereas the amount of oxygen used up by decomposing sediment does not.

Fisheries research in 2006

Project title	Description	Staff	Funding source	Date
Fisheries research	*Developing wild trout fishery management methods, including reports of historical fisheries research*	*Dylan Roberts, Dominic Stubbing, Ravi Chatterji*	*Core funds, GC London Fish Group, Fisheries funding appeal*	*1997 - on-going*
Assessment of habitat improvement on brown trout and salmon	*Monitoring brown trout and juvenile salmon abundance after fencing and coppicing on the river Clywedog 1997-2000*	*Dylan Roberts*	*Environment Agency Wales, WHIP (1998-2001)*	*1998-2006*
Monnow Improvement Project (see page 14)	*Large-scale conservation and scientific monitoring of 30km of river habitat on the River Monnow in Herefordshire*	*Dylan Roberts*	*Defra, Rural Enterprise Scheme, Monnow Improvement Partnership*	*2003-2006*
Swans and water crowfoot	*Quantifying the effects of swan grazing on water crowfoot, River Wylye, Wiltshire*	*Jonathan Reynolds, Mike Short, Tom Porteus, Dominic Stubbing*	*Environment Agency, Wiltshire Fisheries Assoc*	*2004-2007*
Salmon habitat	*Pilot study to investigate if juvenile salmon prefer fenced and unshaded streams to unfenced and shaded streams*	*Dylan Roberts*	*Atlantic Salmon Trust*	*2006*
Trout stocking project 1 (see page 11)	*Diploid stocking*	*Ravi Chatterji*	*WTT, Core funds*	*2002-2007*
Trout stocking project 2	*Triploid stocking*	*Ravi Chatterji, Dean Sandford, Dylan Roberts, Dominic Stubbing*	*Environment Agency Riparian owners, Houghton Club, Fishmongers, S&TA*	*2005-2007*

Key to abbreviations: Defra = Department of the Environment, Farming & Rural Affairs; S&TA = Salmon & Trout Association; WHIP = Wye Habitat Improvement Project; WTT = Wild Trout Trust



Stocking rivers with fry

In previous *Reviews* we reported on the effects of stocking adult brown trout on wild fish. This year, we report on our study of the effects of stocking fry.

We used two water courses representative of upland rain-fed rivers (River Arrow and River Honddu) and three lowland spring-fed chalk streams (River Wylye, River Piddle and River Allen). In each river category, we randomly allocated 24 sites (each 50 metres long and at least 100 metres away from any other site) with one of three stocking treatments and a control, using two strains of farmed fry – one reared in a farm with an upland river source (strain U) and one reared in a farm with a lowland chalk spring source (strain L). The three treatments used were strain U fry stocked at a density of 0.5 per square metre, strain U fry stocked at a density of five per square metre and strain L fry stocked at a density of five per square metre. Both strains were mixed-sex diploids and were derived from wild fish over 15 years ago. Strain L fry were nearly three times heavier and about 30% longer than strain U fry at the time of stocking. All fry were marked using fluorescent calcein before stocking.

We electro-fished the sites for a baseline survey in summer 2003. We introduced the farmed fry in spring 2004, and followed this with a post-treatment survey in summer 2004. We counted and measured all brown trout fry and identified them as either wild (no calcein mark) or farmed (calcein-marked).

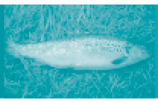
The recapture rate of farmed fry depended partly on the strain (see Figure 1 overleaf), with strain U consistently exhibiting the highest site fidelity. The upland rivers were also the most successful in holding farmed fry. This was probably due to the prevalence of boulders and cobbles which provide nursery habitat for juvenile brown trout. Figure 1 illustrates the relative success of both river types in holding farmed fry.

Key findings

- The upland strain of fry showed higher fidelity to the release site than the lowland strain in both upland and lowland sites.
- Stocking with fry did not affect numbers of wild fry.
- In upland rivers fry stocking caused a small reduction in growth rates of wild fry.
- Stocked fry grew better at lower stocking densities.
- Fry stocking was more successful in upland than lowland rivers.

Ravi Chatterji

We use electro-fishing in our fisheries projects to recapture or count fish populations. (Sophia Gallia/Natterjack Publications)



We found that farmed fry had no significant effect on the numbers of wild fry in either upland or lowland sites. However, the wild fry were slightly (but significantly) bigger in unstocked control sites than in stocked treatment sites in upland rivers (see Figure 2). Although the differences were small, this suggests that fry stocking reduces the growth rate of resident wild fry which might have implications for their future survival. Among the treatment sites, the smallest wild fry were in strain U ($5/m^2$) sites, probably due to the higher densities of farmed fry recovered at these sites (see Figure 1).

Generally, the densities of farmed fry recaptured in 2004 were proportional to the wild fry baseline density in 2003. In other words, fewer farmed fry were recovered in those areas where wild fry numbers were originally low. This suggests that fry stocking programmes used to mitigate for wild fry absence or decline may be ineffective.

In lowland chalk streams, recaptured fry of all types, wild, strain U and strain L, were significantly bigger than their upland counterparts. This supports the idea that fry grow better in chalk streams than in upland rivers.

The average size at recapture of strain U in upland sites was significantly higher in the low ($0.5/m^2$) stocking sites than the high ($5/m^2$) indicating that they grow better when stocked in lower numbers.

This study demonstrates that the success of farmed fry stocking programmes, in terms of numbers recaptured, depends on the nature of the receiving river, with fry stocking in upland rivers proving much more successful than in chalk streams. Stocking at high densities ($5/m^2$) can considerably increase total fry abundance in upland rivers without affecting the underlying numbers of wild fry, although it does reduce their growth. However, stocking farmed fry at the lower density ($0.5/m^2$) improved their survival rate as well as growth.

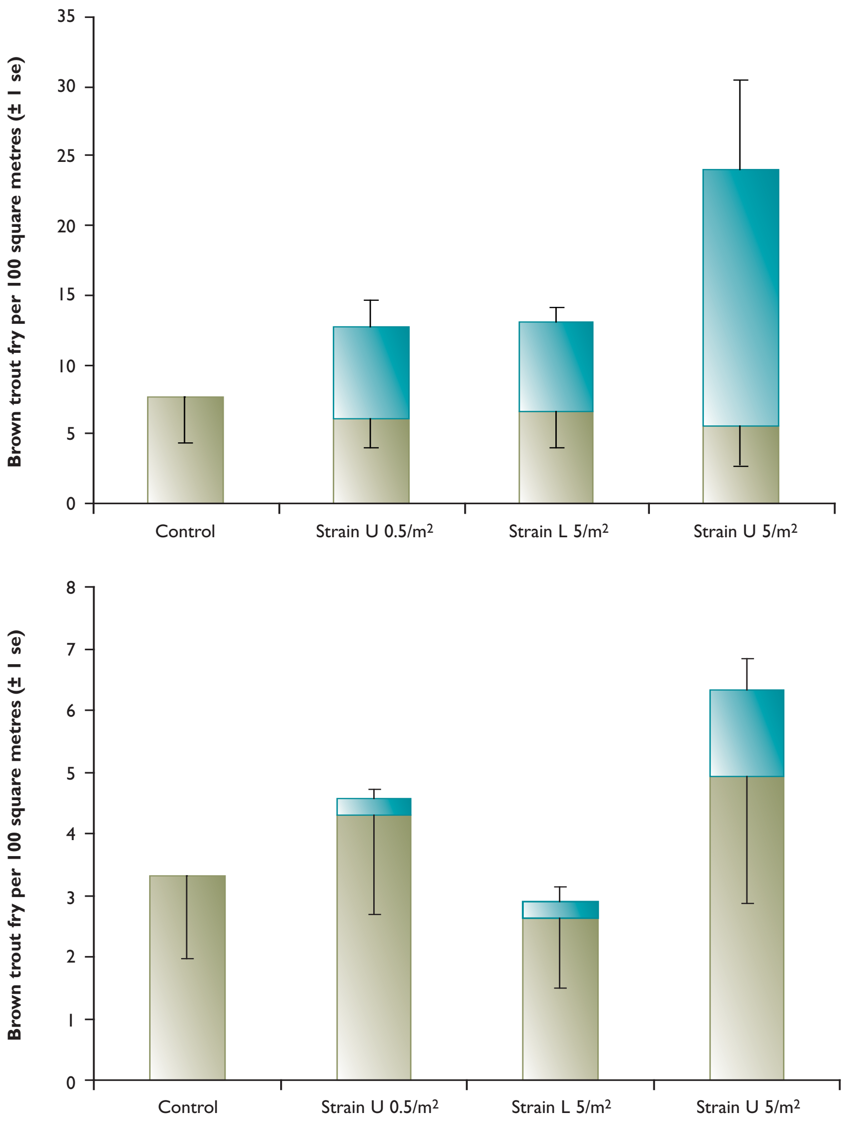
Figure 1

The mean contribution of farmed brown trout fry to the total fry population in upland rivers (top) and lowland chalk streams (bottom), by treatment.

Stocked fry

Wild fry

Error bars pointing downwards refer to wild fry; those pointing upwards refer to stocked fry. There were no stocked fry in the controls.



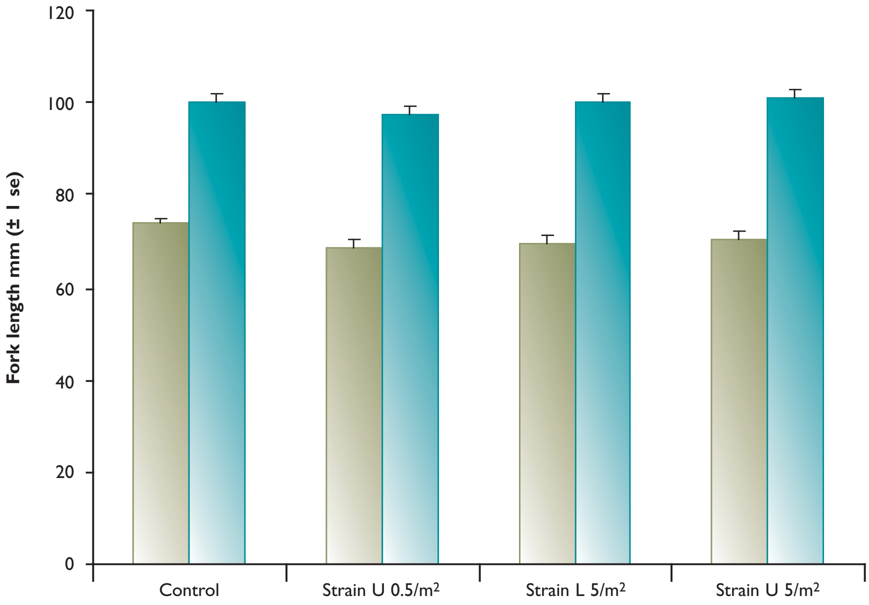


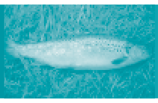
Figure 2

The size (mean fork length, mm) of upland river and lowland chalk stream wild brown trout fry sampled during the summer/autumn period after stocking, by treatment.

Upland river

Lowland chalk stream

Trout fry ready to be released into the project sites. (Ravi Chatterji)



Effect of River Monnow restoration on trout

Key findings

- Trout numbers have varied between years.
- There are no measurable changes in trout numbers resulting from habitat work yet.
- Numbers of trout fry have increased in restored and unrestored areas.
- Habitat quality has increased in restored areas.

Dylan Roberts

Following habitat restoration work, bank-side vegetation has established. (Louise Shervington)

The Monnow Project, which started in 2003, completed its habitat restoration work in 2006. In total, over 60 kilometres of stream bank are now protected from cattle and sheep by fencing. The vegetation is growing back and four tributaries are returning to a more 'natural' form. The aim of the project has been to increase numbers of brown trout for fishing by improving the quality of habitat. Opening dark tunnelled streams by coppicing also makes them more fishable.

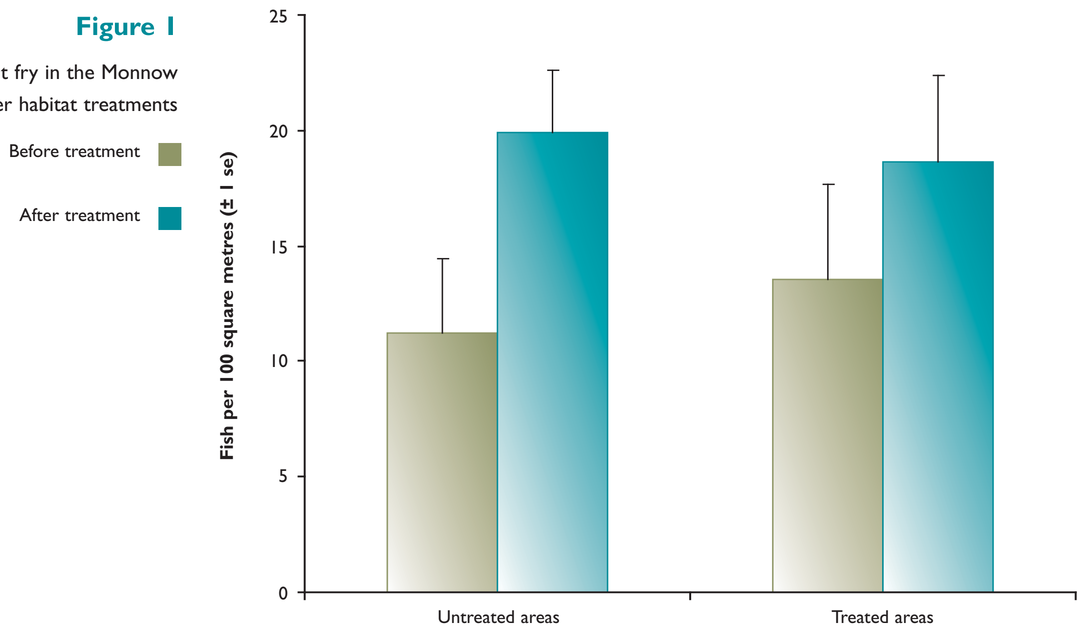
An important part of the project has been to measure trout abundance before and after habitat restoration. This is being done with electro-fishing surveys on 10 pairs of randomised experimental treatment and control sites.

We have also measured the effect of the restoration work on the number of bullheads, which are important as a species listed at risk in the EU Habitats Directive.

On our River Monnow sites we undertook two years (2003 and 2004) of pre-treatment surveys and two years post-treatment in 2005 and 2006. The results of electro-fishing show that numbers of brown trout vary between years but, as yet, there has been no measurable change in numbers of trout fry, parr or older trout due to the treatments on any stream. Figure 1 shows that the mean density of trout fry

Figure 1

Densities of brown trout fry in the Monnow before and after habitat treatments



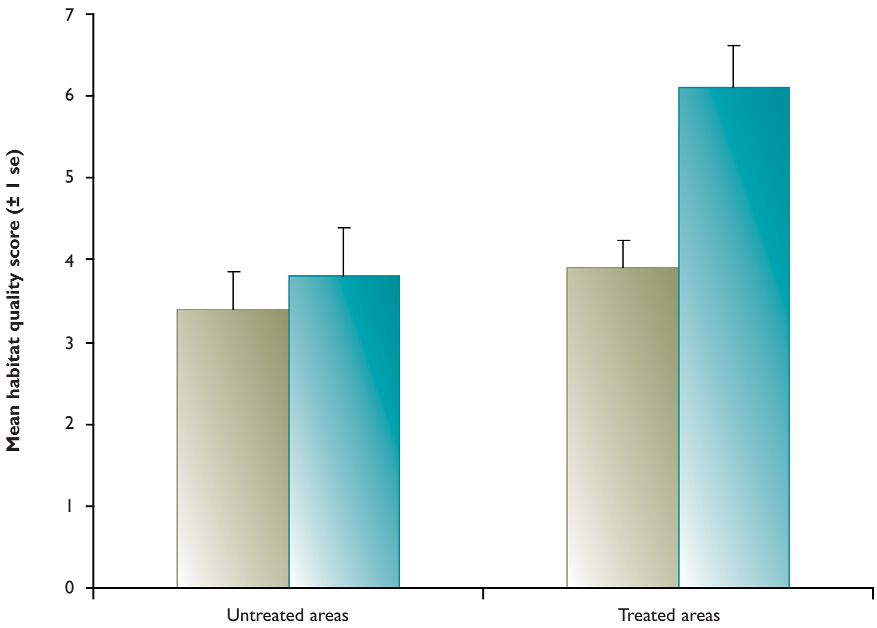


Figure 2

Habitat quality for trout of less than 20cm on the Monnow before and after treatment

Before treatment

After treatment

(0+ years old) per 100 square metres has increased following treatments, but they have also increased in control areas. We found similar patterns between treatment and control sites for other age classes of trout.

In addition to counting trout, we have also used HABSCORE to measure the quality of habitat available to trout. HABSCORE is a statistical model developed by the Environment Agency to asses the suitability of habitat for brown trout and juvenile salmon. It takes into account the types of stream flow eg. pool, riffle or glide, substrate characteristics, eg. boulders, cobbles, gravel or silt and stream widths and water depths. It also takes into account the percentage of over-hanging and in-stream vegetation. HABSCORE can be used to predict densities of trout in most age classes.

Our results show that HABSCORE values have increased as a result of our treatments (see Figure 2). This indicates that the project has had a positive effect on the trout's habitat. We hope that trout numbers will begin to respond soon.

The mammoth task of coppicing and erecting sheep fences to 60 kilometres of the Monnow's river bank is now complete.
(The Game Conservancy Trust)

Upland ecology summary for 2006

Key achievements

- Long-term monitoring continued.
- The Upland Wader Experiment neared completion and showed interesting results.
- We gained a clearer understanding of black grouse populations and provided advice based on research results.

David Baines

The core of our uplands work focuses on the red grouse and, in 2006, we continued our long-term monitoring by counting in spring and summer (see page 18). Red grouse research also incorporates studies of habitats, such as moorland drainage (see page 28), disease such as strongylosis and louping ill and the study of red grouse populations. Three PhDs relating to red grouse were underway in 2006, one of which reached completion. Ellie Watts' work on tick ecology (see page 30) showed that tick distribution is complicated by the other hosts around (eg. deer and mountain hares) and by the vegetation on the moor. Nils Bunnefeld's study of how shooting affects grouse populations and Julie Black's work on how grouse management is tied in with conservation of other species will be reported on in future years. In addition to these, we congratulate Phil Warren on successfully defending his PhD on red grouse dispersal (see page 26).

Our flagship project, based at Otterburn, is looking at other species, in particular waders, which share the moorland habitat. This Upland Predation Experiment is nearing its completion and is showing some interesting results (see page 21).

Grouse moor. (Laurie Campbell)

Our monitoring work does not start and end with red grouse. We also monitor capercaillie and black grouse. Our data for capercaillie, which spans 15 years, indicates that the population is hampered by the lack of hens rearing broods (see page 36). Meanwhile work on black grouse continued in 2006 and brought us nearer to understanding the key factors limiting population sizes in England, Scotland and Wales (see page 32). Our findings are vital when providing advice to land managers through our black grouse restoration programmes.

The mountain hare is also a subject of our research. This species is becoming more important as a quarry species, so land managers in many areas are keen to encourage its population expansion. In 2006, we completed a study on whether feeding hares over the winter affects their breeding patterns and success (see page 34).

The subject of hen harriers remains contentious and is the focus of much discussion in the uplands. Since the Joint Raptor Study, which took place at Langholm, reported in 1997, we have continued monitoring raptors, grouse, voles, pipits, waders and foxes on the Langholm moor and these data will prove valuable for future studies. During the year we entered discussions to develop a new phase of work at Langholm, which, if successful, will reconcile differences between grouse moor interests, conservation of associated moorland species, and hen harrier conservation. This new phase is due to begin in 2007 and we will report on it in future *Reviews*.

Upland research in 2006

Project title	Description	Staff	Funding source	Date
Stongylosis research	*Developing strongylosis control techniques*	*David Newborn, David Baines, Mike Richardson*	*Core funds*	*2006-2011*
Grouse monitoring (see page 18)	*Annual long-term counts and parasite monitoring in England*	*David Newborn, David Baines*	*Core funds, Gunnerside Estate*	*1980 - on-going*
Black grouse research (see page 32)	*Ecology and management of black grouse*	*David Baines, Mike Richardson*	*Core funds*	*1989 - on-going*
North Pennines black grouse recovery	*Black grouse restoration*	*Philip Warren*	*MoD, English Nature, RSPB, Northumbrian Water*	*1996-2006*
Release of low-ground gamebirds	*Effects of releasing on wild gamebirds of moorland and moorland margins*	*David Baines Annelie Jonsson*	*W J Handley Trust*	*2005-2006*
Upland Predation Experiment (see page 21)	*Effect of grouse moor management on other bird species*	*David Baines, Kathy Fletcher Rob Foster, Craig Jones, Philip Chapman*	*Uplands Appeal, Core funds*	*1998-2008*
Langholm research	*Monitoring raptors, grouse, voles, pipits, waders and foxes on Langholm Moor*	*David Baines Mike Richardson*	*SNH, Core funds*	*2003-2007*
Scottish grouse research (see page 18)	*Long-term monitoring of red grouse and worm burdens*	*Adam Smith, David Howarth*	*Scottish Trustees, Core funds*	*1985 - on-going*
Mountain hare ecology (see page 34)	*Effects of supplementary feeding on mountain hare demography*	*Adam Smith*	*NERC*	*2005-2006*
Tick control	*Tick control in a multi-host system*	*Adam Smith, David Howarth, Allan Macleod*	*Scottish Trustees, Various charitable trusts*	*2000-2007*
Woodland grouse (see page 36)	*Ecology and management of woodland grouse*	*David Baines, Martin Dalimer*	*SNH, LIFE, The Dulverton Trust*	*1991-2006*
PhD: Red grouse	*Grouse population dynamics in relation to shooting*	*Nils Bunnefeld Supervisors: David Baines; E J Milner-Gulland/Imperial College*	*John Stanley Trust Studentship*	*2005-2007*
PhD: Grouse management and conservation	*Quantifying the impacts of grouse management on the conservation of wildlife in the North Pennines*	*Julie Black Supervisors: Nick Sotherton; E J Milner-Gulland/Imperial College*	*ESRC/CASE Studentship*	*2005-2007*
PhD: Tick ecology (see page 30)	*Spatial ecology of sheep ticks*	*Ellie Watts Supervisors: Adam Smith; Justin Irvine/CEH; Alan Bowman/Aberdeen Univ*	*NERC/CASE Studentship*	*2003-2006*

Key to abbreviations: CEH = Centre for Ecology & Hydrology; ESRC = Economic and Social Research Council; LIFE = European Union Financial Instrument for the Environment; MoD = Ministry of Defence; NERC = Natural Environmental Research Council; RSPB = Royal Society for the Protection of Birds; SNH = Scottish Natural Heritage.

Red grouse monitoring

Key findings

- Spring densities of red grouse were lower in 2006 than 2005 in northern England, but remained at similar levels between the two years in Scotland.
- July counts from northern England showed higher productivity in 2006 than 2005, and in Scotland there was a slight increase in breeding success in 2006.
- Worms were at low levels in England, but moderate levels in Scotland.

David Baines
Adam Smith

Red grouse in northern England

In the North of England we count grouse at 26 sites in spring and again in July every year. Numbers crashed across most of the North of England in the winter of 2004/05 because of strongylosis. However, not all the regions suffered and the North York Moors and the Bowland Fells maintained breeding densities (see Table 1). Overall spring densities in 2006 were slightly lower than in 2005 as the majority of the populations recovered from the crash. The major difference in 2006 was the increased productivity evident in the July counts (see Table 2) with all regions except Bowland having similar or improved chick production. In 2006 hen grouse on the counts areas produced an average of two extra chicks per hen in July. Although shooting was limited in 2006, the increasing stocks are encouraging for 2007.

Strongylosis in England

Strongylosis levels in 2006 were generally low, with a number of factors contributing to this. The birds carrying high worm burdens died in spring 2005, then spring itself in 2005 was cold and dry, which reduced worm survival thus preventing worm recovery. This was followed by a hot dry summer, which reduced worm numbers further. This dramatic reduction in worm larvae meant that worm burdens in 2006 were at their lowest level since 1990 (see Figure 1). Red grouse populations entered the winter of 2006/7 in very good condition and with few worms.

Red grouse in Scotland

We conducted counts on 24 sites in spring and July, mostly in the Highlands. There was little difference in spring densities between 2005 and 2006, with an average of 24 birds

Table 1

Spring densities of red grouse in the North of England by region

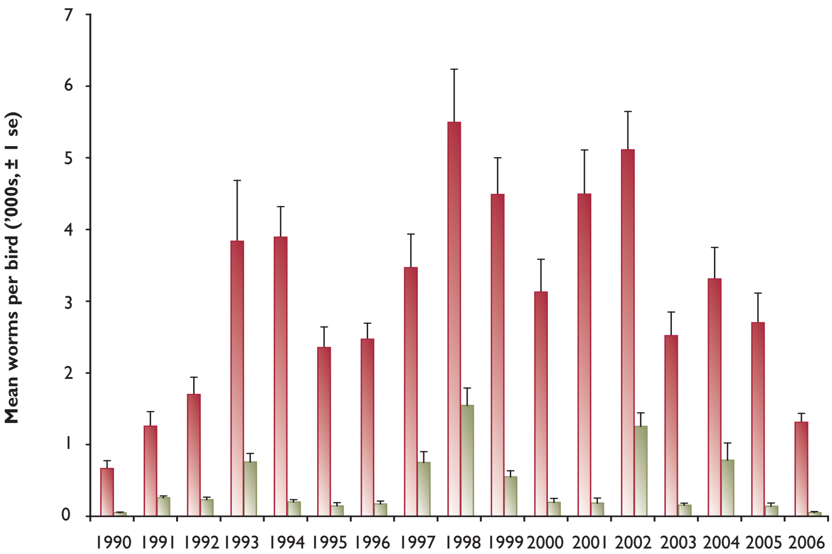
Region	Number of sites		Spring pair density (pairs per 100ha)	
	2005	2006	2005	2006
Peak District	1	1	25	16
Bowland	4	4	18.5	21.5
North York Moors	5	5	35.6	35.6
South Dales	4	4	34.2	26.2
North Dales	12	12	28.2	17.8
Overall	26	26	29	23

Figure 1

Mean worm burdens in adult and young red grouse on eight moors in northern England, 1990-2006

Adult

Young



Morgan pointing a grouse during grouse counting in Scotland. (Adam Smith)

Table 2

July densities of red grouse in the North of England by region

Region	Number of sites 2005	Number of sites 2006	Young-to-hen ratio 2005	Young-to-hen ratio 2006	July density (birds per 100ha) 2005	July density (birds per 100ha) 2006
Peak District	1	1	5.6	5.5	130	116
Bowland	4	4	4	3.5	75	80
North York Moors	5	5	4.5	5.2	149	205
South Dales	4	4	3.9	5.1	112	174
North Dales	12	12	2.8	6.4	66	149
Overall	26	26	3.6	5.5	93.4	152

per 100 hectares in 2005 and 22 birds per 100 hectares in 2006. Adult mortality in spring was also similar, with 18.3 adults per 100 hectares remaining to breed in 2006 (a loss of 16% from the spring) compared with 19.7 adults per 100 hectares (a loss of 19%) in 2005. However, across Scotland the breeding season was affected by the cold wet spring as was evident in Strathspey where the mean hatch date was five days later in 2006 than 2005 (see Figure 2). This cold start was followed by good weather in June and July, which probably helped produce the slight improvement in breeding success, with a mean of 1.5 young grouse per surviving adult in 2006 compared with 1.1 in 2005. Because there were fewer adult birds to breed, July densities were the same in 2006 as in 2005, with an average of 61 adult and young birds per 100 hectares (see Figure 3, overleaf).

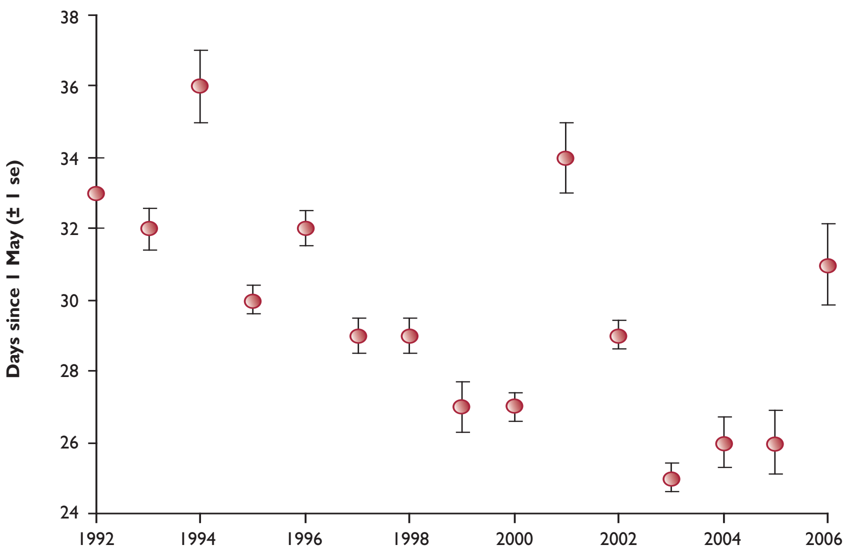


Figure 2
Mean date on which red grouse hens hatched their clutch on five moors in upper Strathspey, 1992-2006

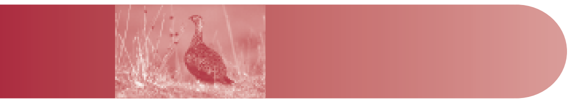
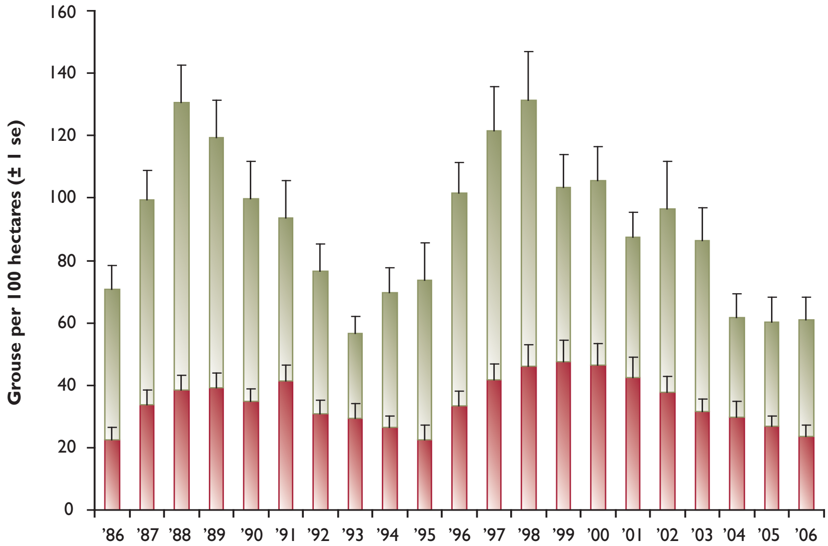


Figure 3

Average density (per 100 hectares) of young and adult grouse in July/August from 24 sites in Scotland 1990-2006

Young

Adult



Strongylosis (Scotland)

In contrast to England, the worm burdens were very variable across Scotland in 2006. Data from five sites sampled since 1990 suggest that although burdens are moderate, they are still above the very low levels seen in the early and mid-1990s (see Figure 4).

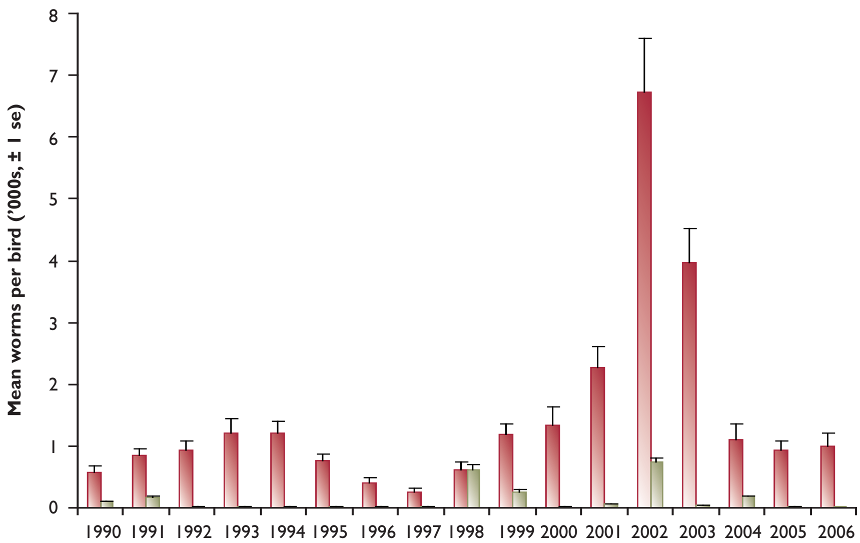
Strongylosis causes cyclic crashes in red grouse populations. (Laurie Campbell)

Figure 4

Mean strongyle worm burdens from shot grouse (young and adults) sampled at five moors in Scotland 1990-2006

Adult

Young



Predator control and ground-nesting waders

In this project, we aim to test whether predator removal by moorland gamekeepers (ie. killing foxes, crows, stoats and weasels) improves numbers or breeding success of other moorland birds. Species like the golden plover, curlew, lapwing, skylark and black grouse are of particular interest. We have four plots, each about 12 square kilometres (1,200 hectares), on which we have measured bird numbers and breeding success since 2000. There are two long-term plots that remain under the same regime for the duration of the project; Ray Demesne has a full-time keeper, and Emblehope is an unkeepered comparison (see Figure 1 overleaf). The management of the other two plots was switched over, so that Otterburn had a full-time keeper from autumn 2000 to autumn 2004, while Bellshiel was unkeepered. After autumn 2004, predator control started on Bellshiel and stopped on Otterburn. This allows us to look at breeding success and abundance on the same plots with and without predator removal.

Indicators of predator numbers on Ray Demesne continued to show low numbers of all the main predators, compared with the long-term unkeepered plot. Since gamekeeping started on Bellshiel, the indices for fox and crow dropped by 70% and 90% respectively, compared with unkeepered years. Foxes increased when predator control stopped on Otterburn (in 2006, we recorded 0.34 scats per kilometre compared with an average of 0.24 scats per kilometre during the keepering period) and crows also increased (in 2006 there were 0.9 crows per kilometre compared with an average of 0.03 crows per kilometre during the keepering period). However, the

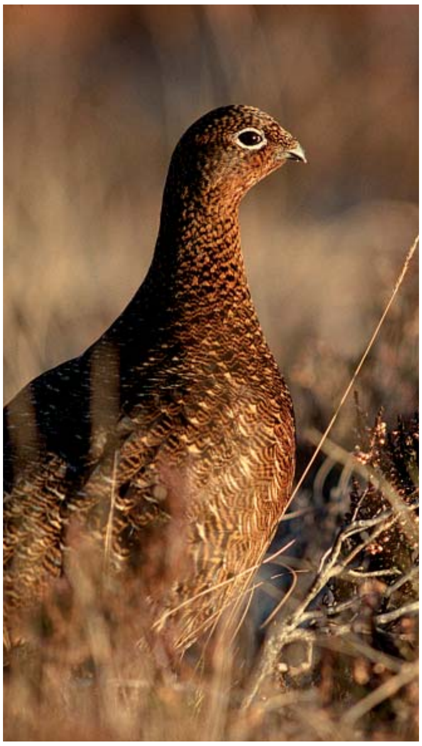
We would like to see curlews do well again in their moorland breeding habitats. (Laurie Campbell)

Key findings

- The Upland Predation Experiment has passed the half-way stage. We are starting to see trends in the data, but no firm conclusions can yet be drawn until the final data are collected in spring 2008.
- Gamekeepers continue to reduce abundance of foxes and crows on the long-term keepered site and on the new keepered site. Fox and crow abundance has increased where we have stopped controlling them but have not yet returned to pre-keepering levels.
- Waders and meadow pipits show a tendency for greater breeding success on sites with predator removal, but the trend in numbers of breeding pairs is not yet clear.
- Red grouse breeding success was poor in 2006 on the long-term keepered plot, possibly due to strongylosis. However, on the new keepered plot, we recorded a four-fold increase in young per hen.

Kathy Fletcher

Keepered period



Though not a red grouse project, we do monitor their numbers on the four study sites. (Laurie Campbell)

Table 1

Spring pair counts in the Upland Predation Experiment, 2000-2006

a. Otterburn plot (keepered autumn 2000-2004, unkeepered since)

	Curlew	Golden plover	Lapwing	Red grouse
2000	17	5	3	26
2001	No data collected owing to Foot and Mouth Disease			
2002	14	11	6	40
2003	9	11	8	81
2004	11	10	6	143
2005	10	13	8	111
2006	16	11	3	69

b. Bellshiel plot (unkeepered 2000-2004, keepered since)

	Curlew	Golden plover	Lapwing	Red grouse
2000	14	4	7	13
2001	No data collected owing to Foot and Mouth Disease			
2002	10	2	4	18
2003	7	0	1	14
2004	4	1	2	9
2005	3	0	0	14
2006	3	3	2	23

c. Ray Demesne plot (keepered autumn 2000-2006)

	Curlew	Golden plover	Lapwing	Red grouse
2000	21	6	12	50
2001	No data collected owing to Foot and Mouth Disease			
2002	18	9	14	55
2003	22	8	18	92
2004	18	7	19	159
2005	17	7	17	165
2006	18	8	11	107

d. Emblehope plot (unkeepered 2000-2006)

	Curlew	Golden plover	Lapwing	Red grouse
2000	4	7	2	26
2001	No data collected owing to Foot and Mouth Disease			
2002	4	7	1	22
2003	3	4	1	16
2004	3	3	1	19
2005	3	4	0	16
2006	2	2	0	18

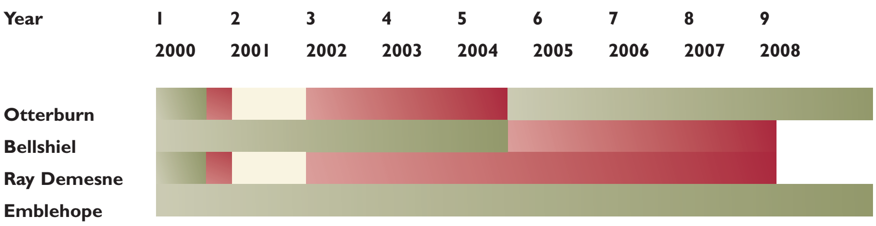
Figure 1

Diagram of the experimental design of the Upland Predation Experiment

Keepered

Unkeepered

Break in keepering and data collection in 2001 owing to Foot & Mouth Disease



abundance of these main predators on Otterburn was still at least 20% lower than in 2000 before gamekeeping started. Although stoats and weasels are also culled on the predator removal plots, the abundance indices show no consistent decline. The abundance of large raptors (peregrine, hen harrier, goshawk and buzzard) was on average seven times higher in 2006 than in 2000 across all plots. However, most of the increase was in buzzard numbers.

In the years with predator control on Ray Demesne, 57% of the 211 nesting attempts by curlew, golden plover and lapwing fledged chicks, compared with 28% of the 39 nesting attempts in 2000 without predator control (see Figure 4 overleaf). On the unkeepered Emblehope plot, 11 out of 51 nesting attempts by waders fledged chicks over the same period (22%), (see Figure 5 overleaf). In 2006, three out of 30 nesting attempts by waders fledged chicks (10%) on the Otterburn plot, compared with 61 out of 86 attempts (71%) in the years when the plot was keepered (see Figure 2 overleaf). The opposite trend occurred on Bellshiel, with five out of the eight wader nesting attempts fledging chicks (63%) in 2006 compared with four out of the 51 attempts (8%) during the unkeepered phase (see Figure 3 overleaf). Compared with numbers of breeding pairs in the baseline year, golden plovers on Otterburn and lapwings on Ray Demesne may have increased slightly, but curlews declined on all plots during the first half of the experiment (see Table 1). Meadow pipits continued to breed better with predator control, but the small number of nests (on average 60 nests across the four plots) means this trend will only become clear with more data (see Figures 2-5 overleaf). Meadow pipit abundance shows no trend in relation to predator control.

Golden plover is a key species in our upland predation experiment. (Laurie Campbell)

Figure 2

Otterburn plot: percentage of pairs that fledged young for curlew, golden plover, lapwing, meadow pipit and red grouse, 2000-2006 (no data for 2001 owing to Foot & Mouth Disease)

Keepered

Unkeepered

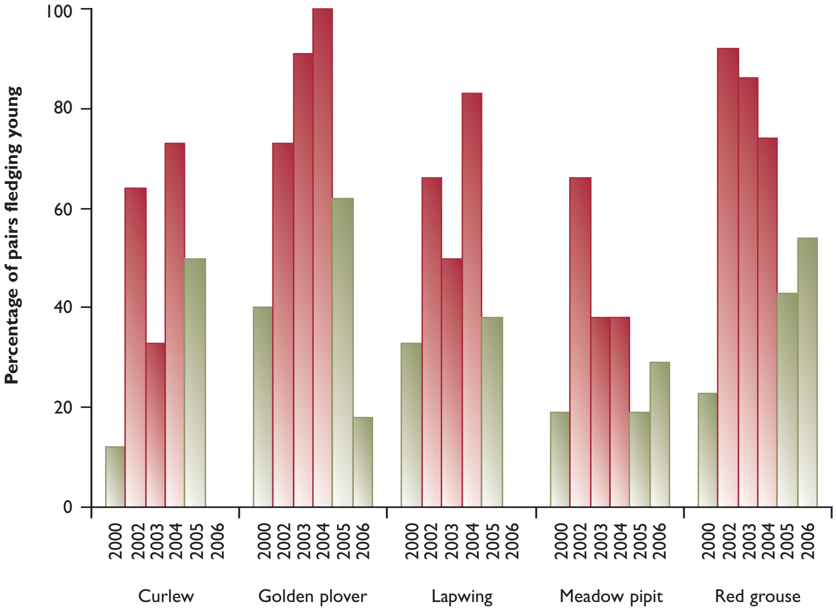
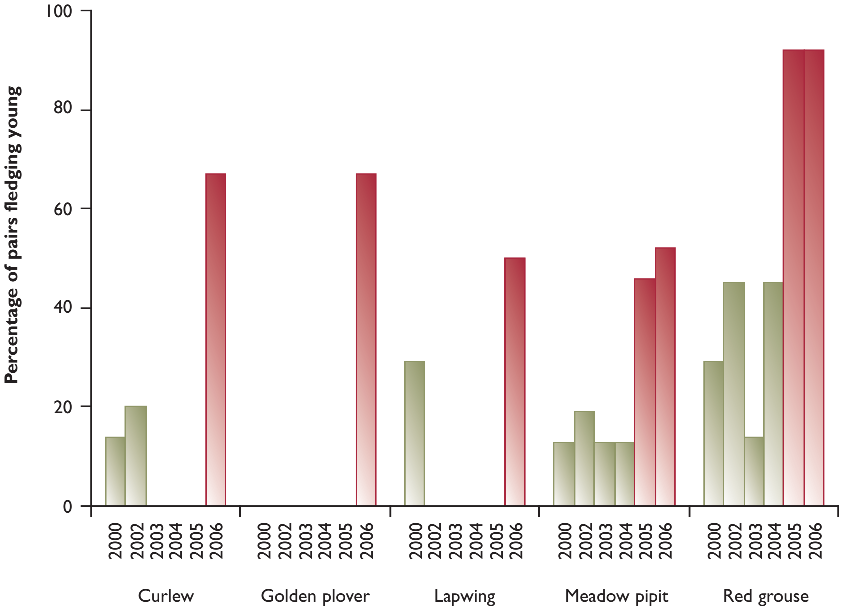


Figure 3

Belshiel plot: percentage of pairs that fledged young for curlew, golden plover, lapwing, meadow pipit and red grouse, 2000-2006 (no data for 2001 owing to Foot & Mouth Disease)

Keepered

Unkeepered



For red grouse, breeding success in 2006 was low, particularly on the plots with high spring densities. The average young per hen was just 3.0 on Ray Demesne compared with the peak of 6.0 in 2003 (see Figure 4). On Otterburn in 2006 there was a 40% reduction in the proportion of hens with broods, and a reduction of 60% in young per hen, compared with the years with predator control (see Figure 2). It is difficult to know yet how much of this reduction was due to strongylosis and how much to increased predation. In contrast, on Bellshiel 92% of hens had broods (compared with an unkeepered average of 40%: see Figure 3) and there were more than four times as many young per hen as in the years with no predator control. On the Ray Demesne plot, 19 young and 14 old red grouse were shot in autumn 2006 to determine strongyle worm burdens. Although the young birds had a low burden (an average of 39 worms per bird) the undosed old birds had reached high levels (averaging 4,683 worms per bird). Medicated grit will be used to reduce strongyle worm burdens on all four plots in 2006/07 together with direct dosing on Otterburn and Ray Demesne, which hold the highest densities of grouse.

Our findings suggest that predator removal may improve the breeding success of some ground-nesting birds in addition to red grouse. By the nature of the study, the numbers of pairs of most species are small and therefore firm conclusions are not possible at this intermediate stage.

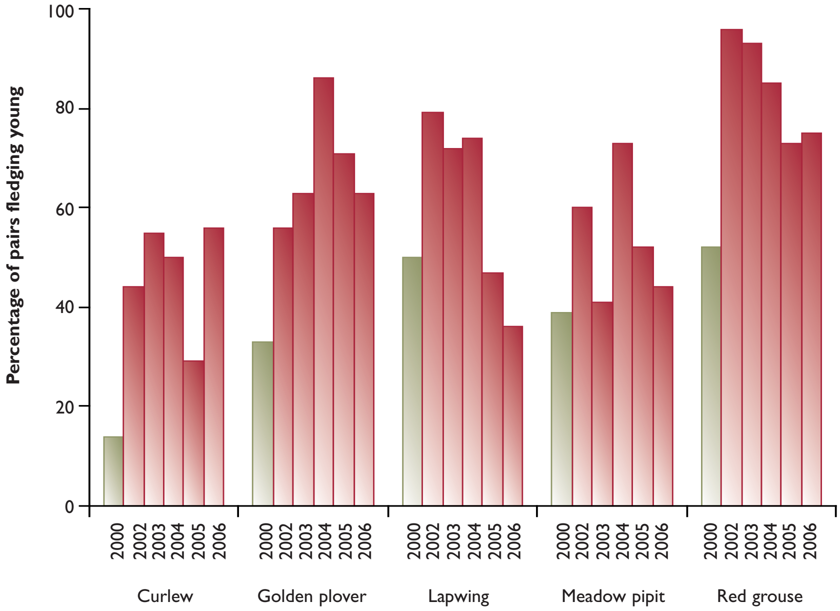


Figure 4

Ray Desmesne plot: percentage of pairs that fledged young for curlew, golden plover, lapwing, meadow pipit and red grouse, 2000-2006 (no data for 2001 owing to Foot & Mouth Disease)

Keepered

Unkeepered

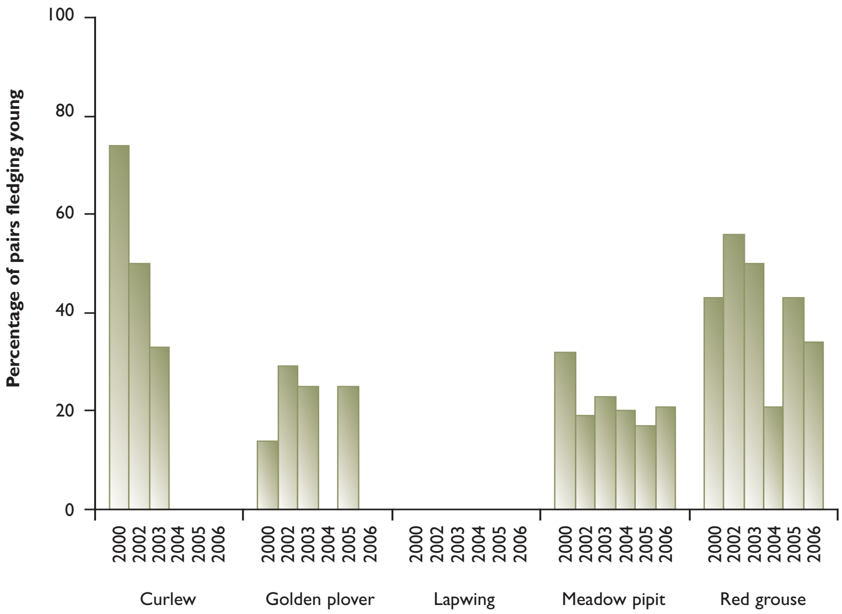


Figure 5

Emblehope plot: percentage of pairs that fledged young for curlew, golden plover, lapwing, meadow pipit and red grouse, 2000-2006 (no data for 2001 owing to Foot & Mouth Disease)

Keepered

Unkeepered

The 'pee-wit' call of the lapwing signals summer on Britain's uplands, but is sadly heard much less on unkeepered moorland. (Laurie Campbell)

Acknowledgements

This project has in large part been funded by our Uplands Appeal. We are therefore very grateful to all those who have contributed to that appeal, including the Peter Moores Foundation.

Red grouse populations in Northern England

Key finding

- Juvenile dispersal is female biased and on average is less than one kilometre.

Phil Warren

Juvenile dispersal, defined as the movement between the place of birth and place of breeding, is an important process in understanding populations. It can influence the growth rates and spread of populations, their gene flow and disease transmission.

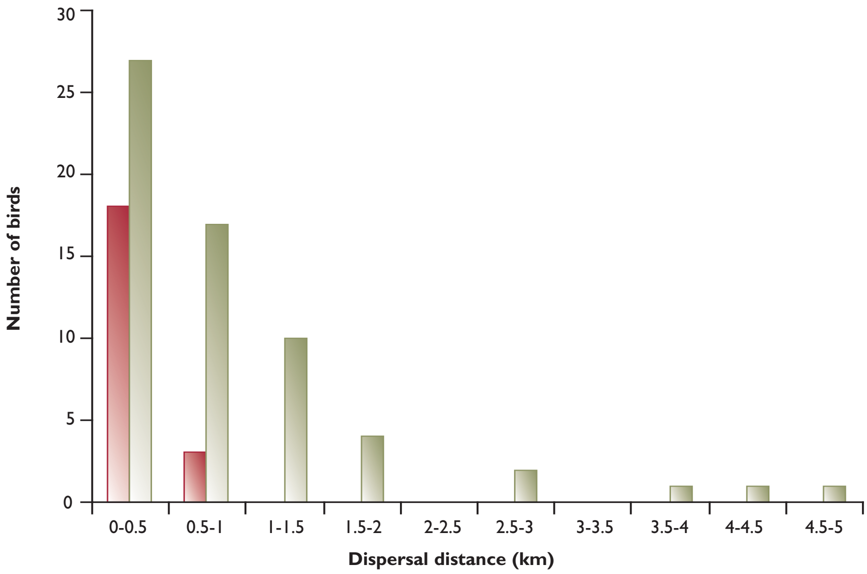
To understand dispersal in red grouse, we caught 146 juveniles over three years and fitted each bird with a radio collar. Dispersal distances were defined as the straight line distance between the place where caught as a juvenile in summer and the centre of the home range in the following spring (or nest sites in the case of females). The timing of dispersal was defined as the mid-point between the date of leaving the natal home range and the date of settling in the territory where they bred.

Figure 1

The dispersal distances of juvenile male and female red grouse 1999-2001 (number of grouse = 84)

Cocks

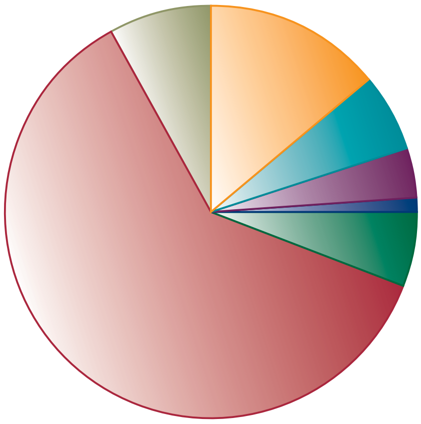
Hens



Male red grouse do not move far from their place of birth. (Laurie Campbell)

Figure 2

Causes of mortality of 121 red grouse on the North Pennines study moors



Stoats made the highest contribution to red grouse mortality after shooting. (Laurie Campbell)

Dispersal began in late September and finished by November. Females dispersed on average 861 metres (ranging from 50 metres to 4,660 metres), which was considerably further than males, which moved only 343 metres (ranging from 90 metres to 660 metres) from their place of birth (see Figure 1). Movements were unrelated to either summer or spring settling densities.

The main cause of mortality through the study was shooting, which accounted for 61% of all deaths (see Figure 2). Losses due to strongylosis were low as the population was in a building phase. These losses would have been higher in 2005, when strongylosis caused a loss of 79% between spring and summer counts.

Juveniles made up 74% of the shooting bag and overall shooting removed, on average, 41% of the summer population, but up to a maximum of 66%. This accounted for, on average, 83% of the over-winter loss. We found that adult grouse hosted 10 times higher parasite burdens than the juveniles.

This research has led to a further PhD study in which Nils Bunnefeld is investigating the effect of grouse age and driven shooting on grouse populations.

Erosion and moorland drainage

Key findings

- Light grazing does not affect sediment run-off in drains.
- Drains continue to erode over time.
- Blocking of drains is the only approach to reduce sediment run-off.

Dave Newborn
Professor P Carling (University of Southampton)

Sediment run-off being collected from Hall Out Moor. (Dave Newborn)

Within the current debate about moorland conditions, we revisit an experiment that we undertook nearly 20 years ago to test the effect of upland drains (grips) on water quality.

Drainage of heather moorland with open drains (usually called grips) had been a part of moorland management for over 100 years and was promoted by government grant during the 1970s, but by the 1980s, there was anecdotal evidence that these drains caused significant erosion. To understand this, in 1987 we established a project on Hall Out Moor in Upper Swaledale in the Yorkshire Dales.

The vegetation on the site was a predominantly cotton-grass/heather mix, with small areas of bilberry and sphagnum.

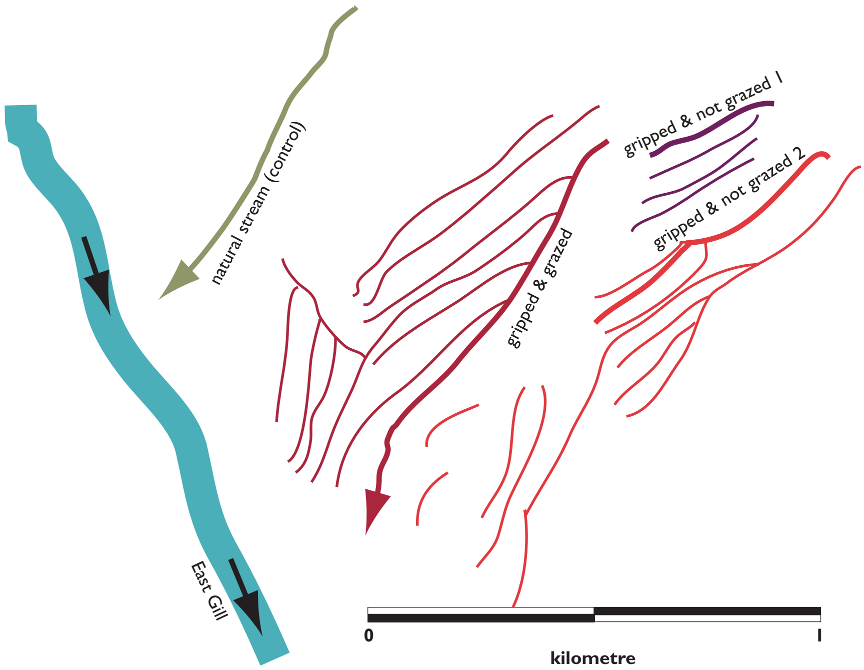
In August 1987, a contractor using specialist drainage equipment drained an area on a west-facing 7° slope.

The drains, when first cut, had a typical bottom width of 30 centimetres, a top width of 68 centimetres, a depth of 36 centimetres and side wall angle of 28°, giving a trapezoidal section of total area 1,764 square centimetres. The average spacing between drains was 22 metres. We chose four drains for our study, one drain 'gripped and grazed', two drains 'gripped and not grazed', and finally a 'natural' small stream half a kilometre away on the same slope, which acted as a control site and was also grazed (see Figure 1). The grazed sites were stocked with Swaledale sheep from 1 May to 31 August each year at a stocking density of one ewe plus lamb at foot to 1.6 hectares. Close to the downstream end of each of the drains we drove a simple vertical plate 90° V-notch weir into the sub-soil such that the base of the V was centrally placed in the drain close the bed of the drain and there was a minimal backwater effect. A metal chute took water and sediment from the V-notch into rectangular collection tanks. The tanks were 180 centimetres long, 120 centimetres wide, 120 centimetres deep and made of marine plywood to give a capacity of 2.72 cubic metres. Within the tanks all sediment fractions coarser than silt were trapped. We monitored and emptied these traps of sediment after significant discharge events between 1987 and 1992.

Between 1991 and 1997 we measured the cross-sectional area of drains at 100-metre intervals down the drains every three months using a profiling frame consisting of 50 vertical steel pins 20 milimetres apart threaded through a bar set horizontally on reference posts driven firmly into the subsoil either side of given cross-sections of the drains. There was no evidence of down-slope variation in changes in drain cross-section between surveys and so data were averaged for each study drain and cross-sectional areas calculated. Deposition or erosion along the length of the drains were recorded as a loss or gain in the total cross-sectional area between surveys.

Figure 1

Plan of the drainage network at Hall Out Moor



The sediment loads we collected between 1987 and 1992 (three per year in each drain) were standardised and expressed as kilograms (dry weight) per one-kilometre length of drain. The drained areas had much higher sediment loads than the natural stream (see Table 1). There was no evidence of seasonal trend, suggesting that erosion is event-driven, either by winter or summer storms.

Profile data show that these drains did not stabilise, but continued to erode over at least four years (see Figure 2). After seven years the grips were still eroding. This is in contrast to other upland drains, such as forestry furrows where run-off may be small and which often grass over after a year or so.

We concluded that the natural hillside streams produce negligible sediment even though subject to grazing, but drains continue to erode after cutting. The amount of sediment in the drains was an order of magnitude greater than in the natural stream (control). Drains did not stabilise and erosion was progressive. Thus where old drainage networks still exist, erosion can only be stopped by blocking them.

Table 1

Kilogrammes of sediment per kilometre of drain per year, 1987-1992

Drain	Sediment (mean kg, ± se)
Gripped and grazed	61.4 (± 8.7)
Gripped not grazed	121.7 (± 44.5)
Natural stream	9.0 (± 6.8)

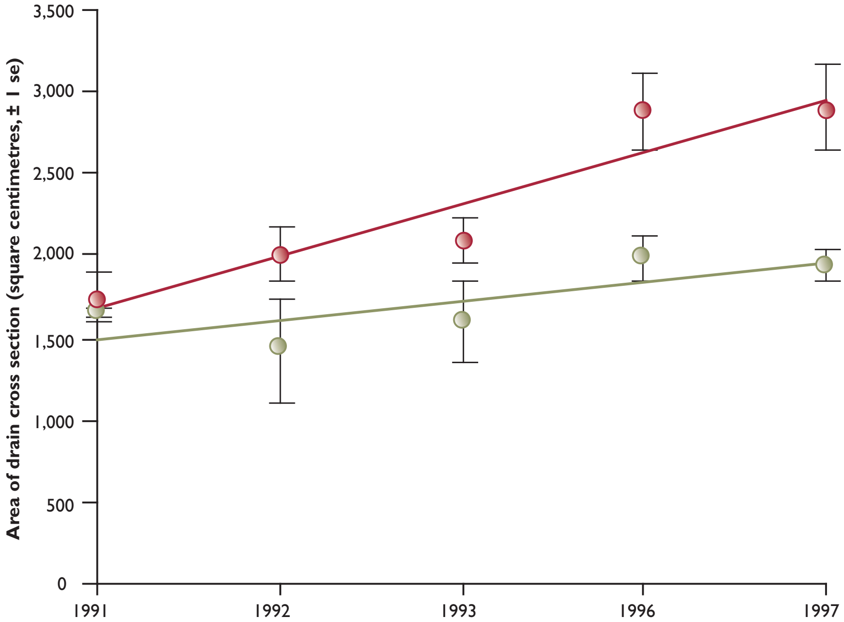


Figure 2

Change through time (1991-1997) of the cross-sectional area of the eroded portions of the gripped and grazed, and gripped and not grazed drains

- Gripped and grazed
- Gripped and not grazed

The gripping plough used in this experiment in 1987. (Dave Newborn)

Tick distribution on Scottish moorland

Key finding

- Both vegetation and host activity are important predictors of tick distribution.

Ellie Watts

High tick numbers are detrimental to grouse chicks, and louping ill, a virus transmitted by ticks, can cause high mortality in grouse. In 2001, 2003 and 2005 we reported on the increasing numbers of ticks on grouse and our efforts to design and test suitable tick control strategies. We collaborated with the Centre for Ecology and Hydrology and Aberdeen University to examine associations between habitats and ticks and between tick hosts and tick distribution.

From May to August of 2004 and 2005 we assessed tick abundance on six grouse moors in central Scotland where tick and deer, hares, grouse and sheep were present at different densities. Within a 100-hectare area on each moor, we sampled 100 random locations for ticks by dragging a one-metre-square woollen blanket over the top of the moorland vegetation for 10 metres. These 'blanket drags' are a standard way to count ticks. We counted the number, and determined the age and sex of the ticks on the blanket after each drag. We also counted the amount of dung from deer, sheep, hares and red grouse at each location.

We found that ticks were patchily distributed, with 80% of all drags having none. We collected approximately 40% fewer ticks per drag in 2005 than in 2004, probably because of weather conditions.

Having accounted for the variations in cover on each of the six study moors, we found between 10% and 15% more ticks in heather than in grass or grass/heather mixes and we found the lowest numbers of ticks on boggy, saturated ground (see Figure 1).

Key hosts for ticks are red deer and mountain hares. The number of ticks was positively related to the presence of red deer dung, but negatively related to the presence of mountain hare dung (see Figure 2).

Both vegetation type and host density do affect the abundance of ticks, but the effect they have varies considerably between the different sites. This highlights the importance of site by site assessments of tick problems in Scotland when control strategies are being considered.

A grouse chick showing scars from tick bites above its eye. (Adam Smith)

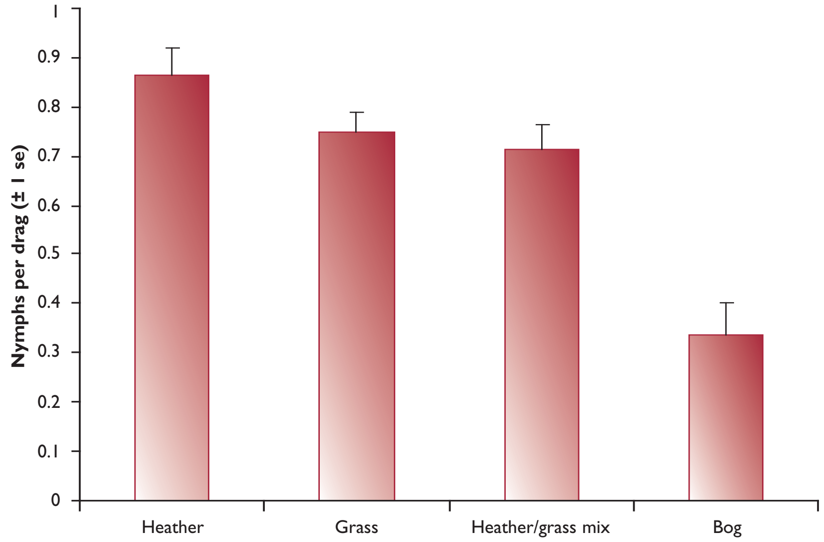


Figure 1

Mean number of nymph ticks per 10-metre blanket drag in different moorland vegetation types

Numbers have been adjusted to account for differences between sites, years, and host density.

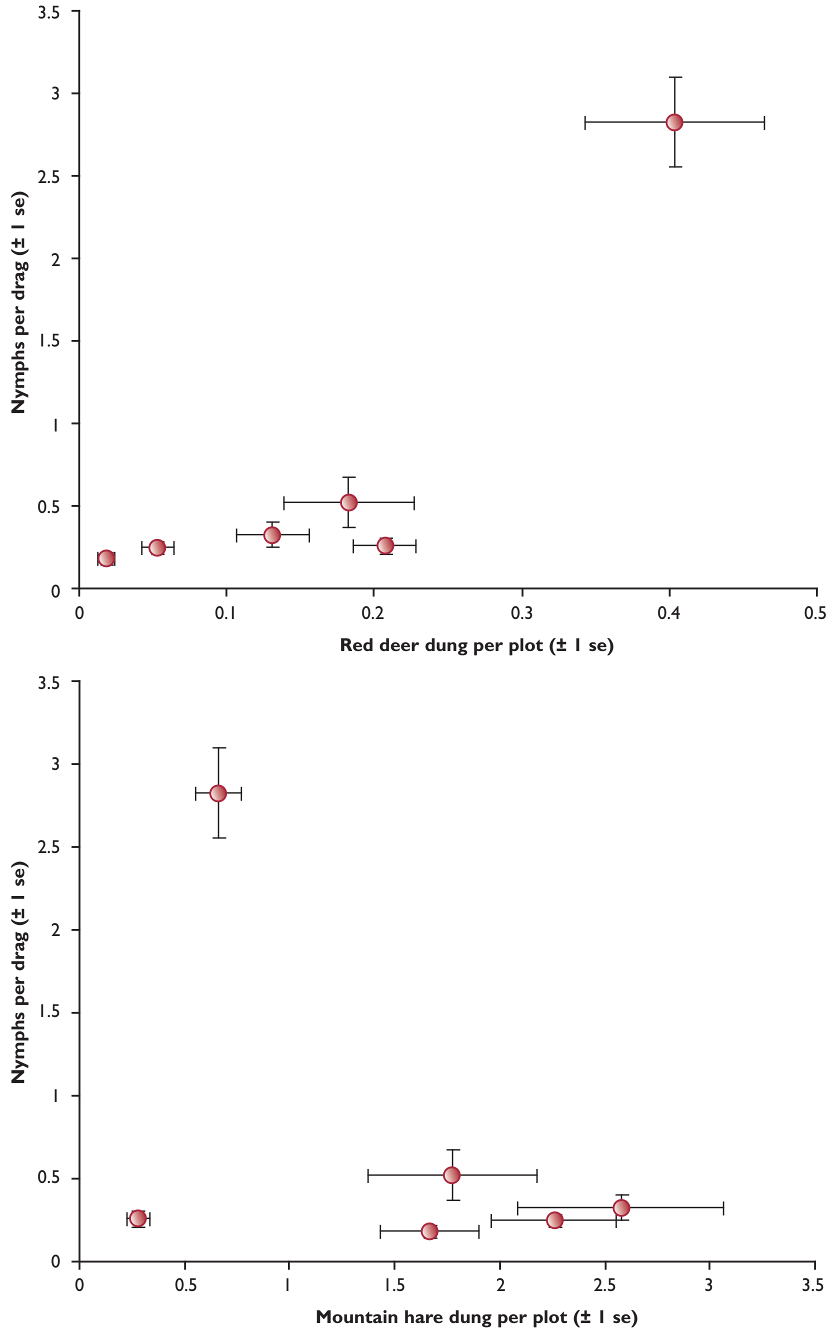


Figure 2

Mean number of ticks per drag in relation to the amount of red deer dung (top) and mountain hare dung (bottom), based on moor averages

Black grouse survival and reproduction

Key findings

- Black grouse breeding success was lower in northern England than in either the Scottish Highlands or North Wales.
- Conversely, both juvenile and adult survival tended to be lower in Wales than in either northern England or the Scottish Highlands.
- Predation was the main cause of death in full-grown birds in all regions, with foxes and raptors most important in Wales and the Scottish Highlands and stoats in northern England.

Dave Baines

During the last century black grouse declined in numbers and range throughout virtually all Western and Central Europe following habitat loss, degradation and fragmentation as a result of agricultural intensification and changes in forest management. In the UK, the decline started over 100 years ago, but has accelerated more recently, with a range contraction of 28% between 1972 and 1991. In 1995/96 there were estimated to be 6,500 males but, by 2005, this had dropped to 5,100 males.

Declines over the last 20 years have been greatest in Central and Southern Scotland and parts of Wales, which contrasts with relative stability in northern England. We compared black grouse breeding success and survival in North Wales, the North Pennines (northern England) and Strathspey and Deeside (Scottish Highlands). The habitats occupied by black grouse differ markedly between the three regions. In the Scottish Highlands, our study birds were associated with edges of old scots pine forest, which contrasted with virtually treeless marginal farmland used in northern England. Welsh birds lived on the edges of heather moorland and younger stands of commercial spruce forests.

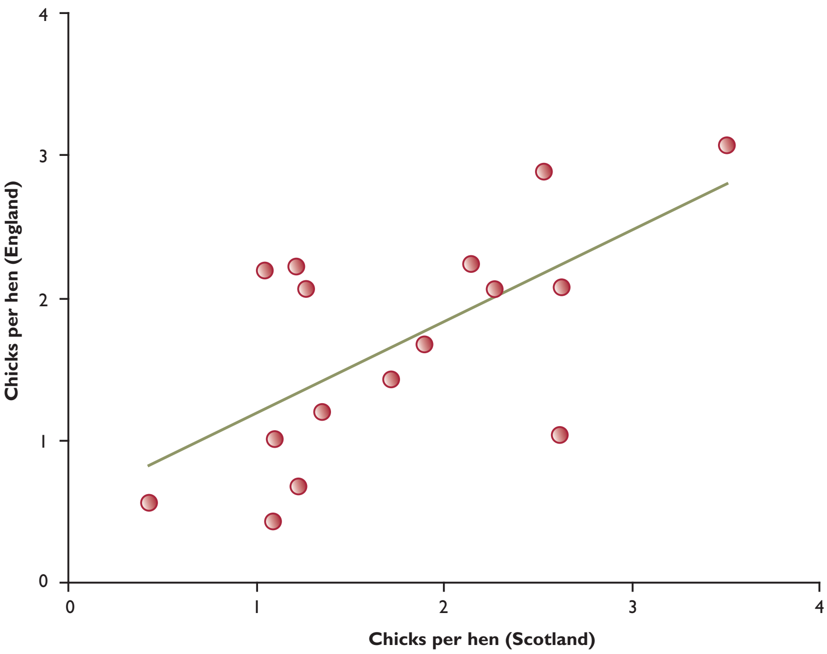
We gathered data on black grouse breeding success between 1997 and 2002 from North Wales, six of which hosted more than 80% of the Welsh black grouse population.

Breeding success varied significantly among the three regions, being lowest in northern England with 1.26 (+ 0.22se) chicks per female and highest in the Scottish Highlands (1.65 + 0.25se) and North Wales (1.73 + 0.25se). A longer time series of counts from 1989 onwards showed that patterns of annual breeding success were correlated between England and Scotland (see Figure 1) suggesting that annual weather patterns common across regions may determine breeding success. These data also showed that the number of males attending leks increased following years of high breeding success (see Figure 2).

We monitored 101 breeding attempts by radio-tagged females in northern England and we were able to break down breeding success into clutch and brood survival. The percentage of hens that successfully reared a brood varied annually from 6% to 42% in response to yearly variations in brood survival ranging from 10% to 73% (see Table 1). Neither clutch size (mean 8.2 eggs) nor clutch survival (the percentage of clutches from which one or more eggs hatched, mean 63%) differed among years. Of the clutches that failed to hatch, 88% were predated; 75% by mammalian

Figure 1

Breeding success of black grouse in England and Scotland showing a positive correlation, 1989-2004



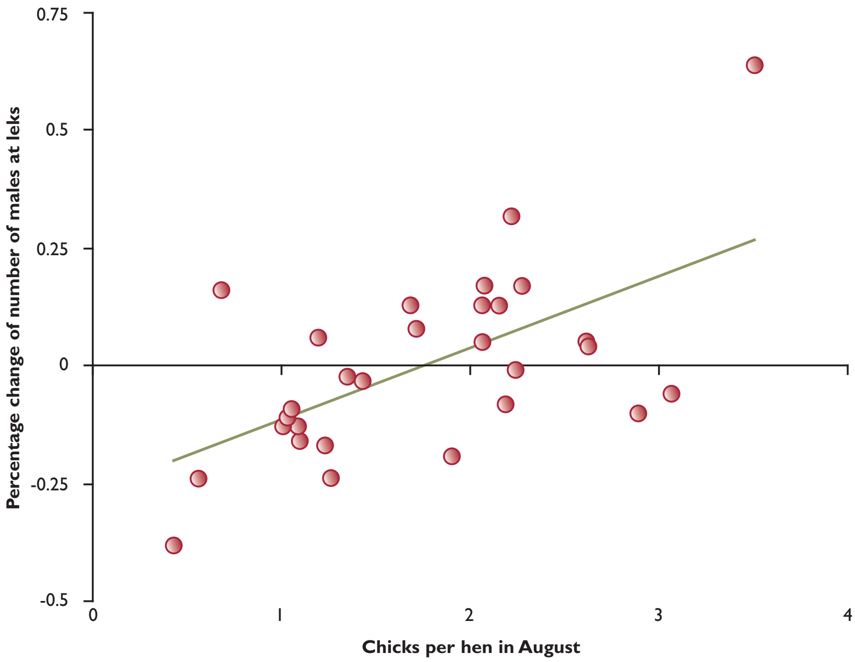


Figure 2

Number of males at leks compared with breeding success the previous year

predators, with stoats taking 57%. We did not gather information on the causes of chick losses.

We estimated survival rates of radio-tagged juveniles and adults from 147 individuals at 15 sites in northern England between 1998 and 2004, from 28 birds at four sites in the Scottish Highlands between 2002 and 2004, and from 39 birds at one site in North Wales between 1999 and 2003. In Wales, the data were collected by Gordon Bowker, funded by Severn Trent Water. We found a non-significant trend for lower survival rates of juveniles in North Wales, with a survival probability of only 0.18 per six months, compared with 0.56 in the Scottish Highlands and 0.65 in northern England. Similarly, annual adult survival was lower in North Wales (0.44) than in either northern England (0.70) or the Scottish Highlands (0.66). Cause of death differed among regions, with poor survival at the Welsh site being associated with 61% of birds being killed by raptors and 33% by foxes. This was similar to the Scottish Highlands where 48% of birds were killed by foxes and 40% by raptors. In northern England, 41% of birds were killed by stoats, but only 30% by raptors and 11% by foxes.

There is now a series of black grouse recovery projects in the UK, so an understanding of the life stages that limit population size in each project area is critical.

We have studied black grouse since the 1980s. (Laurie Campbell)

Table 1

Clutch survival (the proportion of clutches that hatched one or more eggs), brood survival (the proportion of broods that fledged one or more chicks) and overall breeding success (the proportion of clutches from which at least one chick fledged) from radio-tagged female black grouse in northern England between 1999 and 2004

Year	Clutch survival		Brood survival		Breeding success	
	n	Hatch	n	Survive	n	Fledge
1999	8	0.50	4	0.25	8	0.13
2000	15	0.80	9	0.22	12	0.17
2001	Foot and mouth prevented data collection					
2002	17	0.59	10	0.10	17	0.06
2003	31	0.65	15	0.73	26	0.42
2004	30	0.60	18	0.56	30	0.33

Effects of supplementary feeding on mountain hares

Key findings

- PIT tag technology enabled us to log visits of hares to feeding stations.
- Around half the hares fitted with PIT tags on our study moors took supplementary feed, and the individual use of supplementary feed was variable.
- Feeding had no clear effect on survival, but in April male hares on the fed areas were in better condition, and females appeared to breed earlier.
- Over-winter food availability may play a role in driving mountain hare population dynamics.

Scott Newey
Peter Allison
Adam Smith
Isla Graham

In our *Review of 2003,* we reported on studies that investigated the effects of the gut parasite, *Trichostrongylus retortaeformis,* on mountain hares. These showed that reducing parasite burdens increased female fecundity (the ability to reproduce), and that this parasite may therefore contribute to instability in hare populations. Food is another possible factor limiting or regulating populations. Supplementary feeding studies, which are widely used to investigate the role of food limitation, assume that supplementary feed is used by the study population and that all individuals have equal access, but this has rarely been tested.

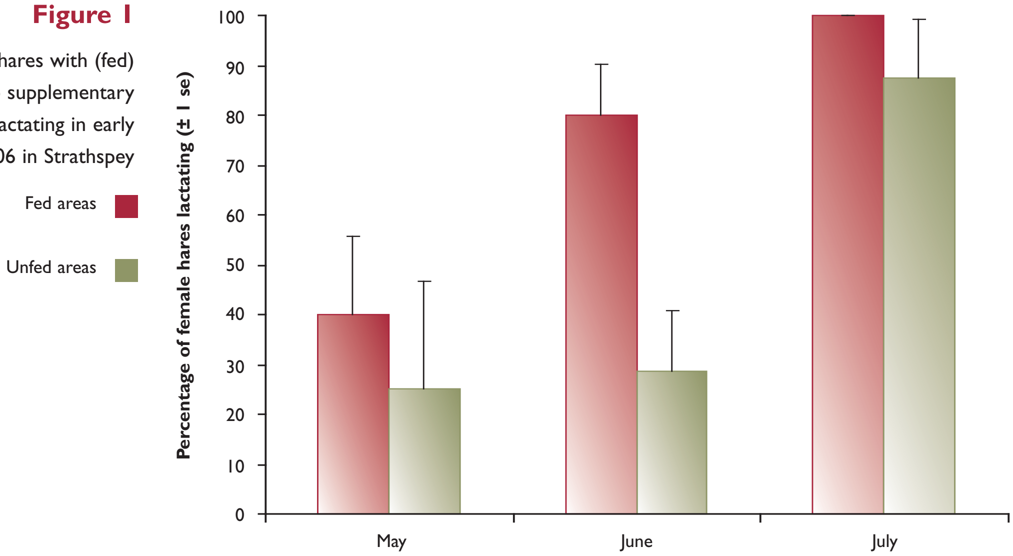
The aims of this project were two-fold. Firstly, to test Passive Integrated Transponder (PIT) tag technology, (PIT tags are similar to the micro-tags used to identify dogs), and use it to monitor individual hare use of feeding stations. Secondly, through radio-telemetry and repeated live-trapping, to investigate how supplementary feed influenced survival, male body condition, and female fecundity.

In autumn 2005, we deployed custom-made feeding stations on two moors in Strathspey. Each station was equipped with PIT tag censors, a decoder and data logger that could read and log PIT tags fitted to wild mountain hares while the hares

University of Central Lancashire placement student, Peter Allison, downloads data from a hare feeding station. (Mosé Nodari)

Figure 1

Percentage of female mountain hares with (fed) and without (unfed) access to supplementary food that were lactating in early summer 2006 in Strathspey



Mountain hare numbers on moorland can rise as high as 300 per 100 hectares at the peak of population cycles, which typically occur every four to 15 years. (Laurie Campbell)

fed from the feeding station. We fitted 125 individual hares from two moors with PIT tags, and over the six-month period of supplementary feeding (October 2005 to April 2006) about 120,000 visits to the feeding stations were logged. In addition an unknown number of non-tagged hares also used the feeders. Intriguingly, of 71 PIT-tagged individuals resident on the two fed areas, only 55% were logged using the feeding stations and there was considerable individual variation in the number and duration of feeding bouts.

The second part of the study examined the survival, body condition and fecundity of hares on fed and unfed areas. Only 26% of the radio-collared individuals survived until the end of the study on the unfed areas compared with 54% on the fed areas, but the difference was not statistically significant. After correcting for body size, males on the fed plots were significantly heavier in April than males on the unfed plots. In April 82% of female hares were pregnant on the fed plots compared with 57% on plots where there was no supplementary feeding, and the proportion of hares lactating during the 2006 breeding season suggested that females on the fed plots bred earlier than did females on the unfed plots (see Figure 1).

Mountain hare populations on heather moorland managed for red grouse sometimes show regular and dramatic changes in numbers and these are often described as cycles. Analysis of mountain hare bag records show that although 50% of the records could be described as cyclic, changes in the length of these cycles (measured from a peak in numbers to the next peak) ranged from four to 15 years. It is currently unclear why some populations are cyclic and others are not, or why there is such a large range in the length of cycles. This study was one of the first to quantify successfully individual use of supplementary feed and, given the limitations of the study, it suggests that over-winter food availability might have a role in affecting changes in mountain hare population size.

Capercaillie breeding ecology

Key findings

- Breeding densities declined by 16% per annum in the 1990s, but are now stable in Strathspey and Moray/Ross-shire.
- Declines continued in the East and South and were linked with poorer breeding success.
- Breeding success was determined by the percentage of hens with broods, which has not changed over time and averages only 30%.
- More work is needed to identify causes of breeding failure.

Dave Baines

We have counted capercaillie and their broods using pointing dogs each summer since 1991 in a range of native and commercial Scottish forests. We have usually based annual estimates of breeding success across all the sample sites on 100 or more hens. Before 2001, we usually sampled 10-14 forests each year, but since 2001 we have sampled at least 20 forests as part of an EU LIFE-Nature funded project. Here we describe national and regional trends in breeding success and density over that period.

Breeding success varied significantly between years (see Figure 1) and averaged 0.78 (se=0.09) chicks reared per hen. During the LIFE project period 2001-06, breeding success did not vary between different forest types or between different regions. Adult densities declined at a rate of 16% per year between 1991 and 1997, but shortly thereafter densities have been stable (see Figure 2). The recent halting of the national decline and more recent local increases have been associated with the work of the Capercaillie Biodiversity Action Plan Steering Group, which initiated significant conservation efforts between 2000 and 2006. These were designed to improve productivity and to increase both adult and juvenile survival. Such was the urgency that significant amounts of public money was spent by the Scottish Executive to remove and mark fences in core capercaillie areas to reduce fence collisions. These efforts were complemented by further fence marking and removal, habitat enhancement and predator (fox and crow) removal as part of the LIFE project.

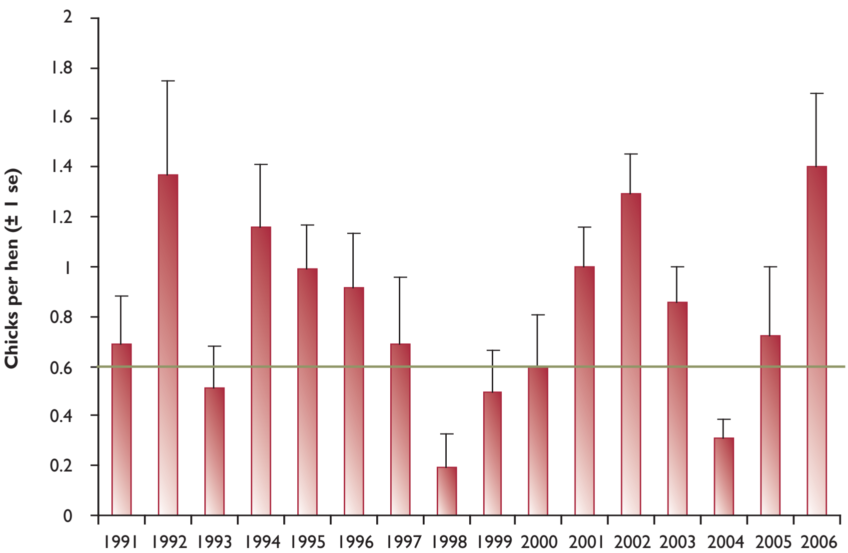
These measures appear to be working. Breeding success showed a slight, but non-significant, improvement during the five years of the LIFE project, with an average of 0.9 chicks per hen per year and in four out of the five years enough chicks were produced to maintain or increase the population. This compared well with an average of 0.6 chicks per hen, the break even point in terms of achieving a stable population, attained in the preceding five-year period. Should these sample sites be representative of the capercaillie breeding range, improvements in numbers appear to be linked not just with a modest improvement in breeding success, but also with a likely increase in the survival of full-grown birds (juveniles and adults). The latter may be associated with extensive predator control or with the removal or marking of hundreds of kilometres of fences, which previously killed an unsustainably high proportion of birds. However, there have been no studies of capercaillie survival rates in Scotland for 10 years, so any important changes in survival attributable to mitigation measures remain undetected.

Breeding success in 2006 was best since 1992, with an average of 1.4 chicks per hen. This is timely as it comes in the final year of the LIFE project and suggests that the extensive work carried out by forest managers for capercaillie is beginning to produce results, particularly when the weather is good, as was the case in summer 2006. Although there are consistent signs of improvement in the fortunes of capercaillie, there are no grounds for complacency and further management is needed. Despite

Figure 1

Capercaillie breeding success, 1991-2006, sampled from 10-20 forests per year in the Scottish Highlands

The estimated level of productivity (0.6 chicks per hen) required to maintain a stable population



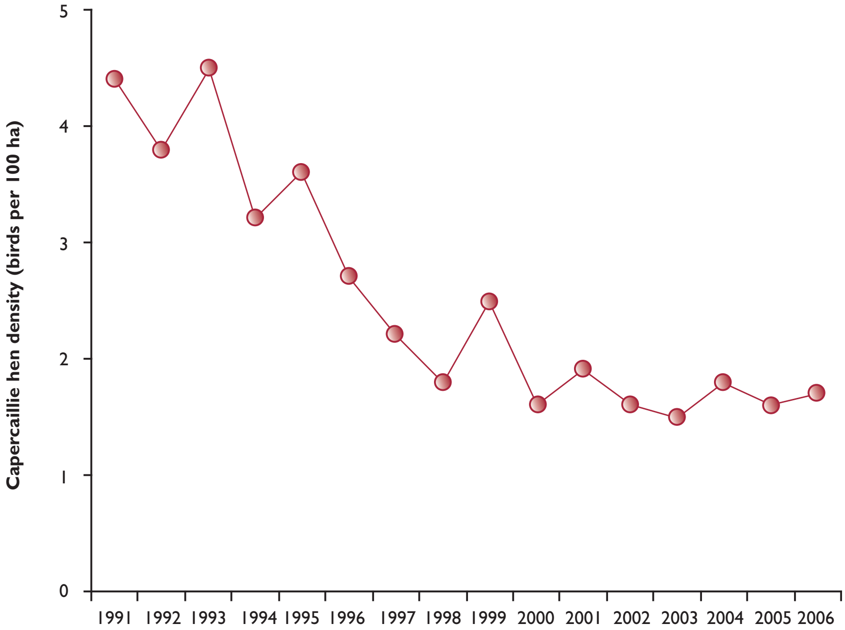


Figure 2

Changes in mean density of hen capercaillie in Scottish forests

adult densities remaining stable in Strathspey and Moray, there were continued declines on the eastern edges of the range in Deeside/Donside and to the south in Perthshire and Argyll. Where capercaillie were declining, breeding success was only 0.54 (se=0.07) chicks per hen compared with 0.90 (se=0.10) where numbers are stable. Worryingly, our long-term counts have shown that 70% of hen capercaillie failed to rear a brood and that it is variations in the proportion of hens with broods that are directly related to overall breeding success.

In spite of management to increase blaeberry and reduce predation, capercaillie breeding success remains generally low in Scotland and our knowledge of their breeding requirements remains imprecise. We still need research on chick habitat requirements, the relative effect of potential predator species and the stage at which chief breeding losses (clutch or chick) occur. The latter in particular is a fundamental knowledge gap, as corrective management to reduce clutch losses through predation are likely to be quite different to those required to improve foraging habitats for chicks or pre-breeding nutrition for hens. We are currently discussing proposals to help fill these gaps in our knowledge and thereby help to ensure that this promising resurgence in numbers of capercaillie is not only maintained, but also enhanced into the future.

Although capercaillie had an exceptionally good breeding year in 2006, the species' future in Scotland is far from secure. (Laurie Campbell)

Farmland ecology summary for 2006

Key achievements

- To raise awareness of the importance of chick food insects we published a guide to their identification and promoted this to our grey partridge groups.
- To guide researchers and advisors we published a review of farmland bird diets.
- We started a new project to investigate ways to increase farmland biodiversity using targeted management of uncropped land.

John Holland

We continually stress the importance of insects for farmland birds ever since identifying the link between insect abundance and grey partridge chick survival. In 2006 we published a review of bird diets as an aid for researchers and advisors developing new management options or investigating the ecology of farmland birds. We now know that most farmland bird chicks (with the exception of doves and pigeons) depend on similar groups of insects, notably beetles, bugs, flies and caterpillars, as well as spiders (see Table 1). Our feeding trials with grey partridge chicks show that they respond to colour and that green insects are preferred. In the winter farmland birds feed predominantly on weed and crop seeds (see Table 2), which is why game cover is so important for their survival.

Insect-rich areas, such as those provided by conservation headlands and low-input cereal crops, are still relatively rare on farmland, so to raise awareness, in the summer we published a brief guide to chick-food insects. Our staff attended two regional grey partridge group meetings to promote the guide, and to show people how to collect and identify chick-food insects. This illustrated to everyone how few chick-food insects there are in crops compared with field margins.

Table 1

Top six groups of insects important in the diet of farmland bird chicks

Order	Life stage eaten	Commonly eaten
Diptera (flies)	Adults, larvae	Crane flies, midges
Coleoptera (beetles)	Adults	Ground beetles, rove beetles, weevils, leaf beetles, scarab beetles and click beetles
Araneae (spiders)	Adults, juveniles	Wolf spiders
Lepidoptera (butterflies, moths)	Adults, larvae, pupae	Looper moths
Hemiptera (bugs)	Adults	Aphids
Hymenoptera (bees, ants, sawflies)	Adults, larvae	Sawflies, ants

Our work on the 'SAFFIE' project is trying to address problems of farmland biodiversity (see page 42) through experiments on weed control using herbicide inputs, row spacing and hoeing. 2006 was our last year of field studies on this project and the final report should be complete in 2007.

We also started another project in 2006, funded by Defra's Sustainable Arable LINK programme. This is examining how best to manage uncropped land for biodiversity. We will make comparisons between farms where the uncropped land is sown with special wildlife mixtures that provide key resources such as insects, seeds, pollen and nectar, nesting and over-wintering sites, and control farms that follow normal

Click beetles (among other beetles) are one of the six top groups of insects important in the diet of farmland bird chicks. (Keith Edkins)

Table 2

Weed seeds important to farmland birds in winter

Families	Species
Polygonaceae (docks, knotgrass)	Knotgrass, dock
Poaceae (grasses)	Meadow grasses, rye grass, cock's-foot
Chenopodiaceae (goose-foots, oraches, glassworts)	Fat hen, Orache
Brassicaceae (brassicas, cresses)	Charlock, shepherd's needle, cultivated brassicas
Asteraceae (daisies, dandelions, thistles)	Groundsel, mayweeds, thistles, burdocks
Caryophyllaceae (chickweeds, stitchworts, campions)	Chickweed, mouse-ears

practice, including some organic farms. The study is being carried out on predominantly arable farms in East Anglia and Wessex and will last until 2009.

In the 'RELU-BIOMASS' project (www.relu-biomass.org.uk), we continue to survey plants and insects in short-rotation coppice and *Miscanthus* plantations in South-western England. We are also looking at birds during the winter in *Miscanthus*.

Farmland research in 2006

Project title	Description	Staff	Funding source	Date
Sustainable arable farming for an improved environment (SAFFIE) (see page 42)	*Enhancing farmland biodiversity by integrating novel habitat management in crop and non-crop margins*	*John Holland, Barbara Smith Sue Southway, Tom Birkett, Steve Bedford, John Simper, Freya McCall, Mark Gibson, Louise Bailey*	*Defra, SEERAD, Natural England, BPC, AIC, CPA, HGCA, Jonathan Tipples, LEAF, RSPB, Sainsbury's Supermarkets Ltd, Syngenta Ltd, National Trust, Wm Morrison Supermarkets plc,*	*2002-2007*
Sawfly ecology	*Investigating the ecology of sawfly over-wintering*	*Steve Moreby, Tom Birkett, Steve Bedford*	*Core funds*	*2000-2007*
Re-bugging the system (see page 44)	*Investigating large-scale habitat manipulation for biocontrol*	*John Holland (with Imperial College, Rothamsted Research and Univ of Kent), Steve Moreby, Sue Southway, Steve Bedford, Tom Birkett, Freya McCall, John Simper, Barbara Smith, Mark Gibson, Louise Bailey, Andrew Brown*	*RELU*	*2005-2009*
Assessing environmental impact of crop production: beyond the GM crop farm-scale evaluations	*Developing a regulatory scheme to assess undesirable indirect effects on farmland ecology and wildlife changes in crop production*	*John Holland (with Rothamsted Research, CEH, BTO, Reading Univ, Southampton Univ & WildCru), Nicholas Aebischer, Julie Ewald*	*Defra*	*2005-2006*
Farm biodiversity	*Determining whether management of uncropped land for biodiversity on conventional arable farms can achieve significant and measurable increases in biodiversity, which are at least equivalent to those attained on organic farms with a primary arable cropping system*	*John Holland (with TAG, Rothamsted Research, & BTO), Tom Birkett, John Simper, Steve Bedford*	*Defra, BASF plc, Bayer CropScience Ltd, Cotswold Seeds Ltd, Dow AgroSciences Ltd, DuPont (UK) Ltd, HGCA, PGRO, Syngenta Ltd, TAG (on behalf of farmers)*	*2005-2010*
Insecticide trial	*Comparing the impact of two insecticides on beneficial insects*	*John Holland, Mark Gibson, Steve Moreby*	*Irvita Plant Protection*	*2006*
PhD: Invertebrate aerial dispersal	*Examining the dispersal of beneficial invertebrates within arable farmland*	*Heather Oaten Supervisors: John Holland; Dr C Godfray/Imperial College*	*RELU Studentship*	*2005-2007*
PhD: Bumblebee nesting ecology	*Enhancing bumblebee nest site availability in arable landscapes*	*Gillian Lye Supervisors: John Holland; Dr D Goulson/Stirling Univ Dr J Osborne/Rothamsted Research*	*NERC/CASE Studentship*	*2005-2008*
PhD: Population genetics of sawflies	*Impact of population dynamics on genetics and the implications for habitat management*	*Angela Gillies Supervisors: David Parish; Steve Hubbard/Dundee Univ*	*BBSRC/CASE Studentship, Core funds*	*2005-2009*

Key to abbreviations:
AIC = Agricultural Industries Confederation; BBSRC = Biotechnology and Biological Sciences Research Council; BPC = British Potato Council; BTO = British Trust for Ornithology; CPA = Crops Protection Association; Defra = Department of the Environment, Farming and Rural Affairs; HGCA = Home Grown Cereals Authority; LEAF = Linking Environment and Farming; NERC = Natural Environment Research Council; PGRO = Processors and Growers Research Organisation; RELU = Rural Economy & Land Use; RSPB = Royal Society for the Protection of Birds; TAG = The Arable Group; WildCru = Wildlife Conservation Research Unit, Oxford University

Pesticides and insects in Sussex and Loddington

Key findings

- Spring/summer applications of insecticides are more damaging than autumn ones.
- Organophosphate insecticides are especially damaging.
- Damaging effects of insecticides continue for a year after application.
- To help farmland bird chicks, we advise reducing insecticide use, especially organophosphates.

Julie Ewald
Steve Moreby
Sue Southway
Dick Potts

Acknowledgements

This project has been funded by the Pesticide Safety Directorate, Defra, the Environment Agency, and Natural England.

It is the good will of the Sussex farmers and the opportunity provided by Loddington that enable us to offer unique insights into the effects of modern agriculture through monitoring and demonstration. Once again we would like to take this opportunity to thank the Sussex farmers for their help.

The Game Conservancy Trust is a worldwide leader in research into the effects of intensive modern agriculture on farmland birds. Our work on the connection between invertebrate abundance, the survival of grey partridge chicks and the consequences for partridge breeding density is the best documented and most convincing link between the decline of a farmland bird and changes in its food supply. We also pioneered methods to mitigate many of the effects of intensive agriculture on other farmland birds and wildlife. Much of this work has taken place on two areas where we have recently compared the relationships between pesticide use and invertebrate abundance, the Sussex study area and our demonstration farm at Loddington.

How the two study areas compare

The two study areas differ in size with the Sussex site covering 6,200 hectares whereas Loddington covers 350 hectares. They differ in the types of arable crops planted – a mixture of spring- and autumn-sown cereals, with spring- and autumn-sown break crops in Sussex, and winter-sown cereals and break crops at Loddington. They also differ in insecticide use. In Sussex, after an increase in insecticide use from 1970 to 1995 (both overall and in intensity) an average 70% of arable fields were treated with, on average, 1.4 insecticide applications per season from 1996 to 2004. At Loddington, from 1993 to 2004, there was no increase in the proportion of arable crops treated with insecticides (62%) or in the intensity of insecticide use, with an average of 1.2 treatments per arable crop per year. Of particular importance, however, Loddington used only pyrethroids and pirimicarb insecticides.

Invertebrates

Invertebrate samples are taken in Sussex and at Loddington annually in June. The invertebrate groups we chose for analysis were ones that figure prominently in the diet of farmland birds, especially at the chick stage. They included plant bugs and hoppers, caterpillars, leaf beetles and weevils, ground and click beetles, spiders and harvestman, aphids, and indices of chick food for three farmland bird species, grey partridges (CFI), corn buntings (CBI) and yellowhammers (YHI).

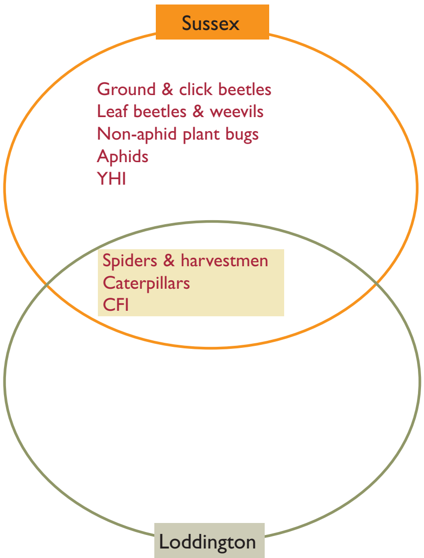
Our analysis took into account crop type, year and the use of herbicides and fungicides. The results of the effects of insecticide use (yes/no), increasing numbers of insecticides, insecticide use in the autumn or spring, types of insecticide used and insecticide use in the previous year (controlling for whether insecticides were used in the current year) are summarised in Figure 1. Only those invertebrate groups where we found significant results are listed, with the type of effect indicated – negative when the use of this type of insecticide treatment resulted in fewer invertebrates, positive when it resulted in more. When groups are listed within overlapping circles it means that significant results were found at both Sussex and Loddington.

The results support earlier work in Sussex. Insecticides decrease the number of invertebrates in fields, spring/summer applications are more damaging than autumn ones, organophosphate insecticides are especially damaging and, for some invertebrate groups, the negative effects of insecticides can 'carry over' into the summer a year after their application. Although there are more significant adverse effects in Sussex, there are certain invertebrate groups, namely caterpillars, spiders and harvestmen and grey

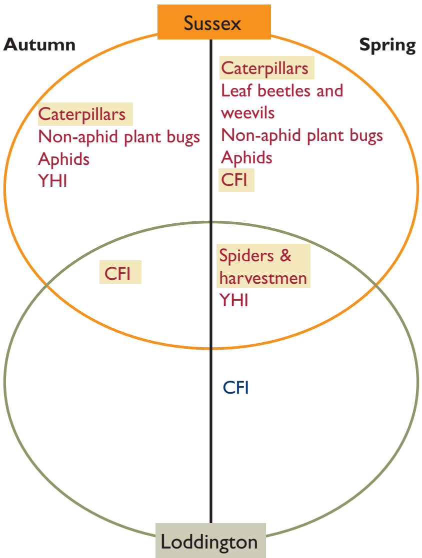
The drop-leg sprayer used at Loddington. (The Game Conservancy Trust)

We found that caterpillars of butterflies and moths were susceptible to increased pesticide numbers, timing of pesticide application and the type of pesticide used. (Ian Kimber)

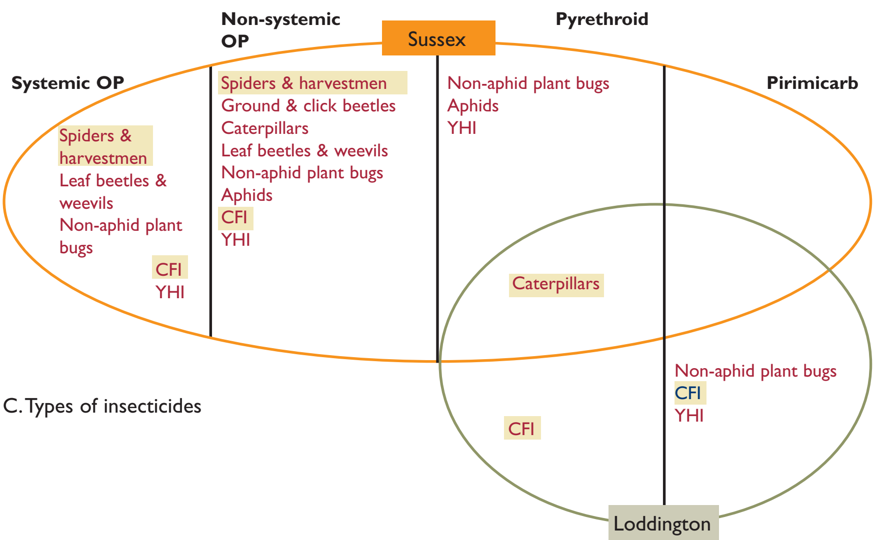
partridge chick food insects, where the negative effects of insecticide are the same. These results support our advice to reduce insecticide use, especially organophosphates, to benefit grey partridge chicks and other farmland birds.



A. Increasing number of insecticides



B. Timing of insecticide applications



C. Types of insecticides

Figure 1

Significant relationships between insecticide use and invertebrate groups in Sussex and Loddington.

Significant negative results shown in red text

Significant positive results shown in blue text

Groups which overlapped most often

We compared the effect of increasing numbers of insecticide treatments (A), the timing of treatment (B) and the type of insecticide (systemic organo-phosphates, non-systemic organo-phosphates, pyrethroids and pirimicarb (C) on the selected invertebrate groups. Those groups whose results are the same in Sussex and Loddington are in the overlapping orange and green circles, allowing a comparison between results from the two areas. For example, considering analysis of the abundance of invertebrates when increasing numbers of insecticide applications were used (A), in both Sussex and Loddington the abundance of spiders and harvestmen, caterpillars and CFI were lower in fields where multiple insecticides applications were used, whereas only in Sussex was the abundance of ground and click beetles, leaf beetles and weevils, non-aphid plant bugs, aphids and YHI lower in fields where multiple insecticide applications were applied. The three groups where the results from Sussex and Loddington overlapped most often (spiders and harvestmen, caterpillars and CFI) are most useful in determining the effect of insecticides on arable wildlife over the time of the two studies.

Enhancing wildlife in wheat crops

Key findings

- Many fields have low weed levels and there is the potential to reduce herbicide inputs in some years where there are no pernicious weeds.
- Levels of desirable weeds usually outweigh the undesirable ones.
- Herbicide inputs can be manipulated to increase beneficial insects and spiders.
- Overall, plots sprayed with amidosulfuron contained the highest numbers of chick food insects.

Barbara Smith
John Holland

Most environmental stewardship options for farmland wildlife focus on the provision of habitats in field edges. However, some species (like the skylark) live in the crop and avoid field boundaries. Within the crop, weeds and seeds are key foods for farmland birds, insects and small mammals all year. But getting a good flora to benefit wildlife is difficult because any approach should not unduly affect the practicalities of farming.

Our research on conservation headlands has demonstrated that some weeds are particularly beneficial to wildlife and that they can be managed without increasing the pernicious ones. These beneficial weeds are typically broad-leaved species that are not usually competitive with the crop. So the challenge is to see whether this idea can be extended to the whole crop, not just the headland. As part of the Sustainable Arable Farming for an Improved Environment (SAFFIE) project, we investigated whether lower herbicide inputs, wider row spacing or spring hoeing could do this in winter wheat. There is a theory that germination and weed growth are greater with wider row spacing because more light penetrates the crop, and that hoeing stimulates spring germination.

In conjunction with ADAS and the Central Science Laboratory, we studied small plots for three years at three sites differing in soil type. Herbicide treatments included

Weeds in the conservation headland of a ripening wheat crop. (John Holland)

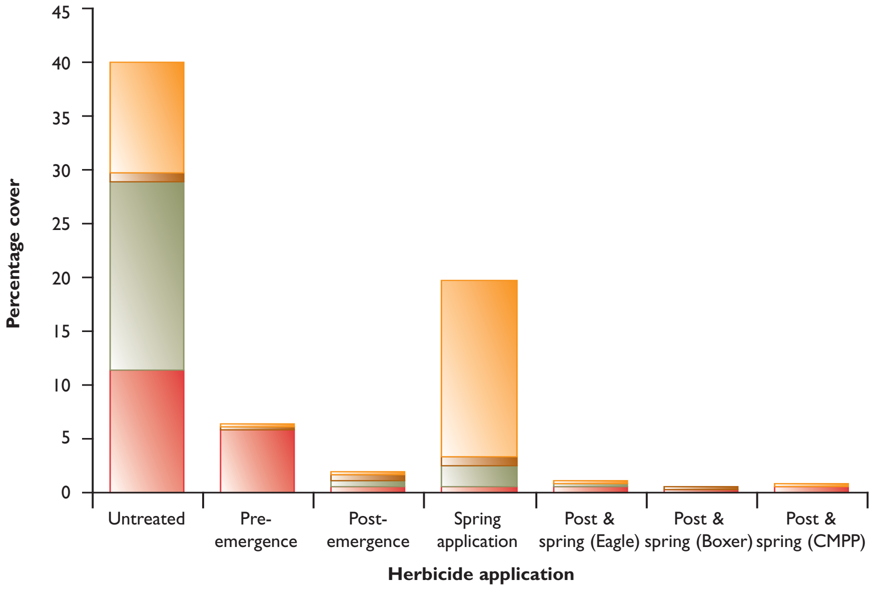


Figure 1

Levels of weed cover for beneficial species that we aim to increase, those having no benefit and undesirable weeds, at High Mowthorpe in 2005, with different herbicides and timing of application

- Beneficial weeds (aim to increase)
- Beneficial weeds (increase if possible)
- Weeds having no benefit
- Undesirable weeds

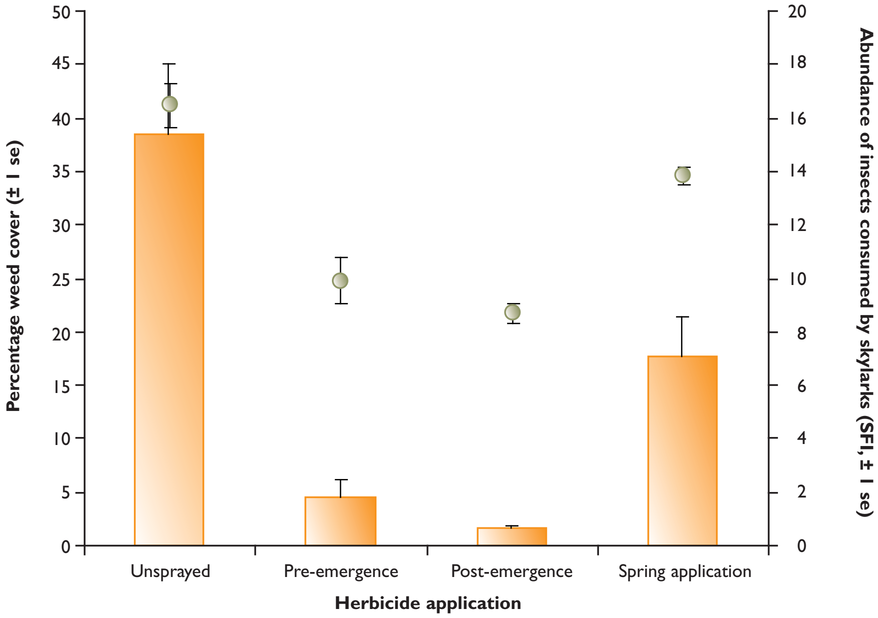


Figure 2

Total weed cover and insects consumed by skylarks (SFI) at High Mowthorpe in 2005

- Total weed cover
- Skylark food index (SFI)

SFI = sum of groups of insects eaten by skylarks (Araneae, Opiliones, Homoptera, Hemiptera, Neuroptera, Lepidoptera, Carabidae, Staphylinidae, Cantharidae, Elateridae and Tipulidae).

untreated, full weed control, and a range of pre-emergence, post-emergence and spring-applied herbicides either applied in sequence or alone. These were adjusted according to soil type and the weed flora. The wide-spaced rows were twice the standard spacing of 12.5 centimetres, but with the same seed rate. We measured the abundance and diversity of weeds and seeds from all treatments. We also collected insects using a D-vac suction sampler during late June within each plot for four of the treatments. There were three replicates of each treatment in 2003 and five in the subsequent two years.

In all herbicide treatments, the abundance of beneficial weeds was almost always higher than that of the pernicious species. Weed levels remained very low, often less than 5% in all herbicide treatments, except in one year. Insect and spider abundance was usually highest where weed cover was greatest. Overall, the single spring application of amidosulfuron (Eagle) allowed most beneficial weeds to survive (see Figure 1) and frequently this treatment supported the most skylark food items (see Figure 2). The wide-spaced rows or spring hoeing had few consistent benefits.

This study indicates that there is scope to manipulate weed cover within winter wheat using herbicides, which should benefit farmland wildlife. Weed levels were lowest at the sites with sandy and chalky soils. Our next challenge is to identify threshold weed levels for different insects so that we can give better guidance on weed control and thresholds.

Acknowledgements

This project was sponsored by Defra, SEERAD and Natural England (formerly English Nature), through the Sustainable Arable LINK programme. The industrial funders are British Potato Council, Agricultural Industries Confederation, Crop Protection Association, Home-Grown Cereals Authority, Jonathan Tipples, LEAF, RSPB, Sainsbury's Supermarkets Ltd, Syngenta, the National Trust, and Wm Morrison Supermarkets plc. Visit www.saffie.info for more details.

Re-bugging the system

Key findings

- Aerial predators are more effective at controlling aphids than ground predators.
- Six-metre wide margins boost numbers of ground predators but not aerial predators.
- Predatory flies were unable to fly far into the crop from a field margin, but lacewings and soldier beetles were.

Heather Oaten
John Holland

Tom Birkett records aphid numbers in an area from which ground-active and flying predators of aphids are excluded. (The Game Conservancy Trust)

Acknowledgements

Funding for this project was provided by the Research Council's UK Rural Economy and Land Use programme. Our thanks to Peter Shallcross for allowing access to the study sites. Please visit www3.imperial.ac.uk/rebug for more details.

There is widespread concern about the use of insecticides in food production and there is considerable research into potentially viable biological control alternatives, nevertheless pest control in UK field crops still relies mostly on chemical pesticides. Pest thresholds help to ensure insecticides are only applied when economic damage threatens, but the lack of adoption of bio-control is mainly because we know little about the contribution that natural predators make to pest control.

With our partners from Rothamsted Research, Imperial College, London and the University of Kent, we are evaluating the relationships between pests and their predators and parasitoids (parastic wasps), and how these are affected by natural habitats such as hedgerows and field margins.

We have found that predators which fly (eg. hoverflies, parasitic wasps and long-legged flies) are more effective at reducing the number of cereal aphids than ground-active ones (eg. beetles and spiders). We also found that the presence of six-

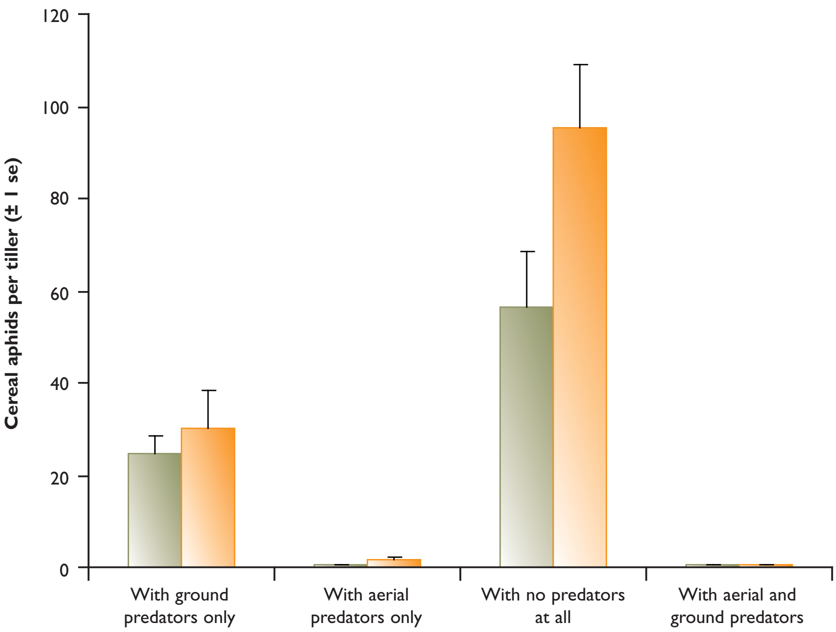
Figure 1

Aphid abundance in the presence of different groups of predators

Fields with standard (two-metre) margin

Fields with six-metre wide grass/flower margin

Standard margins were two metres wide with a well-established mix of grass and herbaceous plants typically found in a hedge base.



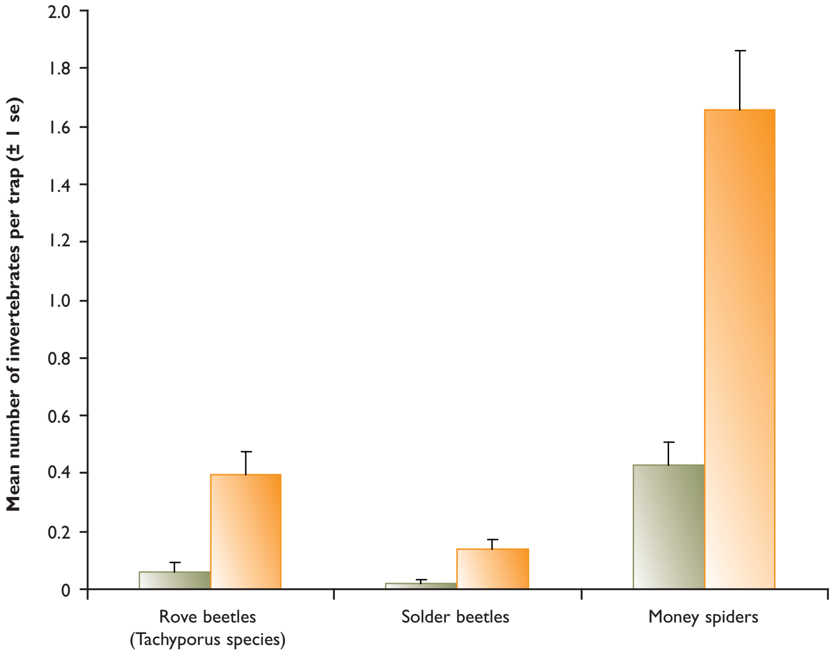


Figure 2

Invertebrate numbers in fields with and without six-metre margins

Fields with no margin

Fields with six-metre margin

Greater numbers of three invertebrate groups were caught on sticky traps in fields with six-metre margins than fields without a margin.

metre-wide flower-rich field margins made little difference to the abundance of these predators in an area where there was plenty of natural habitat (see Figure 1).

However, we did find that fields surrounded by six-metre grass margins contained a significantly greater number of money spiders, soldier beetles and aphid-eating rove beetles than fields without a margin (see Figure 2), and the total number of aphid predators flying over the field was significantly greater earlier in the season (beginning of May) where a margin was present. However, these predators may disperse further than a single field early in the season.

By positioning traps at different distances from the field margin (20 metres, 40 metres and 80 metres) we were able to determine how far from the field margin they could fly. Predatory flies were unable to fly very far from the field margin, whereas lacewings and soldier beetles showed the opposite trend, as they may have been searching for aphid prey or, in the case of lacewings, aphid patches within which to lay their eggs (see Figure 3).

This work forms the basis for a larger study to be carried out over the next couple of years looking at the effects natural habitats at farm and landscape scale on aphid control.

Sticky traps to catch flying predators of aphids. (Heather Oaten)

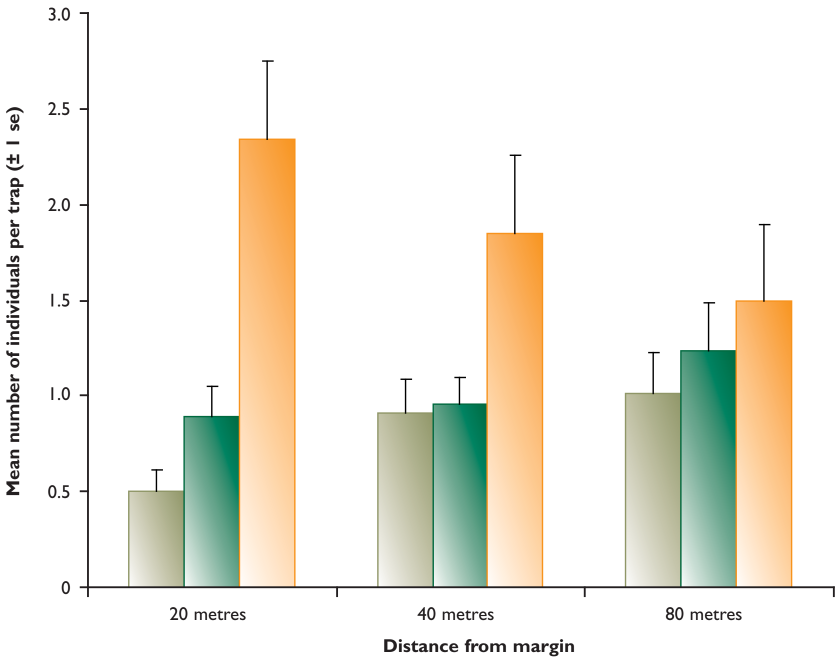


Figure 3

The effect of distance from the margin on numbers of three groups of aphid predators caught on sticky traps

Lacewings

Soldier beetles

Predatory flies

Rotational stubble set-aside management for insects

Key findings

- Plant diversity was poor on set-aside fields and invertebrate numbers were generally low. However, set-aside still had more plants and insects than a typical arable crop.
- Owing to the low numbers found, invertebrate abundance was similar between fields that were sprayed or cut and unmanaged fields.
- Spraying is the preferred management option. It allows vegetation to die back slowly and while doing so provides invertebrate food and shelter during the nestling period, and is harmless to mammals and birds compared with cutting.

Steve Moreby

The three pictures above show, from L-R: Poor set-aside, average set-aside and the very good which is likely to be perceived as too weedy by many farmers, causing problems in future years. (Steve Moreby)

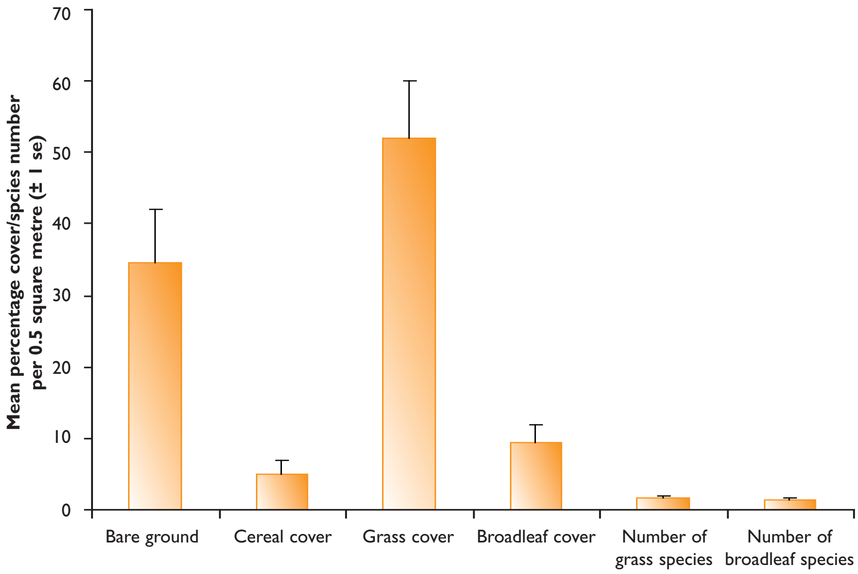
Under MAFF regulations in the 1990s, cereal stubbles put into rotational set-aside could be managed to control weeds by cutting at any time and ploughing after 1 May. Cutting vegetation early in the summer can result in direct mortality of mammals and birds, and the destruction of nests and breeding habitat.

After pressure from us and other conservation bodies, set-aside regulations were changed. Currently under Defra regulations there must be a green cover on the stubble over winter, which in most cases is natural regeneration. This cover can be sprayed off with glyphosate (Roundup) from 15 April, but to achieve best weed control on most fields, it is not normally sprayed until late May. Ploughing and cutting should not be carried out before 15 July but, if essential, steps should be taken to minimise the disturbance to wildlife. These changes have allowed flexible field management with green cover over winter, providing food for birds during a period when it can be scarce and, as ploughing and cutting should not be carried out until July, this safeguards the period when most ground-nesting birds have eggs or fledglings.

In our study, we looked at the effects of spraying or cutting set-aside on vegetation and invertebrates. We examined 31 fields, each on separate farms in southern England, of which 21 were sprayed, five had the vegetation top-cut leaving a sward of at least 25 centimetres in height, and five were unmanaged. We measured vegetation cover before management (cutting or spraying) in late May and sampled invertebrate groups

Figure 1

Percentage cover of vegetation groups and number of species in 31 set-aside fields



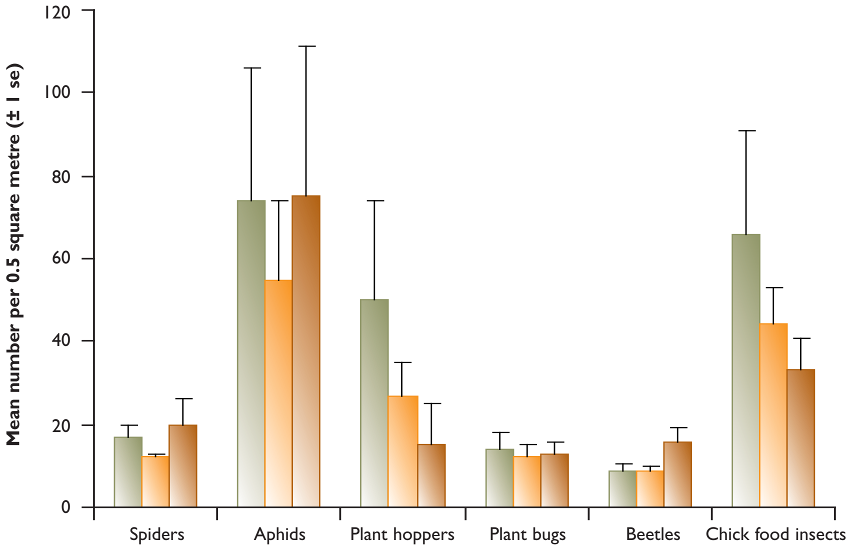


Figure 2

Bird food numbers in relation to set-aside management type

Unmanaged set-aside

Sprayed

Cut

known to be eaten by birds before and after management (early June) at 50 metres into the field.

Before management, the fields had on average 20-40% bare ground, 40-60% grass cover, 7-11% broadleaf cover and 1-7% volunteer cereals (see Figure 1). Although the plant cover may seem high, the floral diversity was very low with just one to two grass species and one to two broadleaf species per sample. The availability of insects was broadly related to the level of plant cover, but this was not always the case. Insect abundance was remarkably unaffected by cutting or spraying (see Figure 2).

Although set-aside was not originally a conservation initiative, but was designed to reduce excess grain production, set-aside fields have often proved to be important in supplying food in the form of grain and seeds to arable birds over winter. In summer, although invertebrate numbers were often very low, they were as good as or better than those found in arable fields (see *Review of 2005*, page 51). In summer, the open vegetation attracts ground-nesting birds and mammals, therefore spraying is the preferred option because some vegetation structure is retained compared with cutting, inhibiting nest predation, as has been found with skylarks. Spraying also allows a slow die-back of vegetation allowing plant-feeding and other invertebrates to survive in the fields during the period when chicks require an insect-rich diet. Overall, set-aside when used in conjunction with other conservation improvements such as game cover and grass-flower strips, can give additional benefit to farmland wildlife.

Cutting can remove all the vegatation structure of set-aside, so spraying can be a preferred option when it comes to management. (Steve Moreby)

Loddington in 2006

Key achievements

- Long-term monitoring continued.
- Developed numerous research projects on soil and water.
- Provided advice on conservation and environment for farmers, practitioners and policy makers.

Alastair Leake
Chris Stoate

Our research in 2006 continued two broad themes. Firstly, 2006 was the fifth year of monitoring of game and songbirds in the absence of predator control. Although not experimental with replication and control sites, this project has improved our understanding of a keeper's role in wildlife conservation. Our latest results are discussed in articles on pages 52 and 54. Winter feeding is widely used to maintain pheasants in good condition and we have begun a new project to assess the contribution this may make to wildlife conservation.

Our second theme is to explore the far-reaching implications of the EU Water Framework Directive through a suite of research projects investigating soil management and water quality. The projects investigate this issue at two scales, from field and ditch to stream and catchment. Hard science is not always enough, and we have now embarked on a project with the local community in our catchment to combine scientific results with the values and concerns of local people. Over the next few years, the Government's water quality objectives will increasingly affect the way farmers manage their land; our research will enable us to provide practical advice to farmers and the many others who visit us at Loddington.

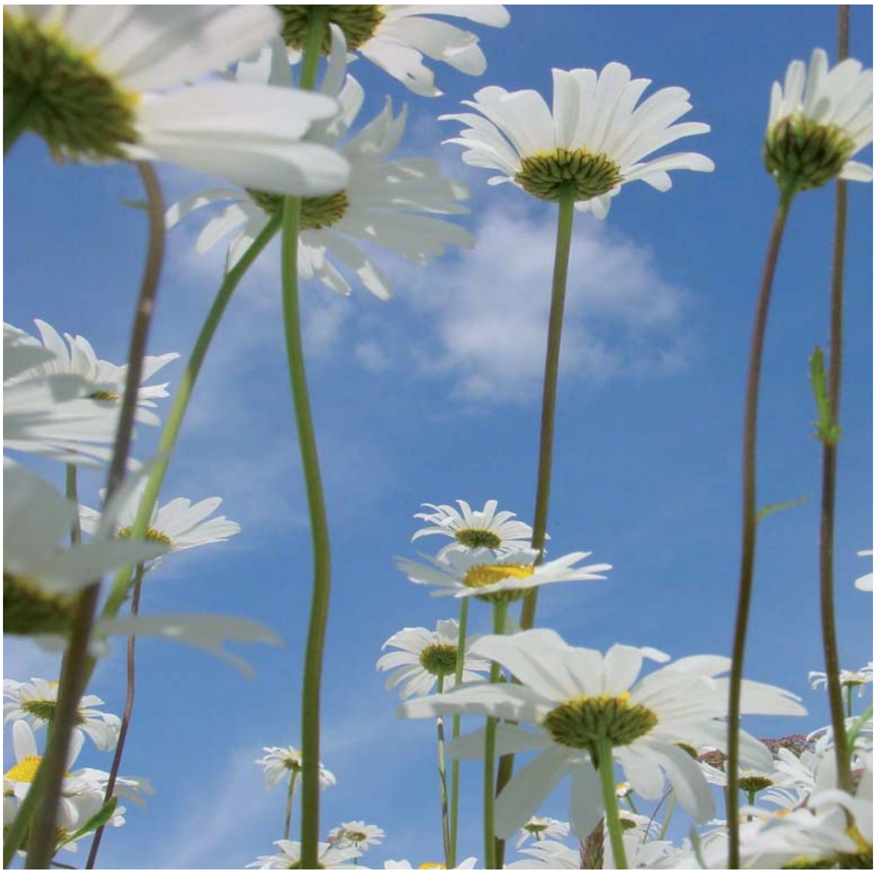
Most farmers are struggling to deal with the demands of Cross Compliance, an essential standard that they need to meet to avoid the risk of losing all or part of their Single Farm Payment. Any breach of the Environmental Stewardship options will also incur a penalty. Through our research we are well placed to advise practitioners and policy makers on both of these.

Projects at Loddington in 2006

Project title	Description	Staff	Funding source	Date
Effect of predation control (see pages 52 and 54)	*Effect of ceasing predator control on nesting success and breeding populations of songbirds*	*Chris Stoate, Alastair Leake, John Szczur, Seb Mankelow, Kate Driver*	*Core funds*	*2001-2008*
Monitoring wildlife at Loddington (see page 52)	*Annual monitoring of game species, songbirds, invertebrates and habitat*	*Chris Stoate, Alastair Leake, Steve Moreby, Sue Southway, Kate Driver, Barbara Smith*	*Core funds*	*1992 - on-going*
SOWAP (see page 56)	*Demonstrating use of conservation tillage to protect and enhance soil resources, water quality and biodiversity*	*Alastair Leake, Chris Stoate, Kate Driver, Ben Gibson*	*EU LIFE*	*2003-2006*
Songbird ecology (see page 54)	*Ecology of songbirds at Loddington, including studies on tree sparrow and spotted flycatcher and influence on nesting success*	*Chris Stoate, John Szczur, Kate Driver*	*Core funds*	*1992 - on-going*
Phosphorus from agriculture: riverine impact study (PARIS)	*Impacts of agriculturally-derived sediment and phosphorus on aquatic ecology in the Eye Brook catchment*	*Chris Stoate*	*Defra*	*2004-2008*
Mitigation options for phosphorus and sediment (MOPS)	*Assessment of beetle banks, and cultivation type and direction, as a means of reducing soil erosion*	*Alastair Leake, Chris Stoate, Kate Driver, Phil Jarvis*	*Defra*	*2005-2008*
Wetting up farmland for biodiversity	*Assessing bird conservation potential of small wet features on farmland*	*Chris Stoate, John Szczur*	*Defra*	*2004-2008*
Herbicides for conservation headlands	*Evaluating dose rate and timing on weed populations in conservation headlands*	*Alastair Leake, Phil Jarvis, Kate Driver*	*BayerCropScience*	*2004 - on-going*
Conservation and Cross Compliance advice	*Providing farmers and landowners with advice on the rules and options*	*Alastair Leake, Chris Stoate, Phil Jarvis*	*Defra*	*2005-2007*
Biodiversity and environmental training for advisors (BETA)	*BASIS-accredited training for agronomists in biodiversity and environmental issues*	*Alastair Leake, Chris Stoate, Peter Thompson*	*Course fees*	*2003-2007*
Soil and waste management	*Training for farmers in understanding Soil Management Plans and the EU Waste Directive*	*Alastair Leake, Phil Jarvis*	*Course fees, Defra, Environment Agency*	*2005 - on-going*
Wildlife seed mix agronomy using organic methods	*Developing methods for organic farmers growing wildlife seed mixes*	*Alastair Leake, Kate Driver*	*English Nature/ Natural England*	*2004-2006*
Eye Brook	*Community heritage project*	*Chris Stoate*	*Heritage Lottery Fund*	*2006-2010*
PhD: Songbird productivity and farmland habitats	*Songbird nesting success in relation to habitat, predator abundance and weather*	*Patrick White (Supervisors: Chris Stoate; Ken Norris/Reading Univ)*	*BBSRC CASE Studentship*	*2005-2008*
PhD: Birds and bees	*Role of pollinating insects on autumn berry abundance as food for birds*	*Jenny Jacobs (Supervisors: Chris Stoate; Ian Denholm, Juliet Osborne/Rothamsted Research; Dave Goulson/Stirling Univ)*	*BBSRC CASE Studentship*	*2004-2007*

Key to abbreviations: BBSRC = Biotechnology and Biological Sciences Research Council; Defra = Department of the Environment, Farming and Rural Affairs; LIFE = European Union Financial Instrument for the Environment

The farming year at Loddington in 2006



In 2006, we joined Entry Level Stewardship, choosing options that were mainly already in place, so now we are rewarded for our conservation efforts. *(Alastair Leake)*

Key results

- Winter wheat performed well, oilseeds and oats acceptably, but beans had a reduced yield.
- Market prices for combinable crops rose, increasing gross margins.
- Lamb prices were high.
- Game crops had a reasonable year.

Alastair Leake

2006 saw a much needed improvement in the price of combinable crops. With world wheat stocks at an all time low and variable weather patterns around the planet the market responded by driving prices up. This resulted in a £15 per tonne increase in wheat prices from 2005. With Cross Compliance placing more pressure on the farm to maintain the environmental standards set by Defra, the rising market prices are certainly welcome.

Subsidy payments are now disconnected from production, so it is easier for producers to calculate the costs of production and compare them with income received. Grade three soils like those at Loddington restrict output compared with farms on better soil types for arable crop production. Consequently low output prices

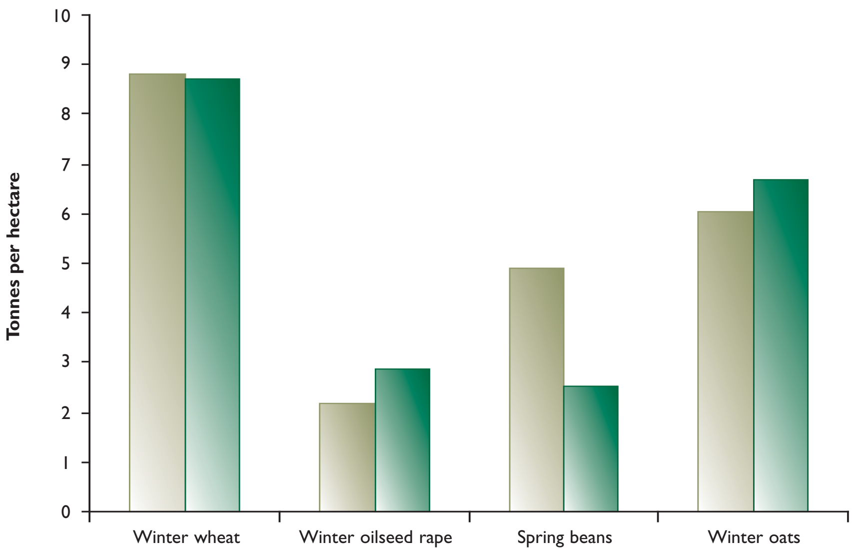


Figure 1

Crop yields at Loddington in 2005 and 2006

2005

2006 (estimated)

Table 1

Arable gross margins (£/hectare) at Loddington 1994-2006

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005*	2006†
Winter wheat	773	1,007	981	551	668	723	572	603	518	836	536	591	829
Winter barley	596	877	802	625	478	534	403	315	328	-	-	-	-
Winter oilseed rape	520	808	868	593	469	468	523	329	611	614	477	381	400
Spring oilseed rape	433	-	-	-	-	-	-	-	-	-	-	-	-
Winter beans	450	626	574	616	507	553	573	331	452	491§	415§	541§	408§
Winter oats	-	-	-	-	-	-	-	-	462	759	545	516	666
Linseed	473	535	-	497	-	477	-	-	-	-	-	-	-
Set-aside	301	331	335	326	296	317	205	204	251	247	217	194	185

* revised figures § spring beans †estimated figures

Table 2

Farm conservation costs at Loddington 2006 (£ total)

Set-aside *(wild bird cover)*[1]	
(i) Farm operations	1,111
(ii) Seed	1,200
(iii) Sprays and fertiliser	509
Total set-aside costs	**2,820**
Conservation headlands[2]	
(i) Extra cost of sprays	0
(ii) Farm operations	96
(iii) Estimated yield loss	790
Total conservation headland costs	**886**
Grain for pheasants	994
Grass strips	212
Stewardship (CSS & ELS)	6,473
Woodland	820
Total conservation costs	**12,205**
Stewardship income (CSS & ELS)	(9,888)
Total profit foregone	
- conservation	**2,317**
- research and education	**5,693**
	8,010

[1] Area of wild bird cover = 7.4 ha

[2] Area of conservation headlands = 4.4 ha

Further information on how these costs are calculated is available from The Game Conservancy Trust

are felt more severely by us. Continually managing just to break even is not sustainable in the long-term; re-investment in machinery, buildings and equipment is essential. New health and safety standards, such as the level of micro-toxins in grain, mean that we need to continually re-invest to remain a viable farming business.

We entered the farm into Entry Level Stewardship (ELS) in February 2006. Buffer strips, pollen and nectar mixtures, beetle banks, hedgerows and management plans were the main items we selected. Many of these were existing features and we are pleased to be able to claim funding now for our long-term diligent stewardship.

Lambing progressed smoothly though March. Although the lambing percentage of 155% was not as high as in previous years, the average price of £43 a lamb was one of the highest recorded at Loddington. We sold 95% of lambs into the 'finished' market. Animal movement and identification records have been a priority in 2006 to keep up with the statutory management requirements. Information from the Rural Payments Agency Inspectorate indicates that over half the Cross Compliance failings in 2006 were associated with livestock record keeping or animal identification. Such failings can result in a reduction in the Single Farm Payment.

We drilled spring beans at the end of February in uncharacteristically dry weather. Crop emergence was exceptionally good, but temperatures in the high 30 degrees centigrade in mid-July caused sudden leaf loss and a reduced yield.

Game crops had a reasonable year, with high summer rainfall giving the spring-sown kale a real boost.

Our joint machinery venture with Oxey Farm continues to produce real cost savings for both businesses. We now have a yield meter that allows us to yield-map the farm and provides data for research. Initial indications are that soil type has a significant effect on the yield pattern of a field. Fields with areas of the lighter loamy Efford series appear to grow bigger yields. However, given a dry or droughty summer the situation might be reversed with the heavier Hanslope and Denchworth clays fairing better.

Another piece of new technology is a scanner fitted to a variable rate control box on our Kuhn fertiliser spreader. This allows more accurate application of nitrogen to the crop in the spring.

Winter wheat performed well and even a fortnight's rain in August did not dampen the market, which continued to rise. Oats and oilseeds had an average harvest in terms of weather and yield. We grew two fibre crops, hemp and flax, as part of a trial to evaluate the suitability of the soils and climate in the East Midlands. Results look promising and, should they become commercially viable, will provide us with two more spring crops. These are good for spreading our autumn workload, reducing our herbicide bill and the pressure from herbicide-resistant blackgrass, as well as providing winter stubbles for the benefit of wildlife.

We drilled our 2007 harvest crops in near-perfect conditions, giving the crops an encouraging start in the warm moist autumn. Our oilseed rape established with just one cultivation pass and the crop emerged very well.

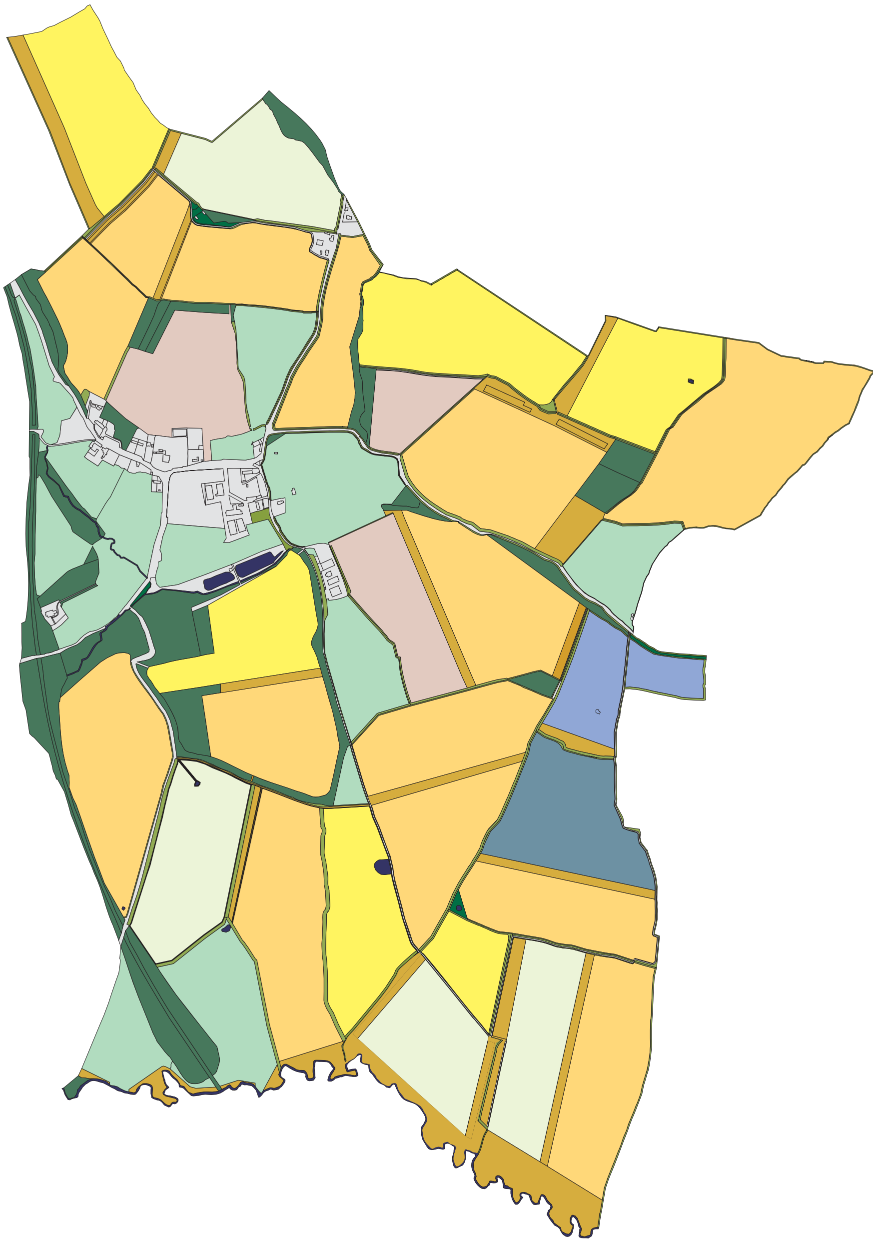


Figure 2

Loddington Estate cropping 2005/06

- Woodland
- Permanent pasture
- Winter wheat
- Spring beans
- Winter oilseed rape
- Winter oats
- Phacelia on set-aside
- Hemp and flax
- Set-aside
- Hedgerow/verge

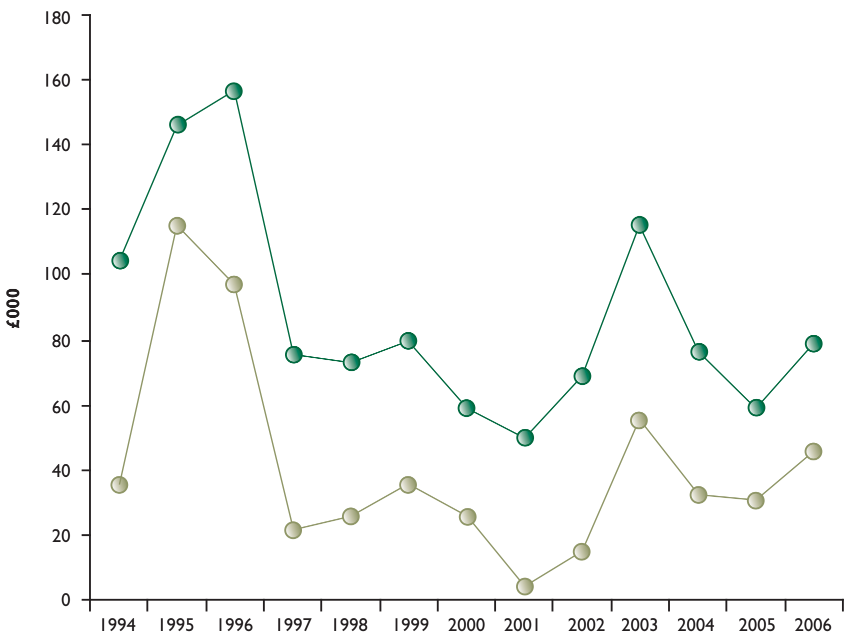


Figure 3

Gross profit and farm profit at Loddington 1994-2006

- Gross profit
- Farm profit

Loddington game monitoring

Key findings

- Red-legged partridges, pheasants and hare numbers are now at the lowest since our work began.
- Winter feeding appears to sustain spring pheasant numbers.

Chris Stoate

It is five years since we stopped controlling predators at Loddington and numbers of game are much lower than they were in 2001. Hare numbers are now very low (see Figure 1). We have kept the habitat more or less the same at Loddington for over a decade, so it is an increase in predation that is the most likely cause of the hare decline.

Gamebird numbers have dropped too, and there has been no shooting at Loddington for four years. Red-legged partridges were down to 14 birds in autumn 2006, compared with 140 in 2001. Autumn pheasant numbers were up slightly on 2005, but at 114 birds, less than a quarter of the 527 present when predator control finished (see Figure 2). Across all the years, there is a clear relationship between the number of hens and the number of young produced (see Figure 3). However, in the absence of predator control, this has not been sufficient to maintain autumn numbers. It is the lack of production due to predation of eggs and young that has mainly caused the decline in autumn numbers of pheasants at Loddington. Figure 3 also shows that the number of young present in autumn is reduced when hen numbers exceed 100.

Spring numbers of pheasants have declined since we stopped predator control, but not as much as autumn numbers. In fact, in the past three years, spring numbers have been at least as high as autumn numbers. This must be due to immigration from neighbouring areas where birds are released. This might in part be because of the habitat, but another reason is likely to be the food we provide through the winter.

Figure 1

Hare numbers at Loddington

Hares

Predator control in place

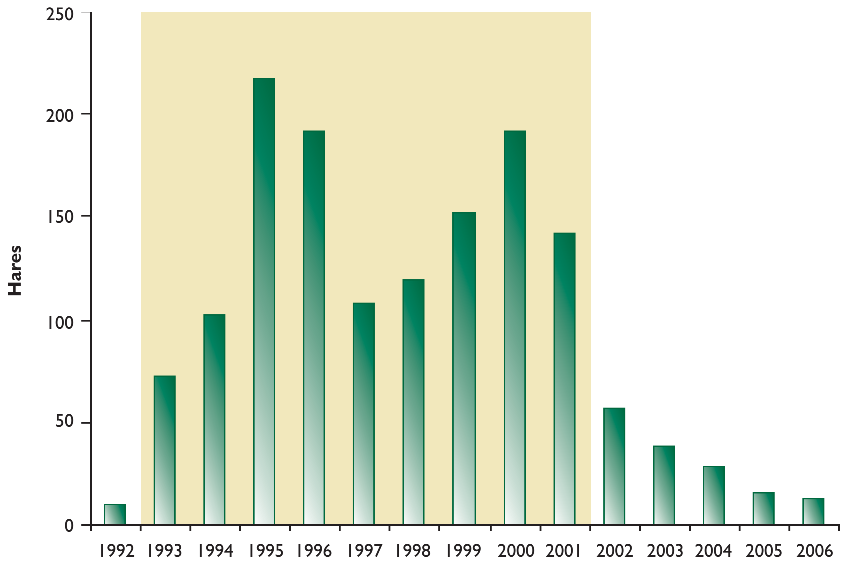


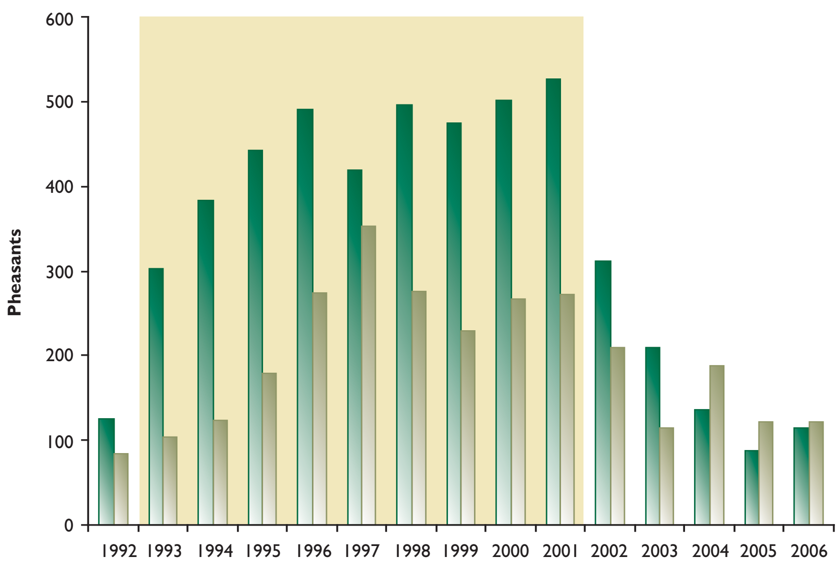
Figure 2

Autumn and spring pheasant numbers at Loddington

Autumn pheasants

Spring pheasants

Predator control in place



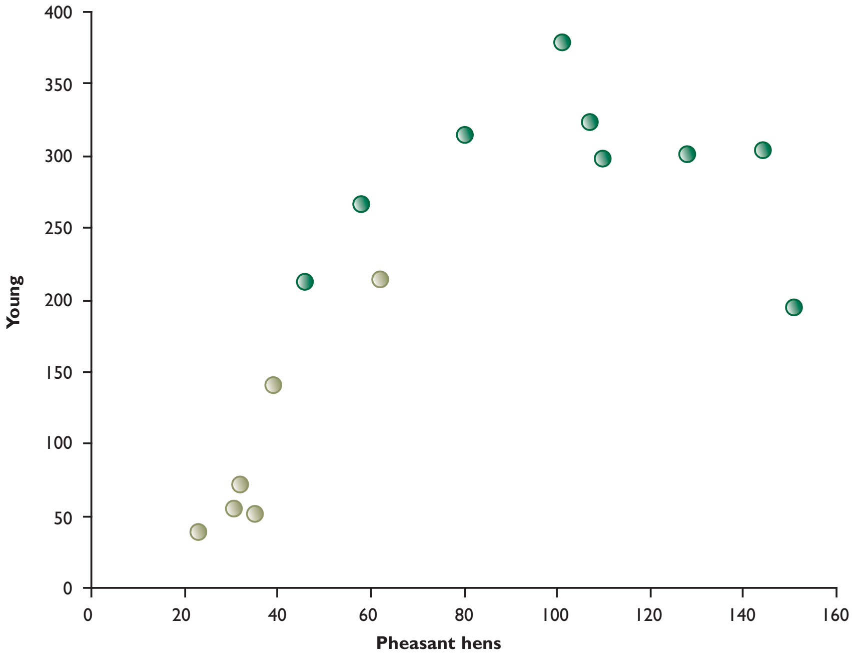


Figure 3

Pheasant chick production in relation to numbers of breeding hens

Years without predation control

Years with predation control

As on other shoots across the country, we do this to maintain pheasants in good condition on the farm over winter. This winter feeding policy is probably now the key to maintaining pheasants at Loddington in the absence of predator control. We now plan to stop winter feeding so that we can understand its influence on game and non-game species.

Come winter, the feeders are filled and are used by game and songbirds alike. (Sophia Gallia/Natterjack Publications)

Songbirds at Loddington

Key findings

- Abundance of BAP songbird species has declined by 30% since our keeper left.
- For species such as spotted flycatcher and song thrush, our results suggest that increased nesting success resulting from predator control may contribute to changes in abundance.
- For other species, winter feeding of game may have greater benefits. We are currently investigating this.

Chris Stoate

Our management at Loddington has essentially gone through three phases (see Table 1) and during each phase we have mapped the breeding territories of songbirds across the farm (1992, 1998, 2001 and 2006). We also have bird abundance data from transect counts carried out each year. Our PhD student, Patrick White, is also analysing the nest survival data that John Szczur has collected since 1995, and in the case of blackbird, most years since 1992.

Table 1

Changes in game management at Loddington since we inherited the farm in 1991

	Up to 1992	1993-2001	2002-2006
Predator control	No	Yes	No
Habitat and set-aside management	No	Yes	Yes
Systematic winter hopper feeding*	No	Yes	Yes

** There was reduced winter feeding in 2001/2 and 2002/3, but this was restored in subsequent years*

Figure 1

Songbirds at Loddington

Songbirds

Predator control in place

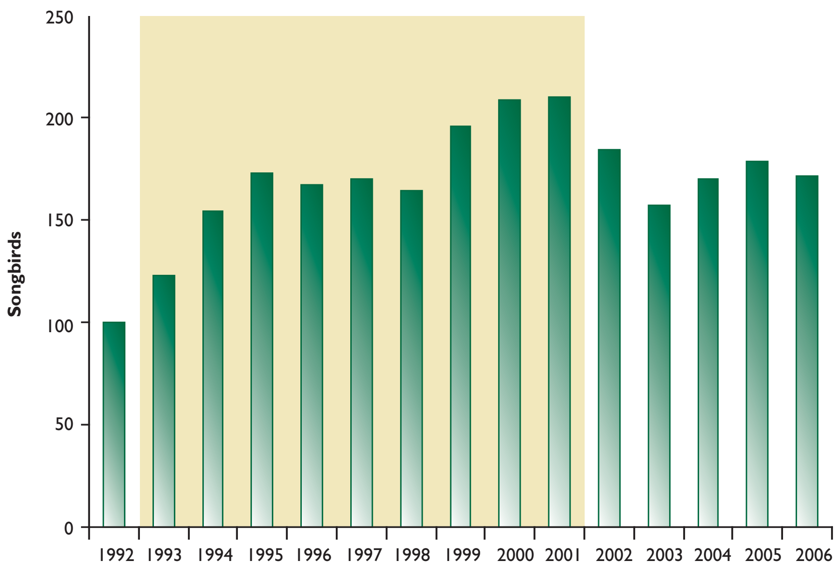


Figure 1 shows overall songbird abundance at Loddington. Numbers increased in response to game management at Loddington from 1993, but declined in the first two years without a keeper. Habitat, predator control and winter feeding affect the different species in different ways and some species have continued to increase while others have declined. For the seven Biodiversity Action Plan (BAP) species, the territory mapping data suggest an overall decline of 30% (see Table 2), and transect data also reveal a decline in recent years relative to numbers on another local farm (see Figure 2). For some of these species, such as the migratory spotted flycatcher, winter conditions at Loddington are unimportant. Song thrush, bullfinch and linnet tend not to take wheat from the feed hoppers, whereas we know that tree sparrows do.

One way to shed more light on these changes is to look at nest survival over the periods with and without predator control. These data show a significant difference in nest survival between years with and without predator control for the four species we have analysed so far (see Table 3). This may have contributed to the changes in abundance that these species have shown over the same periods.

These results suggest that, for some species, predator control could contribute to the restoration of breeding numbers. However, other game management practices such

The blackbird is probably our most-studied songbird at Loddington. (Laurie Campbell)

Table 1

Numbers of breeding territories for key songbird species at Loddington

	1992 (base year)	1998 (habitat & predator control)	2001 (habitat & predator control)	2006 (no predator control)
BAP species				
Skylark	36	36	37	33
Song thrush	14	48	64	34
Spotted flycatcher	8	11	14	6
Tree sparrow	3	0	7	11
Linnet	10	21	25	17
Bullfinch	6	11	12	6
Reed bunting	3	3	3	5
Total	**80**	**129**	**162**	**112**
As percentage of 1992	*100%*	*161%*	*203%*	*140% (-30% on 2001)*
Other study species				
Dunnock	46	86	144	97
Blackbird	66	143	143	98
Whitethroat	25	44	45	48
Chaffinch	135	178	229	161
Yellowhammer	57	55	54	46
Total	**329**	**396**	**615**	**360**
As percentage of 1992	*100%*	*120%*	*187%*	*109% (-41% on 2001)*

as habitat and winter food supply also contribute and the importance of these other factors differs between species. Winter feeding is an important and widely practised component of game management for shooting and we need to understand better the possible contribution this makes to songbird conservation. We are testing this at Loddington by stopping the use of hopper feeders and continuing the monitoring of game and songbird numbers. Monitoring of a small number of remaining hoppers will also provide more information on which species use them and which do not.

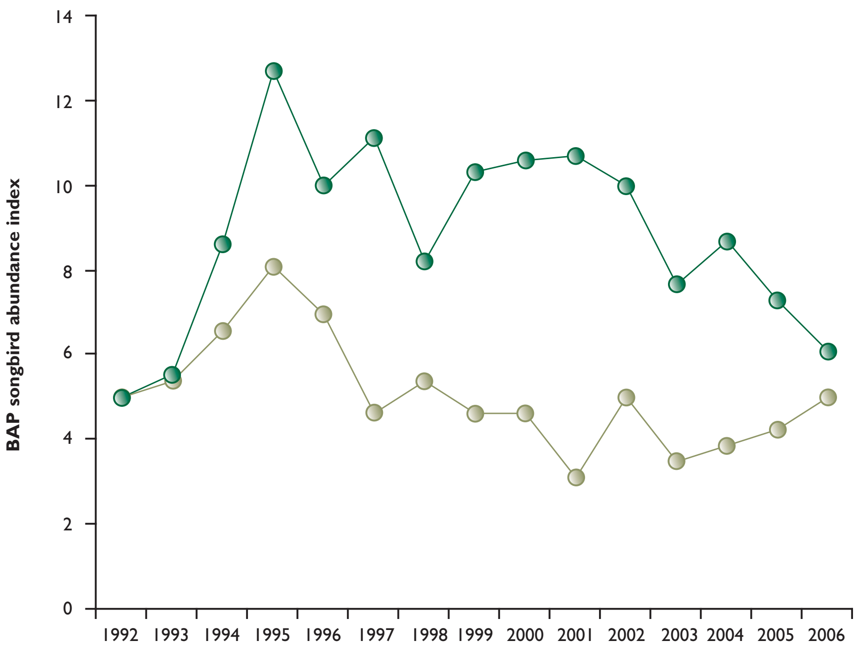


Figure 2

Abundance of BAP species of songbirds at Loddington compared with a nearby farm

Table 3

Daily nest survival rates (± se) for four study species at Loddington

	Keeper	No keeper
Blackbird	25.7 ± 3.0	8.9 ± 2.3
Chaffinch	28.1 ± 5.6	14.4 ± 4.2
Songthrush	23.6 ± 4.5	11.6 ± 4.0
Yellowhammer	32.3 ± 7.4	16.9 ± 5.5

Europe-wide project on soil and water

Key findings

- Soil loss was significantly reduced through 'conservation agriculture'.
- Substantially more earthworms were found under 'conservation tillage' than conventional ploughing.
- Skylarks were more abundant where conservation tillage rather than ploughing was practised.

Alastair Leake

The Soil and Water Protection Project (SOWAP) was established in 2003 with four million Euros of funding from the European Union LIFE programme and support from global crop protection specialists, Syngenta. As well as launching the project at Loddington, it used the farm as one of its original four sites internationally (the others being in Devon, Hungary and Belgium, with a subsequent two sites in Slovakia and France). We report here on some of the project's findings.

The project's vision appears simplistic, being "to find and demonstrate ways of better managing the land". In reality the complexity of balancing soil management, economic crop production, agronomy, soil ecology, wildlife, aquatic ecology with rainfall patterns across three European countries proved a considerable challenge. It is believed that the intrinsic capacity of cultivated systems to support crop production is being undermined by soil erosion, salinisation and loss of biodiversity, but this loss of capacity is masked by increasing use of fertiliser, water and other agricultural inputs. SOWAP has shown that whatever strategy is chosen there are difficult trade-offs between productivity, ecosystems and poverty reduction (in global terms, a high priority for 21st century agriculture).

Central to SOWAP's approach was the proposition that there would be real benefits for the environment by reducing the amount of tillage used for crop establishment. Such an approach should improve soil 'strength' (the ability of soils to resist erosion and remain productive), and reduce soil erosion. Reduced soil disturbance was also thought to benefit the soil flora and fauna, which might lead to more food up the chain for birds and mammals. Less soil erosion should also reduce sediments and chemical run-off into nearby streams and ponds.

The effects of tillage varied according to crop rotation, soil type and weather pattern. At SOWAP's Belgian site, soil loss was significantly reduced by 'conservation agriculture', which involved a range of techniques to maintain productivity and minimise the environmental effects of agriculture, including 'conservation tillage' (which disturbs the soil less intensively than conventional agriculture). Generally, the project found that the shallower the tillage method used, the less run-off there was (see Figure 1). This was mainly due to the incorporation of crop residues resulting in elevated soil organic matter. The project estimated that if farmers across the whole of Flanders, where very few have currently adopted conservation tillage, were to do so, it would reduce erosion to around 25% of current levels.

Measurement of earthworm densities in the UK indicated substantially more earthworms per square metre under conservation tillage than plough (see Figure 2). The more earthworms in the soil, the more burrows they create, which improve soil drainage and reduce water and sediment run-off. Earthworms also incorporate organic matter, increase soil fertility and provide food for birds and mammals.

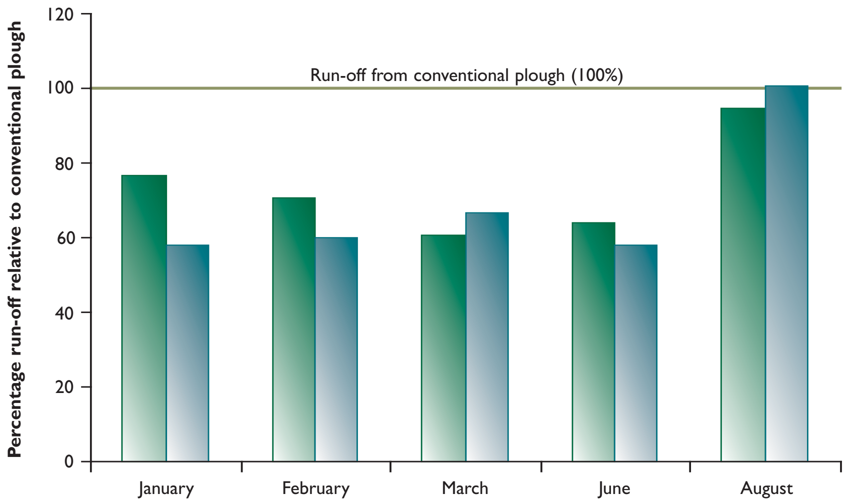
Across all sites, the project found skylarks to be more abundant on fields with conservation tillage owing to increased densities of surface-dwelling invertebrates and

Figure 1

Run-off collected in tanks from winter wheat with conservation tillage 20054-2005, in comparison with conventional plough

Shallow conservation tillage

Deep conservation tillage



availability of weed seeds. There were also differences in the soil microbial community between the different tillage treatments, attributable in part to the levels of soil organic matter (see Figure 3).

Changes in weather patterns have particular implications for farmers in the UK. Although the total annual rainfall at Loddington has changed little, the pattern in which it falls has, with extended periods of little rainfall punctuated by torrential downpours.

Creating a soil structure that can absorb this will reduce run-off and erosion as well as creating a reservoir in the soil pores to sustain crop production during periods of drought. Increasing soil organic matter is vital to this and a fundamental component of conservation agriculture.

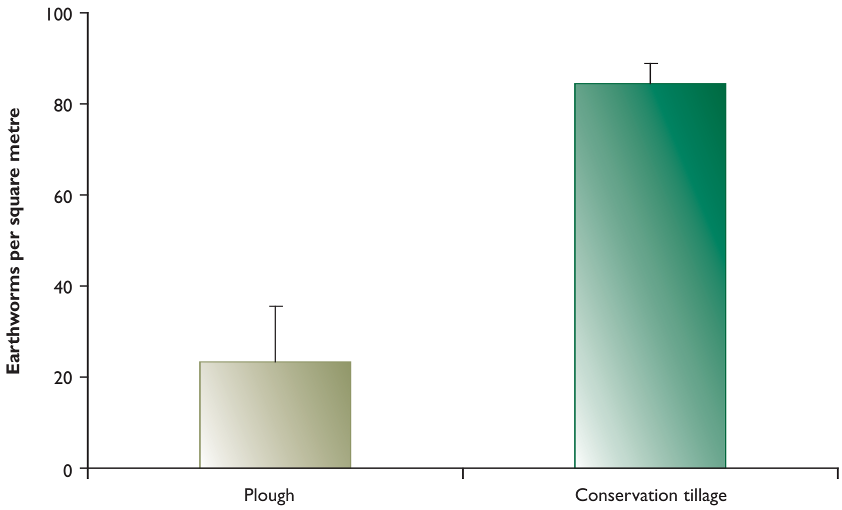


Figure 2

Earthworm numbers in plots under plough and conservation tillage

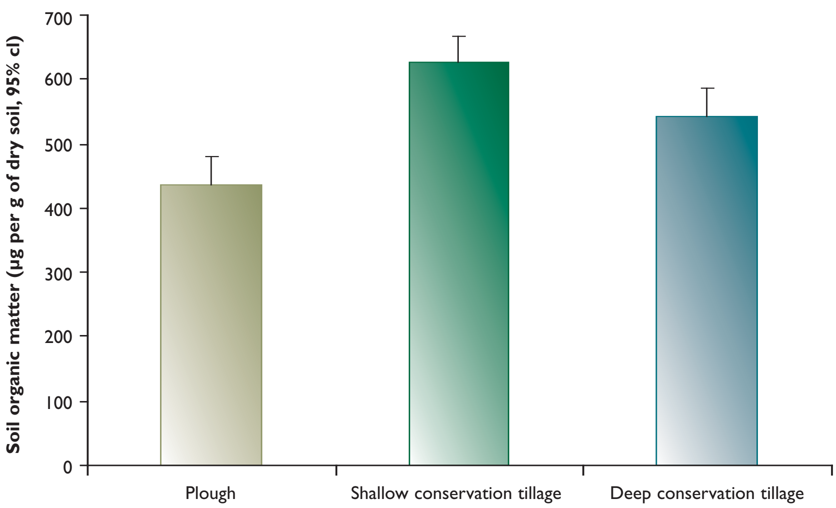


Figure 3

Soil organic matter in plots under plough and conservation tillage

Data for all figures provided by administrators of the SOWAP project.

One of the SOWAP project's run-off collection stations at Loddington.
(Sophia Gallia/Natterjack Publications)

Woodland game ecology in 2006

Key achievements

- We reported key findings and recommendations from long-term studies of impacts of releasing on habitats and wildlife.
- In 2006, breeding success of wild pheasants in East Anglia was much lower than usual.
- Three PhD studies, all looking at aspects of the ecology of released game, were submitted during the year.

Rufus Sage

In 2006 we produced a full report on our work on the effects of releasing lowland game on wildlife and habitats and an accompanying guidelines document (see page 60). The report is a compendium of many studies that have gone into the development of releasing guidelines.

New research in this area continued during 2006. We looked at the effect that released pheasants may have on hedgerows near release woodlands, which they use for accessing feed and driving areas on shoots (see page 68). We also did some preliminary work on woodland ground flora at old release pen sites and on the insect community inside woodland release pens. We conducted further songbird counts in game and non-game woods in Hampshire and Dorset during February and March to determine whether the differences found in early winter (see *Review of 2005* pages 28-29) persisted until spring.

Three PhD studies involving woodland game ecology finished during 2006. Clare Turner, who submitted her thesis at the end of the year, provided us with a unique insight into what really happens to released pheasants and reported key findings in the *Reviews of 2003* and *2004*. Dave Butler also finished fieldwork for his study of imprinting gamebird chicks in America (see page 62). In early 2006, on the back of this study, we secured UK Research Council funding for a follow-on PhD with Imperial College London. The fieldwork for this study will be done on an estate in Austria. Tracy Greenall has been writing-up her PhD on wildlife and game at the Lees Court Estate (see page 66).

In the Eastern counties, under the supervision of Roger Draycott, James Palmer has been looking at the spatial relationship between farm crops and breeding success in wild game. We did further analysis of our woodcock data in 2006 (see page 64), providing a clearer direction for future research. This is important given that a revised EU management plan for woodcock, commissioned by the EU this year, stressed the need for all member states to ensure sustainable hunting owing to uncertainty about adult survival rates and the status of some breeding populations.

Woodland is a very important habitat, vital to many species featured in our research. (Sophia Gallia/Natterjack Publications)

Wild pheasants in East Anglia

In 2006 breeding stocks of wild pheasants in East Anglia were 15% lower than in 2005

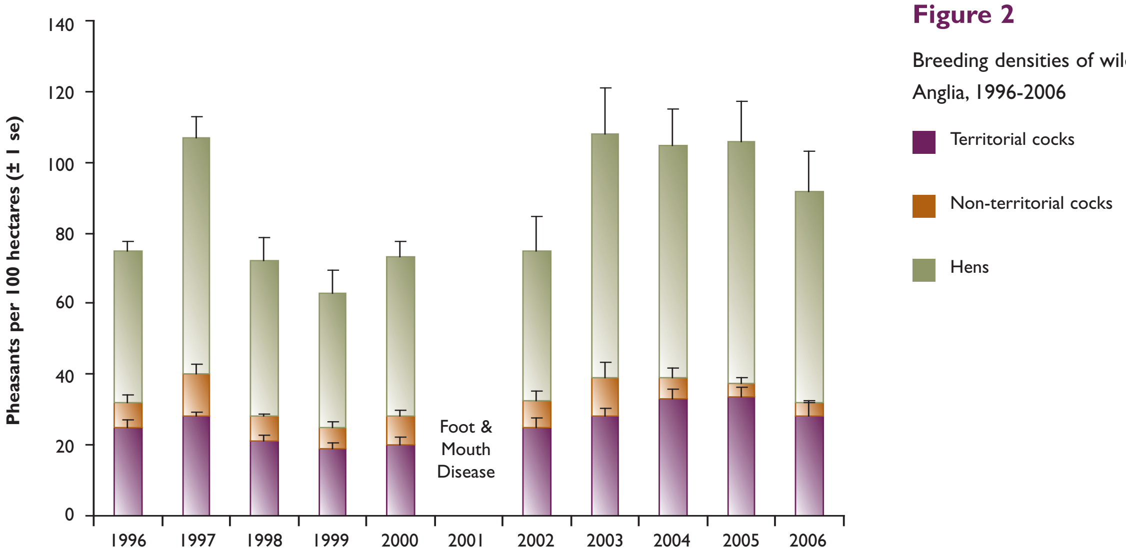


Figure 2

Breeding densities of wild pheasants in East Anglia, 1996-2006

(see Figure 1). Despite good weather in June and July breeding success was poor across all count sites with below-average productivity (1.3:1 compared with 10-year average of 1.7:1). This resulted in disappointing figures in autumn (37 young per 100 hectares in 2006 compared with 65 young per 100 hectares in 2005). Several of the sites recorded higher than usual mortality in nesting hens in 2006, which probably accounts for the low productivity. The cause of these losses is unclear, but it is likely to be linked to the very cold conditions in May when hens were nesting. Some estates are concerned that disease was important too, although post-mortem examination of sick and healthy birds have so far proved inconclusive. We are encouraging gamekeepers and landowners responsible for managing wild pheasants to submit any sick or freshly dead birds to their vets for post-mortem analysis. This information will help us to determine if there are significant diseases in wild pheasants.

Pheasant and woodland research in 2006

Project title	Description	Staff	Funding source	Date
Pheasant population studies (see page 58)	*Long-term monitoring of breeding pheasant populations on releasing and wild bird estates*	*Rufus Sage, Maureen Woodburn, Roger Draycott*	*Core funds*	*1996 - on-going*
Wildlife in energy crops	*Social, economic and environmental implications of increasing land-use under under energy crops*	*Rufus Sage (with Rothamstead Research), Mark Cunningham, Maureen Woodburn*	*RELU*	*2006-2008*
Birds in Miscanthus	*Studying birds in winter and summer Miscanthus plantations*	*Rufus Sage, Mark Cunningham*	*Defra*	*2006-2008*
Releasing pheasants, and hedgerows (see page 68)	*Comparing hedgerows with and without game management*	*Rufus Sage, Andrew Hoodless, Roger Draycott*	*Research Funding Appeal*	*2006*
Game crops and wild game	*Relationship between cropping and gamebird productivity in East Anglia*	*Roger Draycott, James Palmer*	*Chadacre Trust*	*2005-2006*
Releasing pheasants, and woodlands	*Birds in woodlands with and without releasing, plants and insects in existing and extant release pen sites*	*Andrew Hoodless, Rufus Sage*	*Research Funding Appeal*	*2006*
Origins of wintering woodcock	*Pilot study of use of stable isotopes to study woodcock migration*	*Andrew Hoodless*	*Private donors*	*2006-2007*
PhD: Dispersal in released pheasants	*Radio-tracking of released pheasants - mortality and dispersal in relation to density and habitat quality*	*Clare Turner Supervisor: Rufus Sage; Simon Leather/Imperial College*	*Research Funding Appeal*	*2001-2006*
PhD: Lees Court Estate Project (see page 66)	*Quantifying the biodiversity and economics of a quality, released bird shoot following management for game, including comparison sites*	*Tracy Greenall Supervisor: Rufus Sage; Nigel Leader-Williams/DICE at Kent University*	*Sir John Swire Charitable Trust, Lees Court Estate, Holland & Holland*	*2000-2006*
PhD: Imprinting gamebird chicks	*Human imprinting gamebird chicks to release and recover as a tool for sampling chick-food invertebrates in crops*	*Gwendolen Hitchcock Supervisors: Rufus Sage; Simon Leather/Imperial College*	*BBSRC*	*2006-2009*

Key to abbreviations:
BBSRC = Biotechnology and Biological Sciences Research Council; DTI = Department of Trade and Industry; RELU = Rural Economy and Land Use.

New guidelines for sustainable gamebird releasing

Key findings

- We have new good-practice recommendations relating to releasing for shooting based on nature conservation issues.
- We have properly quantified some of the benefits habitat management for released birds can have on woodlands and farmland.

Rufus Sage

Over the last three *Reviews,* we have reported our work on releasing gamebirds for shooting and its effect on habitat and wildlife. The work had the following broad aims: to identify any negative effect of releasing; to provide appropriate solutions; to discount any unfounded criticism; and to quantify any positive effects.

Although some work continues, much is already published in the peer-reviewed scientific literature. Alongside these papers we have compiled this work into a single report and produced a set of preliminary guidelines based on it. Some of the main conclusions and advice are as follows.

- Red-legged partridge releases onto improved ground do not usually conflict with nature conservation interests, but releasing directly onto unimproved grasslands – such as chalk downland – may do. We recommend avoiding releases onto semi-natural grassland.
- We recommend that only between 700 and 1,000 birds per hectare or 300-400 per acre, depending on the quality of the woodland flora are put into any release pen.
- We recommend that no more than one third of the total woodland on a shoot should be enclosed by release pen.
- Woodland areas that are managed for game outside release pens tend to have a more open canopy, better flora, better edge shrubbiness and more songbirds in summer and winter. By keeping the greater part of the woodland free of release pen, we think the conservation balance on the whole will be positive. So, as an example, a 500-hectare shoot with 30 hectares of woodland should have no more than around 10 hectares of release pen containing in total no more than 10,000 pheasants.

Our guidelines will help to minimise any conflicts between pheasant releasing and the conservation of important woodlands and their flora and fauna. (Rufus Sage)

No more than one third of the total woodland on a shoot should be enclosed by release pen. (Rufus Sage)

- Hedgerows can be damaged by pheasants and red-legged partridges if large releases are encouraged to spread into them. By using lead-in strips that run between release points to game crops, we think that the effect of large releases can be diluted by discouraging them from concentrating in hedgerows. Nevertheless, shoots encourage hedgerow retention.

Conflicts can arise between released birds and particularly sensitive habitats and wildlife species. Often such sensitive spots can simply be avoided and the gamebirds released elsewhere.

We hope that these guidelines will help shoot managers to improve the conservation balance of their releases. All these guidelines have been incorporated into the new Shoot Assurance Scheme developed by the Code of Good Shooting Practice.

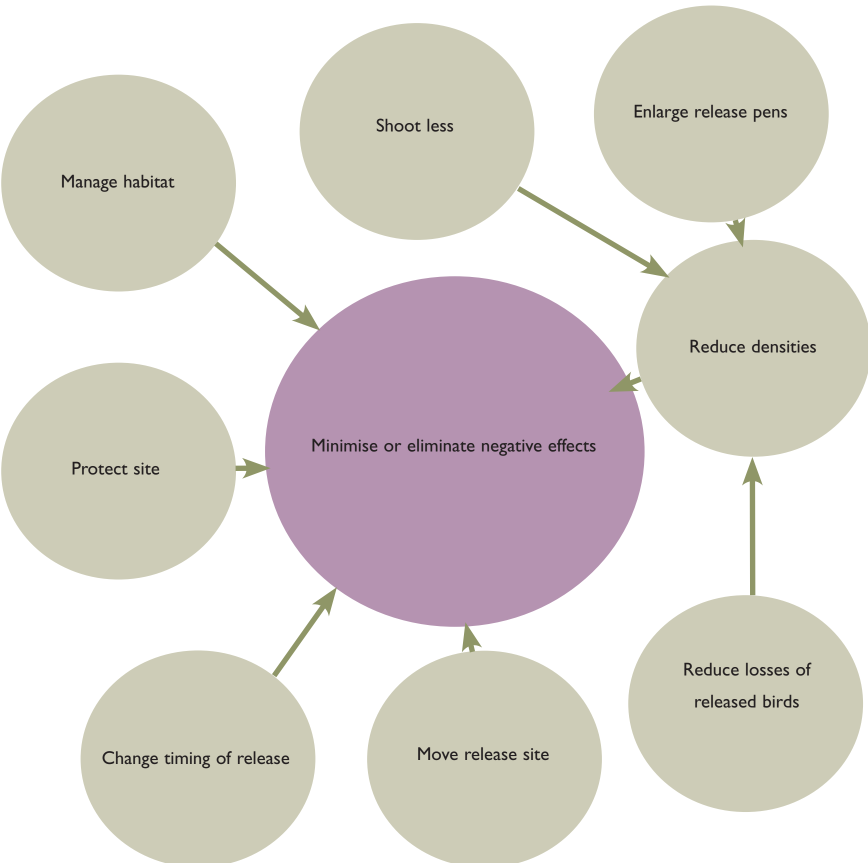


Figure 1

Simple measures that can resolve possible negative effects of releasing

One aim of our research on releasing is to identify possible negative impacts of releasing on habitats and wildlife and another is to provide recommendations about how these impacts can be minimised or eliminated. A simple approach is to reduce densities, or the numbers released, and there are number of ways a shoot can do this.

What insects are available to chicks?

Key findings

- Human-imprinted chicks eat the same insects as wild chicks.
- Insect selection by chicks appears to be instinctive.
- Human-imprinted chicks can further our knowledge on the habitat needs of gamebird broods.

Dave Butler

Insects play a crucial role in the diet of gamebird chicks, and biologists often use insect abundance to measure how important different habitats are for foraging broods. The greater the abundance of insects the better, but not all insects are available, with many being beyond the reach of chicks. For this reason, insect abundance, as measured by standard insect sampling techniques such as sweep-netting and vacuum samplers, does not accurately reflect the foraging value for chicks.

To provide a more biologically relevant assessment of brood habitats, researchers in the United States have begun using hand-reared northern bobwhite quail chicks

Table 1

Prevalence of seven invertebrate groups in diet of wild and human-imprinted northern bobwhite quail chicks, 2003-2004

Order of numerical importance	**2003**		**2004**	
	Wild chicks (8 broods)	*Imprinted chicks (8 broods)*	*Wild chicks (10 broods)*	*Imprinted chicks (10 broods)*
1	Beetles (27%)	Ants (73%)	Ants (34%)	Ants (74%)
2	Plant bugs (22%)	Beetles (9%)	Leaf hoppers (25%)	Leaf hoppers (9%)
3	Ants (19%)	Plant bugs (7%)	Beetles (22%)	Beetles (8%)
4	Leaf hoppers (13%)	Leaf hoppers (4%)	Plant bugs (8%)	Plant bugs (4%)
5	Spiders (12%)	Other (3%)	Grasshoppers (5%)	Grasshoppers (3%)
6	Grasshoppers (5%)	Grasshoppers (2%)	Spiders (5%)	Spiders (1%)
7	Other (2%)	Spiders (2%)	Other (1%)	Other (1%)

Dave Butler demonstrates how human-imprinted chicks will readily follow and return to a handler. (Dave Butler)

Imprinting one-day-old northern bobwhite chicks. (Dave Butler)

foraging in the wild. The chicks are first imprinted onto the researchers, so that the chick forms a bond to a parent figure, in this case a human, shortly after hatching. When the chicks are eight to 12 days old, they are then taken into the field and allowed to forage in small groups with the handler following closely. After half an hour, the chicks are gathered up and penned overnight where their faeces are collected and examined for insects.

Although human-imprinted chicks may offer an appropriate method for assessing the foraging value of brood habitats, the validity of this new technique remained untested. Because imprinted chicks have little foraging experience, a key assumption is that insect selection by gamebird chicks is instinctive. To test this, we collaborated with Tall Timbers Research Station in Florida to compare the insect selection by wild and human-imprinted northern bobwhite chicks.

During 2003 and 2004, we collected faecal samples from the night roosts of 18 radio-collared wild broods. In the afternoon before collecting these samples, imprinted chicks were allowed to forage at locations where the radio-collared wild broods had been found one to two hours previously. We analysed the faecal samples from both chick types to determine the insect composition of their diets. We also collected insect samples using a vacuum sampler to assess overall insect abundance.

The faecal samples of the imprinted chicks contained the same insect groups as those of wild chicks (see Table 1). Beetles, plant bugs and ants accounted for over 80% of both diets, but the proportions varied between the two types of chick. A higher proportion of ants were found in the diet of imprinted chicks.

The results of this study suggest that insect selection by human-imprinted bobwhite quail chicks is similar to wild chicks. Such chicks could therefore provide a more 'chick-relevant' technique for measuring the foraging value of habitats than standard methods. In 2007, we begin a PhD project that will use imprinted pheasant chicks to assess the insect availability in brood-rearing habitats in Austria.

A human-imprinted northern bobwhite chick foraging in woodland in Florida. (Dave Butler)

A successful partnership between Tall Timbers Research Station in Florida and The Game Conservancy Trust. (Dave Butler)

Understanding woodcock distribution

Key findings

- Woodcock are more likely to breed in landscapes that contain a high proportion of woodland and relatively low proportions of housing and improved grass.
- The chance of breeding woodcock being present in a wood is increased by the diversity of woodland stand types, the absolute number of different stands and gamekeeper density. The chance is reduced in woods with a high proportion of young trees.

Andrew Hoodless
Inigo Urrutia
Neville Kingdon
Julie Ewald

Above right: An understanding of woodcock distribution is an important precursor to providing management advice. (Laurie Campbell)

The woodcock remains 'amber-listed' as a bird of conservation concern within Britain owing to a probable decline in breeding numbers during the last 30 years. In previous *Reviews* we have reported on survey methods and numbers of males found in our 2003 breeding survey (see *Reviews of 2003* and *2004*). This highlighted regional differences in woodcock occurrence. However, a clear understanding of what influences woodcock distribution and what constitutes good breeding habitat is important if management is to be implemented to improve the species' status.

Using our survey of roding males at 907 woods, we investigated which landscapes and types of wood influenced the occurrence and abundance of breeding woodcock. The presence of a roding male cannot be taken as proof of a female nesting, but it is a good indicator of habitat suitability. We split the sample into woods where woodcock were breeding and woods where they were absent. We then compared the countryside around the two groups of woods using Geographical Information System (GIS) data based on satellite images. This was repeated at five scales, within radii of one kilometre, five, 10, 20 and 30 kilometres from the survey point. There were significant habitat differences in every case, which were similar at all five scales. Woodcock were present in more heavily wooded landscapes and were less likely to occur in woods

Figure 1

Comparison of mean percentages of habitats within a five-kilometre radius (80 km²) of survey points where roding woodcock were present and where they were absent

Woodcock present

Woodcock absent

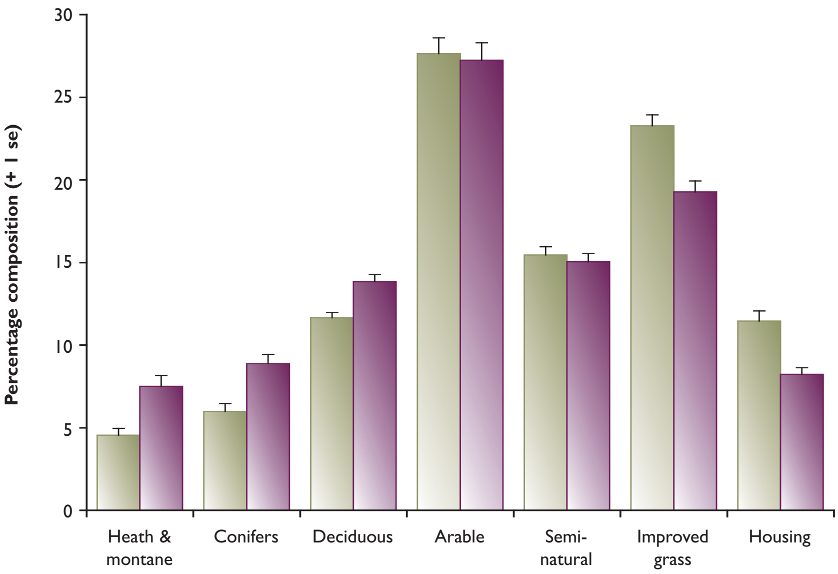


Table 1

Factors influencing the occurrence of roding male woodcock in woods in Britain

Variable	Relationship	Significance
Easting	Positive	*
Northing	Positive	***
Amount of woodland (ha/km²)	Positive	***
Diversity of tree stands	Positive	*
Number of tree stands	Positive	***
Proportion of young trees	Negative	**
Gamekeeper density (number per km²)	Positive	***

*Significance: * $P<0.05$, ** $P<0.01$, *** $P<0.001$.*
A smaller P-value (more asterisks) equates to greater influence.

surrounded by land with a high proportion of housing or improved grassland. The biggest differences between woods with and without woodcock occurred at the five-kilometre radius (80 square kilometres) scale (see Figure 1).

Having established that the amount of woodland in the landscape influenced the likelihood of woodcock being present, we examined this in relation to several additional variables thought likely to be relevant based on the species' ecology (see Table 1). The likelihood of breeding woodcock being present increased further north and east. Relative to woods where woodcock were absent, woods with breeding woodcock had a greater diversity of types of tree stands (deciduous, coniferous, young trees, coppice, shrubs) and a greater number of individual stands, but a lower overall proportion of young trees. The chance of breeding woodcock being present also increased as the number of gamekeepers within five kilometres increased. Roding male abundance was lower in woods with a high proportion of conifers, but higher in woods with more ground vegetation.

This takes us a step closer to understanding how woodland and its management can influence breeding woodcock, but it only explains a small proportion (less than 20%) of the variation in our data. We also need to look at other important variables, such as soil type, which is likely to influence food availability for woodcock.

Acknowledgements

We are grateful to the volunteers who participated in the survey and to the BTO Regional Representatives who organised the survey coverage. Graham Bull provided a copy of the Forestry Commission's *National Inventory of Woodland and Trees*. This work was funded by the Shooting Times Woodcock Club and an anonymous English charitable trust.

Breeding woodcock distribution is influenced by the proportion and type of woodland in the landscape. (Andrew Hoodless)

Biodiversity and wild birds on a reared pheasant shoot

Key findings

- Pheasant productivity increased with conservation management.
- Songbird territories significantly improved.
- Crop yields did not diminish.

Tracy Greenall

The Lees Court Estate Project aimed to discover whether a large commercial pheasant shoot, releasing a substantial number of reared birds, could simultaneously improve wildlife including wild breeding pheasants.

Before the project's start, the in-house farm was typically modern, with arable ploughed to the field edges, fields block-cropped for convenience, and hedgerows cut annually and often sprayed along the base for weed control. Woods were used primarily as sites for release pens.

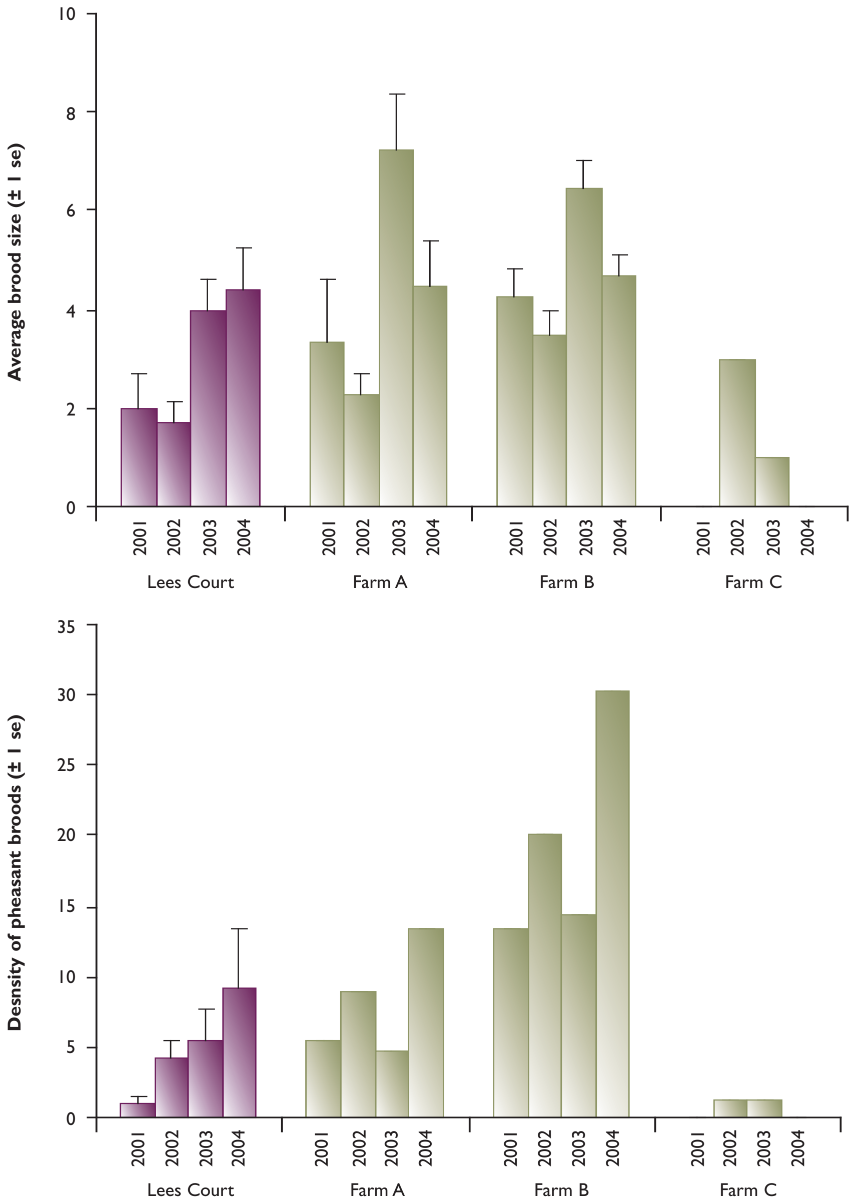
In 1999, Countryside Stewardship was adopted, creating grass strips along arable field margins and providing insect-rich feeding areas for gamebird chicks – potential nesting areas and also buffering hedgerows from spray drift and suppressing weeds.

Gamekeeping focused on wild birds, providing habitat, food and protection from predators. Supplementary food beyond the shooting season was provided to enhance the condition of hens before they nested.

We counted the pheasant population from 2001 to 2004; and songbirds, butterflies, bumblebees and other insects from 2001 to 2003. For comparison, we also studied three neighbouring farms. Farm A is predominantly arable and worked by a tenant, although some land is retained for shoot management, including the field headlands. A combination of naturally-regenerated and sown grass margins, these

Figure 1

Wild pheasant breeding success (brood size, top, and brood density, below) at Lees Court compared with three nearby farms



There are plenty of suitable areas for wild game to breed at Lees Court. (Lees Court Estate)

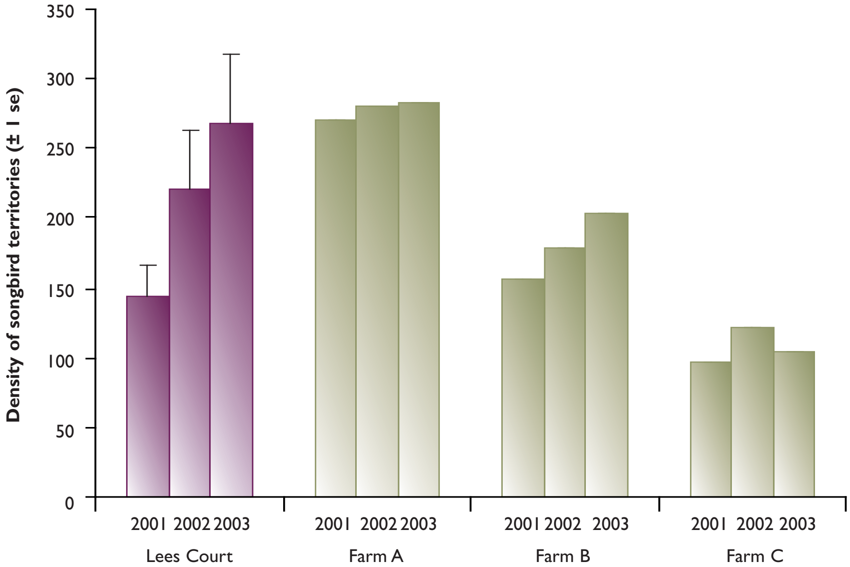


Figure 2

Songbird territories at Lees Court compared with three farms nearby

headlands are either included within an agri-environment scheme or as permanent set-aside. The shoot is small and non-commercial; a small number of gamebirds, predominantly pheasants, are released each year. Along with that necessary for the small-scale rearing programme, the gamekeeping and land management are directed at encouraging wild gamebird productivity.

Farm B is a mixture of arable, grazed parkland and fruit orchards. Historically, a large-scale reared shoot, gamebird releasing ceased in the mid-1990s when gamekeeping and land management altered to maximise wild productivity. Uncropped field margins are sown on a two-year rotation, with mixes such as cereals with phacelia and lucerne. The shoot is non-commercial and predominantly wild pheasants.

Farm C is tenanted arable land with no shoot and no gamekeeping. Like Lees Court before the project, plough extends to field boundaries, any remaining hedgerows are cut regularly and woodland is left unmanaged.

During the project, Lees Court showed improving pheasant productivity (see Figure 1). Farms A and B had significantly more pheasant chicks than Lees Court, but Farm C had almost none.

The number of songbird territories at Lees Court significantly improved under the new management, reaching densities comparable with Farms A and B (see Figure 2).

This study shows that it is possible to increase wild gamebird productivity in the presence of a substantial number of reared birds through careful management integrated with commercial farming. During this project, neither crop yields nor the shoot were negatively affected by the new management. Over time, wild pheasant productivity may continue to rise, although the degree of gamekeeping effort needed for wild gamebirds may limit the increase. Songbirds were positively affected by the new management, supporting the view that wild gamebird management benefits other wildlife and demonstrating that such benefits are not confined to wild shoots.

In 1999 Lees Court Estate entered the Countryside Stewardship Scheme. (Lees Court Estate)

A view of the Lees Court Estate in Kent. (Lees Court Estate)

Effects of pheasant management on hedges

Key findings

- The structure and woody species richness of hedges adjoining woods on game estates were very similar to those on non-game farms.
- Woody cover at the base of hedges was 10% greater in hedges next to pheasant release woods than in those next to non-game woods, suggesting that pheasants do not damage woody shrubs.
- Hedge management was similar at game and non-game sites but hedges on game estates were more frequently buffered from adjacent fields by grass margins or uncultivated strips.

Andrew Hoodless
Roger Draycott

Hedges are an important habitat for birds and insects in our countryside. They are also often the main dispersal routes of pheasants from woodland release pens, and many gamekeepers use them to entice pheasants away from the pen to flushing cover. Our previous research showed that in grassland regions plant structure was reduced in hedges near release pens, and this was related to the scale of the release (see *Review of 2004* pages 36-37). We also found more bare ground near the release pen than further along the hedge. Both effects were subtle, however, and we wanted to investigate management effects on a broader scale on farms with and without pheasant releasing. We supposed that two opposing mechanisms might affect hedge structure on shoots: large game estates in particular might have retained and managed hedges for sporting purposes for many years leading to increased complexity, whereas repeated pheasant releasing might have degraded the bases of these.

We measured hedge structure and species composition in summer along 100-250 metre sections of hedge leading off 150 woods, 60 in East Anglia and 90 on the Hampshire and South Wessex Downs. 51 hedges were on farms with no shoot, 34 adjoined woods on game shoots where pheasants were not released and 65 adjoined pheasant release woods. We first compared all hedges on game shoots with those on farms without shooting and then looked for differences between hedges adjoining releasing and non-release woods on game shoots.

We found few differences in the structure of hedges between game shoots and farms without shooting. The average hedge heights, widths and profiles were all similar. There was no difference in hedge bank widths nor the average number of woody species per 30-metre section (4.5 and 4.6 species on non-game and game sites respectively). However, woody cover at the hedge base was 1.1 times greater in hedges on game shoots and there was more cover in the base of hedges next to releasing woods than non-release woods (see Figure 1). There was a higher proportion of young hedges (less than 25 years old) on game shoots (20%) than on farms without shooting (10%). This suggests more planting by game shoots, but most aspects

Grass margins adjacent to hedges are more common where there is a shoot. (Andrew Hoodless)

Frequency of hedge trimming is similar whether a farm has a shoot or not. (Andrew Hoodless)

of hedge management, such as trimming frequency, were the same as on farms without shooting. Grass margins and uncultivated strips next to hedges were more common on game shoots: 30% of game hedges had a margin of at least two metres on one side of the hedge and 22% had margins on both sides, compared with 24% and 12% respectively of hedges on farms without game shooting.

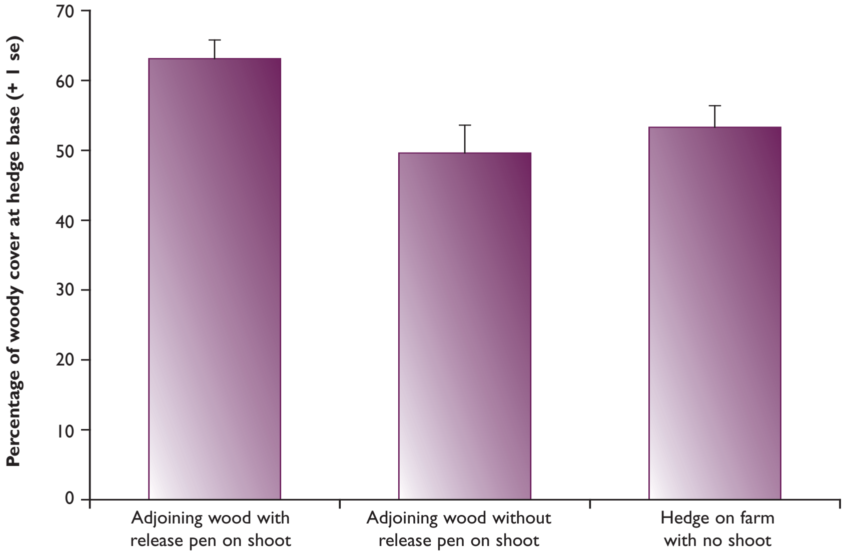


Figure 1

Comparison of the percentage cover of woody shrub stems of hedges adjoining woods on shoots and on farms without shoots

Partridge and biometrics research in 2006

Key achievements

- Participating farms in our Partridge Count Scheme bucked the national trend.
- Partridge recovery project continued to deliver an increased grey partridge population.
- Grey partridge releasing experiment reached advisory stage.
- Long-term data collection for Sussex and National Gamebag Census continued.

Nicholas Aebischer

2006 has been another successful year with regard to our Partridge Count Scheme (see page 72). The participating farms are achieving increases in grey partridges, bucking the national trend that is measured by the BTO/JNCC/RSPB 2005 Breeding Bird Survey. It is a clear demonstration that those with a vested interest in conserving the species are the most successful at doing so.

On our grey partridge recovery project at Royston (see page 74) we are edging closer to the number of pairs that we predicted the area could support given the right habitat, food and protection from predators that a gamekeeper, such as Malcolm Brockless, can provide. Although the rate of increase lessened in 2006, grey partridges continue to thrive on the area and we hope to achieve the predicted levels by 2008. On the adjacent reference area, numbers remain relatively low.

Sadly, in the autumn of 2006, we said farewell to Stephen Browne, who has moved to Fauna and Flora International. The latest results from the grey partridge reintroduction experiment that he and Francis Buner worked on allow us to provide advice to those wanting to restore wild greys to areas where they have gone extinct. Releasing to re-establish a breeding population is much harder than releasing for shooting and we advise against doing this unless all the habitat needs are in place first (see page 76). Elina Rantanen is investigating the fate of released grey partridges in Oxfordshire, as a PhD study. In Scotland, David Parish has also been working with grey partridges, but these projects are mid-way through and we will report on them in future years.

Two PhD projects drew close to finishing in 2006. The first, by Sarah Callegari on the potential damage of large-scale partridge releasing adjacent to chalk downland, reached its 'writing-up' stage and was reported to our members in the *Review of 2005*.

2006 was our 37th year of monitoring on our Sussex study area. The long-term data that it provides is used in a number of projects. For instance, on page

A pair of partridges released as part of our partridge releasing experiment, which we have completed. We now publish guidelines on page 76. (Francis Buner)

40, Julie Ewald compares how insects have been affected by pesticides use in Sussex and at Loddington.

The National Gamebag Census is another long-running project. Analysis of its bag data shows some fascinating trends in mammals and birds. In this Review, we report on waterfowl (see page 78) and brown hare (see page 82).

Partridge and biometrics research in 2006

Project title	Description	Staff	Funding source	Date
Grey partridge recovery project (see page 74)	*Restoration of grey partridge numbers: a demonstration project*	*Malcolm Brockless, Tom Birkett, Stephen Browne, Roger Draycott, Julie Ewald, Nicholas Aebischer, Kate Driver*	*GC-USA, Research Funding Appeal, Core funds*	*2001-2008*
Partridge Count Scheme (see page 72)	*Nationwide monitoring of grey and red-legged partridge abundance and breeding success*	*Neville Kingdon, Nicholas Aebischer, Julie Ewald, Nina Graham, Dave Parish*	*Core funds*	*1933 - on-going*
Partridge releasing experiment (see page 76)	*Determining best release methods as a tool for restoring grey partridges in the UK*	*Nicholas Aebischer, Francis Buner, Stephen Browne, Des Purdy*	*Westminster Overseas Fellowship, GC-USA, Payne-Gallwey Charitable Trust*	*2004-2007*
National Gamebag Census (see page 78)	*Monitoring game numbers with annual bag records*	*Nicholas Aebischer, Gillian Gooderham, Peter Davey, Julie Ewald, Nina Graham*	*Core funds*	*1961 - on-going*
Trends in mammal bags (see page 82)	*Analysing mammalian cull data from the National Gamebag Census under the Tracking Mammals Partnership*	*Nicholas Aebischer, Jonathan Reynolds, Gillian Gooderham*	*JNCC*	*2003-2010*
Trends in bird bags	*Developing a tool for improving hunting bag data of huntable and 'pest' bird species*	*Nicholas Aebischer, Peter Davey (with BASC)*	*Defra, SEERAD*	*2006-2007*
Sussex study	*Long-term monitoring of partridges, weeds, invertebrates, pesticides and land use on 62 square kilometres of the South Downs*	*Julie Ewald, Nicholas Aebischer, Steve Moreby, Dick Potts (consultant)*	*Core funds*	*1968 - on-going*
Impact of pesticides (see page 40)	*Developing an indicator of the impact of pesticides on farmland wildlife*	*Nicholas Aebischer, Julie Ewald, Nina Graham*	*PSD, Environment Agency, English Nature*	*2005-2006*
Monitoring East Lothian Local BAP	*Monitoring effects of LBAP measures on bird populations in East Lothian*	*David Parish, Hugo Straker*	*Various charitable trusts*	*2001 - on-going*
Unharvested crops and songbird populations	*Large-scale field experiment investigating the impact of winter feeding on songbird populations*	*David Parish*	*SEERAD*	*2004-2008*
Monitoring SEERAD's agri-environment schemes	*Camparing biodiversity on in- and out-scheme farms across Scotland*	*David Parish Non-GCT collaborators*	*SEERAD*	*2004-2008*
Management of grasslands for game and wildlife	*Studies of granivorous birds in intensive agricultural grasslands of SW Scotland*	*Dave Parish (with SAC and Glasgow University)*	*SNH, Core funds*	*2006-2009*
The genetics of the grey partridge	*Comparison of partridge genetics for populations from different regions of England*	*Dave Parish (with LandCatch Natural Selection)*	*LandCatch Natural Selection*	*2005-2006*
PhD: Released partridges on NNR chalk grassland	*Comparing flora and fauna on high density partridge release sites on chalk downland NNR with similar chalk downs*	*Sarah Callegari (Supervisors: Rufus Sage; Graham Holloway/Reading Univ)*	*English Nature Research Funding Appeal*	*2002-2006*
PhD: Oxfordshire partridges	*Quantifying the fate of released grey partridges in Oxfordshire*	*Elina Rantanen (Supervisors: Francis Buner; Prof D McDonald/Oxford Univ)*	*Private individual, Core funds, various charitable trusts*	*2006-2008*
PhD: Bobwhite quail (see page 62)	*Investigating the ecology of bobwhite quail chicks*	*David Butler (Supervisors: Rufus Sage; John Carroll/Georgia Univ Simon Dowell/John Moore Univ, Liverpool)*	*Tall Timbers Research Station*	*2005-2007*

Key to abbreviations:
BASC = British Association for Shooting & Conservation; Defra = Department for Evironment, Farming and Rural Affairs; JNCC = Joint Nature Conservation Committee; PSD = Pesticides Safety Directorate; SEERAD = Scottish Executive Environment and Rural Affairs Department; SNH = Scottish Natural Heritage.

Partridge count scheme

Key findings

- Grey partridge numbers in areas counted in our Partridge Count Scheme are, in general, rising.
- BTO survey of random sites across the UK shows the species as still declining.
- Those with an interest in grey partridges are demonstrating that they can reverse the declines of this gamebird.

Julie Ewald
Neville Kingdon

A late spring and a harvest that began early but then was interrupted with wet weather resulted in delays in partridge counting in both spring and autumn. Results from spring and autumn counts of grey partridges by members of the Partridge Count Scheme (PCS) in 2006 are summarised in Table 1. Spring densities were slightly up, but with sites in Scotland slightly down, compared with 2005. The autumn densities over the whole of the country were also up on last year. The higher young-to-old ratio in Scotland meant that PCS farms in this region ended the year with a similar density to 2005. In the south there were lower autumn densities than in 2005.

The first Biodiversity Action Plan target for the grey partridge was to halt the national decline by 2005. The BTO/JNCC/RSPB Breeding Bird Survey (2005), however, indicates that, nationally, the grey partridge population is still declining – down by 14% from 2004 to 2005 and by 40% from 1994 to 2005.

This is opposite to what has been happening on areas registered with the PCS where, instead of declining, grey partridge numbers have increased. PCS members have recorded an 8% increase in pairs between 2005 and 2006, and nearly a 50% increase since 2000. Sites in the PCS counted 9,837 grey partridge pairs in the spring of 2006 (around 15% of the 65,000 spring pairs that is the current estimated UK population of grey partridges).

The BTO survey samples randomly selected areas across the UK, whereas the PCS results are from those farms and estates that are actively seeking to increase numbers of grey partridges. It is encouraging to see those trying to make a difference succeeding. Since November 2006, the Government has revised the BAP targets for a range of species including the grey partridge. For the latter, the new target is 90,000 pairs by 2010. To achieve this, we think it is important that everyone with an interest in this gamebird gets involved in the Partridge Count Scheme. We will provide guidance

Our count scheme shows that areas managed by those with an interest in conserving grey partridges are making a difference. (Malcolm Brockless)

Peter Thompson addressing a local grey partridge group during a farm walk in Dorset. (Sophia Gallia/Natterjack Publications)

and there are local partridge group meetings to support local conservation efforts. Join via our website (www.gct.org.uk/partridge) or contact Neville Kingdon by email (nkingdon@gct.org.uk) or telephone (01425 651066).

Table 1

Grey partridge counts

a. Densities of grey partridges pairs in spring 2005-2006, from contributors to our partridge count scheme

	Number of sites		***Spring pair density (pairs per km² (100ha))***		
Region	*2005*	**2006**	*2005*	**2006**	**Comparison**
South	*164*	188	2.2	2.5	increase
Eastern	*258*	269	5.5	6.7	increase
Midlands	*183*	166	3.5	3.6	increase
Wales	2	2	0.7	0.0	decrease
Northern	*182*	191	*4.7*	4.8	increase
Scotland	*189*	163	*3.9*	3.5	decrease
Overall	978	**979**	*4.1*	**4.5**	**increase**

b. Densities and young-to-old ratios for grey partridges in autumn 2005-2006, from contributors to our partridge count scheme

	Number of sites		***Young-to-old ratio***		***Autumn density (birds per km² (100ha))***		
Region	*2005*	**2006**	*2005*	**2006**	*2005*	**2006**	**Comparison**
South	*163*	151	*1.7*	1.8	9.9	7.2	decrease
Eastern	*229*	228	*2.3*	2.3	*28.0*	33.8	increase
Midlands	*162*	154	2.0	2.1	*14.7*	15.9	increase
Wales	2	2	-	-	*0.0*	0.0	no change
Northern	*172*	181	*3.1*	2.7	23.9	29.6	increase
Scotland	*149*	150	2.5	3.0	20.2	20.2	no change
Overall	877	**866**	2.4	**2.4**	*19.9*	**22.7**	**increase**

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

Grey partridge recovery project in 2006

Key findings

- The number of spring pairs on the demonstration area in 2006 was 4.5 times higher than at the 2002 start.
- Autumn numbers in 2006 have increased 11-fold on the demonstration area.
- Equivalent figures for the increases on the reference area were 2.2 and 3.2 times respectively.

Nicholas Aebischer
Malcolm Brockless
Nina Graham

Our grey partridge recovery project at Royston has completed its fourth full year, with encouraging results. It seeks to demonstrate how to restore numbers of wild grey partridges, as part of our role as lead partner for the grey partridge under the UK Government's Biodiversity Action Plan. The demonstration area is south-west of Royston, Cambridgeshire, on 1,000 hectares of arable land on chalk, surrounded by a reference area of similar size. Based on landscape type and partridge-specific management, we expect to achieve a spring density of 18.6 grey partridge pairs per 100 hectares (250 acres) from the predictions in our book, *A Question of Balance*.

Our management includes habitat creation, predation control and supplementary feeding. Since the project began in 2002, habitat improvement has continued on the demonstration area. Through the use of set-aside, Countryside Stewardship, Entry Level and Higher Level Schemes, partridge nesting cover now amounts to 18% of land area, and insect-rich brood-rearing habitat (in the form mainly of wildlife mixtures and game-cover crops) covers 10% of land area. Predation control is targeted at foxes, mustelids, rats and corvids. We provide supplementary wheat in hoppers from autumn to late spring, with at least two hoppers per grey partridge pair.

We count the partridges in March (spring pair counts) and just after harvest (autumn counts). We record the sex of all grey partridge adults, and in the autumn counts, the number of young birds present in each covey. Following a cold dry start to 2006, which delayed our spring count, we found 13 pairs of grey partridges per 100 hectares on the demonstration area, up 16% on the previous year and 4.5 times as many as at the beginning of the project (see Table 1). On the reference area, density was only 2.8 pairs per 100 hectares, still below what we expect for unmanaged land.

June was warm and dry, ideal for partridge chicks, which were first seen on 9 June. July was the same, but hotter (at 34°C, 19 July was the hottest day since 1911) and with a massive thunderstorm (75mm of rain in five hours). Unbelievably, most of the game came through it, and although a rainy end to the summer delayed the harvest, autumn counts on the demonstration area revealed good productivity (young-to-old

Figure 1

Distribution of grey partridge coveys at Royston in autumn 2006, showing barren pairs, single males and brood sizes

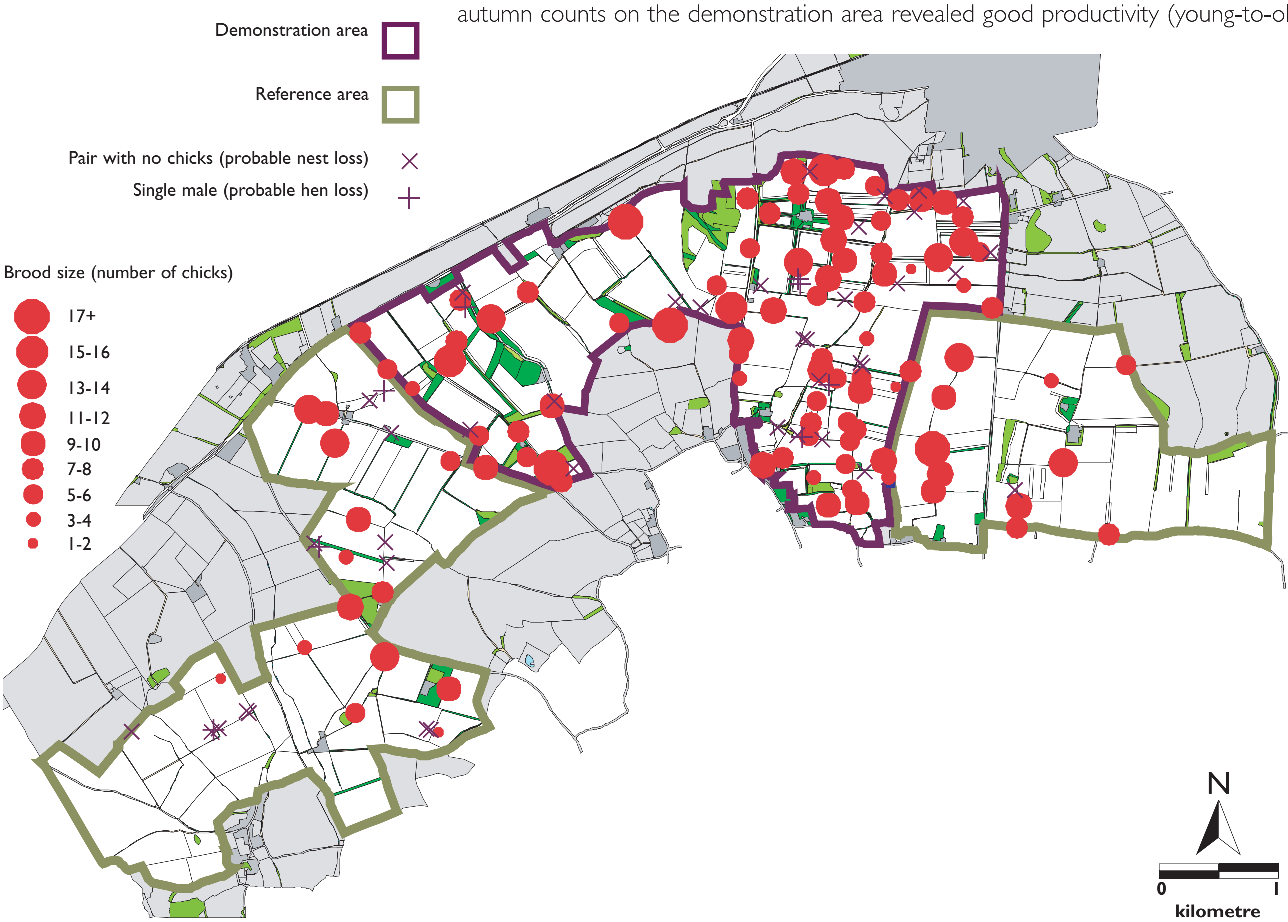


Table 1

Grey partridge counts on the recovery project at Royston, 2001-2006

a. Spring pairs per 100 hectares

Area	2002	2003	2004	2005	2006	Expected
Demonstration	2.9	**5.1**	**8.0**	**11.2**	**13.0**	**18.6**
Reference	1.3	2.1	1.4	2.1	2.8	3.7

b. Autumn birds per 100 hectares

Area	2001	2002	2003	2004	2005	2006
Demonstration	7.6	**28.8**	**39.2**	**53.4**	**60.8**	**87.8**
Reference	8.1	6.4	18.3	11.8	18.6	25.9

Bold *denotes years/area managed for grey partridges.*

ratio of 2.6) and excellent bird densities (87.8 birds per 100 hectares). This represented an increase of 44% compared with autumn 2005, equivalent to 11 times more than when we started (see Table 1). On the reference area, reproductive success was similar (young-to-old ratio of 2.7), as was the increase in density relative to the previous year, but at 25.9 birds per 100 hectares, autumn density on the reference area remained far below that on the demonstration area.

The target of 18.6 pairs of partridges per 100 hectares now looks less daunting. Although unlikely to be reached in 2007, it should be achievable in 2008 if the increase in spring pair density continues. Thank you to all the farmers on the two areas for allowing us access to conduct this work.

We provide at least two hopper feeders filled with wheat from autumn to late spring per grey partridge pair. (Malcolm Brockless)

Grey partridge releasing guidelines best practice

Key findings

- The majority of released birds settled within 1.5 kilometres.
- Artificially-reared spring pairs had the lowest breeding success of all four groups compared and should therefore not be released.
- Breeding success of fostered birds was highest, but only where habitat requirements were met during all seasons.

Francis Buner

A female grey partridge radio-tagged for our intensive study. (Francis Buner)

2006 was the second and final season of our project aiming to find the best methods of re-establishing grey partridges through releasing in areas where they have disappeared, and where a suitable environment has been restored. We have been working on 26 sites split between East Anglia and southern England where we followed the fates and breeding success of radio-tagged (intensive sites) and colour-ringed birds (extensive sites) of individuals released using four different techniques (bantam-reared fostered, artificially-reared fostered, coveys released in autumn, and pairs released in spring). For more details about methods used and first year results see *Reviews of 2004* and *2005*. Here we present preliminary results for the two research years combined.

In March, the re-sighting rate from the spring counts for fostered birds released in the previous August across intensive and extensive sites averaged 18.9% in East Anglia and 16.7% in southern England. That of birds released as full-grown family coveys in November averaged 18.9% in East Anglia and 19.5% in southern England (see Table 1), indicating no significant differences in over-winter survival between the two regions. No data were available for the spring pairs as they were released after these counts (in April). As in other studies, the majority of losses were due to predation.

In the following autumn counts in September, the average summer survival rate (survival from birds encountered in spring and re-sighted in autumn) of fostered birds was 51.0% in East Anglia and 25.4% in southern England. The releases of full-grown birds yielded survival rates of 28.9% for autumn coveys and 13.6% for spring pairs in East Anglia and 33.8% and 7.8% respectively in southern England, indicating that spring pairs survived less well during summer than the other three groups (see Table 1).

In terms of fidelity to the release site of our radio-tagged birds in southern England, the distance moved from the release site to the spring location did not vary between fostered and autumn released birds and averaged 1.35 kilometres. The number of birds found in spring within a radius of 1.5 kilometres was between 65% and 75%, depending on the release technique used. The distance moved from the release site to the nesting site was 1.8 kilometres (se = ±0.5) for bantam fostered birds, 1.0 kilometres (se = ±0.1) for artificially fostered birds, 1.4 kilometres (se = ±0.2) for autumn released birds and only 0.5 kilometres (se = ±0.1) for spring pairs. Where conditions on the release site were favourable (ie. over-winter foraging and escape cover right into spring, predator control and low disturbance pressure), site fidelity of our released birds was therefore satisfying.

Overall, summer survival and breeding success of released birds was low. In southern England, depending on the release strategy used, we sighted no more than 6% of released hens during the autumn counts. However, of all the hens counted in autumn, an average of 32.5% of fostered hens managed to raise chicks. We never recorded spring pairs producing chicks (see Table 2). In East Anglia, breeding success

Table 1

Re-sighting rate (%) of released grey partridges at all sites in East Anglia and southern England, based on the number of marked birds seen during the spring and autumn counts in 2005 and 2006 combined

Releasing method	Date of release	East Anglia: *No of sites*	East Anglia: *Mean re-sighting rate (± 1 se)* *March*	East Anglia: *Mean re-sighting rate (± 1 se)* *September*	Southern England: *No of sites*	Southern England: *Mean re-sighting rate (± 1 se)* *March*	Southern England: *Mean re-sighting rate (± 1 se)* *September*
Bantam-reared	August	8	18.4 (4.2)	48.5 (13.7)	7	15.9 (5.1)	26.0 (10.2)
Artificially-reared	August	8	19.4 (3.6)	53.6 (12.1)	6	17.5 (4.3)	24.8 (8.3)
Non-fostered chicks	August	0	n/a	n/a	3	14.1 (7.9)	10.3 (10.3)
Autumn release	November	8	18.9 (7.2)	18.9 (11.4)	8	19.5 (3.0)	33.8 (6.5)
Spring pairs	April	8	n/a	13.6 (3.7)	8	n/a	7.8 (1.8)

Figures in March are rates since release, figures in September are summer survival rates (ie. rates from March to September).

Table 2

Breeding success of released grey partridges at all sites in East Anglia and southern England, based on the number of marked hens seen during the autumn counts in 2005 and 2006 combined

Releasing method	East Anglia*			Southern England		
	Females released	*Females seen*	*Females with broods*	*Females released*	*Females seen*	*Females with broods*
Bantam-reared	104	23.1%	42%	217	3.2%	43%
Artificially-reared	140	9.3%	54%	217	4.1%	22%
Non-fostered chicks	none	n/a	n/a	214	0.0%	0%
Autumn release	155	7.1%	9%	282	5.7%	25%
Spring pairs	100	12.2%	30%	200	6.0%	0%

** Data for 2005 only.*

was in general higher than at the southern sites, most likely owing to more intensive predator control. This might also explain why at least seven spring pairs managed to produce chicks. As in southern England, fostered hens achieved the highest breeding success (48%, see Table 2).

In summary, the following release strategies are feasible. Where at least three pairs per 100 hectares are still present, we recommend habitat management according to our Royston demonstration project over releases. Where fewer or no grey partridges are encountered, we recommend releasing autumn coveys, followed by intensive monitoring in the following spring. Where at least 16% of the birds released can still be found within a radius of 1.5 kilometres to the release site, we recommend intensifying predator control into the breeding season, followed by fostering chicks to barren pairs.

Pierre Damiens releasing a pair of grey partridges in the spring. (Francis Buner)

National Gamebag Census: water birds

Key findings

- UK bags have doubled over time for mallard, teal, wigeon and Canada goose, been stable for greylag and halved for moorhen.
- With the possible exception of moorhen, UK bags track known population changes in these species.

Nicholas Aebischer
Peter Davey

Through the National Gamebag Census (NGC), we monitor the bag sizes not only of the resident gamebird species that we have reported on in previous years, but also of a range of waterbirds, several of which were added onto the Census form in 1983 in the wake of the Wildlife & Countryside Act (1981). These records provide an index of population change that can be compared to standard surveys of abundance conducted by the Wildfowl and Wetlands Trust (WWT), the British Trust for Ornithology (BTO) and the Royal Society for the Protection of Birds (RSPB). Selecting waterbird species with records from at least 30 sites on average each year, we review below the UK trends for mallard, teal and wigeon, all monitored since the NGC began in 1961, and for three new additions to the form, greylag goose, Canada goose and moorhen, that have not previously been analysed. The results presented here were funded by Defra and SEERAD.

All six of these species are legal quarry during the open season (1 September – 31 January, extended to 20 February for wildfowl on the foreshore). Bag records are collected by mailing questionnaires to some 600 NGC contributors at the end of each season. Participation in the NGC is voluntary, and we are grateful to all the owners and keepers who send in their returns each year. For each species, analysis is based on sites that have returned bag records for two or more years. The analysis summarises the average pattern of year-to-year change within sites as an index of change relative to the start year, which receives a value of one.

Mallard (Figure 1)

The mallard is the most common of our resident ducks. It is also reared and released for shooting on just under a quarter of sites where it is shot. The bag index thus reflects changes in numbers released as well as changes in the wild population. Since 1961, numbers released have risen four-fold, while the bag itself has doubled. At the same time, we know from WWT/BTO/RSPB surveys that the mallard has increased steadily as a breeding bird in the UK. A slight decline in bags since the peak in 1999 matches a similar trend in numbers released, and corresponds also to a levelling off in the BTO's Waterways Bird Survey.

Teal (Figure 2)

The teal that are shot in the UK are predominantly winter visitors, originating mainly from Iceland, Fennoscandia and western Russia. The bags show a steady but gentle

Of the data we collect for water birds in our National Gamebag Census, we have most information for mallard. (Laurie Campbell)

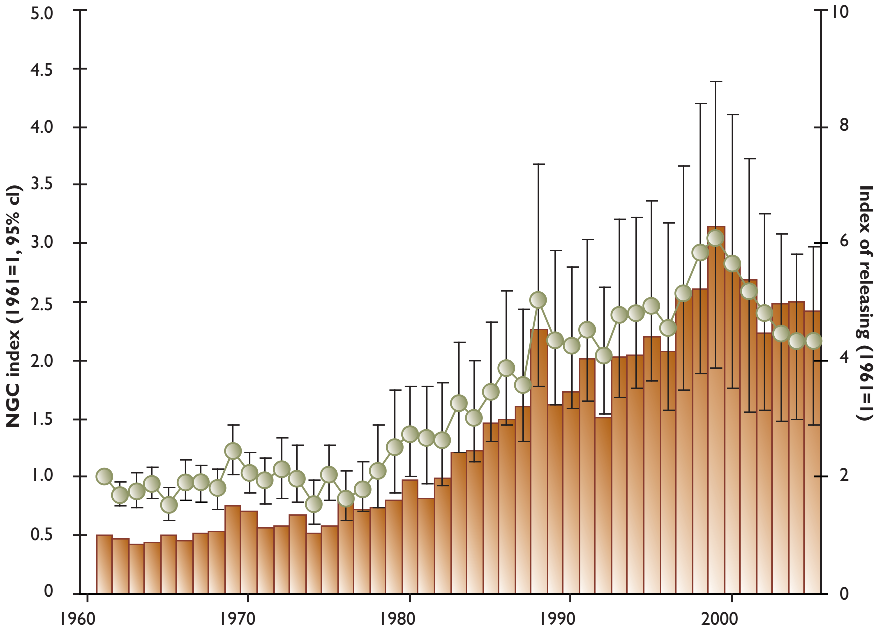


Figure 1

Change in numbers of mallard shot per 100 hectares in the UK and numbers released per 100 hectares from 1961 to 2005

Numbers released

Numbers shot

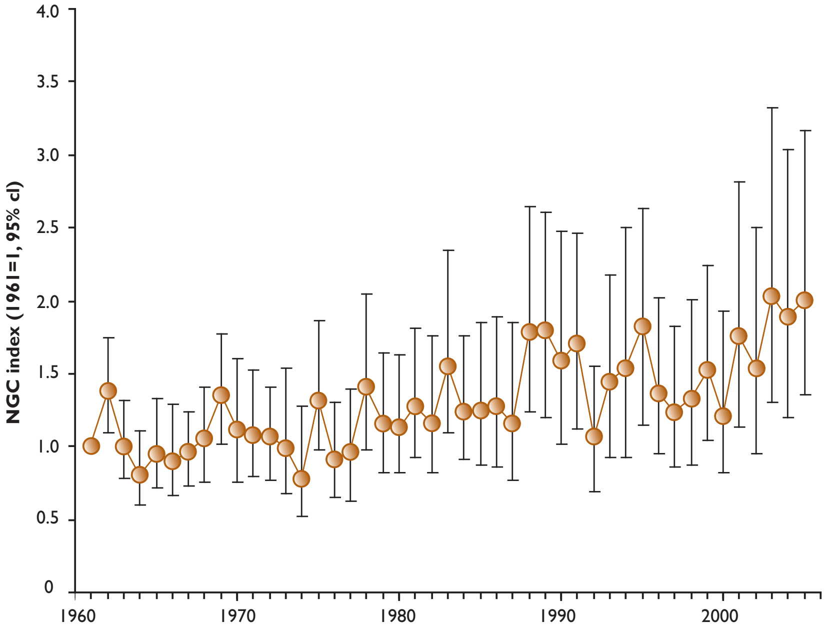


Figure 2

Change in numbers of teal shot per 100 hectares in the UK from 1961 to 2005

The number of teal shot has risen steadily since 1961. (Laurie Campbell)

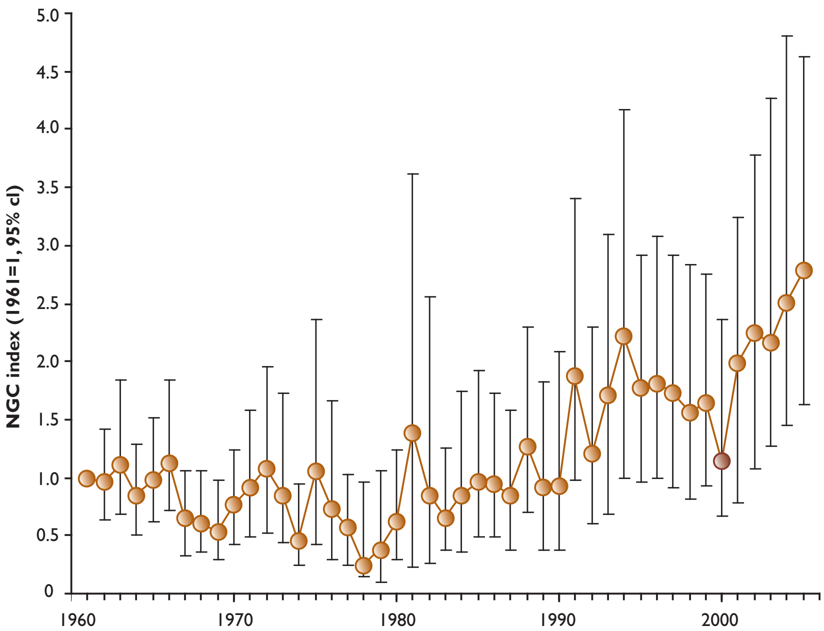


Figure 3

Change in numbers of wigeon shot per 100 hectares in the UK from 1961 to 2005

Numbers of wigeon shot showed a drop through the 1960s and 1970s before increasing. (Laurie Campbell)

The number of greylag geese shot in the UK has remained steady since 1983. (Laurie Campbell)

increase of around 80% over the last 45 years. The increase is similar to that observed from WWT/BTO/RSPB surveys. It has been attributed to an increase in the number of birds occurring on migration, as well as to more habitat as gravel extraction creates more inland water.

Wigeon (Figure 3)

Wigeon are also mostly winter visitors to the UK, breeding in Iceland, northern Europe and eastern Russia. They are largely a coastal species, but have become increasingly widespread on inland flooded grasslands. This may explain why, although the bags seem to decline slightly during the 1960s and 1970s, they increased thereafter so that overall, bags have approximately doubled. This pattern follows the WWT/BTO/RSPB surveys.

Greylag goose (Figure 4)

Apart from geese in north-west Scotland and winter visitors from Iceland, also mostly in Scotland, greylags in the UK are largely the result of re-introductions in the 1960s and 1970s. NGC sites contributing bag records of this species are split roughly 50:50 between Scotland and England. Records begin in 1983, and since then there has been no detectable change in numbers shot. This is probably because of two opposing trends documented by the WWT/BBS/RSPB surveys, one of decline in the Scottish wintering birds, and one of increase in the English population.

Bags of moorhens have halved, possibly because of a decline in shooting effort. (Laurie Campbell)

Canada goose (Figure 5)

The Canada goose is a North American species that was popular in UK waterfowl collections (first recorded in 1665), then became naturalised through escapes after the Second World War. Numbers have increased rapidly, and it is now widespread across most of Britain. It is not as popular a quarry here as in North America, probably because of its relative tameness, and birds are more likely to be shot as an agricultural nuisance. Nevertheless, the increase in bags, which have nearly doubled since 1983, is comparable to the growth in population over the same period.

Moorhen (Figure 6)

The moorhens shot in the UK are mainly resident birds, supplemented by winter visitors from Iceland and north-west Europe. Since 1983, bags of this species have fallen by half, in contrast to all the other species reviewed here. Although this may reflect a loss of interest on the part of shooters, the WWT/BTO/RSPB surveys imply that there was a decline in breeding population at least during the 1980s. Possible explanations are the disappearance of farmland ponds and the spread along watercourses of the introduced and predatory American mink.

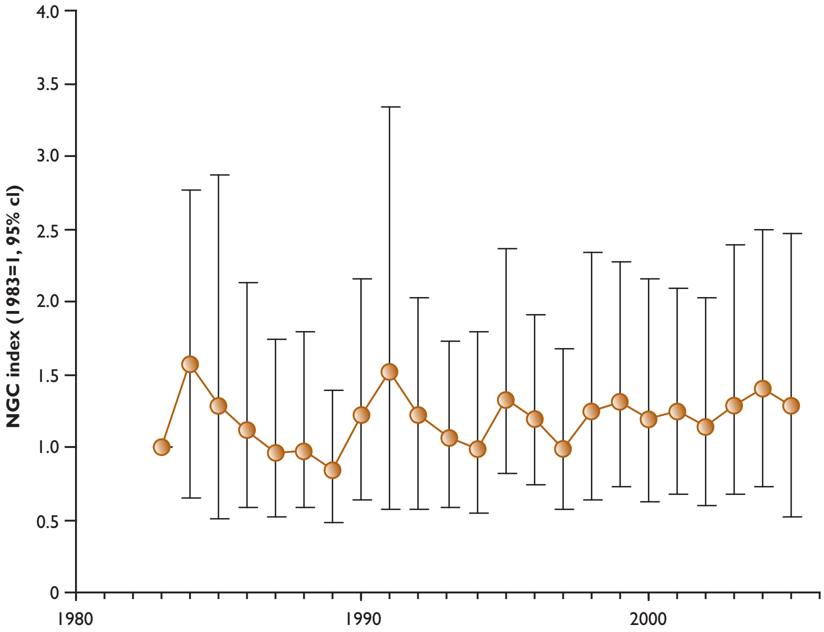


Figure 4

Change in numbers of greylag geese shot per 100 hectares in the UK from 1983 to 2005

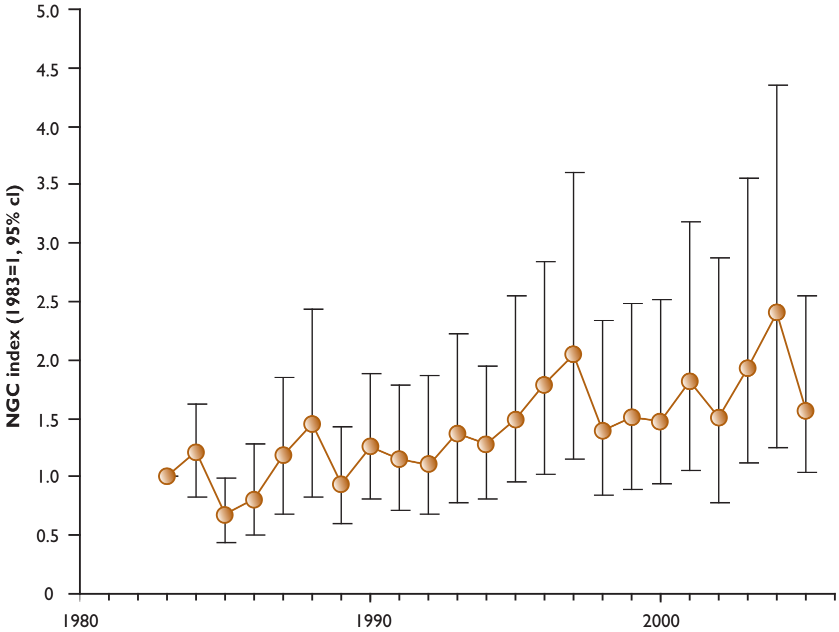
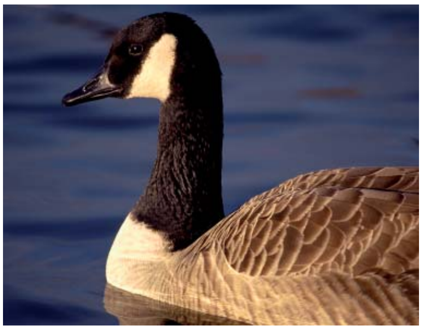


Figure 5

Change in numbers of Canada geese shot per 100 hectares in the UK from 1983 to 2005



The Canada goose is a familiar sight in the UK. Numbers shot reflect the increase in population size. (Laurie Campbell)

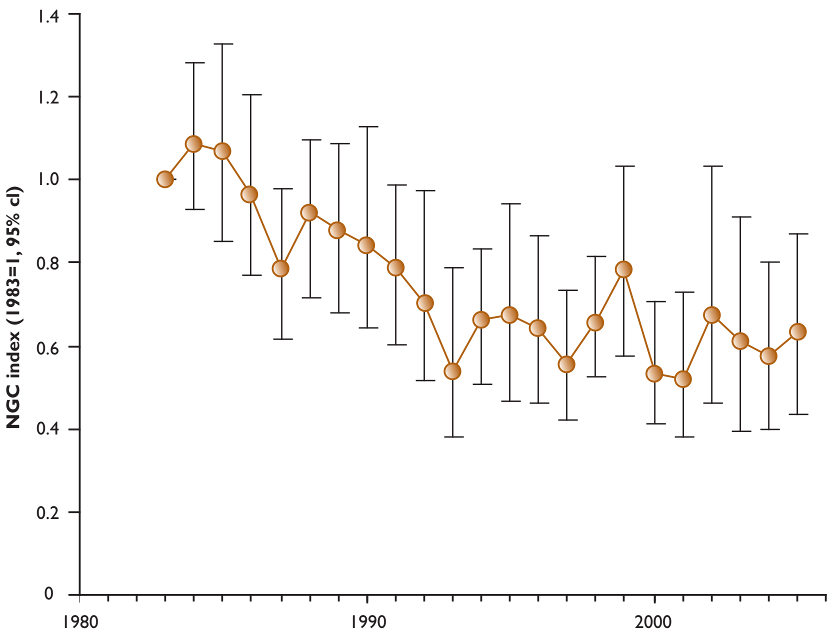


Figure 6

Change in numbers of moorhens shot per 100 hectares in the UK from 1983 to 2005

National Gamebag Census

We always seek new participants to the National Gamebag Census. If you manage a shoot and do not already contribute records to our scheme, please contact the National Gamebag Census Co-ordinator in Fordingbridge on 01425 651019.

National Gamebag Census: brown hare numbers

Key finding

- After 30 years of decline, brown hare numbers are showing promising signs of recovery.

Stephen Tapper
Peter Davey
Nicholas Aebischer

Of our mammal fauna, the brown hare is perhaps the most suited to cultivated land. It rarely frequents woodland or hedgerow, but opts for open arable and pasture. It was rather surprising therefore that during the farming boom times of the 1970s hare numbers showed clear evidence of a decline.

There are few schemes that have monitored the abundance of mammals over long periods and, for the hare, the best data come from the game books of shooting estates. Although such books obviously record the numbers of hares that have been killed, not the number alive, they are quantitative records and, in some cases, they can go back for over a century. When combined, such game books can give a long-term track of the hare bag (see Figure 1). This track indicates that:

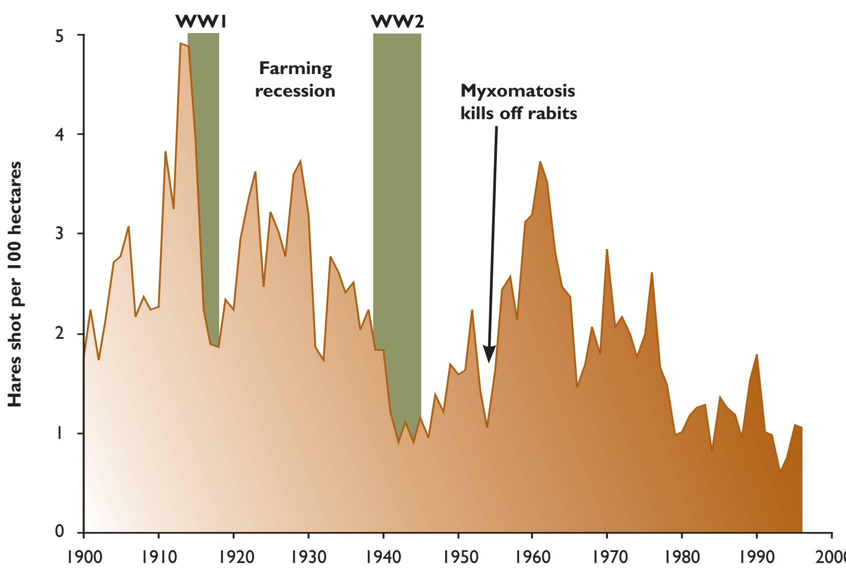
1. In Edwardian times hares were about twice as common as they were in the early 1990s.
2. Hare numbers slumped between the world wars during a period of farming recession when cereal cultivation dropped from three million hectares to under two million.
3. There was little or no formal shooting of any game during the wars probably because most gamekeeping was given up.
4. With the re-establishment of gamekeeping hare bags recovered.
5. Hare numbers peaked in 1961, because of the absence of rabbits following the Myxomatosis epidemic.
6. There was a 30-year decline in bags at least until the mid-1990s. This was caused mainly by the abandonment of traditional mixed farming in favour of modern methods.

This hare decline was also found in Denmark, France, Germany, Sweden, Switzerland and Hungary and, later, in the Poland. It paralleled a loss of farmland birds including the grey partridge. In 1995, following The Convention on Biological Diversity (1992), Britain set up a broad-based Biodiversity Action Plan to recover the status of a range of wildlife. The brown hare was chosen as one of these species and the Action Plan aimed to double the then population by 2010 and maintain its geographic range. The main actions called for improving uptake of agri-environment schemes, reform of the Common Agricultural Policy (CAP), and better use of set-aside. The Game Conservancy Trust and the Mammal Society became joint lead partners for the plan.

In the decade since then there has been significant progress in conserving farmland wildlife. In particular there have been radical changes to the CAP. First, the arable area was reduced by making set-aside mandatory. Later, support shifted from production to a crop-area based payment, and finally to land-area support with a sizeable proportion siphoned off for environmental schemes.

Figure 1

Bag records of hares from an average of 12 English lowland estates from 1900 to 1996



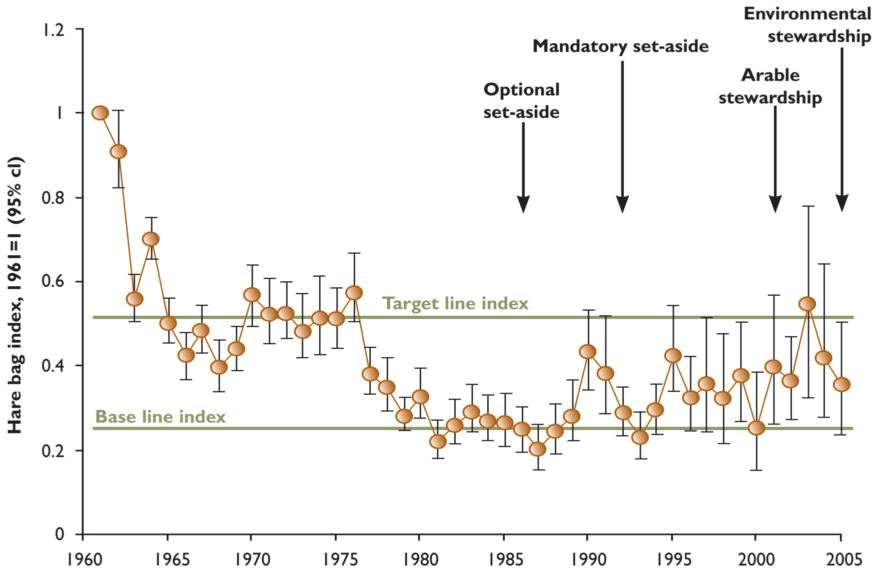


Figure 2

National Gamebag Census trend for brown hare 1961-2005

The graph shows base line and target levels for the Biodiversity Species Action Plan, as well as significant Common Agricultural Policy measures that may have helped to reverse the trend since the mid-1980s

Superimposing these events onto the recent changes in the hare bag it looks as though they may be helping to restore hare populations. Indeed if the use of bag records is a direct indicator of hare numbers then Figure 2 suggests that we may be about halfway to achieving the biodiversity target of doubling numbers by 2010.

This may appear wishful thinking, but there is supporting evidence. The National Gamebag Census is now part of a collaboration with other organisations under the Joint Nature Conservation Committee's Tracking Mammals Partnership (see www.trackingmammals.org). Within this partnership two other schemes have recorded increases in hare numbers in England in recent years – these are the British Trust for Ornithology's Breeding Bird Survey and its Waterways Breeding Bird Survey. Further, as we reported in our *Review of 2003*, the East Midland farms that adopted measures under the trial Arable Stewardship Pilot Scheme, set up in 1998, showed improved hare numbers by an average of 35% compared with farms that did not join the scheme.

National Gamebag Census

We always seek new participants to the National Gamebag Census. If you manage a shoot and do not already contribute records to our scheme, please contact the National Gamebag Census Co-ordinator in Fordingbridge on 01425 651019.

Brown hares may no longer be declining in Britain. Stewardship schemes for farmland appear to be helping. (Laurie Campbell)

Wildlife disease and epidemiology in 2006

Key achievements

- Grey partridges and pheasants reared on rearing field for various projects.
- Research on bits and specs continued.
- PhD on maternal immunity study started.

Chris Davis

Above and right: pheasants and scientists making use of our rearing field facility in 2006. (Des Purdy)

The threat of Avian Influenza (AI), the developing welfare legislation and the weather were key themes of 2006.

On the rearing field, Des Purdy reared grey partridges for our reintroduction trials and pheasants for our study of spectacle use and work on maternal immunity.

In common with many others, our winter cover crop of sorghum failed to materialise owing to the 'drought' and, as a result, our over-wintered hens were subject to wet conditions underfoot. In general the birds did well, the main problems being early mortality in bought-in partridges and a brief outbreak of hexamitiasis in some of the pheasants.

One of the important aspects of work in 2006 was devising ways for separating our birds (gamebirds and bantams) from wild birds, which is likely to be required under the AI legislation. Most of our gamebirds are kept in traditional netted pens with covered feeders and nipple drinkers and, under these conditions, there are few problems. Our bantam hens for the partridge study are effectively free-range. However, by only feeding and watering them in a 10' by 10' sectional area covered in weather netting, potential contamination from wild birds is effectively eliminated. The culmination of this work was an autumn visit by a delegation from the Defra AI team to see how gamebirds were reared and released using these techniques.

David Butler and his team conducted a Defra-funded study on the use of bits and spectacles. This study has a further year to run and, so far, we have made weekly visits to over 16 game farms across England and Wales. We are very grateful for the time and expertise of these co-operators. This study is gathering data to support new codes under the Animal Welfare Act (2006). The final report should be available in 2008.

In co-operation with Edinburgh University, Matt Ellis began a PhD on maternal allocation of resource and its impact on offspring health and fitness. His first year's work has entailed setting up a coccidiosis infection model and devising techniques for rearing birds in disease-free units.

We also spent a lot of time in 2006 liaising with Defra on disease surveillance strategies, animal welfare, AI and flock health in relation to gamebirds.

Gamebird welfare research in 2006

Project title	Description	Staff	Funding source	Date
Gamebird health	*Disease prevention and control in game and wildlife*	*Chris Davis, Des Purdy*	*Core funds, Lord Iliffe Charitable Trust, Roxton Bailey Robinson*	*1998 - on-going*
Bitting study	*Investigating the welfare aspects of bits and specs*	*Chris Davis, Dave Butler*	*Defra*	*2005-2008*
Rearing field	*Provision of research facility*	*Chris Davis, Des Purdy*	*Core funds*	*2000 - on-going*
PhD: Maternal immunity	*Investigating the extent of any immunity in pheasant chicks acquired from their mothers*	*Matthew Ellis (Supervisors: Chris Davis; Emma Cunningham/Edinburgh Univ)*	*BBSRC/CASE Studentship*	*2006-2008*

Key to abbreviations: BBSRC = Biotechnology and Biological Sciences Research Council; Defra = Department for the Environment, Farming and Rural Affairs.

Predation research summary for 2006

Our ambition to improve all aspects of predator control leads to a broad front of activities, from the minimalist design of snares and traps (see *Review of 2005*, page 63), through tunnel trap designs, acoustic attractants, to mathematical modelling to determine best culling strategies. We deal directly with suppliers and manufacturers, gamekeepers, scientists, technical colleges, wildlife trusts, government departments and, via the media, with the general public.

Our research on mink control continues to inform the discussion of how to manage these predators in a conservation context. In March, Jonathan Reynolds was an invited speaker at an international symposium on mink control at Stornaway. Our work in Herefordshire on mink and water voles (see page 86) addresses the now widespread problem of what to do if the species of concern is already locally extinct and must be re-introduced into an environment full of predators. This is exactly analogous with the grey partridge reintroduction work reported on page 76.

In New Zealand, predators introduced from Europe (stoat, ferret, rat) are a disaster for native birds, and their control is essential for bird conservation. Initially, the NZ Department of Conservation used spring traps imported from the UK, but found it necessary to develop a new design to meet the International Standard on Humane Trap Testing. Given the demonstrated humaneness of the new traps, we have arranged to oversee their introduction to the UK and Europe, assuming approval by Defra.

Defra commissioned us to review the potential of shooting as a means of badger population control in the context of bovine Tb. At the time of commission Defra had not decided whether any form of badger culling should be included in its Tb-control policy. Our brief was to provide the best possible basis for decision-making, examining the technique from all angles. We concluded that although shooting was entirely appropriate, and probably quite an efficient means of reducing badger numbers, it was best suited to specialised operators. As we go to press, the report is due to be published on Defra's website (www.defra.gov.uk).

Key achievements

- GCT mink raft technique presented at an international mink symposium.
- Demonstration project begun on the River Dore to reintroduce water voles while controlling mink.
- New Zealand tunnel trap design considered for use in the UK.
- Advised Defra on feasibility of shooting as a means of badger population control, in the context of bovine Tb.

Jonathan Reynolds

If Defra deems badger culling to be necessary, then night-shooting could contribute substantially to an effective cull. However, competence to do this humanely requires some specialist knowledge, for instance of badger anatomy. This long section of a road-killed badger shows that the vital heart and lungs are placed well back in the body. (Jonathan Reynolds/Austin Weldon)

Predation research in 2006

Project title	Description	Staff	Funding source	Date
Mink control strategies	*Experimental eradication of mink on parts of Itchen and Avon catchments*	*Jonathan Reynolds, Mike Short, Tom Porteus*	*Environment Agency, Core funds*	*2003-2006*
Fox control methods	*Experimental field comparison of fox capture devices*	*Jonathan Reynolds, Mike Short, Austin Weldon*	*Core funds*	*2002-2006*
River Monnow (see page 86)	*Re-introduction of water voles combined with mink removal on the River Dore*	*Jonathan Reynolds, Ben Rodgers*	*Defra, Environment Agency, National Grid*	*2006-2008*

Key to abbreviations: Defra = Department for the Environment, Farming and Rural Affairs.

Life on the river bank again

Key findings

- High initial mink density on the River Dore, but mink raft technique leads to rapid clearance of mink from the river.
- 300 captive-bred water voles released once river was clear of mink.
- Mink reinvasion during autumn dispersal rapidly contained, and probably caused minimal predation on released voles.

Jonathan Reynolds

When the fisheries-inspired River Monnow Project (see *Review of 2003*, page 98) finished in June 2006, it had restored river-bank habitat along 64 kilometres of the rivers forming the upper Monnow catchment in Herefordshire. Livestock had been fenced back, trees had been selectively coppiced to break up the 'tunnel' canopy, and lush ground vegetation once again flourished on the river banks. In terms of larger wildlife, though, the riverbanks remained barren. Where were the water birds? Where was dear old Ratty? Like the fish, these had probably been victims of long-term degradation of the Monnow's riverside habitats. But at the same time another curse had appeared in the form of American mink. The drastic impact of mink on water voles nation-wide seems beyond doubt. We have much less idea about the impacts of mink on other riparian wildlife species.

Water voles had last been seen in the upper Monnow catchment in 1998. We put a proposal to Defra to re-establish them artificially through the release of captive-bred animals. This would of course have been foolish without first clearing the area of mink, so the plan brought together our own mink control techniques using our GCT Mink Raft, and the expertise of our collaborator Derek Gow in captive-breeding water voles for subsequent release. These were both well-developed strategies and we were confident that we could make this project work. It would then serve as a demonstration of how to restore water voles to catchments where they had been lost.

We chose to concentrate on the most suitable of the Monnow tributaries, the relatively sedate River Dore. With its tributaries this made up about 40 kilometres of water. We constructed mink rafts in January 2006 and placed them on the river in March at one-kilometre intervals. On the rivers of Hampshire and Wiltshire where we developed the rafts, it was typical to find mink on 30% of rafts at the first inspection. On the Dore, virtually all rafts picked up mink signs during the first month, suggesting a much higher mink density and a greater challenge. But the raft system works and by mid-June, after 13 mink had been killed, on only two rafts towards the lower end of the river did tracks indicate that mink were still locally present (see Figures 1 and 2).

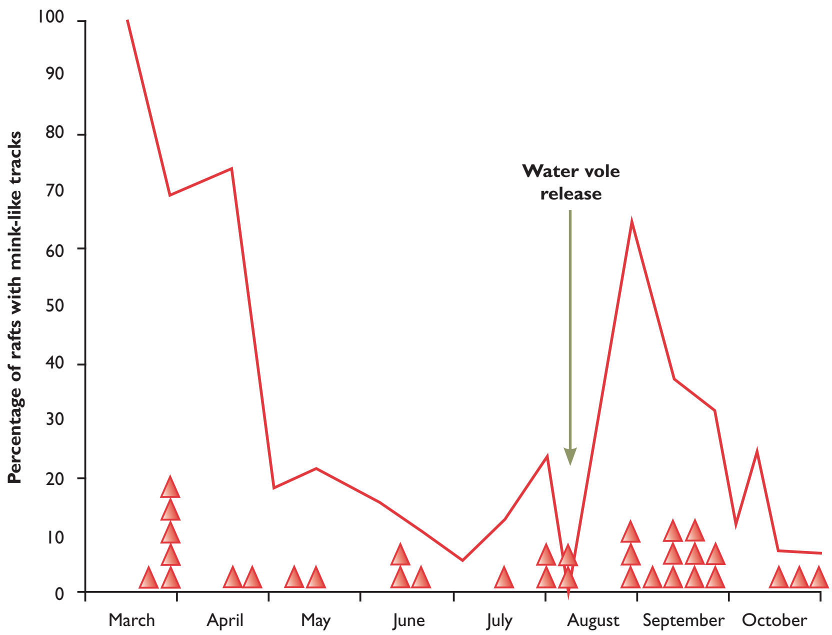
Meanwhile, Derek Gow's water voles were producing large numbers of young. These were released in late July/early August as juveniles close to breeding weight, mimicking natural events. On the river bank, sibling groups were housed together in open fronted cages, where they were fed regularly until they dispersed of their own accord. For most groups this happened within a week. There were no predation incidents before release, so around 300 voles dispersed along the lush late-summer river banks.

Figure 1

Mink detection and capture on the River Dore in Herefordshire, 2006

Mink capture ▲

Evidence of mink on rafts (red line) was very high in spring 2006, but dropped rapidly as mink were killed (red triangles). The dispersal season in August/September caused anxious moments, but was swiftly brought under control.



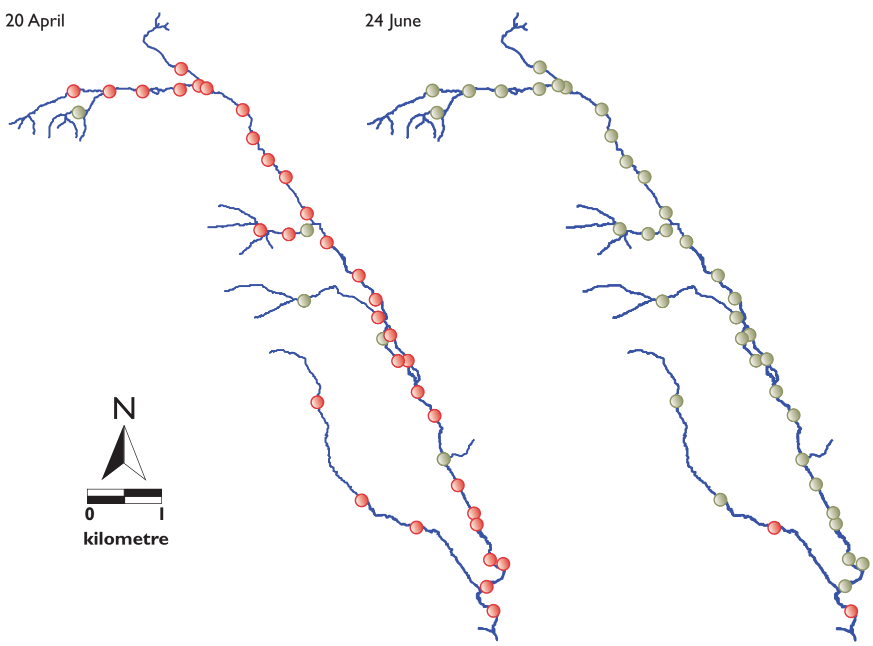


Figure 2

Mink rafts on the River Dore in April and June 2006

Mink raft showing signs of mink

Mink raft without signs of mink

Initial clearance of mink from the River Dore was very rapid. In the eight weeks between these two maps, all but two rafts had ceased recording mink tracks, owing to the capture of 13 mink.

In late summer, mink families too break up and disperse, leading to a sudden influx of mink to any control zone. On the Dore, this was quite dramatic, again suggesting a high density of mink in surrounding catchments. Within a fortnight of releasing the voles, the number of rafts with mink signs rose from zero to 26 (out of 40). We shortened our raft-checking regime to ensure that incoming mink were swiftly detected and removed and, reassuringly, none of them proved to have water vole remains in its intestines. These mink appeared to have entered the Dore from downstream.

Winter is a period of relative inactivity for water voles, and we don't really expect much sign of them until after they have bred in spring. However, we are confident that come spring they will breed, provided we maintain the river corridor free of mink.

Ben Rodgers at work with a GCT Mink Raft on a habitat-restored section of the River Dore. (Jonathan Reynolds)

Scientific publications in 2006

by staff of The Game Conservancy Trust

Baker, H, Stroud, DA, Aebischer, NJ, Cranswick, PA, Gregory, RD, McSorley, CA, Noble, DG & Rehfisch, MM (2006)
Population estimates of birds in Great Britain and the United Kingdom. *British Birds*, 99: 25-44.

Barker, A (2006)
Further descriptions of *Dolerus* larvae (Hymenoptera: Tenthredinidae), with notes on larval identification and feeding habits. In: *Recent Sawfly Research: Synthesis and Prospects*. Eds: SM Blank, S Schmidt & A Taeger. Goecke & Evers, Keltern. 83-96.

Browne, SJ (2006)
Effect of nestbox construction and colour on the occupancy and breeding success of nesting tits *Parus* spp. *Bird Study*, 53: 187-192.

Browne, SJ, Aebischer, NJ, Moreby, SJ & Teague, L (2006).
The diet and disease susceptibility of grey partridges *Perdix perdix* on arable farmland in East Anglia, England. *Wildlife Biology*, 12: 3-10.

Callegari, S (2006)
The impact of released gamebirds on the nature conservation value of chalk grassland in central southern England. Unpublished PhD thesis. Reading University.

Peter Thompson

Davies, GM (2005)
Fire behaviour and impact on heather moorland. Unpublished PhD thesis. University of Edinburgh, Edinburgh. 195p.

Davies, GM, Legg, CJ, Smith, A & MacDonald, A (2006)
Developing shrub fire behaviour models in an oceanic climate: Burning in the British Uplands. In: *Proceedings of the 5th International Conference on Forest Fire Research*, Coimbra, Portugal. CD-ROM.

Diaz, A, Green, I, Smith, B & Carrington, I (2006)
Ecological drivers in mine site rehabilitation. In: *Proceedings of the First International Seminar on Mine Closure*, 13-15 September 2006. Eds: A Fourie & M Tibbett. Australian Centre for Geomechanics, Perth, Australia. 51-60.

Draycott, RAH, Woodburn, MIA, Ling, DE & Sage, RB (2006)
The effect of an indirect anthelmintic treatment on parasites and breeding success of free-living pheasants *Phasianus colchicus*. *Journal of Helminthology*, 80: 409-415.

Ewald, JA, Callegari, SE, Kingdon, NG & Graham, NA (2006)
Fox-hunting in England and Wales: its contribution to the management of woodland and other habitats. *Biodiversity and Conservation*, 15: 4309-4334.

Hart, JD, Milsom, TP, Fisher, G, Wilkins, V, Moreby, SJ, Murray, AWA & Robertson, PA (2006)
The relationship between yellowhammer breeding performance, arthropod abundance and insecticide applications on arable farmland. *Journal of Applied Ecology*, 43: 81-91.

Holland, JM (2006)
A review of cultivation practices on soil and water quality and the environment. In: *The BCPC International Conference - Crop Science & Technology 2006*. 37

Holland, JM, Hutchison, MAS, Smith, B & Aebischer, NJ (2006)
A review of invertebrates and seed-bearing plants as food for farmland birds in Europe. *Annals of Applied Biology*, 148: 49-71.

Holland, JM, Southway, S, Birkett, T & Moreby, S (2006)
The relative merits of field and boundary habitats for conservation biocontrol. *Landscape Management for Functional Biodiversity IOBC wprs Bulletin*, 29: 57-60.

Hoodless, A & Baines, D (2006)
Breeding density and habitat use of common snipe in upland Britain. In: *Sixth European Woodcock and Snipe Workshop - Proceedings of an International Symposium of the Wetlands International Woodcock and Snipe Specialist Group*, 25-27 November 2003, Nantes, France. International Wader Studies 13. Ed: Y Ferrand. Wetlands International, Wageningen, The Netherlands. 95-101.

Hoodless, AN, Inglis, JG & Baines, D (2006)
Effects of weather and timing on counts of breeding snipe *Gallinago gallinago*. *Bird Study*, 53: 205-212.

Hoodless, A, Lang, D, Fuller, R, Aebischer, NJ & Ewald, JA (2006) Development of a survey method for breeding woodcock and its application to assessing the status of the British population. In: *Sixth European Woodcock and Snipe Workshop - Proceedings of an International Symposium of the Wetlands International Woodcock and Snipe Specialist Group*, 25-27 November 2003, Nantes, France. International Wader Studies 13. Ed: Y Ferrand. Wetlands International, Wageningen, The Netherlands. 48-54.

Jones, CA, Basch, G, Baylis, AD, Bazzoni, D, Biggs, J, Bradbury, RB, Chaney, K, Deeks, LK, Field, R, Gómez, JA, Jones, RJA, Jordan, VWL, Lane, MCG, Leake, A, Livermore, M, Owens, PN, Ritz, K, Sturny, WG & Thomas, F (2006) *Conservation agriculture in Europe: an approach to sustainable crop production by protecting soil and water?* SOWAP, Bracknell, UK 110p.

Leake, AR (2006)
Conservation agriculture. In: *Where the land is greener; case studies and analysis of soil and water initiatives worldwide*. Eds: Hanspeter Liniger and William Critchley. WOCAT 2007: 77-84. ISBN 978-92-9081-339-2.

Leake, AR & Jarvis, PE (2006)
Practical on-farm measures to reduce soil erosion and water pollution. In: *The BCPC International Conference - Crop Science & Technology 2006*. 45

Lloyd, S & Gibson, JS (2006)
Haematology and biochemistry in healthy young pheasants and red-legged partridges and effects of spironucleosis on these parameters. *Avian Pathology*, 35: 335-340.

Moreby, SJ, Aebischer, NJ & Southway, S (2006)
Food preferences of grey partridge chicks, *Perdix perdix*, in relation to size, colour and movement of insect prey. *Animal Behaviour*, 71: 871-878.

Pollard, KA & Holland, JM (2006)
Arthropods within the woody element of hedgerows and their distribution pattern. *Agricultural and Forest Entomology*, 8: 203-211.

Reynolds, JC, O'Mahony, D & Aebischer, NJ (2006)
Implications of 'cyclical' population dynamics for the conservation of Irish hares (*Lepus timidus hibernicus*). *Journal of Zoology*, 270: 408-413.

Rushton, SP, Shirley, MDF, Macdonald, DW & Reynolds, JC (2006) Effects of culling fox populations at the landscape scale: A spatially explicit population modeling approach. *The Journal of Wildlife Management*, 70: 1102-1110.

Sage, RB, Cunningham, M & Boatman, N (2006)
Birds in willow short-rotation coppice compared to other arable crops in central England and a review of bird census data from energy crops in the UK. *Ibis*, 148 Supplement 1: 184-197.

Stoate, C & Jarvis, P (2006)
A practical appraisal of on-farm costs of Environmental Stewardship and other influences on farmers' adoption of it. *Aspects of Applied Biology*, 80: 3-9.

Stoate, C & Szczur, J (2006)
Potential influence of habitat and predation on local breeding success and population in spotted flycatchers *Muscicapa striata*. *Bird Study*, 53: 328-330.

Stoate, C, Whitfield, M, Williams, P & Driver, K (2006)
Wetland habitat creation and mitigation of water pollution from field drains: use of buffer strip pools within an arable landscape. In: *Water and the Landscape: The Landscape Ecology of Freshwater Ecosystems*. IALE (UK), Oxford. 331-334.

Summers, DW, Roberts, DE, Giles, N & Stubbing, DN (2006)
Retention of visible implant and visible implant elastomer tags in brown trout in an English chalk stream. *Journal of Fish Biology*, 68: 622-627.

Note: the publications listed as 2005 did not appear in print before the Review of 2005 went to press. For a complete record of the scientific publications by staff of The Game Conservancy Trust, we therefore include them here.


Peter Thompson

Financial report for 2006

Summary and key points

- Income increased by 11% overall, with unrestricted income rising by 8.5%.
- Total costs increased by 10.9%.
- There was a surplus of 2% of income on the General Fund.

The summarised accounts for the year ended 31 December 2006, set out on pages 92 to 93, are not the statutory accounts but are a summary of information relating to the consolidated Statement of Financial Activities and Balance Sheet of the Game Conservancy Trust Limited. These incorporate the results of the Allerton Research and Educational Trust and the two wholly-owned subsidiaries Game Conservancy Limited and Game Conservancy Events Limited. The full annual accounts, which were approved by the Trustees on 26 April 2007, and from which the summarised accounts have been derived, have been independently audited; and the auditors' report was unqualified. The full accounts, the auditors' report and the Trustees' annual report, all of which have been submitted to the Charity Commission, may be obtained from the Trust's Headquarters.

Review of financial transactions and position

Following the issue of a uniting direction by the Charity Commission, the accounts now incorporate the Allerton Research and Educational Trust. The previous year's figures have been restated so that they are included on the same basis.

The Game Conservancy Trust Limited enjoyed solid support from its funders which enabled it to carry out the planned research programme and develop initiatives in policy and profit, education and practice referred to elsewhere. Thanks to this support the Charity hit its financial targets and achieved a small surplus of 2% on Unrestricted Funds.

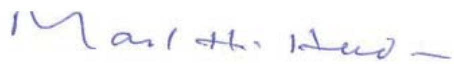
The Charity spent £4.3 million, or 66% of its total expenditure, on its charitable objects this year (2005: 65%).

Total income increased by 11% in the year and unrestricted income increased by 8.5%. Increasing unrestricted income was one of the Trust's fundraising aims. Total costs increased by 10.9%.

The managers of the unrestricted fund investments met their objective of achieving double the return on cash with a total return in the year of 9.3%. On endowment funds, the funds invested achieved a total return of 2.8% on the fixed interest holdings and 18.2% on equities, which both exceeded the relevant benchmarks.

The Trustees have reviewed the reserves policy and have adopted a new policy based on an assessment of risk to future income flows. The resulting number is then tested against current rates of expenditure to ensure that it is robust. The policy is that there should be a minimum level of liquid reserves equivalent to three months total expenditure. At the end of the year the Charity had met its reserves target.

It will be seen from the Balance Sheet that the uniting direction with the Allerton Research and Educational Trust has meant that the accounts include that Trust's endowment of £4.5 million, the capital of which cannot ordinarily be spent.



M H Hudson
Chairman of the Trustees

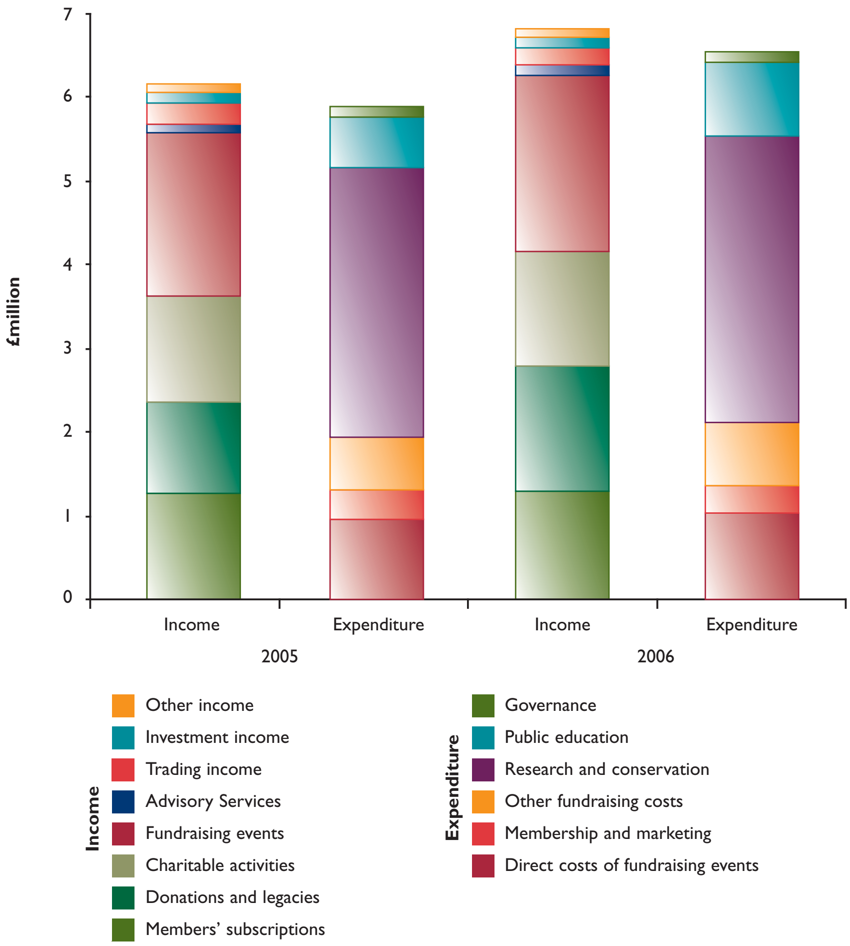


Figure 1

Incoming and outgoing resources in 2006 (and 2005) showing the relative income and costs for different activities

Independent auditors' statement

to the Trustees and Members of The Game Conservancy Trust

We have examined the summarised accounts set out on pages 92 and 93.

Respective responsibilities of Trustees and Auditors
The Trustees are responsible for preparing the summarised accounts. Our responsibility is to report to you our opinion on the consistency of the summarised accounts within the Annual Review with the full annual Consolidated Accounts and Trustees' Report. We also read the other financial information contained within the Annual Review and consider the implications for our report if we become aware of any apparent misstatements or material inconsistencies with the summarised accounts.

Basis of opinion
We conducted our work with reference to Bulletin 1999/6 'The auditors' statement on the summary financial statement' issued by the Auditing Practices Board for use in the United Kingdom.

Opinion
In our opinion the summarised accounts are consistent with the full annual Consolidated Accounts and Trustees' Report of The Game Conservancy Trust for the year ended 31 December 2006.

FLETCHER & PARTNERS
Chartered Accountants and Registered Auditors
Salisbury, 26 April 2007

consolidated

Statement of financial activities

for the year ended 31 December 2006

	Unrestricted Funds £	Restricted Funds £	Endowed Funds £	**Total 2006 £**	Total 2005 (restated) £
INCOME AND EXPENDITURE					
INCOMING RESOURCES					
Incoming resources from generated funds					
Voluntary income					
Members' subscriptions	1,299,323	2,432	-	**1,301,755**	1,267,958
Donations and legacies	529,410	957,104	-	**1,486,514**	1,089,054
	1,828,733	959,536	-	**2,788,269**	2,357,012
Activities for generating funds					
Fundraising events	1,983,464	104,452	-	**2,087,916**	1,944,740
Advisory Service	138,381	-	-	**138,381**	108,947
Trading income	192,578	-	-	**192,578**	238,253
Investment income	41,792	96,942	-	**138,734**	145,871
Charitable activities	106,837	1,267,455	-	**1,374,292**	1,273,542
Other income	53,138	49,272	-	**102,410**	86,077
TOTAL INCOMING RESOURCES	4,344,923	2,477,657	-	**6,822,580**	6,154,442
RESOURCES EXPENDED					
Costs of generating funds					
Direct costs of fundraising events	1,034,367	-	-	**1,034,367**	959,321
Membership and marketing	313,041	-	-	**313,041**	339,932
Other fundraising costs	777,860	-	-	**777,860**	639,008
	2,125,268	-	-	**2,125,268**	1,938,261
Activities in furtherance of the charity's objects					
Research - Lowlands	800,431	982,132	-	**1,782,563**	1,576,350
Research - Uplands	448,831	262,400	-	**711,231**	749,902
Research - ARET	30,073	477,791	-	**507,864**	489,837
	1,279,335	1,722,323	-	**3,001,658**	2,816,089
Conservation	71,079	336,571	-	**407,650**	393,012
Public education	609,917	278,085	-	**888,002**	624,707
	1,960,331	2,336,979	-	**4,297,310**	3,833,808
Governance	111,301	-	-	**111,301**	117,379
TOTAL RESOURCES EXPENDED	4,196,900	2,336,979	-	**6,533,879**	5,889,448
NET INCOME/(OUTGOING) RESOURCES	148,023	140,678	-	**288,701**	264,994
OTHER RECOGNISED GAINS AND LOSSES					
Realised gains on investments	41,089	-	8,285	**49,374**	57,387
Unrealised gains/(losses) on investments	55,948	-	186,968	**242,916**	403,884
NET MOVEMENT IN FUNDS	245,060	140,678	195,253	**580,991**	726,265
BALANCES AT 1 JANUARY	2,390,305	369,991	-	**2,760,296**	2,293,295
Prior period adjustment	-	96,329	4,350,286	**4,446,615**	4,187,351
Balance as restated	2,390,305	466,320	4,350,286	**7,206,911**	6,480,646
BALANCES AT 31 DECEMBER	£2,635,365	£606,998	£4,545,539	**£7,787,902**	£7,206,911

consolidated

Balance sheet

at 31 December 2006

	2006		2005 (restated)	
	£	£	£	£
FIXED ASSETS				
Tangible assets		2,927,301		3,026,445
Investments		3,681,929		3,535,719
		6,609,230		6,562,164
CURRENT ASSETS				
Stock	199,215		170,811	
Debtors	1,177,412		948,540	
Cash at bank and in hand	863,260		505,184	
	2,239,887		1,624,535	
CREDITORS:				
Amounts falling due within one year	770,792		692,893	
NET CURRENT ASSETS		1,469,095		931,642
TOTAL ASSETS LESS CURRENT LIABILITIES		8,078,325		7,493,806
CREDITORS:				
Amounts falling due after more than one year		290,423		286,895
NET ASSETS		£7,787,902		£7,206,911
Representing:				
CAPITAL FUNDS				
Endowment funds		4,545,539		4,350,286
INCOME FUNDS				
Restricted funds		606,998		466,320
Unrestricted funds:				
Total designated funds	232,330		237,060	
Revaluation reserve	378,859		453,333	
General fund	2,031,162		1,701,905	
Non-charitable trading fund	(6,986)		(1,993)	
		2,635,365		2,390,305
TOTAL FUNDS		£7,787,902		£7,206,911

Approved by the Trustees on 26 April 2007 and signed on their behalf

M H HUDSON
Chairman of the Trustees

Staff of The Game Conservancy Trust
in 2006

CHIEF EXECUTIVE	Teresa Dent BSc, FARAgS
Personal Assistant	Wendy Smith
Head of Finance	Alan Johnson ACMA
Finance Assistant - Trust	Stephanie Slapper
Finance Assistant - Limited	Lin Dance
Accounts Clerk (p/t)	Sue Connelly *(until June)*
Accounts Clerk (p/t)	Barbara Griffiths *(from October)*
Head of Administration & Personnel	Kate Oliver *(until July)*
Head of Administration & Personnel	Jenny Channell *(from July)*
Administration & Personnel Assistant	Jayne Cheney *(from November)*
Receptionist/Secretary	Joanne Hilton
Head Groundsman	Craig Morris
Seasonal Groundsmen/Rearing Field Assistants	Tom Sowman *(May-June)*, Will Barton *(July-September)*
Headquarters Cleaner (p/t)	Rosemary Davis
Headquarters Janitor (p/t)	Chris Johnson
Head of Information Technology	James Long BSc
DIRECTOR OF POLICY AND PUBLIC AFFAIRS	Stephen Tapper BSc, PhD
Head of Media Relations	Morag Walker MIPR
Press & Publications Assistant	Louise Shervington
DIRECTOR OF RESEARCH	Nick Sotherton BSc, PhD
Secretary (p/t)	Lynn Field
Head of Fisheries Research	Dylan Roberts BSc
Fisheries Biologist	Dominic Stubbing HND, MIFM
Fisheries Research Scientist	Ravi Chatterji BSc, MSc
Research Assistants	Brian McCloy FdScSFA *(until Sep)*, Rob Lewis *(until Sep)*, Dean Sandford *(from Sep)*
Placement Students *(Sparsholt)*	Gary Donnahue *(until May)*, Gavin Hunter *(until May)*, Simeon Osborne BSc *(until August)*, Neil Lewin *(until August)*
Fisheries Project Assistant	Steffan Jones BSc *(until March)*
Monnow Project Co-ordinator	Gill Watkins *(until August)*
Monnow Team Leader	Ben Rodgers BSc *(until July)*
Head of Lowland Gamebird Research	Rufus Sage BSc, MSc, PhD
Ecologist - Pheasants, Wildlife (p/t)	Maureen Woodburn BSc, MSc, PhD
Ecologist - Partridges, Pheasants	Roger Draycott HND, MSc, PhD
Ecologist - Pheasants, Woodcock	Andrew Hoodless BSc, PhD
Project Ecologist - Energy Crop Studies	Mark Cunningham BSc, MSc
Research Assistant	Pamela Marshall-Ball BSc *(until September)*
PhD Student *(Imperial College)* - Pheasant Releasing Studies	Clare Turner BSc *(until August)*
PhD Student *(Kent)* - Pheasant Releasing Studies	Tracey Greenall BSc, MSc
PhD Student *(Reading)* - Gamebird Releasing Studies	Sarah Callegari BSc, MSc *(until August)*
PhD Student *(Imperial College)* - Human-imprinted chicks	Gwendolen Hitchcock
Placement Student - University of Liverpool	Rob Lewis BSc *(until September)*
Placement Student - Harper Adams	James Palmer BSc *(until June)*
Ecologist - Scottish Lowland Research	David Parish BSc, PhD
PhD Student *(Dundee)* - Sawfly Genetics	Angela Gillies BSc
PhD Student *(Glasgow)* - Yellowhammer Ecology	Graeme Cook BSc, MSc *(from October)*
Honours Student *(Dundee)*	Caroline King *(from October)*
Head of Wildlife Disease & Epidemiology	Chris Davis BVM&S, MRCVS
Game Technician/Stockman	Des Purdy BSc, PhD
Project Scientist	Clare Turner BSc *(until August)*
PhD Student *(Edinburgh)* - Maternal antibody transfer in pheasants	Matt Ellis BSc *(until September)*
Rearing Field Assistant	Matt Ford *(May-September)*
Rearing Field Assistant	Heidi Venn BSc *(until August)*
Project Officer - Bitting Study	Dave Butler BSc
Head of Predation Control Studies	Jonathan Reynolds BSc, PhD
Research Assistant	Mike Short HND
Research Assistant	Thomas Porteus BSc, MSc
Research Assistant	Austin Weldon BSc *(until April)*, Ben Rodgers BSc *(from September)*
Head of Entomology	John Holland BSc, MSc, PhD
Post Doctoral Entomologist	Barbara Smith BSc, PhD
Senior Entomologist	Steve Moreby BSc, MPhil
Entomologist	Sue Southway BA
Entomologist	Tom Birkett BSc, PgC
Ornithologist	John Simper BSc, MSc *(from April)*
Field Assistant	Andrew Brown *(June-December)*
PhD Student *(Imperial College)* - Insect Dispersal	Heather Oaten BSc, MSc
PhD Student *(Southampton)* - Bumblebees	Gillian Lye BSc
PhD Student *(Cardiff)* - Predatory Insects	Jeff Davey BSc
Assistant Entomologist	Steve Bedford
Placement Student	Freya McCall *(until July)*, Louise Bailey *(from Sept)*, Mark Gibson *(from June)*
Director of Upland Research	David Baines BSc, PhD
Office Manager, The Gillett	Julia Hopkins
Black Grouse Recovery Officer	Phil Warren BSc, PhD
Research Assistant - Black Grouse	Michael Richardson BSc, Pam Staley *(April)*
Senior Scientist - Upland Predation Experiment	Kathy Fletcher BSc, PhD

Research Assistant - Upland Predation Experiment	Robin Foster HND
Research Assistant	Annelie Jonsson BSc, MSc *(until July)*
Placement Student	Richard Goswell *(from August);* Michelle Phillips *(from July)*
PhD Student *(Imperial College)* - Red Grouse	Nils Bunnefeld
PhD Student *(Imperial College)* - Grouse M'ment & Conservation	Julie Black
Head Gamekeeper - Upland Predation Experiment	Craig Jones
Gamekeeper - Upland Predation Experiment	Philip Chapman
Trainee Gamekeeper - Upland Predation Experiment	Joe Pattison *(until June)*
Assistant Gamekeeper	Paul Bell *(from December)*, Tony Jenkins *(from December)*
Senior Scientist - North of England Grouse Research	David Newborn HND
Placement Student	William Watson *(until June)*
Senior Scientist - Scottish Upland Research	Adam Smith BSc, MSc, DPhil
Ecologist - Mountain Hares	Scott Newey BSc, MSc *(until January)*
Woodland Grouse Scientist	Martin Dallimer BSc, MSc, PhD *(until May)*
Research Assistant - Scottish Upland Research	David Howarth
Research Assistant - Woodland Grouse	Allan MacLeod BSc *(from April)*
Seasonal Research Assistant	Katy Clark BSc, MRES *(until September)*
PhD Student *(Aberdeen)* - Spatial Ecology of Sheep Ticks	Ellie Watts BSc
Placement Students	Peter Allison, Emily Mockford *(until Aug)*, William Bartholomew BSc *(from Aug)*
Head of the Allerton Project	Alastair Leake BSc (Hons), MBPR (Agric), PhD, ARAgS, MIAgM, MIAgE
Secretary (p/t)	Jenny Kipling *(until July)*, Natalie Augusztinyi *(from July)*
Head of Research for the Allerton Project	Chris Stoate BA, PhD
Ecologist	Kate Driver BSc
Ecologist	John Szczur BSc
Placement Students	Ben Gibson *(until June);* Rebecca Lockyer *(from Sep); RIchard Roberts (from Sep)*
Field Assistant	Seb Mankelow *(April-August)*
PhD Student *(Stirling)* - Birds and Bees	Jenny Jacobs BSc
PhD Student *(Reading)* - Songbird Breeding Success	Patrick White BSc *(from October)*
Game Manager - Royston	Malcolm Brockless
Farm Manager	Philip Jarvis HND
Farm Assistant	Michael Berg
Catering Assistant (p/t)	Jeanette Parr

DEPUTY DIRECTOR OF RESEARCH	Nicholas Aebischer Lic ès Sc Math, PhD
Secretary & Librarian	Gillian Gooderham
Assistant Biometrician	Peter Davey BSc
Grey Partridge Ecologist	Stephen Browne BSc, MSc, PhD *(until September)*
Westminster Fellow - Grey Partridges	Francis Buner Dipl Biol, Cand Dr Phil II
Placement Student *(Centre National pour la Promotion Rurale)*	Pierre Damiens *(until February)*
Placement Student *(ENITA Clermont-Ferrand)*	Antoine Santarelli *(June-July)*
EU Leonardo da Vinci Placement *(Florence)*	Nadia Bazihizina, Laurea Magistrale *(from September)*
DPhil Student *(Oxford)* - Released Grey Partridges	Elina Rantanen
Head of Geographical Information Systems	Julie Ewald BS, MS, PhD
Partridge Count Scheme Co-ordinator	Neville Kingdon BSc
Research Assistant - GIS	Nina Graham BSc
Research Assistant	Suzanne Richardson BSc, MSc *(from September)*
Placement Student *(John Moores, Liverpool)*	Katy Hickey *(from September)*
Placement Student *(John Moores, Liverpool)*	Natasha Deckker *(until August)*

as at 1 May 2007

DIRECTOR OF FUNDRAISING	Edward Hay	020 7290 0110, ehay@gct.org.uk, 07717 856951
Personal Assistant	Gemma Mason BA	020 7290 0116, gmason@gct.org.uk
London Events Manager	Lucinda Jamieson	020 7290 0110, ljamieson@gct.org.uk, 07919 990624
London Events Assistant	Mima Lopes	020 7290 0110, mlopes@gct.org.uk
Northern Regional Fundraiser	Henrietta Appleton BA, MSc	01833 622028, happleton@gct.org.uk, 07889 891956
Southern Regional Fundraiser	Max Kendry	01789 840348, mkendry@gct.org.uk, 07803 180957
Eastern Regional Fundraiser	Lizzie Herring	01284 831028, lherring@gct.org.uk, 07885 897647
Fundraiser - Scotland	Andrew Dingwall-Fordyce	01771 613263, 07831 707501
Fundraising - Donations and Trusts (p/t)	Christopher Langley	020 7290 0110, clangley@gct.org.uk

DIRECTOR OF MEMBERSHIP & MARKETING	Chris Washington-Sare *(from July)*
Head of Membership Records/Funding Manager/Legacies	Corinne Duggins Lic ès Lettres
Data Co-ordinator - Renewals	Jenny Bowen-Jones *(until April)*, Annie Nadin *(from August)*
Data Co-ordinator - Membership	Lisa Roberts
Data Administrator: Gift Aids/MRs/New Members (p/t)	Bridget McKeown
Corporate Sponsorship Manager	Liz Scott
Sales Centre Manager	Mike Davis

DIRECTOR SCOTLAND	Ian McCall BSc[1]
Secretary - Scottish HQ	Irene Johnston
Secretary - Scottish Auction	Miranda Fox
PR & Education - Scotland	Katrina Candy HND

DIRECTOR OF ADVISORY & EDUCATION	Ian Lindsay BSc[3]
Co-ordinator Advisory Services (p/t)	Lynda Ferguson
Field Officer – Farmland Ecology	Peter Thompson DipCM, MRPPA (Agric)
Head of Education	Mike Swan BSc, PhD[4]
Regional Advisor - Central & Southern Scotland & Northern England	Hugo Straker NDA[2]
Regional Advisor - Eastern & Northern England (p/t)	Martin Tickler MRAC
North of England Regional Advisor & Biodiversity Officer	Mike McKendry ARICS *(until December)*
Secretary to Mike McKendry (p/t)	Gillian Robson *(until December)*

[1] Ian McCall is also Regional Advisor for Tayside, Fife, Northern Scotland & Ireland; [2] Hugo Straker is also Development Officer for Central and Southern Scotland; [3] Ian Lindsay is also Regional Advisor - Wales, Midlands; [4] Mike Swan is also Regional Advisor for the South of England.

Index of research projects

covered in this Review