RELU PROJECT END OF AWARD REPORT FORM

REFERENCE NUMBER
RES-240-25-0006
TITLE
Linking evidence and policy for managing biodiversity in the agricultural landscape
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This is the End of Award Report form for research projects in the Rural Economy and Land Use Programme. RELU is supported jointly by the Biotechnology and Biological Sciences Research Council, the Economic & Social Research Council and the Natural Environment Research Council, with additional funding from the Department for Environment, Food and Rural Affairs and the Scottish Executive's Environmental Rural Affairs Department.

The form should be completed and returned on, or before, the due date to:

The Evaluation Reports Officer, Communications & Information Directorate, Economic and Social Research Council, Polaris House, North Star Avenue, Swindon SN2 1UJ

Please note that the Report can only be accepted if all sections have been completed in full, and all award-holders have signed declaration one.

Award holders should submit seven additional copies of this Form, and eight copies of the research report and any nominated outputs to be evaluated along with the Report.

ACTIVITIES AND ACHIEVEMENTS QUESTIONNAIRE

1. Non-Technical Summary

A 1000 word (maximum) summary of the main research results, in non-technical language, should be provided below. The summary might be used by the Research Councils to publicise the research. It should cover the aims and objectives of the project, main research results and significant academic achievements, dissemination activities and potential or actual impacts on policy and practice.

This project developed and tested a new method for integrating scientific evidence into policy and practice, using wildlife conservation on farmland as a demonstration. We aimed to combine expert evaluation of synthesized evidence with consultation of practitioners and policymakers, to identify research priorities in important areas where evidence is weak or incomplete.

The project had three main objectives: i) identify the range of options for managing farmland to benefit wildlife, ii) synthesize scientific evidence for the effectiveness of these interventions and iii) for each intervention, quantify the importance to practitioners and the level of current scientific understanding, and use this information to set research priorities. Other objectives were to assess knowledge amongst farmland conservation practitioners of the available interventions and the evidence relating to them.

An interdisciplinary project team comprising ecologists, rural social scientists and agricultural policy analysts worked together to compile a list of 118 interventions to benefit wildlife on agricultural land.

Evidence for the effectiveness of each intervention was gathered using systematic review methods, and each piece of evidence (743 in total) summarised in plain English. These summaries will be published as a synopsis of evidence on farmland conservation in temperate Europe, on the website www.conservationevidence.com and as a book. A preview of two interventions is already available on the website.

Fifty-four people involved in the policy and practice of farmland conservation took part in the project as 'practitioner' consultees. We asked them how important the interventions were for farmland conservation. They scored each intervention from 1 (not important) to 5 (very important). We also asked how much they knew about a selected subset of interventions, including whether they had heard of it, how much scientific evidence they thought existed for it, and whether they thought it benefitted wildlife.

A team of ten experts in agricultural ecology, policy or rural social science evaluated the evidence for each intervention, based on the compiled synopsis. They assessed how much we know about each intervention (% certainty) and whether the evidence showed a benefit to wildlife. The evaluation process was based on a method of gathering expert judgement using iterative scoring rounds, called the Delphi technique.

We found a high level of awareness of farmland interventions among practitioners. On average, they had heard of 29 out of the 34 interventions for which levels of awareness were tested. They also had good knowledge of the amount of scientific evidence that

exists about the interventions - their assessment correlated with our expert evaluation of how much evidence exists.

However, the practitioners generally had less good understanding of the results of research. Their answers to whether each intervention benefits wildlife did not correlate with expert responses to the same question, based on evidence. For example, for the intervention 'Increase crop diversity', 74% of practitioners answered 'yes, this will benefit wildlife', while experts unanimously responded 'don't know'. Increasing crop diversity is a compulsory greening element in the proposed reformed Common Agricultural Policy, so the mis-match between our assessment of evidence and practitioner opinion is of particular interest.

We identified ten interventions that should be research priorities for farmland conservation, having high importance to practitioners and low certainty of scientific knowledge about their effectiveness for wildlife conservation. These research priorities are listed below, with the highest priority first:

Research priorities for farmland conservation - things to find out about:

1. Provide specialist advice to farmers and land managers
2. Manage woodland edges to benefit wildlife
3. Provide training for land managers, farmers and farm advisers
4. Control invasive non-native plants on farmland (such as Himalayan balsam, Japanese knotweed)
5. Connect areas of natural or semi-natural habitat
6. Manage the agricultural landscape to enhance floral resources
7. Provide buffer strips alongside water courses (rivers and streams)
8. Provide bat boxes, bat grilles, improvements to roosts
9. Support or maintain low-intensity agricultural systems
10. Restore or create wood pasture

Some research priorities are difficult to generate direct scientific evidence for, due to technical or methodological difficulty, or the expense of the studies needed. Landscape-scale interventions such as connecting habitats, for example, fall into this category. However, some would be easier to test, such as the effectiveness of bat boxes, grilles and roost improvements in farmed areas.

We ran a similar process for wild bee conservation based on a previously published synopsis of evidence. There are remarkable similarities between the two lists of research priorities, even though they were devised using different sets of evidence, and independent assessment processes with different groups of practitioners and experts. Both processes identified training land managers, connecting areas of semi-natural habitat and enhancing floral resources at a landscape scale as priorities for research.

For wildlife conservation on farmland, we also identified advocacy priorities. These interventions had high importance to practitioners, high certainty of scientific knowledge about effectiveness for wildlife conservation and unanimous agreement among ten experts that the evidence demonstrates a benefit to wildlife. They are presented with the highest priority first.

Advocacy priorities for farmland conservation - interventions that evidence-based policy should support:

1. Restore or create species-rich semi-natural grassland
2. Plant nectar flower mixture/wildflower strips
3. Plant wild bird seed or cover mixture
4. Create uncultivated margins around intensive arable or pasture fields
5. Create skylark plots
6. Use mowing techniques to reduce mortality
7. Reduce fertilizer, pesticide or herbicide use generally
8. Leave uncropped, cultivated margins or plots (includes 'lapwing plots')
9. Reduce management intensity on permanent grasslands
10. Use organic rather than mineral fertilizers

Based on this work, we advocated that some of these interventions be incorporated into the proposed compulsory greening requirements of the future CAP, in a response to the UK Government's consultation on Common Agricultural Policy (CAP) Reform post-2013.

As our expert panel did not evaluate the relative magnitude of the effects, some of the interventions have relatively small, localised effects or only affect a few species, whilst others have larger benefits. We are now developing the method further to account for effect size.

2. Dissemination

A. Please outline any specific plans you have for further publication and/or other means of disseminating the outcomes and results of the research.

The synopsis of evidence on farmland conservation in temperature Europe will be published as a book by Pelagic Publishing (citation below), and made freely available as a searchable database and pdf on the website www.conservationevidence.com.

Dicks, L. V., Danhardt, J., James, K., Jönsson, A., Randall, N., Showler, D. A., Smith, R. K., Turpie, S., Williams, D. & Sutherland, W. J. (in prep) *Farmland conservation: evidence for the effects of interventions in northern Europe*. Pelagic Publishing.

Once published (it will also be available as a pdf for free), we will publicise it strongly through the University press office, our own websites, Twitter, on-line book retail outlets, and by exhibiting it at conferences such as the Society for Conservation Biology and sending out review copies. We have pre-ordered a hundred copies of the book to send out to key people in agricultural conservation and policy in the UK and Europe.

Three scientific papers based on this work are in preparation. One describes the priority setting process and the research and advocacy priorities identified. One uses our response to CAP Reform to demonstrate how this method of evidence synthesis can inform policy at the highest level. A third analyses levels of awareness and perceptions of evidence about farmland interventions among the consulted practitioners.

We will be presenting one aspect of this work (a method to measure impact) at the European Congress for Conservation Biology in Glasgow in August 2012.

We have been invited to present the work to the British Trust for Ornithology (BTO) as part of its lunchtime seminar series, although a date is not set yet.

All 54 practitioners who completed the survey will be sent copies of all outputs, including pdf versions of the output papers relating to farmland conservation and the full farmland synopsis.

B. Please provide names and contact details of any non-academic research users with whom the research has been discussed and/or to whom results have been disseminated. This should include contacts made during the lifetime of the award.

Many research users were present at the Cambridge Conservation Seminar given in February, and the Cambridge Programme for Sustainability Leadership's meetings of the Dairy Industry in February and March. Below is a list of those who contacted us afterwards to express an active interest.

- Peter Bainbridge (Defra)

- John Holland (Game and Wildlife Conservation Trust) jholland@gwct.org.uk

The following research users were involved with the project throughout, and have an good understanding of the results:

- Susan Turpie (Scottish Government)
- Clunie Keenleyside (Institute for European Environmental Policy)
- Alison McKnight (Smiths Gore)

3. Nominated Outputs (see Guidelines 1.4)

You are invited to nominate two outputs to be assessed along with this report. **Eight** copies of any nominated outputs must be submitted with the End of Award Report. Please also provide **one** printed copy of publicly available web-based resources.

NOMINATED OUTPUT 1
Sutherland, W. J., Goulson, D., Potts, S. G. & Dicks, L. V. (2011) *Quantifying the Impact and Relevance of Scientific Research. Plos One,* **6**. DOI 10.1371/journal.pone.0027537

NOMINATED OUTPUT 2
Response to Defra consultation on Common Agricultural Policy Reform Post 2013, submitted 05 March 2012. This is included as Annex B of this report.

4. Staffing

Please detail appointments and departures below for ALL staff recruited for this award. Where possible, please note each person's name, age, and grade; and for departing staff, destination type (Academic post, Commercial, Public Sector, Personal or Other) on leaving.

NB. This section must not include anyone who is an award holder.

Title	Initials	Surname	Date Of Birth	Grade	Appointment Date	Departure Date	Destination Type & Post

5. Virements

Investigators can vire funds between grant headings without reference to the ESRC, except where major capital items are being provided for. Please detail below any changed use of resources and the benefits or problems this produced.

6. Major difficulties

Please detail below any major difficulties, scientific or administrative/logistical, encountered during your research and comment on any consequent impact on the project. Further details should be included in the main report, including any advice you might have for resolving such problems in future projects.

Completing summaries of 743 individual studies for the synopsis of evidence was a very time-consuming task that was underestimated in the original project proposal. In reality, writers were able to sustain rates of between 2 and 3 summaries per day, when combined with locating references and completing administrative tasks associated with compiling the synopsis. This rate should be built into forthcoming funding applications. It means that 743 studies take close to 300 person days to summarise, which would be 1.3 years' work for one person.

To complete the synopsis in draft form within the timeframe of the project, we established a collaborative effort, using paid or unpaid time from a team of nine writers in addition to the post-doctoral researcher funded on the project. Each writer worked full or part time for between one and six months. Five of these writers were supported financially from other funding sources. Between March and January 2011, the project therefore had additional financial support from the Scottish Government (one writer), the Natural Environment Research Council (one writer), the Swedish Research Council Formas (two writers) and Arcadia (one writer).

This collaboration had four positive impacts on the project:

- Ongoing collaborations were established, for example with University of Lund.
- A method of collaborative working was devised that is already being employed to write other synopses in disparate teams.
- The dissemination of results will be wider.
- The writer team enabled us to translate studies from two other languages - German and Swedish.

7. Other issues and unexpected outcomes

Please describe any outcomes of your research, beneficial or otherwise that were not expected at the outset, or other issues which were important to the research but are not addressed in 6 above. Further details should be included in the main report.

Our ability to respond to a Defra consultation on Common Agricultural Policy Reform post 2013 using results from this project was not anticipated, because the reform proposals were not published when the project was planned. The CAP Reform proposals make a small number of specific interventions compulsory rather than voluntary, and these interventions can be matched with interventions in our list for which we have compiled and evaluated evidence. We have prepared a scientific paper on using evidence in policy on the basis of this important science policy interaction.

8. Contributions to the RELU Programme

Please describe your contributions to RELU's overall objectives, and note any impacts on your project resulting from your involvement in the Programme.

This project has mainly contributed to the 'Science' and 'Knowledge Transfer' objectives of RELU.

Science: *To deliver integrative, interdisciplinary research of high quality that will advance understanding of the social, economic, environmental and technological challenges faced by rural areas and the relationship between them.*

The project has developed and tested a new, interdisciplinary method of using science in policy and practice.

Knowledge Transfer: *To enhance the impact of research on rural policy and practice by involving stakeholders in all stages of Relu, including programme development, research activities and communication of outcomes.*

The outputs of this project - the method itself, the set of priorities and most importantly the synopsis of evidence on farmland conservation in temperate Europe - will greatly enhance the impact of research on rural policy and practice.

The project has made the body of existing research relating to farmland conservation highly accessible to all stakeholders, in a format that a number of stakeholders (RELU Visiting Fellows) were involved in designing from the outset. New and forthcoming research can easily be added to the same online information resource and made immediately accessible.

This research is highly relevant to agricultural and rural policies and practices that aim to support biodiversity at all scales from individual farms to overarching European policies such as the Common Agricultural Policy.

Involvement in the RELU Programme helped us in two ways. First, by providing Visiting Fellows from the stakeholder community. These people contributed substantially to the project, for example by providing contact details for practitioners to approach, particularly from Wales and Scotland. Secondly, we used the list of RELU stakeholders directly, when developing the list of practitioners to contact.

9. Nominated Academic Assessor

Please suggest the name of one person who would be suitable to act as an independent academic assessor for your project. Please include a full postal address, e-mail address and telephone number.

Dr Julia Jones
Senior Lecturer in Conservation Biology
School of Environment, Natural Resources and Geography
University of Bangor
Bangor
Gwynedd LL57 2UW

10. **Nominated User Assessor** (Optional)

Please suggest the name of one non-academic user who would be suitable to act as an independent assessor for your project. Please include a full postal address, e-mail address and telephone number.

David Bullock
Head of Nature Conservation
Heelis House
Kemble Drive,
Swindon, SN2 2NA

Linking Evidence and Policy for Managing Biodiversity in the Agricultural Landscape

Research Report

RES-240-25-0006

Background

It is widely accepted that there is a need to make better links between science and policy (Ward *et al.*, 2001; Cohen, 2006; Pawson, 2006; Pretty *et al.*, 2007) and that for environmental issues there is a considerable gap between the generation of results by the research community and the needs of practitioners and policymakers (Lubchenco, 1998; Lawton, 2007; Pretty *et al.*, 2007). When making decisions, it is not unusual for policymakers and practitioners to examine only subsets of possible solutions and to be aware only of subsets of the evidence base (Pullin *et al.*, 2004). There is a similar problem when identifying research priorities. The complete range of possible options has not usually been identified, and the extent to which each option has already been answered by research is not readily determined.

There are good reasons for this disconnect. Many practitioners and policymakers lack access to scientific databases such as the Web of Knowledge or to recently published journal articles. Comprehensive scientific literature searches take more time than such people typically have available, and frequently produce an extensive but largely irrelevant literature. For example, in one review (Stewart *et al.*, 2006) the initial search produced 33,500 papers. After reading each title or abstract, just 38 relevant papers were identified. Practitioners and their advisers almost never have resources for such a task. As a result decisions may be made without recourse to much of the most relevant scientific literature (Sutherland *et al.*, 2004).

There is renewed discussion and debate about the most appropriate management for European farmland and about the best means of maintaining and restoring biodiversity within the agricultural landscape (ACRE, 2007), especially as the Common Agricultural Policy goes through a new process of reform (Commission, 2011). At present advice is offered through advisers and a range of publications. The quantity and quality of the evidence-base used for recommendations are often unclear. While it may sometimes be necessary to make decisions with incomplete evidence (or even no evidence) we believe it is important that practitioners know when they are doing so.

Objectives

The overall goal of this project was to test a novel means of integrating agricultural research and practice. The six specific objectives are listed below, along with a summary of work that has been done to achieve them. Data generated by the project, including scores used to meet Objectives 3 to 5, have been offered to the UK Data Archive as Excel spreadsheets (see Table 6).

1. Identify the comprehensive range of options for managing agricultural land to benefit biodiversity.

This objective has been met. The list of 118 interventions is given in Table 1.

2. Synthesise the published and grey literature to determine the evidence for the effectiveness of these interventions.

This objective has been met collaboratively, with additional financial support from the Scottish Government, the Natural Environment Research Council (Grant reference NE/F008627/1), Swedish Research Council Formas (Grant numbers 215-2009-737 & 210-2009-1680) and Arcadia.

We used a systematic map of literature carried out by collaborators at Harper Adams University College as the starting point, and refined the list of references with our own criteria, as described in the Methods section. Between March and March 2012, nine people worked on summarising a total of 743 individual studies. The database of references and a draft version of the written synopsis of evidence on farmland conservation have been offered to the UK Data Archive. Two interventions from the synopsis have been published on the Conservation Evidence website as a preview.

Final editing and preparation of the synopsis for publication as a book, and online database was not possible in the timeframe of the project. We will complete this work during 2012, and submit the final text to the UK Data Archive.

3. Quantify the importance of the various possible interventions to the practitioners, assess the quality of the evidence relating to each and combine these to derive a novel means of identifying research priorities based upon the mismatch between identified priorities and evidence quality.

This objective has been met. Importance scores for each farmland intervention were gathered from 54 conservation practitioners and policymakers, using an online survey tool. Evidence relating to each intervention was evaluated by an expert panel. Importance scores and expert assessment were combined to identify both research and advocacy priorities (see Tables 4 and 5 in the Results section).

We ran a similar process to identify research priorities from 54 interventions to conserve wild bees in the UK. The results are given in Table 3, and have been published in a scientific paper (Sutherland *et al.*, 2011b), which is presented as a nominated output from the project.

4. Determine the level of awareness of the range of different interventions by practitioners.

This objective has been met. The level of awareness of a subset of 34 interventions relevant to lowland arable farms among 53 conservation practitioners and policymakers was evaluated using an online survey tool. The results are described in the Results section (Figure 2).

5. Assess the perceptions of the quality of evidence by practitioners prior to our review and compare with the actual evidence quality.

This objective has been met. Perceptions of 53 practitioners and policymakers of available scientific evidence for a subset of 34 interventions relevant to arable farms were evaluated using an online survey tool. These were compared with our expert assessment of the certainty of knowledge based on compiled evidence (see Figure 4). We also assessed the level of practitioner knowledge about what the evidence tells us, as well as how much evidence there is (see Figure 5).

6. Assess how successful this process is considered by practitioners and those involved in identifying research priorities.

This objective has been partially met. We have begun gathering evidence of the impact of our outputs as written case studies. We have not been able to assess the usefulness of the approach as applied to farmland conservation, because the outputs from the project are not yet prepared in their final accessible format.

Methods

Ethics statement

The Cambridge Psychology Research Ethics Committee has given ethical approval to this research project. Each practitioner who took part gave us their informed written consent, either by signing a consent form or by ticking an obligatory consent box in an online survey.

Developing a list of interventions for farmland conservation

A list of interventions to conserve wildlife on farmland was developed collaboratively by a team of thirteen experts (see *Interdisciplinarity* for information about these people). An initial list of interventions based on agri-environment options available in UK countries was circulated among the group, discussed and amended at two project meetings in November and December 2010. A number of interventions that are not currently agri-environment options were added during this process, such as 'Provide nest boxes for bees (solitary or bumblebees)' and 'Implement food labelling schemes relating to biodiversity-friendly farming'.

Interventions relating to the creation or management of habitats not considered commercial farmland (such as lowland heath, salt marsh and farm woodland) were removed, although use of such habitats for grazing commercial livestock could be included under the intervention 'Employ semi-natural areas for rough grazing'.

The language used for interventions was chosen to be non-judgemental and understandable to a wide range of practitioners. We choose awareness over education, for example, wildlife over biodiversity and agricultural chemicals over pollution. The intervention 'Introduce agri-environment schemes generally' was changed to 'Pay farmers to cover the cost of conservation measures (as in agri-environment schemes)'. The intervention 'Control perennial weeds in nature conservation areas' was changed to 'Control injurious weeds without damaging other plants in nature conservation areas'.

The list was organised into categories based on the International Union for the Conservation of Nature (IUCN) classifications of direct threats and conservation actions. To make it more accessible to the agricultural community, we grouped the interventions that fell under the threat category 'Agriculture' by farming system, with separate sections for interventions that apply to arable or livestock farms, or across all farming types.

Reviewing and summarising the scientific literature

We began with the list of 1,157 references identified by collaborators at Harper Adams University College for a systematic review on the effectiveness of agri-environment schemes as interventions for conserving biodiversity in temperate Europe (http://www.environmentalevidence.org/SR35.html). This list of references was drawn up using a peer-reviewed search protocol (see Box 1) and included reviews and unpublished reports. It is soon to be published as a systematic map[1] in the journal *Environmental Evidence*. It was passed to

[1] A systematic map identifies relevant studies, based on abstracts, but does not describe or synthesize their results

us in December 2010, after non-relevant and duplicate studies had been removed, but before its publication online.

Box 1 Initial search protocol
Ten online databases were searched (ISI Web of Knowledge, Science Direct, Blackwell Synergy, Ingenta Connect, Index to Theses Online, CAB Abstracts, Centre for Ecology and Hydrology online database, ConservationEvidence.com, Defra online database, NERC Open Research Archive) using the following search terms:

Farm* AND biodiversity
Organic AND biodiversity
Farm* AND diversity or abundance not fish
Agri-environment*
Farmland or farming AND bird*
Farm* AND invertebrate* not fish
Agri-environment* AND biodiversity

Following peer review of the systematic map, a further search was carried out using the following term:

Farmland or farming AND mammal or reptile or amphibian

Each of the 1,157 references was assessed, consulting the full text where possible. Those matching the following two criteria were included in our synopsis of evidence:

1 - There was an intervention that conservationists would do to benefit wildlife on actively farmed land
2 - The effects of the intervention were monitored quantitatively.

These criteria exclude studies examining the effects of specific interventions without actually doing them. For example, predictive modelling studies and studies looking at species distributions in areas with longstanding management histories (correlative studies), were excluded. Such studies can suggest that an intervention could be effective, but do not provide direct evidence of a causal relationship between the intervention and the observed biodiversity pattern.

The project team agreed to exclude from the synopsis studies relating to organic and integrated farming. These interventions were considered to be combinations of farm management techniques, rather than single interventions. Where the actual intervention (for example, reduced agri-chemical use) was clearly defined, the studies were included under that specific intervention. Studies monitoring the uptake of agri-environment schemes, but not their effects on wildlife, were also excluded.

References providing evidence on organic farming (149 references), integrated farm management (29 references), uptake of agri-environment schemes (12 references) and correlative evidence on any intervention (139 references) were labelled and retained in an Endnote database. A strategy was agreed to summarise and include these studies in the synopsis if time allowed during the course of the project, in the following order of priority: 1) organic and integrated farming; 2) correlative evidence; 3) uptake. Unfortunately, time did not allow the project to progress to this stage.

The strategy for studies published in more than one place was to summarise the most recent, but refer to the other publications (except for PhD theses, conference proceedings and Defra reports unavailable online, which are not referred to if their main findings are published subsequently).

Altogether we excluded 569 studies. The remaining 588 studies were given unique reference numbers, and catalogued in an Excel spreadsheet allocated to interventions they tested. This spreadsheet was kept updated throughout the writing process. Additional studies published or completed in 2010 or before were added if recommended by the expert team or identified within the literature during the summarising process. We also searched the Conservation Evidence database using the new Sphinx[2]-driven advanced search facility (designed and built during 2011, not available when the systematic review was conducted), for studies from Europe on arable or pasture land. This yielded an additional 38 relevant studies.

In total, 765 individual publications or reports were identified for inclusion in the synopsis.

Each reference that we could access the full text of was summarised in plain English (200-300 words). Shorter paragraphs (150 words) were written about each intervention tested, for inclusion in a synopsis of evidence on farmland conservation in temperate Europe. A team of nine writers worked on this between March and December 2011, with additional financial support from the Scottish Government, the Natural Environment Research Council (Grant reference NE/F008627/1), Swedish Research Council Formas (Grant numbers 215-2009-737 & 210-2009-1680) and Arcadia. Two
writers were German and Swedish nationals, enabling us to translate any studies written in German or Swedish.

Between October and January 2011, a tenth writer worked voluntarily to compile summary key messages for each intervention and another volunteer intern worked on adding the text to the Conservation Evidence.com online database. Both of these processes are ongoing.

Setting research priorities: a study on wild bee conservation

We tested our approach to setting research priorities using a previously completed synopsis of evidence on wild bee conservation (Dicks *et al.*, 2010). From this, we identified 54 interventions that could benefit wild bee populations in the UK, based on our own knowledge, the literature and advice from an international seventeen-member advisory board (these advisers are named in (Dicks *et al.*, 2010).

We provided the list of interventions to a group of people who use research on bee conservation. We used purposive sampling (subjective sampling with a purpose) as described by Sutherland *et al.* (2011a) to invite a diverse set of suitable practitioners. They should be considered a consulted group (referred to here as 'practitioners'), rather than an attempt to sample the full population of people with an interest in bee conservation. The sample was stratified to represent as much of the UK as possible, and to represent what we consider to be the important interest groups in the policy and practice of bee conservation - national and local policymakers, conservation NGOs (Non-Governmental Organisations), farmers, farm adviser and consultants, and researchers.

We initially approached 113 practitioners. They comprised ecological consultants with an interest in insect conservation identified from the Institute of Ecology and Environmental Management

[2] Sphinx is an open-source search server http://sphinxsearch.com

online members database, representatives from key UK conservation agencies and Government environment departments (Natural England, the Northern Ireland Department of Environment The Rural and Environment Directorate of the Scottish Government, the Countryside Council for Wales, the Department for Environment Food and Rural Affairs), representatives from UK NGOs with an interest in insect conservation (including Buglife, Butterfly Conservation, The Bumblebee Conservation Trust and the Bees, Wasps and Ants Recording Society), researchers working on issues related to bee conservation and members of the Association of Local Government Ecologists (one from each county was approached, selected at random from the online database of members). In thirty cases, our initial contact suggested someone else with more appropriate experience and knowledge.

These people were asked to allocate 1,000 points between the different interventions, according to how they consider each action should be prioritised. The order in which interventions were presented was varied by using four different score sheets were used, in which the categories were presented in a different order. The re-ordering was done systematically, by reversing the order or switching the middle categories to the outside for both the original and reversed order, so that each intervention appeared in a range of positions, near the beginning, near the end or somewhere in the middle of the list.

For each intervention an importance score (called 'priority score' in Sutherland *et al* 2011b) was generated by taking a mean score across all practitioners.

Three experts in bee ecology and conservation (Lynn Dicks, Dave Goulson and Simon Potts) assessed the evidence for each intervention - evaluating 159 individual publications in total.

Certainty of knowledge about the effectiveness of each intervention in benefitting wild bee populations was scored on a percentage scale (0% = no useful evidence presented, 100% = fully resolved). The experts generated scores using an approach based on the Delphi technique (Sutherland, 2006). They initially scored independently and all the scores were shown to all three experts. Each intervention was discussed at a one day workshop, during which the experts independently adjusted their scores. A mean score across the three experts was used as the final score for each intervention or publication.

To test for differences in scoring between scorers, or according the order of presentation of interventions, we ran a Principal Components Analysis on the scorers' results (44 scorers, 54 variables for each), using a correlation matrix so the variables were given equal weight. We used analysis of variance on the first two principal component axes scores to test for any difference between scorers according to the scoresheet they used, or the practitioner group they belonged to.

To identify interventions that should be research priorities, we plotted the interventions by certainty of knowledge score (the extent to which the issue is solved) and importance to practitioners. Interventions that are largely unsolved but assigned high priorities, in the bottom right quadrant of the plot, can be considered research priorities.

As part of this study on wild bee conservation interventions, we used the priority and certainty of knowledge scores to develop a quantitative measure of impact for each individual publication, according to its contribution to knowledge on each intervention. More details of this method are given by Sutherland *et al.* (2011).

Setting research priorities for farmland conservation: Practitioner questionnaire

We consulted practitioners using an online survey, built using the tool Survey Monkey.

We devised the following five questions about each intervention.

Question	Answer options
1. Have you heard of this?	Yes or no
2. Assuming it benefits wildlife, how important is this intervention for conservation on farmland?	Scale 1 (not important) to 5 (very important)
3. Have you ever used it, or been involved in implementing it?	Yes or no
4. In your opinion, does this intervention benefit wildlife?	Yes, no or don't know
5. How much scientific evidence do you think there is about whether this benefits wildlife?	Scale 1 (no evidence) to 5 (excellent scientific understanding) or don't know

To check the list of interventions was understandable, we ran a pilot survey on 20 Harper Adams agriculture students. This contained Questions 1 and 3 only. In response to comments on this pilot survey, we removed the intervention 'Create buffer strips around GM crops', because GM crops are not grown commercially in the UK.

The project team agreed that sending a list of 118 interventions, with five questions about each, would be poor practice and unlikely to be effective. Four options were considered for shortening the list:

OPTION 1 - Allow consultees to choose subsections of the list according to interest.
OPTION 2 - Reduce the list by amalgamating interventions.
OPTION 3 - Ask all five questions about a fixed subset of the list and only Question two about the full list.
OPTION 4 - Ask all five questions about a randomly allocated subset of the list (different each time), and only Question two about the full list.

It was considered necessary to ask Question 2 about the full list in order to meet the third project objective of setting research priorities based on the state of scientific knowledge. This rules out option 2. Options 1, 3 and 4 allow analysis of awareness levels and perception of evidence for a subset of the interventions only. Of these, option 3 was considered the most likely to generate unbiased results with sample sizes amenable to analysis.

We used a non-random subset of 34 interventions relevant on lowland arable farms to ask all five questions. These were a selected from the 'Arable' and 'All farming types' sections of the list to represent a wide range of scientific knowledge levels (number of relevant studies ranging from 0 to 105) and levels of awareness identified in the pilot survey.

The five questions formed part 1 of the survey, with one intervention per page. The following three parts of the survey listed interventions for i) all farming types, ii) livestock or mixed farms and iii) interventions relevant to particular species or habitats, and asked Question 2 only. A copy of online survey (version A) used in the study is provided as Annex A.

The order in which interventions were presented was varied to avoid bias according to question order. Four different versions of the survey were distributed in equal number, with categories and interventions presented in different orders. The re-ordering was done systematically, as before, so that each intervention appeared in a range of positions, near the beginning, near the end or in the middle of the list.

When the survey was circulated to an email list (Farming and Wildlife Advisory Group), four links were sent in the invitation email. Respondents were directed to use different links according to the initial letter of their surname.

Printed paper or electronic pdf versions of each survey were offered to all practitioners. A reduced version of the survey with the full list of interventions but Question 2 only, was constructed as a shorter option if needed.

How we selected practitioners

Again, we used purposive sampling (subjective sampling with a purpose) to invite a diverse set of suitable practitioners. They should be considered a consulted group of conservation practitioners and advisers (referred to here as 'practitioners'). We did not attempt to sample the full population of people with an interest in farmland conservation.

Our sample was stratified to represent as much of the UK as possible, and to represent what we consider to be the important interest groups in the policy and practice of farmland conservation - national and local policymakers, conservation NGOs, farmers, farm advisers and consultants, and researchers. We did not include farmers, land manager or farm advisers not directly involved with wildlife conservation in farmland.

The initial list was compiled from the following groups:

- Stakeholder or adviser groups convened to develop agri-environment schemes in Wales and Scotland (we did not find similar groups for England and Northern Ireland)
- Farmland specialists from national Biodiversity Action Plan forums or stakeholder groups for Wales and Scotland (we could not find equivalent groups for England and Northern Ireland)
- Relevant people selected from the list of 645 'land' stakeholders gathered by the Rural Economy and Land Use Programme. We selected national and local/regional policymakers, NGO representatives, farmers, consultants or advisers with relevant interests (including Rural Development Programme for England managers, for example, but not local authority Chief Executives or economists).
- Members of the Institute of Ecology and Environmental Management (IEEM) arising from a search for 'agri-environment' specialists on the website, or contacting us following an article in their magazine *In Practice*.
- Personal contacts of the project team. These were national, regional and local policymakers, and practitioners engaged with wildlife conservation.
- Finally, we contacted the Campaign for the Farmed Environment and the Farming and Wildlife Advisory Group (FWAG) to ask for further contacts or access to their email lists. The survey was circulated on a newsletter to all FWAG staff - approximately 90 advisers.

The final list included 290 conservation-oriented farmers, farm advisers, ecological consultants, local government policymakers, conservationists from non-governmental organisations and non-departmental public bodies. Of these, we successfully contacted 253.

We ran a Principal Components Analysis on the practitioner importance scores (responses to Question 2; 54 scorers, 118 variables for each), using a correlation matrix so the variables were given equal weight. We used analysis of variance on the first two principal component axes scores to test for any significant difference between the four groups of scorer: policymakers (national and local/regional), NGOs, farmers and farm advisers/ consultants.

Setting research priorities for farmland conservation: Expert assessment of evidence

We evaluated the certainty of knowledge and what is known about the outcome of each intervention based on the compiled evidence, using a Delphi-like expert assessment process of iterative scoring with discussion. Ten experts did this scoring (see *Interdiscplinarity* for more details). The experts were given a summary of the evidence available, in the form of a draft synopsis with references, and asked two questions about each intervention:

1 - How much do we understand the extent to which this intervention benefits wildlife on farmland? [A percentage scale, 0 = no evidence, 100% = certainty].

2 - Based on the evidence presented, does this intervention benefit wildlife? [Yes, no or don't know].

Each expert initially scored independently. During the first round of scoring, guidance was developed on how to score, in response to queries from the experts. This guidance is presented in Box 2.

BOX 2 Guidance given to experts on how to score

How to deal with evidence from target vs non-target groups

Score for whether there is an overall benefit, particularly to the group or groups of wildlife that are important beneficiaries (skylarks for skylark plots, or flower-visiting insects for nectar and pollen mix). Non-target groups that benefit incidentally also count towards the score if there is evidence, but with less weight. How you account for lack of evidence about non-target groups depends on how important you consider the effects on non-target groups to be in achieving 100% certainty.

For example, if there were no studies on the effects of skylark plots on skylarks but several studies showing the grass snakes and rare arable flowers use the plots, this would count as some, but low, certainty of knowledge. If however, there were 25 studies showing an increase in skylark populations in the landscape following the introduction of skylark plots, but declining populations in areas without skylark plots, this might be a contender for 100% knowledge. However, if you rate the plots as a conservation measure for rare arable flowers as well, you might consider the lack of evidence on this group prevents knowledge from reaching certainty.

How to assess evidence that is only part of the answer

Score according to what we know about whether the ultimate objective of the intervention is being achieved - this is usually an increase in healthy populations or area of habitat. Knowledge about whether the intervention serves its proximate purpose, such as whether birds or insects use the resource provided, should not provide full certainty.

How to deal with mixed evidence/mixed benefits

If there are benefits to some groups and no benefits or adverse effects on other groups, it is up to your judgement to decide whether the answer to the question 'Does it benefit wildlife?' is 'yes' or 'don't know'. This will depend to

some extent on the size of the effects - a massive positive impact on a target group, and a tiny adverse effect on a non-target group might get a 'yes', whereas a tiny positive effect on the target group and a massive adverse effect on a non-target group might get 'no' or 'don't know'.

You can think of it as: would you advise this is a course of action for wildlife conservation on farmland, based on the evidence presented?

Round two of the scoring took place during a one day workshop in November 2011. All the scores for each intervention were shown anonymously to each expert. Certainty scores (Question 1) were arranged in rank order rather than in the order of scorers. The number of yes, no and don't know answers were presented. Each intervention was discussed in turn, and the experts independently adjusted their scores. Those who had given an outlying score in the first round were not identified, and could choose whether or not to defend their position during this discussion. A mean second round score across the ten experts was used as the final certainty score for each intervention.

During this process, 31 interventions were excluded from further evaluation because the expert group felt the relevant literature was not adequately covered by our reviewing method. This is discussed in more detail in the Results section. It left 85 interventions for which evidence was evaluated.

We identified research priorities more accurately than in the wild bee conservation study, by calculating an index of research priority *(RPI)* based on the geometric distance of each intervention from maximum importance, minimum certainty of knowledge, using simple Pythagorean geometry. The shorter the distance, the higher the research priority. For each intervention *RPI* is calculated as follows:

Equation 1

$$RPI = \frac{1}{\sqrt{\left(\left(c/20\right)^2 + (5-i)^2\right)}}$$

Where *RPI* = Research Priority Index, c = certainty score, i = importance score.

We also identified interventions that could be considered advocacy priorities using an index of advocacy priority *(API*, calculated using Equation 2*)*, based on the geometric distance from maximum importance, maximum certainty of knowledge. The shorter the distance, the higher the advocacy priority. Interventions were only identified as advocacy priorities if they had unanimous agreement among experts of a benefit to wildlife.

Equation 2

$$API = \frac{1}{\sqrt{\left(\left(5-\left(c/20\right)\right)^2 + (5-i)^2\right)}}$$

Website development and re-design

As part of this project, co-funded by Arcadia, we have re-designed the Conservation Evidence website (www.ConservationEvidence.com). The website was previously able to carry the farmland synopsis and individual summaries of studies in a searchable database format, but the synopsis and individual studies were not linked, the search engine was poor and there were no facilities to download references or synopsis text, or link to other websites.

We worked with a web design company throughout the 2011 to rebuild the site, including the underlying database. We re-structured the database to meet data exchange standards proposed by the Conservation Measures Partnership[3], so that information from the site can be more easily shared with other websites and databases.

Interdisciplinarity

The project team incorporated academics from rural social science (Ian Hodge, Jules Pretty) and ecology or conservation science (William Sutherland, Lynn Dicks, Henrik Smith, Gavin Siriwardena, Will Peach, Jörn Scharlemann, Nicola Randall, Rebecca Smith) and agricultural policy analysts working in the private or public sector (Clunie Keenleyside, Alison McKnight and Susan Turpie). The latter were all RELU Visiting Fellows assigned to the project.

These people were all directly involved in compiling the list of interventions and the questionnaire sent to practitioners. All except Susan Turpie, Alison McKnight and Jules Pretty were also involved in the Expert Group that conducted an assessment of the evidence. Therefore, each methodological stage of the project was carried out by a multi-disciplinary team.

During this project we have developed, tested and refined an interdisciplinary method for setting research and advocacy priorities, based on thorough synthesis and expert evaluation of existing evidence combined with the identification of key societal concerns by practitioners. The method combines elements of the Delphi process, developed in the social sciences for refining expert judgments and forecasting (Rowe and Wright, 1999;Bolger *et al.*, 2011), with review methods developed in the medical and natural sciences (Higgins and Green, 2011) and the use of online survey techniques (Dillman *et al.*, 2009).

Results

Synopsis of evidence on farmland conservation

The full list of 118 interventions is given in Table 1.

In total, 765 studies were identified for inclusion in the synopsis of evidence. 743 have been summarised. These studies each provide evidence for between 1 and 13 interventions. The remaining 22 were either incomplete references that could not be found, or were inaccessible (such as PhD theses costing over £100 to have scanned) or written in a language that our team could not translate, such as Danish.

The mean number of studies providing evidence for each intervention was 9.98 (range 0-105). The intervention with the highest number of relevant studies was 'Plant nectar flower mixture/wildflower strips'. For 40 interventions, we found no evidence.

[3] http://www.conservationmeasures.org/initiatives/standards-for-project-management

Key to symbols in Table 1

† Interventions used in the arable farming subset to assess patterns of knowledge amongst practitioners.

∝ Interventions for which experts felt a substantial amount of correlative evidence was excluded from the process.

⊗ Interventions excluded from priority-setting because experts felt evidence was unlikely to have been fully captured by the review process. Also marked are two interventions excluded from full synthesis of evidence (see Methods section).

Table 1 Full list of interventions to benefit wildlife on farmland. Interventions are grouped into categories based on the farming system and the threat or action.

Category	Name of intervention
All farming systems	Support or maintain low-intensity agricultural systems[∝]
	Practise Integrated Farm Management[⊗]
	Increase the proportion of natural or semi-natural habitat in the farmed landscape[∝]
	Pay farmers to cover the costs of conservation measures (as in agri-environment schemes)[†]
	Use 'cross compliance' environmental standards linked to all subsidy payments[†]
	Implement food labelling schemes relating to biodiversity-friendly farming (organic, LEAF marque)
	Reduce field size (or maintain small fields)[† ∝]
	Provide (or retain) set-aside areas in farmland[†]
	Connect areas of natural or semi-natural habitat[∝]
	Manage hedges to benefit wildlife (includes no spray, gap-filling and laying)[†]
	Manage stone-faced hedge banks to benefit wildlife
	Manage ditches to benefit wildlife[†]
	Restore or maintain dry stone walls
	Plant new hedges
	Protect in-field trees (includes management such as pollarding and surgery) [†]
	Plant in-field trees (not farm woodland)
	Maintain in-field elements such as field islands and rockpiles[†]
	Manage woodland edges to benefit wildlife
	Plant wild bird seed or cover mixture[†]
	Plant nectar flower mixture/wildflower strips[†]
	Manage the agricultural landscape to enhance floral resources[†]
	Create uncultivated margins around intensive arable or pasture fields[†]
	Plant grass buffer strips/margins around arable or pasture fields[†]
	Provide supplementary food for birds or mammals
	Make direct payments per clutch for farmland birds
	Provide other resources for birds (water, sand for bathing)
	Mark bird nests during harvest or mowing
	Provide refuges during harvest or mowing
	Provide foraging perches (e.g. for shrikes)

Category	Name of intervention
	Provide nest boxes for birds
	Provide nest boxes for bees (solitary bees or bumblebees)
	Introduce nest boxes stocked with solitary bees[⊗]
	Provide red squirrel feeders[⊗]
	Provide otter holts[⊗]
	Provide badger gates[⊗]
Arable farming	Increase crop diversity[†∝]
	Implement 'mosaic management', a Dutch agri-environment option
	Take field corners out of management[†]
	Leave overwinter stubbles[†∝]
	Create beetle banks[†]
	Plant nettle strips
	Leave unharvested cereal headlands within arable fields[†]
	Leave uncropped, cultivated margins or plots (includes 'lapwing plots') [†]
	Plant crops in spring rather than autumn[†∝]
	Undersow spring cereals, with clover for example[†]
	Create rotational grass or clover leys by undersowing spring cereals
	Convert arable land to permanent grassland[†]
	Reduce tillage[†]
	Add 1% barley into wheat crop for corn buntings[†]
	Create corn bunting plots[†]
	Create skylark plots[†]
	Plant cereals in wide-spaced rows[†]
	Re-establish rare or declining arable weeds[†]
	Use new crop types to benefit wildlife (such as perennial cereal crops)
Perennial (non-timber) crops	Maintain traditional orchards[⊗]
	Restore or create traditional orchards[⊗]
	Manage short-rotation coppice to benefit wildlife (include 8 m rides) [⊗]
Livestock farming	Maintain species-rich, semi-natural grassland[∝⊗]
	Restore or create species-rich semi-natural grassland[†]
	Add yellow rattle seed (*Rhinanthus minor*) to hay meadows[⊗]
	Reduce management intensity on permanent grasslands (several interventions at once)
	Raise mowing height on grasslands
	Delay mowing or first grazing date on grasslands
	Use mowing techniques to reduce mortality
	Reduce grazing intensity on grassland (including seasonal removal of livestock)
	Leave uncut strips of rye grass on silage fields
	Plant cereals for whole crop silage
	Maintain rush pastures[∝⊗]
	Maintain traditional water meadows (includes management for breeding and/or wintering waders/waterfowl) [∝⊗]
	Restore or create traditional water meadows[⊗]
	Maintain upland heath/moorland[∝⊗]

Category	Name of intervention
	Restore or create upland heath/moorland[⊗]
	Plant Brassica fodder crops (grazed i*n situ*)
	Use mixed stocking
	Use traditional breeds of livestock
	Employ areas of semi-natural habitat for rough grazing (includes salt marsh, lowland heath, bog, fen) [∝⊗]
	Maintain wood pasture and parkland[∝⊗]
	Restore or create wood pasture
	Exclude livestock from semi-natural habitat (including woodland)
	Mark fencing to avoid bird mortality[⊗]
Residential & commercial development	Maintain traditional farm buildings
	Provide bat boxes, bat grilles, improvements to roosts
	Provide owl nest boxes (Tawny owl, Barn Owl)
Agri-chemicals	Convert to or maintain organic farming systems[⊗]
	Leave headlands in fields unsprayed (conservation headlands)[†]
	Buffer in-field ponds[⊗]
	Provide buffer strips alongside water courses (rivers and streams)
	Reduce chemical inputs in grassland management
	Restrict certain pesticides[⊗]
	Make selective use of spring herbicides[⊗]
	Use organic rather than mineral fertilizers[†]
	Reduce fertilizer, pesticide or herbicide use generally[†]
Transport & service corridors	Manage land under power lines to benefit wildlife
Hunting and trapping (for pest control, food or sport)	Avoid use of lead shot[⊗]
	Provide 'sacrificial' grasslands to reduce the impact of wild geese on crops
	Use scaring devices (eg gas guns) and other deterrents to reduce persecution of native species
	Enforce legislation to protect birds against persecution
	Use alerts to reduce grey partridge by-catch during shoots
Natural system modification	Manage heather by swiping to simulate burning[⊗]
	Mange heather, gorse or grass by burning[⊗]
	Raise water levels in ditches or grassland
	Remove flood defence banks to allow inundation
	Re-wet moorland[⊗]
	Create scrapes and pools
Invasive & other problematic species	Control invasive non-native plants on farmland (such as Himalayan Balsam, Japanese knotweed)
	Control bracken[⊗]
	Control scrub[⊗]
	Control weeds without damaging other plants in conservation areas
	Control grey squirrels[⊗]
	Control mink[⊗]

Category	Name of intervention
	Control predatory mammals and birds (foxes, crows, stoats and weasels)
	Protect individual nests of ground-nesting birds
	Erect predator-proof fencing around important breeding sites for waders
	Remove coarse fish[⊗]
	Manage wild deer numbers[⊗]
	Provide medicated grit for grouse[⊗]
Education & awareness	Provide training for land managers, farmers and farm advisers[†]
	Provide specialist advice to farmers and land managers[†]

Practitioner survey for farmland interventions

Our survey of farmland interventions was completed by 54 respondents (Table 2). This is an estimated response rate of 15.7%, if you include 90 FWAG advisers in the number of people contacted. Four respondents took up the offer of a printed paper or pdf version, and posted their completed surveys in hard copy. Forty-nine completed the full survey online. One respondent asked for a reduced version of the survey with the full list of interventions but Question 2 only.

Of the 18 farmers who completed the survey, 17 had medium or large (>50 ha), lowland arable or mixed farms. One was a livestock farmer with a large upland farm (>100 ha).

Figure 1 shows the results of our initial Principal Components Analysis (PCA) with respondents identified by scorer group. Analysis of variance showed no significant differences between scorer groups (p=0.937 for axis 1 values, p=0.444 for axis 2 values). This analysis was limited to 22 scorers by missing values, which were frequent in the dataset due to the size of the questionnaire (32 respondents had missing values). We plan to develop the analysis further using imputed values to include all 54 respondents before publishing the research.

Table 2 Respondents to survey of farmland conservation interventions

Group	Number of respondents
Policymakers (national and regional/local)	9
NGO representatives	15
Farmers	18
Advisers/consultants	11
Anonymous	1
TOTAL	**54**

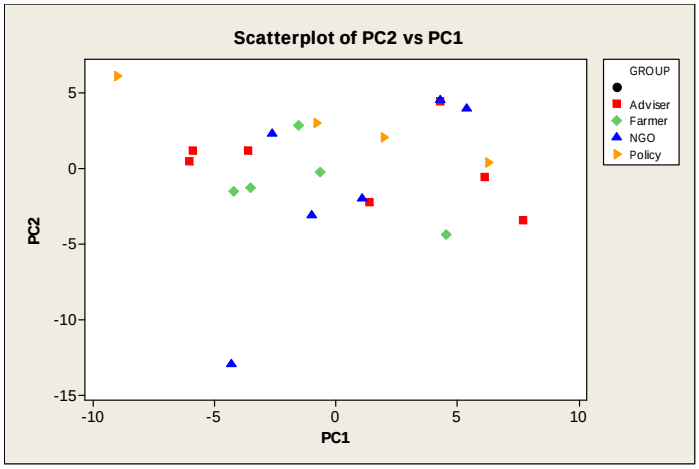

Figure 1 First two principal components axis scores for scorers of farmland interventions

Level of awareness of farmland interventions among practitioners

Of the 34 interventions relevant to lowland arable farms, respondents had heard of an average of 29.3 (responded 'yes' to Question 1; see Figure 2). This demonstrates a high level of awareness of different interventions. There was no significant difference between groups (Kruskal-Wallis test p-value = 0.5937). The greatest variation in awareness level was amongst farmers. One farmer had only heard of 12 of the 34 interventions, another had heard of all of them. The single upland livestock farmer in the group had heard of all 34 interventions.

Only two interventions had not been heard of by more than half of the respondents (>27). These were 'Add 1% barley into wheat for corn buntings' and 'Create corn bunting plots'. These are specific interventions being tested or considered by either an individual farmer or the RSPB. They have not been widely recommended.

Expert assessment of evidence

Figure 3 shows how expert assessment of the certainty of knowledge about each intervention increased with the number of publications (or references), both for wild bee conservation and farmland conservation.

During the workshop that accompanied the second round of expert scoring for farmland interventions, the experts felt strongly that evidence for some interventions was unlikely to have been captured by our review process. Two main reasons were identified for this:

- The intervention does not usually occur on commercially active farmland
- The initial search protocol is likely to have either missed or excluded much of the relevant evidence

To avoid misleading results, we excluded such interventions from further analysis. This led to the exclusion of a further 31 interventions (in addition to organic and integrated farming, which had already been excluded). We therefore present results for 85 interventions. The interventions excluded are marked ⊗ in Table 1.

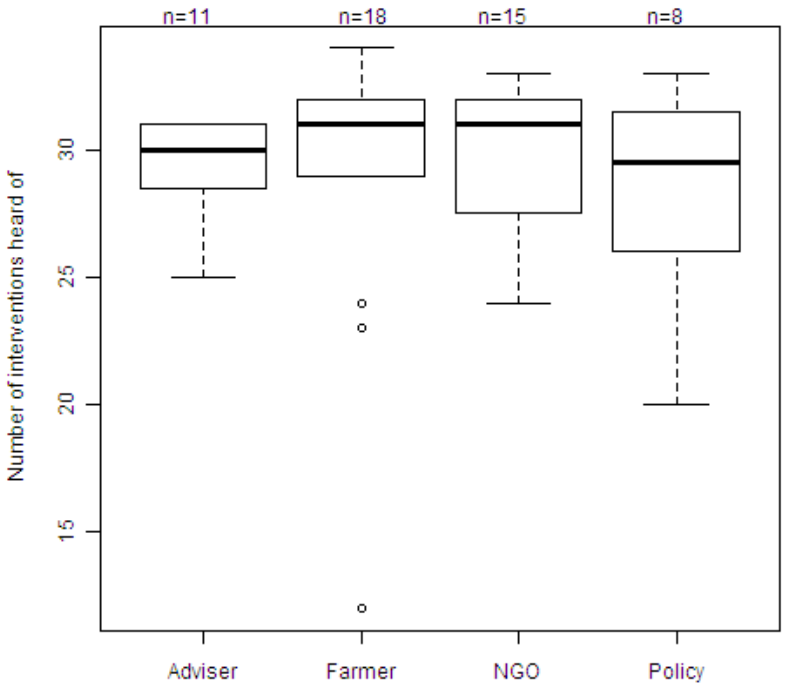

Figure 2 Number of arable farming interventions that each group said they had heard of (responded 'yes' to the question 'Have you heard of this?'). From a subset of 34 interventions.

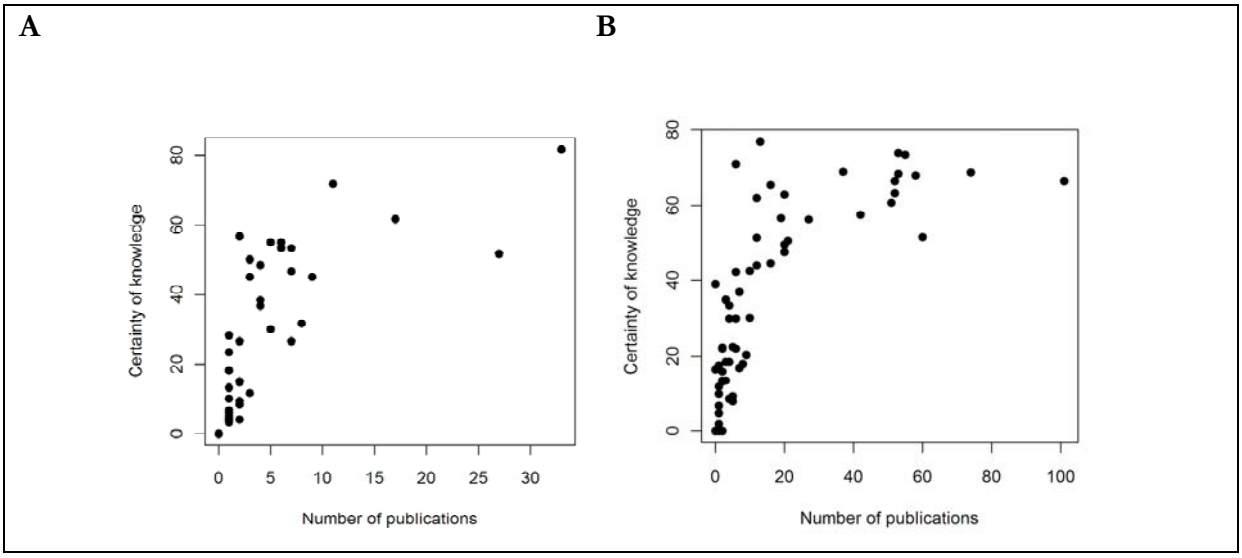

Figure 3 Acquisition of knowledge: Certainty of knowledge as assessed by experts, plotted against number of individual references found for each intervention. A for wild bee conservation; B for farmland conservation.

The expert group also identified 13 interventions for which they felt a substantial amount of relevant correlative evidence had been excluded from our process because it did not meet the criterion for the intervention to have been carried out. We retained these interventions in the assessment process if this was the only issue with them. They are marked ∝ in Table 1. For these interventions, it is important to stress that our priorities have been identified on the basis of direct experimental evidence only.

Comparison of expert assessment of evidence base with practitioner knowledge

We found a good correlation between expert assessment of the evidence (% certainty of knowledge) and practitioners' knowledge of how much evidence exists (Figure 4, Spearman rank correlation coefficient *rho*=0.56, p=0.0006).

However, when practitioners and experts were asked whether the interventions benefit wildlife, practitioner opinions (without access to our synthesis of evidence) do not correlate well with expert assessment of the evidence, at least at the 5% significance level (Figure 5, Spearman rank correlation coefficient *rho* =0.33, p=0.09966). This suggests that whilst the practitioners know where there has been research, they do not know or understand what the findings of that research are.

This suggestion is further supported when we compare how experts and practitioners responded to the question 'Does this intervention benefit wildlife?' for individual interventions (Figure 6). This is possible for 25 interventions. We captured no evidence for nine of the 34 selected lowland arable interventions, so we have no expert assessment for them.

Figure 6 shows disagreement between practitioner knowledge and expert assessment of evidence for some interventions. Of the eight interventions for which experts unanimously agreed the evidence demonstrated a benefit to wildlife, none received similar unanimous agreement of a benefit to wildlife from practitioners. The least agreement was for 'Create skylark plots' and 'Use organic rather than mineral fertilizers', for which 17% and 15% of practitioners respectively felt there was no benefit to wildlife.

The only intervention that practitioners unanimously answered 'yes, this intervention benefits wildlife' was 'Pay farmers to cover the costs of conservation measures'. Expert assessment of evidence was less certain about this, with four of the ten experts responding 'don't know'.

There were two interventions that the majority of experts felt did not benefit wildlife, according to the evidence - 'Plant cereals in wide-spaced rows' and 'Convert arable land to permanent grassland'. For the intervention 'Increase crop diversity', experts unanimously responded 'don't know', although 74% of practitioners answered 'yes, this will benefit wildlife'.

Increasing crop diversity is a compulsory greening elements in the proposed reformed Common Agricultural Policy (European Commission, 2011; Defra, 2011), so the strong mis-match between our assessment of evidence and practitioner opinion is of particular interest for this intervention.

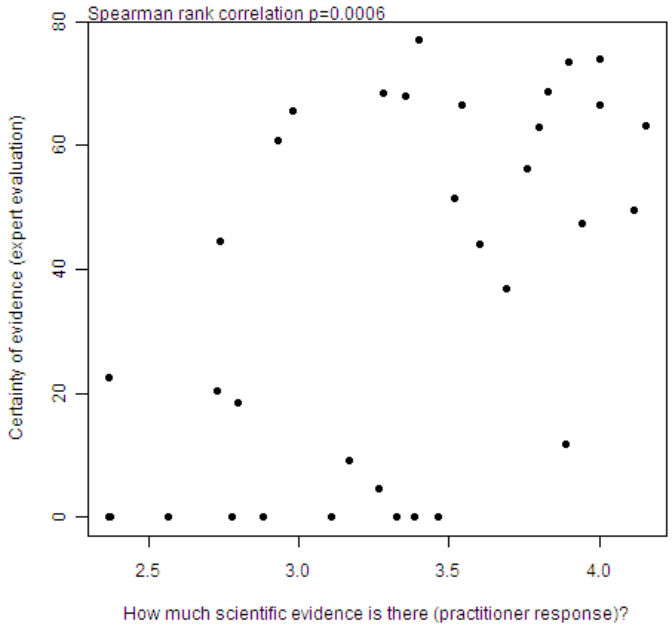

Figure 4 Comparison of expert and practitioner assessment of the amount of scientific knowledge about each intervention. Mean certainty of evidence (%) score is plotted against mean practitioner response to the question: 'How much scientific evidence do you think there is about whether this benefits wildlife?', scored between 1 (no evidence) and 5 (excellent scientific understanding).

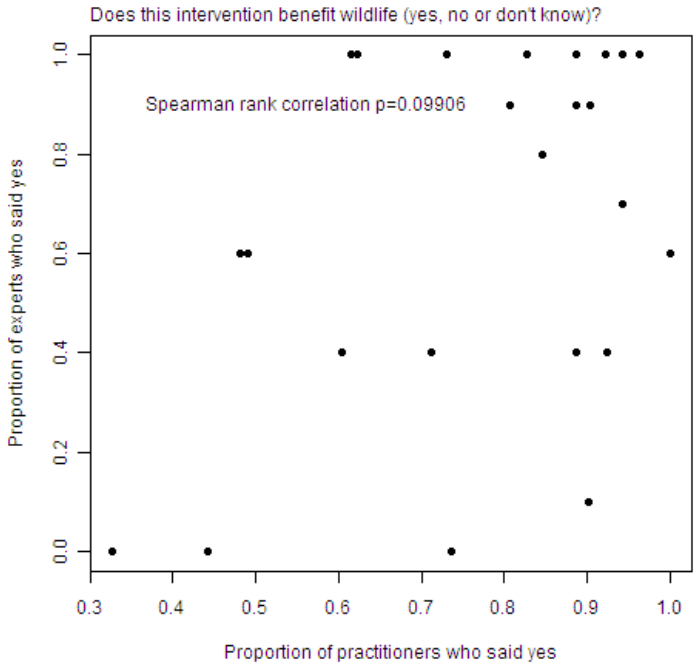

Figure 5 Comparison of expert and practitioner responses to the question 'Does this intervention benefit wildlife?', showing the proportion of each group who responded 'yes'. Practitioners were asked to respond in their own opinion. Experts were asked to respond based on evidence presented.

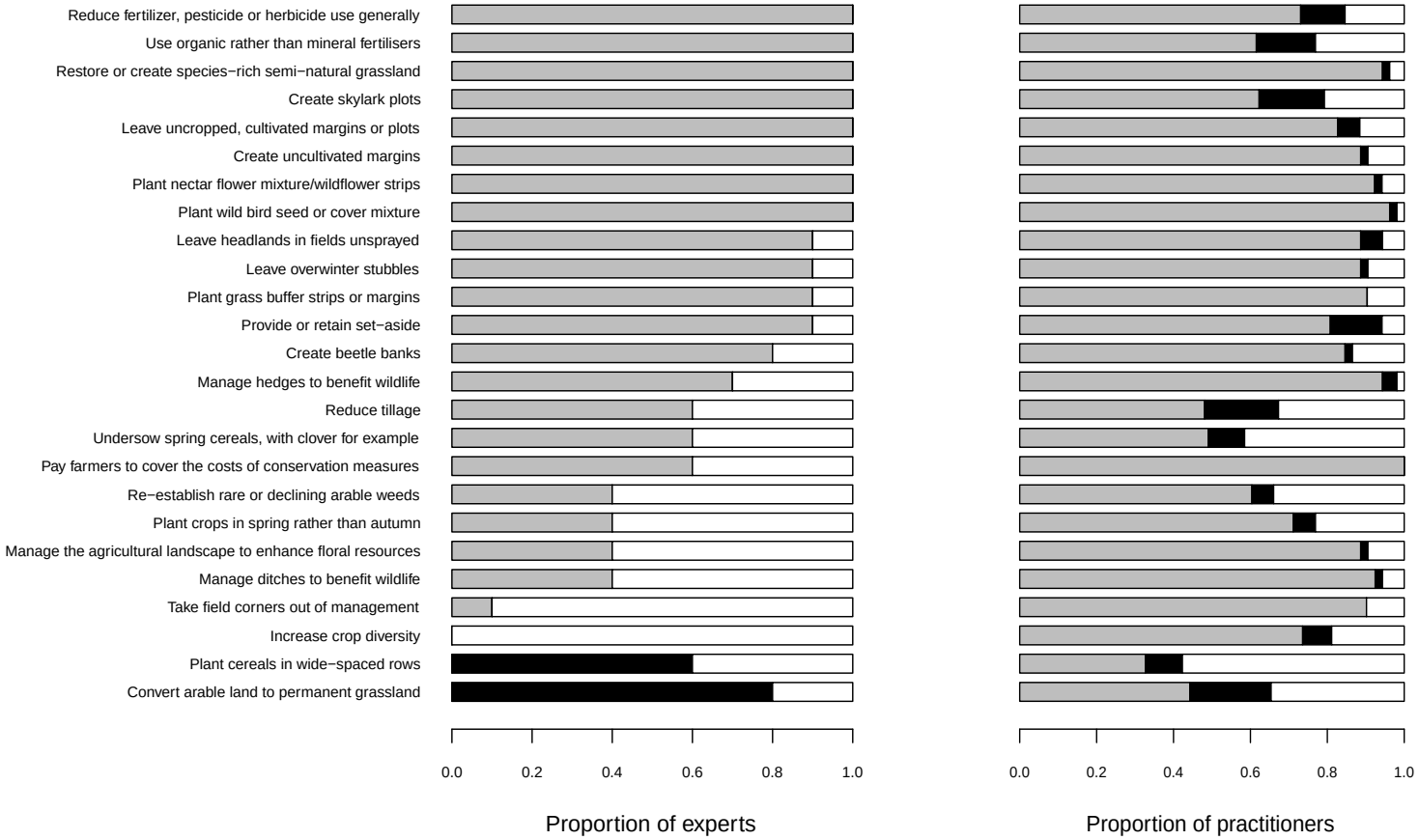

Figure 6 Proportions of experts (left) and practitioners (right) who answered yes (grey), no (black) or don't know (white) to the question 'Does this intervention benefit wildlife' for 25 interventions. Interventions are shown in rank order, according to the proportion of experts who said 'yes'.

Figure 7 shows the how certainty of knowledge and importance scores were combined to generate research priorities for wild bee conservation. The ten priorities identified are listed in Table 3. The practitioner respondents who generated these importance scores comprised 8 national policymakers, 13 local/regional government ecologists, 9 from conservation NGOs, 6 academics and 8 farmers, advisers or consultants - 44 respondents in total (of 143 approached, giving a response rate of 31%). Our Principal Components Analysis showed no significant differences between scorer groups or question presentation orders (see Sutherland *et al.* 2011b).

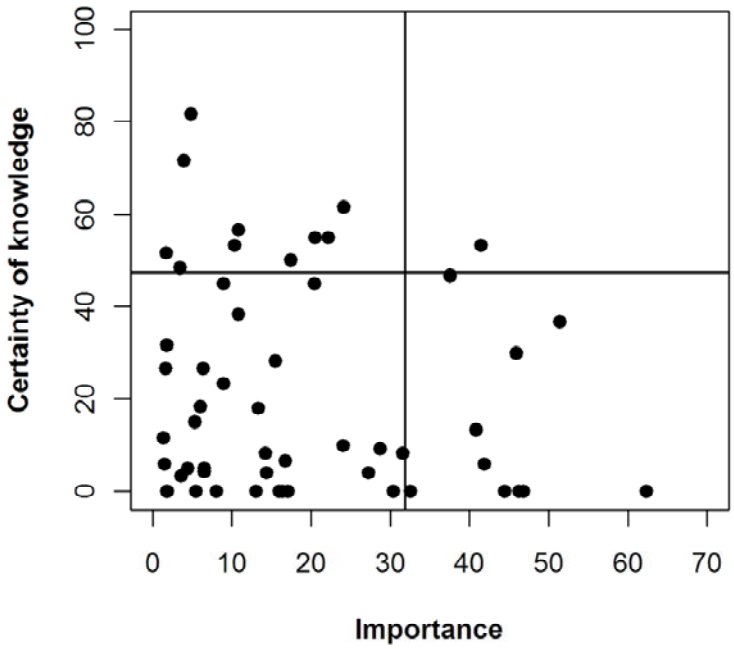

Figure 7 Setting research priorities for wild bee conservation. Each intervention to conserve wild bees is plotted according to its mean certainty of knowledge score (assessed by three experts) and mean importance score (assessed by 44 practitioners). The ten interventions in the 'research priority' quadrant of high priority, low certainty of knowledge (bottom right) are listed in the Table 3. Lines are drawn at the 80% quantiles for knowledge and priority scores.

Table 3 Research priorities identified for wild bee conservation
Ten interventions for wild bee conservation with high priority scores (>31.9, above the 80% quantile) and low certainty of knowledge (<47.3, below the 80% quantile).

Intervention	Certainty of knowledge	Mean importance score
Increase the proportion of natural habitat in the farmed landscape	0.0	62.3
Restore species-rich grassland vegetation	36.7	51.4
Protect existing natural or semi-natural habitat to prevent conversion to agriculture	0.0	46.8
Connect areas of natural habitat together	0.0	46.3
Introduce agri-environment schemes generally	30.0	45.9
Provide training to conservationists and land managers on bee ecology and conservation	0.0	44.4
Increase the diversity of nectar and pollen plants in the landscape	6.0	41.9
Restore species-rich grassland on road verges	13.3	40.8
Plant parks and gardens with appropriate flowers	46.7	37.6
Raise awareness amongst the general public through campaigns and public information	0.0	32.5

Table 4 shows the top ten research priorities for farmland conservation, identified using the Research Priority Index (Equation 1). There are remarkable similarities between these two lists of priorities, even though they were devised using a different set of evidence, and two independent assessment processes with different groups of practitioners and experts.

Both processes identify training land managers, connecting areas of semi-natural habitat and enhancing floral resources at a landscape scale as priorities.

Some research priorities are difficult to generate direct scientific evidence for, due to technical or methodological difficulty, or the expense of the studies needed. Landscape-level interventions such as connecting habitats, for example, and education and awareness-raising, fall into this category. However, some would be much easier to test. Testing the effectiveness of restoring species-rich grassland on road verges for bee conservation, for example, or bat boxes, grilles and roost improvements in farmed areas, seem relatively straightforward.

Table 5 shows the top ten priorities for advocacy in farmland conservation. These interventions are rated as important by practitioners, with good quality evidence demonstrating they are effective in benefitting wildlife.

Table 4 Top ten research priorities in farmland conservation (high importance, low certainty of knowledge). Interventions are presented in rank order, with the highest Research Priority Index first

Intervention	Certainty of knowledge	Mean importance score	Research Priority Index[1]
Provide specialist advice to farmers and land managers	0	4.37	1.59
Manage woodland edges to benefit wildlife	0	4.32	1.47
Provide training for land managers, farmers and farm advisers	0	4.31	1.46
Control invasive non-native plants on farmland (such as Himalayan Balsam, Japanese knotweed)	0	4.15	1.17
Connect areas of natural or semi-natural habitat	13.5	4.31	1.04
Manage the agricultural landscape to enhance floral resources	11.8	4.17	0.98
Provide buffer strips alongside water courses (rivers and streams)	16.9	4.34	0.93
Provide bat boxes, bat grilles, improvements to roosts	0	3.81	0.84
Support or maintain low-intensity agricultural systems	0	3.74	0.79
Restore or create wood pasture	6.7	3.74	0.77

[1] Calculated using Eqn 1.

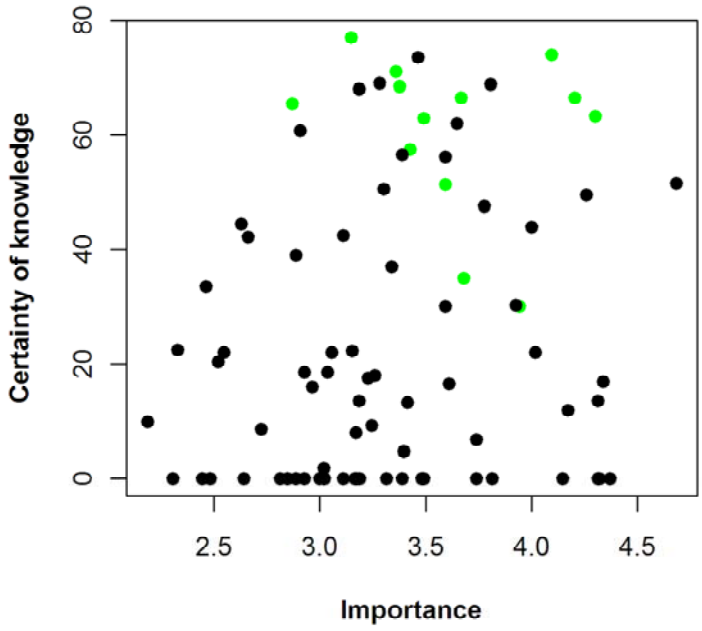

Figure 8 Setting research and advocacy priorities for farmland conservation. Each intervention to conserve wildlife on farmland is plotted according to its mean certainty of knowledge score (assessed by ten experts) and mean importance score (assessed by 54 practitioners). The Research Priority Index given in Table 4 is based on the distance from the bottom right of this graph. The Advocacy Priority Index, given in Table 5, is based on the distance from the top right. Green points are interventions for which experts unanimously said 'yes' this does benefit wildlife.

Table 5 Top ten advocacy priorities in farmland conservation. These interventions had unanimous agreement among experts that evidence demonstrates a benefit to wildlife, as well as high certainty of knowledge and high importance. Interventions are presented in rank order, with the highest Advocacy Priority Index first

Intervention	Certainty of knowledge	Mean importance score	Advocacy Priority Index[2]
Restore or create species-rich semi-natural grassland	74	4.09	0.63
Plant nectar flower mixture/wildflower strips	66.5	4.20	0.54
Plant wild bird seed or cover mixture	63.3	4.30	0.51
Create uncultivated margins around intensive arable or pasture fields	66.5	3.67	0.47
Create skylark plots	77	3.15	0.46
Use mowing techniques to reduce mortality	71	3.36	0.46
Reduce fertilizer, pesticide or herbicide use generally	68.5	3.38	0.44
Leave uncropped, cultivated margins or plots (includes 'lapwing plots')	63	3.49	0.41
Reduce management intensity on permanent grasslands (several interventions at once)	57.5	3.43	0.38
Use organic rather than mineral fertilizers	65.5	2.87	0.36

[2] Calculated using Eqn 2.

Capacity-Building and Training

This project developed new collaborations between early career researchers at University of Cambridge (Dr Lynn Dicks), Harper Adams University College (Dr Nicola Randall) and University of Lund, Sweden (Annelie Jönsson). Dr Dicks is now involved with a Systematic Mapping Methods Group established by Dr Randall under the Collaboration for Environmental Evidence.

Dr Dicks undertook basic training in data analysis using R.

Results on wild bee conservation were presented as an oral paper at the British Ecological Society Annual Meeting in Leeds, UK, and the European Ecological Federation Conference in Avila, Spain, in September 2011.

Preliminary results of priority-setting for farmland conservation were presented at the International Congress for Conservation Biology in Auckland, New Zealand, December 2011. A draft preview of the farmland synopsis was available on the Conservation Evidence exhibition stand at that conference, both online and in print. It generated substantial interest.

Our method of measuring the potential impact of individual items of evidence has been accepted for presentation as an oral paper at the European Congress for Conservation Biology (ECCB) in Glasgow, August 2012.

Outputs and Data

The main project outputs are listed in Table 6, along with their stage of completion and destination.

Knowledge Transfer, User Engagement and Impacts

An article about this project was published in a special agri-environment issue of *In Practice*, the Bulletin of the Institute of Ecology and Environmental Management (IEEM) in March 2011. Thirteen members of IEEM contacted us after reading the article. Five actively engaged with the project by completing the practitioner survey.

Results were presented to the Cambridge Natural History Society, and as a Cambridge Conservation Seminar organised by the Cambridge Conservation Initiative.

Table 6 Project outputs

Output	Format	Stage of completion	Final destination
Synopsis of Evidence on Farmland Conservation	Text (Word)	Draft text used for expert assessment (interventions with evidence only) offered to UK Data Archive. Two interventions already published on website	UK Data Archive Conservation Evidence website
References Database	Data (Excel)	Offered to UK Data Archive	UK Data Archive
Intervention List	Data (Excel)	Offered to UK Data Archive, two interventions published on website	UK Data Archive Conservation Evidence website
Practitioner Questionnaire Results	Data (Excel)	Offered to UK Data Archive	UK Data Archive
Expert Assessment of Evidence	Data (Excel)	Offered to UK Data Archive	UK Data Archive
Quantifying the impact and relevance of scientific research	Paper	Published	Sutherland, W.J., Goulson, D., Potts, S.G. & Dicks, L.V. (2011). Quantifying the Impact and Relevance of Scientific Research. *Plos One* 6, DOI 10.1371/journal.pone.0027537
Patterns of knowledge amongst farmland conservation practitioners	Paper	In preparation	unknown
Setting evidence-based priorities for farmland conservation	Paper	In preparation	unknown
Making evidence-based policy creation transparent and auditable	Paper	In preparation	unknown

Following the Cambridge Conservation Seminar, Dr Dicks was invited to take part in the Cambridge Programme for Sustainable Leadership's Natural Capital Leader's Platform, a business-led programme in which influential global companies are working to address the impacts of ecosystem and natural capital degradation on their core businesses. Dr Dicks has attended two meetings on Linking Land-use and Dairy Value Chains, to explain the approach to integrating evidence and practice developed in this project. Senior representatives from key businesses in the dairy sector, including Nestle, Dairy Crest, Unilever and Yeo Valley were there. Further interaction with several of these companies is expected.

Results from the project were submitted in response to a Defra consultation on Common Agricultural Policy Reform post 2013. The text of this response is included as Annex B.

A main output of the project is the ConservationEvidence.com website, which has been re-designed with greatly enhanced functionality, including the ability to download text and references, and to save and recall searches. The new site interacts directly with users, providing the opportunity to submit suggested pieces of evidence to the Conservation Evidence team from individual intervention pages.

Since we launched the new site in August 2011, it has had over 14,450 unique visitors from 164 different countries. Overall, 23% of visitors to the site are returning visitors[4].

At an international workshop on 14 February 2012 in London, 'Insect pollinators: linking research and policy', organised by the Foreign and Commonwealth Office, the Department for Business Innovation and Skills and the Science and Innovation Network, Defra's Science Co-ordinator Peter Costigan used Conservationevidence.com to illustrate how research and policy can be linked through synthesis of evidence. He recommended the website to all delegates.

Future Research Priorities

This project has devised a method for setting research and advocacy priorities, based on synthesized existing evidence. The method could be applied in many areas of policy and practice. We are already developing the expert assessment part of the method further to account for the relative magnitude of the effects of interventions. Another research direction is to find ways to incorporate different kinds of evidence, such as correlative and predictive modelling information that was excluded here, and to test the sensitivity of our priority-setting process to the type of evidence considered.

Elements of this method will be used in a forthcoming NERC-funded Knowledge Exchange Programme on agriculture and food to address issues relevant to the sustainable intensification of agriculture. This is likely to include prioritising interventions to maintain ecosystem services on farmland.

During the project, we developed a method of evaluating the potential impact of individual pieces of research (Sutherland *et al.*, 2011b). This has generated interest from several research funding organisations and we would like to develop it further, using all or part of the farmland evidence synopsis.

Another priority is to test and develop the usability of the Conservation Evidence website as an information resource for target groups such as policymakers and practitioners.

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[4] Internal traffic within the project team is excluded from these numbers

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