Evaluating the current state and potential of citizen science involving farmers

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Foreword

Natural England commissioned this research project to map existing farm-based citizen science research infrastructure across England, and to identify opportunities for enhancing farmer involvement in citizen science. By conducting a comprehensive review of all farm-based initiatives and developing a database, this project helps identify the types of data being collected and the technologies used for data management and sharing. This information sheds light on the current landscape of citizen science initiatives and helps us to identify thematic and geographical areas where farmer engagement can be enhanced.

This project was closely aligned with another complementary research project, *Farmer Engagement with Citizen Science and Environmental Data Collection, NECR582*, which sought to gain an understanding of the role and engagement of farmers in citizen science initiatives related to environmental data collection across England. Together, these projects provide a deeper understanding of farmer involvement in environmental research, with the ultimate goal of improving their engagement and participation in citizen science initiatives.

The findings from this research will inform Natural England's strategies for enhancing farmer involvement in citizen science, helping to identify gaps and opportunities for greater participation. By doing so, we aim to foster a more collaborative approach to environmental monitoring and management, where farmers are empowered to contribute to and benefit from evidence-led decision-making.

Natural England commissions a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Executive summary

Monitoring farmland is essential for assessing environmental health, including ecosystem services, biodiversity, and productivity. Its importance is increasing due to policy changes, the rise of sustainable agriculture, and opportunities for diversifying farm income through carbon and biodiversity accounting. Advances in technology also enable more precise, high-resolution monitoring.

The aim of this project was to understand existing farmland-based citizen science initiatives across England, with an in-depth focus on initiatives involving farmers and farmland in environmental data collection, and to identify gaps and opportunities to increase farmer involvement in citizen science. In our definition of ‘citizen science’, we included recording by public volunteers and voluntary recording by farmers, and we considered farmers voluntarily sharing data that was collected by others.

The project aimed to understand farmland-based citizen science initiatives in England through three key activities: a **rapid literature review**, a public **online survey** to map current initiatives, and a **participatory workshop** with stakeholders to explore gaps and opportunities.

The **rapid evidence review** expanded on Ruck et al.'s (2022, 2024) work on European citizen science programs for biodiversity monitoring, adding insights from 33 additional publications. Despite this, no new UK-based citizen science schemes were identified beyond those already covered. The review found that only a small percentage (1-2%) of citizen science activities focus on agriculture, while a larger portion (40%) involve biodiversity sampling on farmland, though often without a specific emphasis on agricultural settings. Birds are the most commonly monitored taxa, followed by pollinators and butterflies. Farmer engagement in citizen science is generally higher when linked to practical agricultural benefits, such as crop yield or pest monitoring, though participation is often limited by time constraints and other factors. The review highlights potential opportunities to integrate citizen science with participatory agricultural research to enhance farmer involvement and expand participation. However, there is limited evidence linking farmer engagement in citizen science to improved environmental outcomes, with one study suggesting that the potential impact of such initiatives may not always be fully realized.

The **online survey**, received 37 responses, including 28 focused on farmland. The survey revealed diverse levels of farmer involvement, from active data collection to merely providing land access for volunteers. Most initiatives collected multiple data types, primarily biodiversity and habitat data, with birds being the most frequently recorded taxa. While the majority of activities were large-scale and nationally focused, there were gaps in coverage, particularly in upland areas and Scotland. Survey participants emphasized the importance of longer-term funding and highlighted the value of farmer involvement for gaining access to un-surveyed land and enhancing biodiversity monitoring. However, the expectation that increased farmer participation would lead to positive biodiversity outcomes requires further empirical investigation.

For the **participatory workshop**, 45 participants from 17 organizations attended an online workshop to explore gaps, opportunities, and barriers to involving farmers and farmland in citizen science. The workshop included talks on relevant projects and discussions on key questions. Participants identified several needs: better incentives for farmer participation, improved communication between citizen science and farming communities, and the use of technology to facilitate data collection and build trust. Concerns about data reliability and confidentiality were also raised. Additionally, the workshop highlighted the importance of linking biodiversity monitoring with other aspects of farm business, providing training and skills development, and securing sustained funding for ongoing support and coordination. While there is potential for greater farmer involvement, challenges such as respondent fatigue and a disconnect caused by technology need to be addressed.

Opportunities, priorities, and evidence gaps

- **Priority: Maintain National Citizen Science Monitoring Schemes**
    - Continue support for national biodiversity monitoring schemes, which contribute to key indicators and sometimes struggle with farmland coverage.
- **Opportunity: Add Value to Existing Initiatives**
    - Small additional funding could enhance existing farmer feedback initiatives by scaling data analysis to inform regional and national conservation efforts.
- **Opportunity: Share Farm-Scale Data**
    - Sharing and collating farm management data on a larger scale could improve assessments of land management impacts, though trust and privacy issues must be addressed.
- **Opportunity: Build Citizen Science Capacity**
    - Sustained funding for a citizen science hub and regional coordinators is needed to support farmer engagement in monitoring, addressing risks of volunteer fatigue and short-term funding.
- **Opportunity: Expand Stakeholder Engagement**
    - Future consultations should include commercial stakeholders and focus on upland farmer engagement to explore data-sharing potential and address regional gaps.
- **Research/Evidence Gaps**
    - More research is needed to understand the link between farmer engagement in citizen science and environmental outcomes, as well as the motivations and barriers influencing farmer participation.

Contents

1. Introduction

1.1 Wider context

Data collected by volunteers has a critical role in the monitoring of biodiversity (Chandler et al. 2017, Theobald et al., 2015). This is shown, for example, by recent high-profile studies into insect declines in the UK (Powney et al. 2019, Mancini et al. 2023), and the inclusion of data on over 10,000 species from volunteer-collected data in the recent State of Nature report (Hayhow et al., 2019). Citizen science approaches are also used for collection of a range of other environmental data, for example water quality (van Gönner et al. 2023) and agricultural data such as crop variety performance (e.g. van Etten et al. 2019). Involvement in citizen science can support participants' well-being and nature connectedness (Pocock et al. 2023).

Agricultural policy in the UK is under rapid change, with the development and roll-out of Environmental Land Management Schemes to replace farming subsidies (Defra 2023), and a growing interest in sustainable and regenerative agriculture (Newton et al. 2020). Rapid advancements in technology, including recording apps and automated monitoring stations, open up new opportunities for biodiversity monitoring by citizen scientists, including farmers (Lahoz-Monfort and Magrath 2021). In addition, there are emerging opportunities for farmers and land managers to earn income through carbon credits and biodiversity markets, which may require additional data collection to provide evidence for payments. Within this context of biodiversity declines, technological advancements and rapidly changing agricultural policy and practices, a review of current citizen science research is timely, focussed on the characteristics of those activities that involve farmers and farmland, and on opportunities for further farmer engagement.

1.2 Aims and objectives

Our aim was to understand existing farmland-based citizen science research across England, with an in-depth focus on initiatives involving farmers in environmental data collection. We sought to do this through three objectives:

1. Undertake a rapid evidence review of existing citizen science initiatives involving farmers or farmland across England, including those collecting biodiversity, productivity and environmental data.
2. Create a database of farmland-based citizen science initiatives focussing on those that involve farmers in citizen science or farmer-specific initiatives across England, including the types of data collected and the technologies used for data management and sharing.
3. Identify gaps and opportunities in current citizen science initiatives, including missing themes as well as geographical areas where there may be lower levels of

engagement or limited opportunities for farmers to contribute to environmental monitoring efforts.

Specifically, we sought to achieve these objectives through three activities:

1. A rapid review of the scientific literature to understand the state of play in farmland citizen science and farmer participatory monitoring, reported in Section 3.
2. A public survey that was promoted widely to stakeholders to characterize current citizen science initiatives involving farmers and farmland in England and the UK, reported in Section 4 and in a database.
3. A workshop engaging a range of stakeholders to understand their perspectives on the gaps and opportunities for farmer citizen science, reported in Section 5.

This project ran in parallel with a second project to investigate farmer engagement with environmental data collection, which included farmer consultation through a survey and interviews. In order to avoid overlap, we focussed on engaging with citizen science scheme coordinators, policy-makers and researchers for our public survey and participatory workshop (activities 2 and 3 above). Several farmer cluster groups and farmer organisations did respond to the survey and were included, but we did not actively seek the input of individual farmers. For results from the parallel project on farmer engagement, please see the report Farmer Engagement with Citizen Science and Environmental Data Collection (2024).

1.3 Defining citizen science within the context of farmer and farmland involvement

Citizen science is broadly defined as the involvement of volunteers in the process of scientific research and monitoring (Pocock et al. 2017). This typically involves public participation in the collection of data, but can also involve them in different stages of the research cycle, including defining questions, developing methodology, interpreting results and disseminating findings. Here we use the term ‘citizen science’ broadly to include the wide range of approaches for participatory engagement in science and monitoring. However, we note that there has been debate about terms (and practices) that emphasise greater inclusivity and equity for participants, such as community science and participatory monitoring (Cooper et al., 2021; van de Gevel et al. 2020), rather than viewing participants simply as data collectors for professional scientists.

We found it helpful to reflect on the diversity of approaches that were within scope, at the start of the work. The term ‘citizen science’ can be useful, especially when a broad view of citizen science is considered, thus including structured, semi-structured to unstructured monitoring (Kelling et al., 2019; Pocock et al., 2017).

However, the term ‘citizen science’ may not fully cover the richness of the types of activities that are relevant to this subject within the farmed environment. Other related activities include:

- Co-creation of environmental monitoring.

- ‘Bottom up’ activities such as monitoring initiated by farmer clusters (without professional scientist involvement).
- Participatory monitoring / participatory agricultural research.
- Voluntary monitoring undertaken by contracted staff.
- Voluntary sharing of information that is collected for other purposes, e.g. productivity data.

Table 1: Broad classification of citizen science activities according to their degree of structure. Adapted from Ruck et al. (2024).

Citizen science approach	Description	Implications of this approach
Unstructured	Recording when, where and how the participant chooses.	Requires careful statistical analysis to avoid bias, and opportunities
Semi-structured	Typically following a more-or-less detailed protocol, but with flexibility about when and where this takes place.	Standardises the recording effort, so the dataset is easier to analyse
Structured	Following a protocol at set times and often at locations that have been selected by the project organiser.	Standardises the recording effort, but requires coordination and may limit or reduce uptake by volunteers

Here, and in discussion with stakeholders and the steering group for this project, we defined activities as within scope for our consideration if they met one of the following criteria:

- Voluntary monitoring, e.g. excluding monitoring that is mandated and required by government agencies.
- Sharing data voluntarily through a scheme or activity that collates data across farms, i.e. excluding activities in which data are collected by farmers or their representatives solely for the purpose of supporting that specific farm business, including mandatory reporting or monitoring for incentives (e.g. agri-environment payments). We would expect that by sharing data others can benefit and the individual farmer could gain greater benefit, e.g. by seeing their data in context with others.

Throughout this project we continued to reflect on the ways in which farmers and farmland are, and could be, involved in citizen science (see Figure 1), drawing on our findings from the three activities (rapid evidence review, online survey and participatory workshop). This is considered in more detail in the final discussion Section 5.

Figure 1 gives an overview of some key attributes to be considered in relation to farmer citizen scientist activities, and the importance of considering needs of both data users and farmers as potential citizen scientists. Figure 1 also illustrates the importance of considering feasibility of any additional monitoring designed to involve farmers, and the scientific design of the scheme.

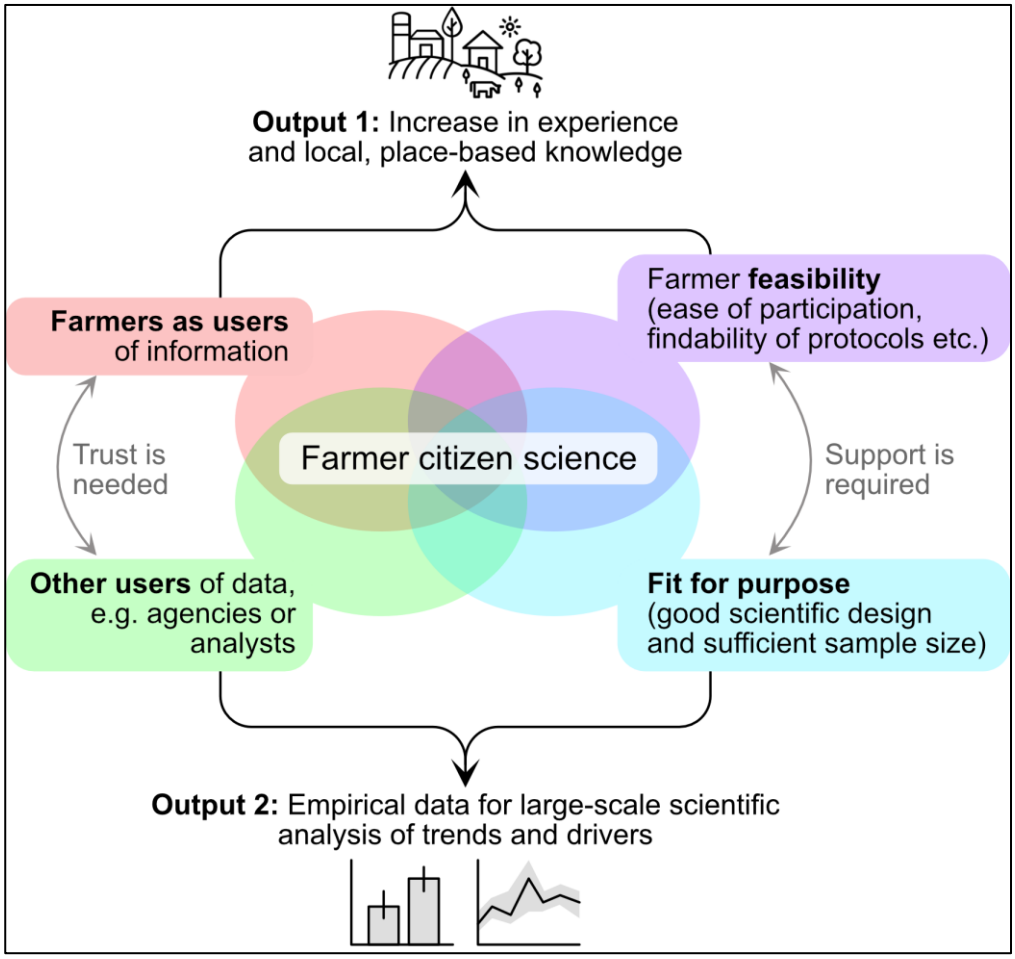

Figure 1: Different attributes that need to be considered with farmer citizen science, showing the importance of considering both data users (farms and policy-makers/researchers) and both the feasibility of the monitoring and the scientific design of any scheme.

2. Rapid Evidence Review

2.1 Aims of the rapid evidence review

A rapid evidence review was conducted to identify and summarise key characteristics of citizen science activities that involve farmers, in order to inform the design of the online survey to collect data to populate a database of these activities within the UK (Section 3). Early into the evidence review process, a review of European citizen science schemes that monitor biodiversity was published as outputs from the EU-funded SHOWCASE project (Ruck et al. 2022, 2024). This review covered 106 citizen science programmes, 49 of which were from the UK, with details of each programme in the supplementary material (Ruck et al. 2024). In addition, Ruck et al. (2022) developed a typology to characterise the citizen science programmes reviewed by both their objective, and the level and type of involvement with farmers and farmland (Ruck et al. 2022).

To capitalise on the information collated in this published review and avoid duplication, we adjusted the scope of our rapid evidence review. For biodiversity publications we focussed on those published since Ruck et al. (2022) conducted their review. For publications addressing productivity and other environmental variables no date restrictions were applied. In addition, we widened the review scope to include lessons learnt from other reviews and over a wider geographical area (outside Europe).

2.2 Methods for the evidence review

We followed the literature review search methodology specified by Ruck et al. (2022), which focussed on citizen science monitoring farmland biodiversity up to 2019. Therefore, to add to the evidence in Ruck et al. (2022), we used search terms for farmland biodiversity citizen science from 2019 onwards, and we used search terms for farmland citizen science in general with no date restrictions. We searched both Google scholar and Web of Science using a combination of narrower title searches and wider keyword searches. Table 2 below gives the number of hits for each search, and the number of references for which the title and abstract were read to determine whether they were included in the review.

Papers were excluded if they met either of two exclusion criteria:

- there was no mention of at least one of these types of data being collected or reviewed: biodiversity; ecosystem services relating to biodiversity (pest control, pollination or soil health); environmental; or productivity data.
- the monitoring described was carried out solely by professional surveyors with no involvement of citizen scientists or farmers.

We focussed on papers from UK and across mainland Europe for individual research studies. For reviews and opinion papers, we included studies from outside Europe.

Shortlisted papers were downloaded and details entered into an Endnote database. Papers were reviewed and key information captured in a spreadsheet, including identifying information (authors, journal, DOI); whether the paper was a review; name of the citizen science activity; study country or region; and type of data collected. Key conclusions and messages from the paper were also summarised in the spreadsheet. Additional relevant references that were cited in the shortlisted papers, but were not identified in the literature searches above, were also included.

2.3 Results of the rapid evidence review

2.3.1 Number and type of studies

The literature review searches (Table 2) resulted in 31 papers being identified, and a further three papers were added from citations within these shortlisted papers, thus 34 references were reviewed.

The 34 papers reviewed included 10 review papers, 15 studies involving landowners or other citizen scientists in primary data collection in a short to medium-term project (1-5 years; e.g. Clarke et al. 2023) and one involving farmers in a longer-term project (7 years; Billaud et al. 2021). The remainder of the papers described new monitoring or analytical approaches (no data collected, e.g. Robinson et al. 2020, Tasser et al. 2019) or assessed the potential of new technologies (e.g. Dehnen-Smith et al. 2016, Reed 2020, van der Velde 2023).

We found that the coverage of the review by Ruck et al. (2022, 2024) was comprehensive. First, our additional literature searches only identified one additional farmland biodiversity citizen science project, and that was from California (Robinson et al. 2020), so was out of Ruck et al.'s scope on European projects. Second, other references to European projects were either new studies from existing citizen science activities that had been covered in their review (e.g. van der Meesch et al. 2022), or short term projects (1-3 years) in which the authors tested a component of involving farmers or farmland in data collection but did not consider the project part of a longer-term citizen science scheme (e.g. Alblas & van Zepen 2023, Clarke et al. 2023). Therefore, we briefly summarise Ruck et al.'s typology and their key findings relevant to this project and follow this with a summary of key conclusions from the other 33 papers reviewed.

Table 2: Rapid evidence review search terms (based on those in Ruck et al. 2022) and numbers of references.

Search engine	Search type	Search term	Date restriction	Number refs reviewed	Number refs checked for relevance	Number refs reviewed
Google Scholar	Title search	farm* AND citizen scien*	None	17400	100	8
Web of Science Core collection	Title search	((farm* OR agri* OR agro*) AND (“citizen scien*”))	None	24	24	10
Web of Science Core collection	Author keyword search	((farm* OR agri* OR agro*) AND (“citizen scien*”))	None	91	91	10
Web of Science Core collection	Wider author keyword search	((farm* OR agri* OR agro*) AND (biodivers* OR wildlife* OR conservation* OR species* OR taxa OR ecosystem* OR habitat* OR bee* OR pollinat* OR bird* OR beetle* OR vascular plant* OR butterfly* OR syrphid* OR hoverfly* OR earthworm*) AND (“citizen scien*” OR “public scien*” OR “civic scien*” OR “community scien*” OR participat* OR “public engag*” OR volunteer* OR non-professional* OR collectiv* OR farmer-led OR “farmer* led” OR monitor*))	2019 onwards	205	100	2

2.3.2 Summary of the review of biodiversity citizen science from the EU SHOWCASE project

In the review of farmland biodiversity citizen science from the SHOWCASE project (Ruck et al. 2022, 2024), the authors found more citizen science programmes in the UK than any other European country (49 out of 106 programmes). Of the total of 106 programmes, only 38 were identified through the literature and online searches - the majority were identified by partners in the SHOWCASE project. This illustrates that many existing citizen science activities monitoring biodiversity are not represented in the academic scientific literature.

From their review, Ruck et al. (2022) developed a typology of citizen science programmes, based on the objectives of the scheme, and whether (and how) it involved farmland or farmers (summarised in Table 3). More citizen science programmes were not farmland-specific (64: Types A and B, Table 3), compared to those that either specifically monitor farmland or include farmers (45: Types C-E, Ruck et al. 2022).

Separately, Ruck et al. (2024) also split citizen science programmes into three types according to their site selection method and broad approach to data collection:

- Type 1 programmes - selection of sites and data collection method were not specified (ad hoc or opportunist records of species, e.g. UK Ladybird Survey).
- Type 2 programmes - fixed methods used but free site selection by volunteers (e.g. UK Butterfly Monitoring Scheme),
- Type 3 have both fixed methods and fixed site selection which is often systematic on a national scale (e.g. UK Breeding Bird Survey).

Across Europe, Ruck et al. (2024) identified approximately equal numbers of citizen science schemes in each of these three categories. However, within the UK there were more schemes where the site selection was free for volunteers to choose (Type 1 or 2) than schemes with sites that were selected systematically to be nationally or regionally representative.

In relation to taxonomic coverage, ‘Birds’ were the taxa most frequently monitored in the citizen science programmes reviewed (33 of 106 programmes). ‘General or wider biodiversity categories’ was the second most frequent (16), followed by ‘Bees and other key pollinators’ (15) and then ‘Butterflies’ (11) (Ruck et al. 2022). There were a large number of taxa (15) which were each recorded by just one citizen science programme, e.g. ladybirds, bats, fungi and weeds (Ruck et al. 2022).

Table 3: Typology developed to describe variation in farmland biodiversity citizen science programmes across Europe. Adapted from Table 3C in Ruck et al. (2022).

Type	Description from Ruck et al. (2022)	Number Cit Sci programmes in Europe, Ruck et al. (2022)
A - Measuring general biodiversity trends	"Large-scale and opportunistic programmes that encourage submission of records on any species, in any location and habitat type… not farmland-specific –may cover farmland, no specific reference to or focus on this."	9
B - Measuring general trends for specific taxa	"Aim to measure mostly national level trends, focus on a particular species. Employ a mix of opportunistic submission of records, and methods such as transect counts, that are carried out on particular sites. May cover farmland, no specific reference to or focus on this."	56
C - Measuring general farmland trends for specific taxa	"similar to Type B with a specific focus on farmland. These are all focused on a particular species or taxa, and are most commonly coordinated on a national scale.	12
D - Measuring the effects of farming-related activity on biodiversity	"more focused and smaller-scale than types A to C, to determine effects of an intervention or farming practice on components of biodiversity. Examples include regular bird counts in farm woodlands planted in the past, pollinator counts on farmland managed in different ways…"	26
E - Engaging farmers (or testing methods with farmers)	"data collection secondary to the engagement of farmers – farmers are closely engaged with and encouraged to carry out biodiversity monitoring on their land, data not necessarily used for research … include monitoring set up to test citizen science methods with farmers, and monitoring tools set up for farmers to engage them with biodiversity on their land."	7

2.3.3 Reviews linking citizen science to farmland and / or agriculture

Overall, we identified 33 papers in addition to Ruck et al. (2022, 2024)'s review that focussed on biodiversity citizen science in Europe. First, we consider five published reviews that link citizen science to farmland and/or agriculture.

Citizen science activities within agriculture or focussed on farmland were found to be relatively rare - for example, less than 1% of projects on the SciStarter citizen science

database (https://scistarter.org/) were tagged with ‘agriculture’, ‘food’ or ‘farm’, and less than 2% of Web of Science studies using the term ‘citizen science’ also include ‘agriculture’ (Ebitu et al. 2021). Ebitu et al. (2021) reviewed 27 studies on citizen science within sustainable agriculture, 10 of which included data collection by farmers or land managers. The focus of the 27 studies reviewed included soil health (5 studies), climate adaptation (4), pest pathogen monitoring (4), invasive species (5), pollination (5) and inputs / outputs (4). All four of the studies applying citizen science data collection to inputs and outputs were in urban settings and related to urban gardeners or horticulturalists, none to rural farmers or land managers. Input and output data are perhaps more likely to be considered part of core farming business data on rural commercial farms, rather than being a potential for additional citizen science or voluntary data collection.

Herzog et al. (2016) reviewed approaches to farmland biodiversity monitoring in North America and Europe, across 11 major monitoring programmes / schemes. Established citizen science monitoring schemes focus on data collection to quantify changes in the populations of wild species, often charismatic groups such as birds and butterflies (Herzog et al. 2016). In contrast, they found that monitoring of farmland management or conservation measures (e.g. agri-environment schemes) was more often conducted by professional surveyors (funded by government), and undertaken at a national scale in some European countries.

Mourad et al. (2020) reviewed 60 studies, and also found projects that linked agriculture and citizen science were comparatively rare, were often local or regional in focus and ran for a specific length of time linked to a project, rather than as a long-term monitoring scheme. They suggest citizen science activities are more likely to engage farmers if they are connected to agricultural practice and directly benefiting farmers - for example, data collection on fertilization, pest control, land use, irrigation or crop yield (Mourad et al. 2020).

Minet et al. (2017) review the potential for ‘crowdsourcing’, which they define as outsourcing tasks or data collection by a large group of non-professionals, in an agricultural context (they term this ‘farmsourcing’). Eight types of agricultural data are identified as suitable for ‘farmsourcing’, including: agricultural land use data; soil data; weather data; crop phenology; weed, pest and disease occurrence; yield; prices; general agricultural knowledge. They identify technical and privacy issues as likely barriers to farmer participation (Minet et al. 2017).

Just one review considered links between citizen science data and both policy and scientific impact. Turbé et al. (2019) sent surveys to coordinators of 108 European citizen science projects to assess their science and policy impact. Of the 45 responses, the majority of projects focussed on nature and biodiversity. Ease of engagement was explored; most projects were considered easy to engage with as they targeted all audiences (80%), required limited to no specific skills (91%) and less than 24 hours per year (75% of projects). In relation to scientific impact, the number of science publications was strongly related to the number of data records available, the spatial extent of the project/data, and the data accessibility.

Gaps were identified between the potential relevance of citizen science schemes to contribute to policy and its actual implementation (Turbé et al. 2019). Respondents estimated that their citizen science project data could contribute to all phases of the policy cycle (problem definition, policy implementation, policy evaluation), but evidence for policy use of these data was less widespread. There was also uncertainty over whether data had contributed to policy in around a third of projects.

Projects were more likely to have contributed to policy if they were older and were easy to engage with, while they contributed to more phases of the policy cycle if they covered a larger spatial extent, were endorsed by academic institutions or were of higher scientific quality. Barriers to connecting citizen science data with policy included balancing requirements for data quality and engagement, achieving data scalability, lack of time and finances and difficulties identifying policy linkages. Turbé et al. (2019) suggest that establishing policy linkages takes time, is complex, that a project's relevance to policy is often indirect, and linkages may need to be made at multiple scales. Recommendations include centralising the access to citizen science resources through a knowledge hub, and making the impacts of citizen science projects more traceable.

2.3.4 Individual citizen science projects involving farmers

A few of the papers reviewed described individual projects involving farmers in data collection, and in one example in the design of the research focus. Crotty et al. (2019) trialled the use of daffodil first flowering date as a 'not before date' for fertilizer application among livestock farmers in Wales, in using a "citizen science" participatory approach to farmer-informed science. The research question was identified from responses to an initial questionnaire on fertilizers sent to 300 farmers, 7% of which mentioned daffodil first flowering date. Farmers were given daffodil bulbs to plant and a soil thermometer, and submitted the soil temperature at date of first flowering either online or via a postcard. The findings provided a scientific validation of local knowledge.

Two of the papers we reviewed describe the Farmland Biodiversity Observatory scheme in France, a national monitoring program with data collection by farmers (van der Meersch et al. 2022; Billaud et al. 2020). This program ran for 7 years, with data collected from over 2300 fields across a range of agricultural systems (arable, grassland, orchards, vineyards; Billaud et al. 2020). The abundances of multiple taxa (solitary bees, earthworms, butterflies, beetles and molluscs) were recorded along with agronomic practices, allowing analyses of temporal trends in abundance in relation to farming practice and surrounding landscape variables (Billaud et al. 2020). A large number of farmers (1216) participated in data collection. However, there was also a high turnover, with an average duration of involvement of 1.22 – 1.39 years (depending on the taxon; Billaud et al. 2020) and for many protocols only some of the suggested survey visits each year were made (e.g. pollinator trap nest monitoring was recommended every month, less than half of participants visited that frequently; van der Meersch et al. 2022). Despite the high turnover, the Farmland Biodiversity Observatory provides a good example of the potential for large

numbers of farmers to be involved in collecting citizen science data that has proven scientific value (Billaud et al. 2020; van der Meersch et al. 2022).

2.3.5 Comparisons of data collection by farmers vs. other citizen scientists

Two studies directly compared data collection by landowners or farmers to other citizen scientists and professional surveyors, and surveyed or interviewed those collecting the data. Garratt et al. (2019) trialled three pollinating insect and pollination monitoring approaches, conducted by farmers, agronomists and scientific researchers, and explored opinions on each of the approaches. Farmers and agronomists were less willing to implement the pollination service protocol than researchers, which was attributed to a need for multiple visits. They were more willing to implement single-visit biodiversity assessments. This illustrates the key limiting factor of farmer time, despite the conclusion from several reviews (e.g. Mourad et al. 2020) that farmers would be more willing to collect data linked to ecosystem services.

Alblas et al. (2023) compared mandatory agri-environment scheme (AES) monitoring of target species in three regions of the Netherlands, in each of which a different stakeholder group was chosen to collect data by the regional agricultural collective (farmer groups and conservation organisations) responsible for AES budget and monitoring. One region employed professional surveyors to collect data, another used non-farmer citizen scientists co-ordinated by an NGO, and the third paid the farmers implementing the AES management to collect data. Semi-structured interviews were conducted with the agricultural collective board members, farmers and other stakeholders. All three regions reported that implementing biodiversity monitoring across the required range of target species was a challenge, given the limited funding. No clear connection was found between farmers conducting the monitoring and incorporating the resulting ecological knowledge into their AES management. Alblas et al. (2023) conclude that linking farmers to NGO volunteers can positively impact farmer commitment and motivation to engage in AES management.

2.3.6 Participatory agricultural research and citizen science

One review and several primary research studies addressed participatory agricultural research, whereby farmers collect data and in some instances co-designed the research with scientists. Many of these participatory research studies employed an experimental approach to test specific question(s) with direct relevance to farmers over short or medium timescales (e.g. van Etten et al. 2019a), in contrast to national citizen science schemes that run long-term monitoring of wildlife populations (Ruck et al. 2024). Despite these differences in focus and timescales between participatory agricultural research and many established citizen science activities, there is cross-over and some projects reviewed used both terms (e.g. van der Etten et al. 2019b).

The types of data collected in the participatory agricultural studies reviewed included crop variety trials (e.g. Steinke et al. 2017), soil health (e.g. Stroud et al. 2019) and biodiversity data with a focus on ecosystem services (e.g. van der Meersch et al. 2022). Two of the studies reviewed were conducted in the UK (Crotty et al. 2019, Stroud et al. 2019), the majority were carried out in other European countries (e.g. van der Meersch et al. 2022) or elsewhere. Some projects have attracted large-scale participation by farmers across several countries (e.g. >12,000 participants in 3 countries, van Etten et al. 2019b). Examples of participatory agricultural research studies are described below, along with a brief summary of the review (Van der Gevel et al. 2020).

Stroud et al. (2019) ran a pilot study (named: #60minworms) involving farmers in monitoring earthworms on 100 fields on their farms in the UK, in order to assess soil health. Some negative feedback was received during farmer recruitment, about farmers previously taking part in scientific surveys but not receiving feedback. Nonetheless, the majority of participants undertook multiple surveys, reported that they would change soil management based on the results and that they had high levels of trust, value and satisfaction in the pilot. An interest was expressed by participants in national trends to benchmark against their individual farm results, and also in between-farm comparisons. A second soil health study by Stroud et al. (2023) worked with farmers in a sustainable soil network to compare the number of earthworms and soil stability below middens (piles of earthworm casts) and in control soil.

A national biodiversity programme using a participatory model involving farmers was trialled for five years to monitor bee populations in France (Van der Meersch et al. 2022). Farmers set trap nests in field boundaries, with a goal to monitor nest occupancy and sealing material monthly. Most farmers missed some of the monthly data collection, with around half sampling at least 5 times. Nesting was found to be correlated to cropping pattern (area of surrounding oilseed rape) in the previous year, and the area of permanent meadows.

Two studies used a participatory approach to engage farmers to compare crop varieties in projects lasting one and four years respectively (Steinke et al. 2017, van Etten et al. 2019b). In each project, farmers grew a subset of varieties from a wider pool and ranked them according to performance (yield, disease resistance, pest resistance or architecture, van Etten et al. 2019a). Van Etten et al. (2019b) showed this approach led to improved variety recommendations that were more closely linked to climatic variables.

Van de Gevel et al. (2020)'s review identifies opportunities for citizen science to contribute to participatory agricultural research, including through new possibilities for interdisciplinary collaboration. Research on the motivations and engagement of citizen science participants, and how these differ with different groups of contributors, has gone beyond a narrower cost-benefit focus on farmer motivations within participatory agricultural research, thus 'citizen science stimulates thinking about motivation as an integrated part of research design and as a critical area of inquiry' (van de Gevel et al. 2020). Another opportunity offered by some citizen science activities is for role differentiation among volunteers, allowing more different levels of engagement than has been the case for some

participatory agricultural studies. Van de Gevel et al. (2020) also identify that citizen scientists use digital technologies to facilitate data collection and transfer, supporting larger-scale participation. Finally, they suggest that most institutions using incentive systems that favour data production over impact, although the outcomes of participatory processes are often part of wider dynamic processes and more difficult to measure than concrete research outputs.

2.4 Conclusions and key findings of the rapid evidence review

The initial aim of the rapid evidence review, to inform the structure and design of the online survey and thus the dataset of citizen science activities involving farmers in England, was superseded by the timely publication of a review of European citizen science programmes monitoring biodiversity (Ruck et al. 2022, 2024). Additional literature searches showed Ruck et al.'s review to be comprehensive in relation to coverage of UK citizen science activities by published scientific papers (because rerunning their search terms did not identify publications describing additional citizen science activities based in the UK). Due to this, in discussion with the project steering group we based the online survey design on the structure and typologies developed by Ruck et al. (2022), and piloted it with two established UK citizen science schemes (see Section 3 for details). Key conclusions from the rapid evidence review are grouped below under broad themes.

2.4.1 Key evidence from review findings

Characteristics of current citizen science in relation to farmland and agriculture

- Only a small proportion (1-2%) of citizen science activities currently listed on directories are specifically flagged as being focussed on agriculture or farmland.
- A larger proportion of biodiversity citizen science activities across Europe (estimated 40% of activities) include at least some sampling on farmland. However, the majority of these citizen science activities measure trends for general biodiversity or specific taxa, with no stated focus on farmland. Monitoring of impacts of farming practices or farmland conservation initiatives may be more often carried out by paid surveyors than volunteers.
- Birds are the most commonly monitored taxon among European citizen science programmes, followed by bees / other pollinators and butterflies. Fifteen taxa were each recorded by just one monitoring programme.
- Across Europe, there were roughly equal numbers of programmes that specify neither site nor method to their citizen science participants (ad hoc records), vs. those that specify method but not site selection, vs. those that specify both method and site selection. Within the UK, a larger proportion of programmes left site selection to the citizen scientists.

Farmer engagement in citizen science and participatory monitoring – barriers and opportunities

- Several reviews suggest farmers may be more likely to engage with monitoring connected to agricultural practice and directly benefitting them, (e.g. crop yield, pest monitoring). However, this needs to be considered with other factors that affect engagement, such as time required. A comparison of monitoring approaches found farmers were more likely to undertake pollinator monitoring than assessments of pollination services, as the latter required multiple visits.
- Citizen science and participatory agricultural research have to some extent developed as separate approaches with typically different timescales, but there are overlaps and opportunities for each to strengthen the other. Some participatory agricultural research projects have been successful in engaging thousands of farmers across several countries. A review identifies that both the cross-disciplinary, nuanced understanding of participant engagement and the use of digital technology within citizen science could strengthen participatory agricultural research and support larger scale participation.

Environmental and policy outcomes of citizen science and farmer involvement

- One study found no link between farmers collecting biodiversity data and improved implementation / quality of agri-environment management in a region, compared to other regions where professional surveyors or other volunteers collected the data. This finding opposes the expectation in several other papers reviewed that farmers who collect biodiversity data may adapt management on their land to benefit biodiversity, but may be unique to the specific context of this study. This topic needs further research.
- We found just one study reviewed scientific and policy impact of citizen science, and concluded that opportunities were missed for these projects to increase impact. Scientific impact related strongly to the number of data records available, spatial extent of the data and data accessibility. Policy impact was greater for citizen science projects that were older, easier to engage with, covered a larger spatial extent, were endorsed by academic institutions and had higher scientific impact.
- A review suggested research institutions use incentive systems that favour data production over impact, although the outcomes of participatory processes are often part of wider dynamic processes and more difficult to measure than concrete research outputs. However, current assessments of research institutions do place increasing emphasis on societal impact.

These key findings have informed our interpretation of results from the online survey (Section 3) the participatory workshop (Section 4) and our work to identify gaps and opportunities (Section 5). We discuss and compare our findings from across all three activities in the final section on gaps and opportunities for farmland citizen science and farmer participatory monitoring (Section 5.2).

3. Characterizing citizen science research and farmer involvement in England

3.1 Online survey

An online survey was developed by the UKCEH project team, with input from the Natural England project steering group. It was reviewed and approved by Natural England's research ethics committee. The aim was to understand and characterise existing citizen science activities which involve farmers or farmland. For this survey, we considered citizen science to be the intentional involvement of volunteers in science and monitoring. This approach allowed for projects and activities that fell outside a more formal definition of citizen science to be considered.

A pilot version of the survey was tested for clarity, relevance, and viability with two known scheme coordinators prior to wider circulation; these were the UK Pollinator Monitoring Scheme and National Plant Monitoring Scheme. Following minor adjustments, an invitation to take part in the survey was disseminated to:

- 29 known UK citizen science schemes identified in the SHOWCASE report (Ruck et al 2022);
- Existing citizen science networks, specifically: the British Ecological Society's citizen science mailing list (about 150 members), the European Citizen Science Association's mailing list, and the UK Environmental Observation Framework (UKEOF) working group (about 30 people within government agencies who were encouraged to pass it on to relevant contacts);
- via social media and;
- known contacts of the project team by email.

Known organisations carrying out citizen science activities involving farmers who did not respond initially were repeatedly emailed and asked to contribute. All contacts were asked to forward the survey to any relevant people and therefore exact numbers reached are unknown. There were some known citizen science schemes that did not respond. It is unclear if this was because there was no or little farmer involvement in the scheme and therefore the survey was of no interest or if the scheme coordinators did not have time/inclination. There was no incentive for survey completion and therefore volunteer coordinators may have been less likely to contribute than citizen science scheme paid coordinators.

Enhanced engagement conversations were held online with four key stakeholders (three of the key NGOs that run citizen science schemes engaging with farmers and a university research team who had just reviewed citizen science biodiversity monitoring, Ruck et al. 2024), at which we explained the context of the project and survey in more detail and promote engagement for completion of the survey.

The online survey questions are given in full in Appendix A1. Note that for the majority of the multiple response questions, respondents were able to tick more than one answer.

3.2 Survey results

3.2.1 About the citizen science activity or scheme

There were 37 responses to the main survey from a wide range of citizen science activities covering multiple purposes. Each response referred to a unique project. Key results are summarised in the tables below. A database is provided with this report containing all the data we collected on citizen science activities.

The two most frequent responses to a question on the main purpose of carrying out citizen science activities were 1) to engage farmers or test methods with farmers, and 2) to measure general trends or changes in biodiversity for individual species in general (i.e. not only on farmland).

Table 4: The main purpose of the citizen science activity of participants of survey. Respondents were asked to select all that apply with % of respondents who selected each answer option (e.g. 100% would represent that all this question's respondents chose that)

What is the main purpose of your citizen science activity	Number of respondents selecting option	Percentage responses
To measure general trends or changes in biodiversity, for individual species or groups of species	18	49%
To measure trends or changes in biodiversity on farmland, for individual species or groups of species	16	43%
To measure how a farming-related activity affects biodiversity, either for individual species or groups of species	11	30%
To measure soil characteristics including soil biodiversity	3	8%
To measure productivity	4	11%
To measure profit	2	5%
To engage farmers, or test methods with farmers	19	51%
Other	13	35%

Those who selected the 'other' category were asked for more details and submitted text responses. Responses in this category were either to add complexity to already offered responses or where existing text did not apply. Responses included "to foster greater land

manager trust in ecological datasets by involving them directly in data collection"; "Recruit, Train, Mentor volunteers for biodiversity recording"; to "measure water quality", to "monitor soil health" and national schemes that "support the collation and verification of biological records, which may be used by many data users for a range of purposes".

3.2.2 Farmer involvement in citizen science activity

Participants were asked about the role farmers have in participating in the citizen science activity. There was a range of responses to this question (Table 5), with the most common roles being 'Farmers permit access to their farmland for other volunteers' and 'Farmers voluntarily collect environmental data, samples or information'. We have combined these categories into two groupings for further analysis:

1. Active involvement – farmers engaged in the scheme directly, actively collecting or sharing data. (24 schemes.)
2. Passive involvement – farmer involvement consists of enabling access to farmland for volunteers to record only, no other involvement. (13 schemes.)

Twenty-four schemes have active farmer involvement; thirteen schemes had passive farmer involvement. Three schemes that completed the survey said they did not currently involve farmers (British Bryological Society recording scheme; UK Ladybird Survey; and English Winter Bird Survey); these schemes have been included in follow up results within the passive farmer engagement numbers as there could be potential for farmer involvement in the future, landowners may be consulted for access but those completing the survey are unaware and the occupation of volunteers is unknown. Please note that these sample sizes are different in numbering from Table 5 because of multiple selection of answers and scrutiny of answers within this specific context.

A relatively high proportion of respondents (32%) indicated that farmers were involved, in some way, in co-design of the activity. It would be valuable to conduct further research to understand what lessons can be learnt from these experiences. Positively, this also indicates that many of the projects represented in our survey were actively engaging farmers at the planning and design stage, which is a more equitable and inclusive way of conducting citizen science.

Table 5: How farmers participate in citizen science activity. Respondents were asked to select all that apply with % of respondents who selected each answer option (e.g. 100% would represent that all this question's respondents chose that option).

How farmers contribute to citizen science scheme?	Number of responses	Percentage responses
Farmers voluntarily collecting environmental data, samples or information	22	60%
Farmers contribute information about farming practices, agri-environment or conservation management for their farmland	18	49%
Farmers helped to design or co-design the activity	12	32%
Farmer(s) co-ordinate the activity	4	11%
Farmers share existing environmental data (originally collected for other purposes)	3	8%
Farmers recruit and co-ordinate volunteers for the activity (including other farmers)	1	3%
Farmers permit access to their farmland for other volunteers to survey	22	60%
Farmers are not currently involved in the activity	5	13%
Other	5	14%

We found that most activities involved between 6 to 25 famers, although a small number of schemes involved many more farmers, with six involving more than 100 farmers. Those in the 'other' category were schemes that were not yet set up fully and so provided aspirational figures of how many farmers would be involved in the future (Figure 3).

Farmland focussed schemes coordinated by larger organisations (e.g. GWCT, BTO, Butterfly Conservation) responded that 26 to 100 farmers are involved; this group contained schemes such as Farm Wader Calendar, Fab Farmers and Carabid monitoring scheme. Larger, longer running national schemes who only require access permissions (e.g. BTO breeding bird survey, Bee Walks) did not know participating numbers of farmers within their activity. From survey enhancement conversations with scheme coordinators, farmer involvement in these schemes is likely to be where public volunteers pro-actively contact farmers without scheme coordinators being involved in the conversations. One scheme in the pilot phase also noted they were unsure of number of future participants.

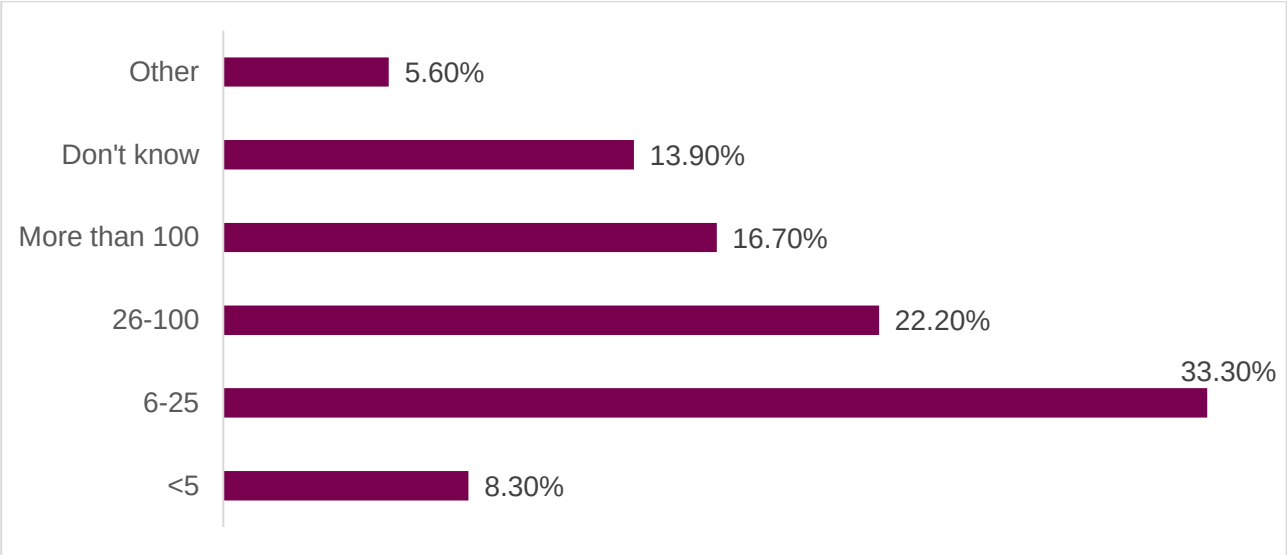

Figure 2: The number of farmers involved (or estimated number) in the citizen science activity. Respondents were asked for one answer; % of total responses.

3.2.3 Data collection in citizen science activities

More than one type of data were collected by 33 of the 37 citizen science activities. The types of data that were most likely to be collected by an activity or scheme were biodiversity data (87%) followed by habitat type (57%). Activities who also collected farm productivity data also collected other types of data (e.g. Arable weed survey collected data on biodiversity; undesirable plant species or weeds; farm productivity / yield (crop or livestock), profit / economic data) (Figure 4). While participants of the survey could select multiple responses there were none that selected all options – please see database for exact responses for combinations of data collected.

Category	Value	Percentage (%)
Biodiversity (see next question for more detail)	32	86.5
Habitat type	21	56.8
Habitat quality	8	21.6
Water quality	8	21.6
Undesirable plant species or weeds	6	16.2
Natural enemies of pests (predators or parasitoids)	5	13.5
Physical soil characteristics, e.g. structure, organic matter	5	13.5
Farm productivity / yield (crop or livestock)	5	13.5

Profit / economic data	4	10.8
Crop pests	3	8.1
Chemical soil data, e.g. carbon or nitrogen	3	8.1
Other	1	2.7

Figure 3: Types of data collected by the citizen science activity. Respondents were asked to select all that apply.

The most common biodiversity data collected were on birds followed by plants (Figure 5). Border et al (2019) also reported birds as having greatest spatial coverage of biodiversity monitoring, as did Ruck et al.'s (2022) review of European biodiversity citizen science monitoring (see Section 2.3.2).

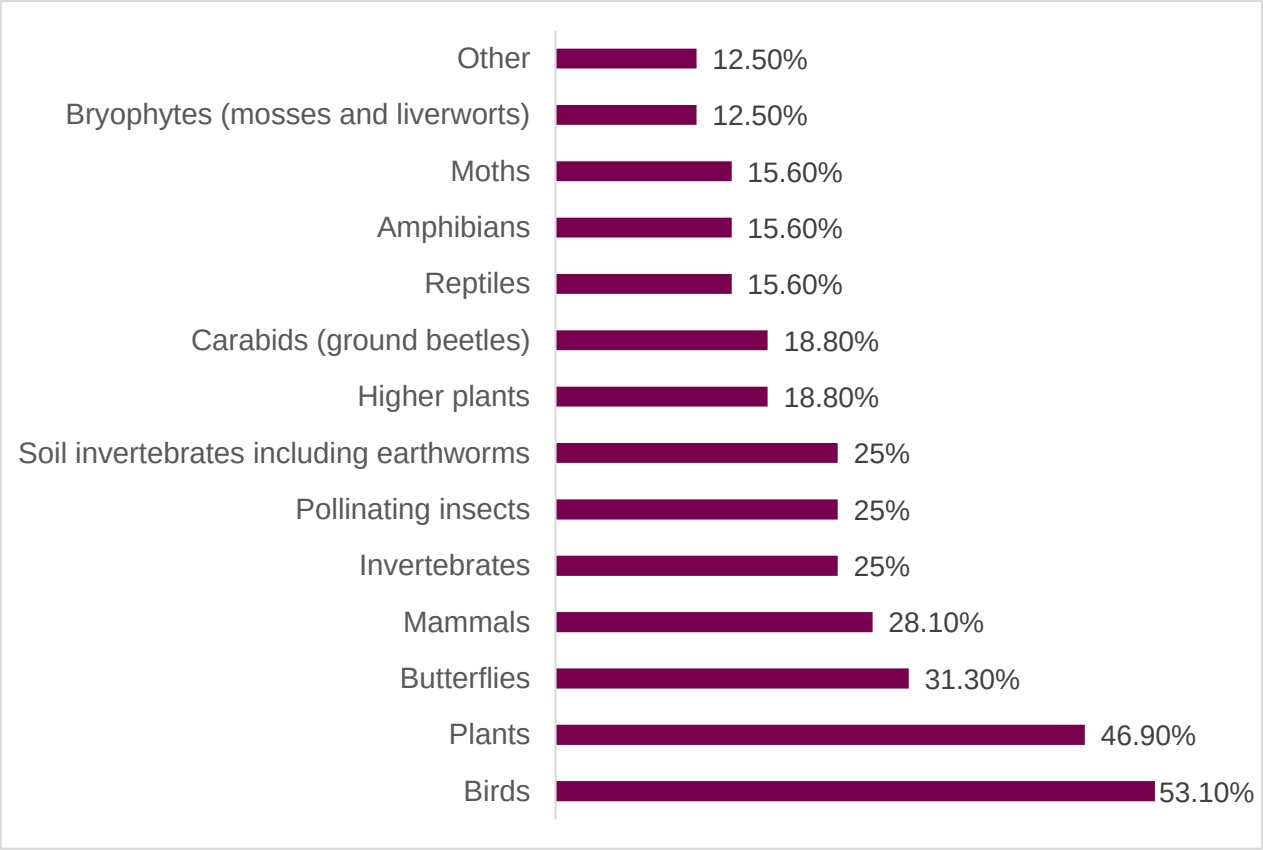

Figure 4: Species or groups in refinement of biodiversity data that are collected by citizen science activities. Respondents were asked to select all that apply; % of respondents who selected each answer option.

The methods used by schemes for gathering data varied widely; with transect or fixed walk methods being the most commonly used (this is not surprising given that these are commonly used methods for sampling biodiversity, such as birds, plants, butterflies). Ad

hoc records on species also represented a large proportion of the data collected on farmland.

Table 6: Methods used for data collection across scheme activities. Respondents were asked to select all that apply with number of responses.

Methods used for data collection across scheme activities	Number of respondents selecting	Percentage responses
Transect or similar survey route walked (set locations, with repeat visits over time)	15	42%
Quadrats surveyed (set locations, with repeat visits across time)	7	19%
Trapping methods in set location (e.g. pan traps for pollinating insects, moth light traps, small mammal traps etc)	5	14%
Timed counts using standard method	7	19%
Fixed fields or land parcels surveyed	9	25%
Automated recording of data (e.g. acoustic recording, temperature)	3	8%
Ad hoc records of species	14	39%
Samples sent for analysis (e.g. soil cores or water samples)	5	14%
Other	8	22%

Data had, in most cases, been collected for 1 to 5 years, but some projects have been collecting data for longer. Within the ‘other’ category less frequent data collections were reported e.g. data not collected annually but had been collected four times since 1990s. In this ‘other’ category a mix of time scales was also reported, depending on which of several recording methods within a scheme was being considered. Please see database for exact comments.

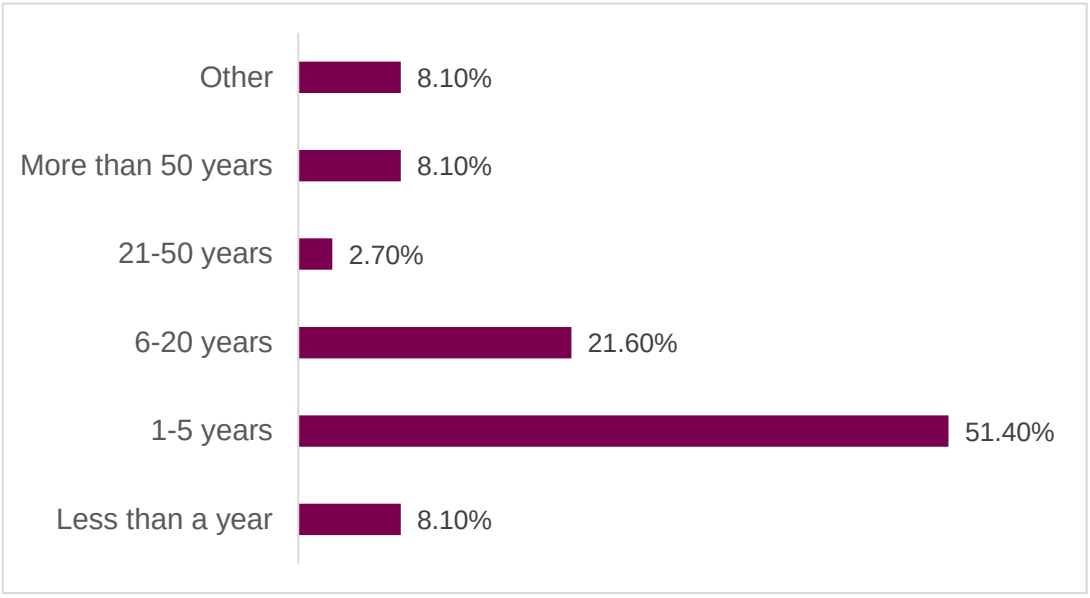

Figure 5: Length of time data had been collected by citizen science activity. Respondents were asked to select one answer, by % of responses.

3.2.4 Size of schemes and geographical spread

Most activities reported via our survey were quite large in scale, operating on more than 100 sites with 2 to 5 visits annually and were national schemes operating over the whole of the UK (Table 7). There were differences in the scale at which schemes with passive and active farmer involvement operated. Passive schemes were more likely to have a national focus; projects with active farmer involvement were more likely to have a regional focus (Table 7). International projects had EU funding and operated within Europe and the UK.

Responses to our survey indicated that farmland was not representatively sampled across these projects. We had only one scheme (Cairngorms Mob Grazing Trails) from Scotland, and no upland schemes from England. Of the active farmer engagement schemes operating within England at a regional level, all operated in lowland habitats. This could be that our survey failed to directly reach those schemes operating in more upland habitats or scheme coordinators in such areas have not engaged with this project but our experience suggests that these schemes are less frequent in such environments. Previously, Border et al. 2019 undertook analysis of structured biodiversity monitoring schemes (birds, bats and butterflies) and unstructured biological recording (33 taxonomic groups). They found that, in general, there are gaps in biodiversity monitoring in harder to reach and harder to survey areas. They found that 1km squares with arable and intensive grassland habitats tended to be more well-sampled, whereas semi-natural grassland and moor/heath/bog were less representatively-sampled. In our survey there were too few responses to conduct meaningful analysis of geographical extent of these regional-scale projects. More detailed research could be conducted by actively engaging with farmer clusters.

Table 7: Geographical scope of citizen science scheme activity and how it relates to the degree of farmer involvement: active (farmers engaged with scheme and collect or provide data) and passive (farmers allow access for other volunteers).

Geographical scope of citizen science activity	Farmer involvement	
	Active	Passive or none
Internationally outside the UK	3	0
Nationally – all of UK	8	8
Nationally – all of England	0	1
Region or landscape within England	8	1
Single farm	1	0
Other	4	3
Total	24	13

3.2.5 Communication and data availability in citizen science activities

Data from most citizen science activities were freely open and available to everyone. However, schemes and activities with active farmer engagement were less likely to have results free and publicly available than schemes with passive farmer engagement (Table 8).

Table 8: Data availability from schemes and number of responses from two farmer involvement categories, active (farmers engaged with scheme and collect or provide data) and passive (farmers allow access for other volunteers).

Are data publicly available, shared with either the farming community or Citizen Scientists?	Farmer involvement	
	Active	Passive or none
Data not publicly available (e.g. only released to research users, or government departments)	6	2
Limited availability of data (e.g. for a fee, with a restricted license)	4	1
Publicly available data, freely and openly available to everyone	9	10

Other	5	0
Total	24	13

Table 9: Responses to the question 'Have you published or circulated any results from your citizen science activity?

Have you published or circulated any results from your Citizen Science activity	Farmer involvement	
	Active	Passive or none
No, we do not intend to publish or circulate the results	1	0
Not yet, but we do intend to make the results available	6	3
Yes – the results are circulated internally to project partners and funders	1	0
Yes – the results are circulated to Citizen Science volunteers and/or farmers	7	2
Yes – the results are free to access for everyone	7	7
Other	2	1
Total	24	13

For many schemes, both with active or passive farmer involvement, results from the citizen science activities were freely accessible for everyone. Those schemes that had not yet published did have the intention of publishing results. Activities that had more active farmer involvement were more likely to circulate results to volunteers and farmers than those with passive involvement. This is not surprising as continued motivation and engagement with volunteers and farmers is critical to the delivery of such schemes, and feedback is often sought by participants.

In an extension to this question, participants were asked if there had been any specific barriers to circulating or publishing results from their citizen science activity. This was a free text response and we received ten responses which fell broadly into four themes that are described below. There appeared to be more responses from schemes with active farmer involvement identifying barriers to scientific publication. Schemes with passive farmer involvement appear to have more barriers surrounding the theme of data sensitivities.

Themes are listed with examples of free text response quotes and the farmer involvement category to which the quote is attributed. Reference number "#" indicates an anonymised respondent number, each number represents a separate individual.

Theme 1: Data sensitivities (4 respondents)

"[project] data [contribute to] official statistics and so are bound by the associated codes of practice. Once published by those methods and timelines, data are available". (#1. Passive)

"On the iNaturalist app, users have to make sure they give permission for their data which is collected to be used by the records centre." (#2. Passive)

"It has taken several years to get to the point where farmers are now happy and comfortable to share some data publicly" (#3 Active)

"*Commercial sensitivities*" (#4. Active)

Theme 2 Capacity including: (1 respondent)

- Time within projects for the dissemination of results
- Time taken because licences for software are expensive e.g.

"OS licensing issues has made sourcing accurate base maps impossible so mapping has been much more difficult and time consuming". (#5. Passive)

Theme 3 – Difficulties publishing scientific results (3 respondents)

"Costs of publishing papers as open access". (#6. Active)

"falls between social science and agricultural science" (#7. Active)

"Research rejected from [discipline-specific] journals for being "glorified knowledge exchange", "not science", "not useful"…" (#8. Active)

Theme 4 – Funding (1 respondent)

"Funding ran out for website displaying results for participants…". (#9. Active)

3.2.6 Future plans for citizen science activities

Respondents were asked about their aspirations for their citizen science scheme (Table 10). Those with passive farmer involvement sought to maintain their current focus, although several sought to expand to more volunteers, including farmers. Given many of these schemes are large and national schemes with focus on long-term monitoring to

report trends in populations over time, it is perhaps not surprising that their primary aspiration is to maintain this vital reporting focus. There was stronger support for growing, expanding and including more farmers in the schemes with active farmer involvement. This may indicate that many of these projects are at an earlier, more exploratory stage.

Table 10: Table with responses on future aspirations for schemes with number of responses for passive and active farmer involvement.

What aspirations do you have for your Citizen Science activity looking forward?	Farmer involvement	
	Active	Passive
Apply for funding to continue or expand	3	0
Develop and grow to include more Citizen Scientist volunteers and grow to include more farmers,	8	5
Develop and grow to include more farmers,	4	0
Maintain current focus	6	8
Other	3	0
Total	24	13

Within the survey, participants were asked about what aspects were important to reach their given aspirations. This was a single response question but there was a scale of importance for each element:

- Very important,
- Fairly important,
- Not important or
- No opinion.

Many participants thought that it was ‘very important’ to have longer-term funding (62%) and additional funding (46%) to achieve their aspirations for the citizen science activity. Improved connections with farmers were thought to be very (44%) or fairly important (42%). Most respondents stated that improved skills for reporting and data capture were fairly important (47%) and more links to networks or policy makers fairly important (58%).

Free text responses were permitted so that participants could add further detail; there were eighteen additional responses.

Examples of free text response quotes and the farmer involvement category to which the quote is attributed are given below. Reference number “#” indicates the anonymised

respondent number (please note #numbers are not consistent between question responses).

Most respondents (12) gave comments that were positive for growth or continuation of their citizen science activity. Additionally, five also confirmed the importance of long-term funding.

"Long-term government commitment to support recording effort, ad-hoc short-term funding is not good enough" (#1 Passive).

"Longer term funding essentially, very little can be achieved with 3 year [name of funding body] agreement, it also needs to be more flexible" (#2 Passive).

"We need funding to pay for licenses and better technical help to use online data available in order for us to analyse the data that we ourselves have recorded". (#3 Passive)

"Additional funding to employ a Volunteer Coordinator who can offer continuous support to our volunteers". (#4 Active*)*

There was a strong perception amongst participants that closer engagement with farmers will result in better outcomes for their scheme in terms of additional data and improved environmental management/outcomes. (4 respondents)

"We would like to build this monitoring into AES [agri-environment scheme] funding structures, to allow us to monitor the outcomes of AES management options without the need for paid/volunteer [scheme taxa] surveyors or placing too much of the monitoring burden on farmers. If the farmers themselves deploy [name] recorders, they will place greater trust in the monitoring datasets that are generated from them." (#5 Active)

"We would like to encourage more members of the public to participate in habitat studies. This would ideally include politicians and decision makers. So that they come to enjoy and cherish nature. This will help them to come to better decisions on how to protect the environment." (#6 Passive)

"The overall aims of the [scheme name] activity are to support farmers to take conservation action to bring about a significant increase in farmland biodiversity across the UK, and to engage more people in biological recording, with an EDI [equity, diversity and inclusion] target involving people aged 18-29." (#7 Passive)

"We want to create a legacy for the project and create personal connections between the volunteers and farmers, so they can continue their biological recording relationship in the future." (#8 Passive)

However, not all engagement and aspirations from participants were perceived as positive. There were two examples from the free text responses that were negative about increasing farmer involvement in citizen science.

"*It should be the role of Gov to provide funding to record fundamental baseline biodiversity data which should underpin all related gov strategies and policy. It is woeful and inadequate to leave this vital work to charities and volunteers."* (#9 Passive)

"Very hostile environment for citizen science. Soil health measurements are business – I started to get abuse (in person and via email) by those who considered earthworm sampling a threat to their [agronomy consultancy] business." (#10 Active)

Negative comments such as these should be considered alongside positive comments. We recommend seeking broader stakeholder consultation on inclusion of farmers in citizen science activities, for example, including commercial companies supporting farm business with productivity and ecosystem service monitoring (e.g. supermarket accreditation schemes), environmental consultancies, independent ecologists and other farm enterprises should be included alongside academics and the coordinators of existing citizen science schemes.

Including additional stakeholders in consultation exercises may help to identify gaps and further opportunities for citizen science, including untapped funding mechanisms or joined up collaborative approaches for greater achievements; especially for those farmers not engaged with AES or environmental policies in general. This would be especially important in emerging markets for farm businesses such as Biodiversity Net Gain and carbon credit/sequestration.

3.2.7 The value and the opportunities for involving farmers more in citizen science activities

Respondents to the survey were also given free text response options for a question on the value and opportunities for involving famers more in citizen science activities. 33 participants added a comment in this section. The full detail of all free text responses is available in the accompanying database. Respondents valued the engagement of farmers for three key reasons:

1. Access to land. (8 respondents)

Farmers and landowners have access to large land area and access to that for schemes is essential for the success of the scheme overall. This is particularly important for schemes seeking to undertake large-scale, national monitoring that is representative across habitats, especially those that engage public volunteers to do the recording.

"Farmers are critical. Given the sheer area of land managed as farmland, simply having cooperation from farmers is essential to allow scheme coverage." (#. Passive)

"Farmland covers a large proportion of the UK, but can be under-represented in monitoring schemes. Anything that redresses this will lead to more valuable data and more representative results." (#2. Passive).

2. Access to knowledge. (9 respondents)

Farmers represented an untapped source of knowledge. Farmers can collect data directly for the citizen science activity or can provide additional contextual data, e.g. information about land management practices or agri-environment schemes. This could contribute to analysis of drivers of biodiversity trends, including the positive impact of interventions (for example, see Billaud et al. 2020).

"As researchers [involving farmers in citizen science] also allows us to gather larger amounts of data across a wider geographic area." (#3. Passive)

"Their [farmers] local knowledge is essential for understanding the data." (#4. Active)

3. Engaging farmers to inform farm management. (15 respondents)

A frequent opinion within the responses was that engaged farmers would undertake land management in a more favourable way, for the species they were recording. Respondents thought that engaging farmers builds trust in the data that they are collecting or that volunteers are collecting on their land. Farmer involvement was also expected to have the consequence that farmers are more likely to respond in a favourable way (making direct management decisions) as a direct result of participation in a scheme (see Section 4.5 for further discussion on the mixed evidence for this). Survey respondents thought that data collection and involvement would create a positive feedback mechanism for farmer engagement and decision-making.

"The involvement [of farmers] nurtures a caring attitude to the environment and helps to break down barriers to change needed to combat the climate emergency and biodiversity emergency". #5 (Passive)

"Getting farmers engaged in data collection fosters greater trust in the resulting datasets, and subtly makes them appreciate the effects of their management on the taxa they monitor" #6 (Active)

"If the farmers are directly involved in the research and data collection they are more invested in the project and likely to make positive environmental changes." #7 (Active)

3.3 Characterising citizen science schemes by their objectives

For our survey, we encouraged responses on activities that were varied and broad ranging, and engaged with schemes that included activities that were not necessarily in published literature. We characterised the UK citizen science activities from our survey using the typology developed by Ruck et al. (2022) and outlined in Section 2.3, although with some caution as some of the activities fall across typology boundaries (and so were counted in more than one category).

The five identified types represent a progression towards increasing relevance for farming communities. Between types A and D, there is also a progression towards focused data collection that enables analysis of the effects of specific farmland practices on (often specific aspects of) biodiversity.

For our survey, we encouraged responses on activities that were varied and broad ranging, and engaged with schemes that included activities that were not necessarily in published literature. We are able to characterise the UK citizen science activities that engaged with our survey in a similar manner to Ruck et al. (2022), although with some caution as some of the activities fall across typology boundaries.

These data may differ to those reported already due to more research into the types of activities that were operating. Within question 1. What is the purpose of the citizen science activity; multiple answer options were permitted. In order to assign a specific typology for the citizen science activity (Table 4.1), additional information was included, provided from answers to questions in the survey and by information gathered from web searches. Within the survey we had responses about projects that were not solely biodiversity related. However, all of them fitted within group E because, although they collected data on water quality, productivity, and soil characteristics, they all stated that farmer engagement was the principle objective of the citizen science activity.

Table 11: Number of citizen science activities from UKCEH survey that fall into Ruck et al. typology categories. Please note that activities may fall into more than one category.

Classes from Ruck et al.'s typology	Number of projects in our survey
A. Measuring general biodiversity trends	1
B. Measuring general trends for specific species/taxa	20
C. Measuring general *farmland* trends for specific taxa	16
D. Measuring the effects of farming-related activity on biodiversity	4
E. Engaging farmers (or testing methods with farmers)	8

Type A. Measuring general biodiversity trends

A key feature of the Type A activities is that data collection is ad hoc and opportunistic, with no systematic selection of sites or habitat types. Records can be sent in from any location, any land or habitat type and without any permissions from landowners. For our survey we had one response from this type of recording scheme and this was from **iRecord**, which has the purpose of supporting the collation and verification of biological records, which may be used by many data users for a range of purposes. Ruck et al. (2022) identified 9 such activities within this typology.

Type B. Measuring general trends for specific species/taxa

The aim of this type of activity is to measure national-level trends, but unlike those in Type A, they focus on a particular species or taxa. From our survey we had twenty examples of citizen science activities, including the two examples from the pilot survey. Ruck et al. (2022) also had this as the most common type of activity. A wide range of taxa were covered by recording activities including bryophytes, plants, mammals, bats, birds, butterflies, bees and ladybirds. This includes surveys that are opportunistic, and those that are structured (i.e. following a protocol at designated sites). They include farmland in order for the results to represent the habitats present across the UK.

Specific examples include UK Ladybird Survey; Mammal Society's National Harvest Mouse Survey; BTO's English Winter Bird Survey; Butterfly Conservation's Wider countryside butterfly survey; PoMS and NPMS see additional database for a list of all activities.

Type C. Measuring general *farmland* trends for specific taxa

These activities are similar to Type B in that they tend to be coordinated on a large scale and aim to gather data on general trends but have a specific focus on farmland. There are 16 examples in the survey these include BTO's Wader calendar; Game and Wildlife Trust's Big Farmland Bird Count and the M&S, Butterfly Conservation and the RSPB Indicator farm project (no website as project is completed). Our survey identified more schemes in this category than Ruck et al. (2022) reported operating in the UK.

Type D. Measuring the effects of farming-related activity on biodiversity

Activities falling within this typology generally had the aim of measuring the effects of a particular farming-related activity on a specific aspect of biodiversity. There were only a few examples of this particular typology in our survey, including UKCEH Carabid monitoring scheme for farmers; NFU's Farm nature discovery event; Plantlife's Cairngorms Mob Grazing Trails and Earthwatch activity Farming with Nature. Whilst we approached all of those from the Ruck et al. 2022 report (5 within this category from the UK in 2022), some did not respond nor complete our survey. From internet searches it would appear some of the schemes identified in that report had come to an end and no information nor forwarding email could be found to gain further insight about the schemes e.g. Northumberland Coast farmland bird monitoring.

Type E: Engaging or testing methods with farmers

Ruck et al. (2022) describes these schemes as still being 'citizen science' in that non-professionals are engaged in some form of biodiversity data collection, but the data collected are not necessarily used for research purposes.

We had eight examples where the principle reason for the citizen science activity was stated as being farmer engagement. These included #60minworms, #30minworms, #WorldWormWeek (no website as this project has now ended); Interreg EU project Fabulous Farmers; Wensum farmers Fenland SOIL Landscape Opportunity Mapping, and People's Trust for Endangered Species' s Healthy Hedgerows app.

3.4 Discussion and summary of online survey

3.4.1 Survey coverage

Ruck et al.'s (2022) recent review of citizen science biodiversity monitoring identified 49 schemes in the UK, of which the majority (33) were general schemes (groups A & B), while just 16 schemes focussed on farmland or engaging farmers (groups C-E). We had responses from 28 citizen science activities in these farmland-focussed categories (groups C-E); Section 3.4 above, which gives us confidence that coverage of our survey was comprehensive, if not exhaustive. The additional activities included in our survey were: a) a few that monitored other responses than biodiversity (Ruck et al. 2022 only reviewed biodiversity citizen science schemes), though the majority of our activities (32 out of 37)

did focus on biodiversity (Section 4.3 above); and b) a few regional activities who self-reported in our survey but were not identified through the academic literature search approach taken by Ruck et al. (2022).

3.4.2 Farmer involvement in current schemes

Farmer involvement in schemes in our survey ranged from those who collect data themselves to those who are only involved to enable volunteers to access land. We have reported on and reflected findings from this survey in terms of active and passive farmer involvement, finding that those with active farmer involvement tended to be more likely to be regional (rather than national), more likely to have limited public availability of data and more likely to circulate results to participants (including farmers).

Our reflections on the levels of farmer involvement in monitoring have informed our further reflections on how we can describe the range of farmer involvement which adds to the descriptions of the purpose of the monitoring, described by Ruck et al.'s typology.

3.4.3 Size and geographical spread of schemes

Most activities reported via our survey were quite large in scale, operating on more than 100 sites with 2 to 5 visits annually and were national schemes operating over the whole of the UK.

There were differences in the scale at which schemes with passive and active farmer involvement operated. Passive schemes were more likely to have a national focus; projects with active farmer involvement were more likely to have a regional focus or single farm focus.

Responses to our survey indicated that farmland was not representatively sampled across the citizen science activities. We had a response from only one scheme from Scotland, and no upland schemes from England. Of those schemes with active farmer engagement and operating at a regional level within England, were in lowland habitats. A gap in general biodiversity monitoring in harder to reach and harder to survey areas has reported elsewhere (Boarder et al. 2019). There were too few responses at a regional scale to complete any further analysis of geographical extent or gaps.

3.4.4 Types of data collected

We found that there was a focus on activities collecting biodiversity data. 32 of the 37 projects in our survey covered biodiversity, birds were most frequently recorded species group in both our survey and Ruck et al. (2022). Plants were next most frequently recorded in our survey (15 out of 37 responses), plants / flowers were less frequently recorded in Ruck et al. (2022) review (10 out of 49 Cit Sci schemes) with other animal taxa more frequent than plants. Habitat type and quality was also frequently recorded in projects in our survey (often associated data collected when recording biodiversity).

Activities in our survey included collecting other types of data, including water, soil, productivity and economic data, but these were a minority (Fig. 4.2).

3.4.5 Data – collection methods and availability

Data from our survey participants was generally collected using transect methodology or ad hoc recording. This in general reflects the types of data that were more predominantly collected within the schemes responding i.e. structured national schemes collecting bird and butterfly data or those that collected individual species data in an unstructured approach.

Reporting of results was considered important and data were generally freely available, or available with licence to use; where data were not available there was an intention to make them so in the future. We did not explore within this survey how much and in what format scheme reporting of results directly to farmers took place; nor what the time frame of such reporting might be or what experience there was of knowledge exchange strategies that were best for farmers. This could be an area for future research.

3.4.6 Scheme aspirations

Most participants thought longer-term funding or additional funding was very important to achieve the aspirations of the citizen science activity. Free text answers and enhanced engagement conversations allowed for greater depth of information to be gathered about scheme activities. When reporting on aspirations for schemes into the future, a full range of responses was given, from continuing as they are now with limited farmer involvement (only for access permission) to increasing engagement with farmers and for farmers to gather data for the schemes/themselves.

3.4.7 The value and opportunities for farmer involvement

Across all types of citizen science activities, there was a clear feeling that it was of great value to involve farmers in citizen science. Gaining access to previously un-surveyed land or continued access for recording is vital to meet biodiversity monitoring needs. Opportunities were also voiced about the importance of fully engaging farmers with recording to bring about changes in management.

There was a clear reasoning and expectation among survey respondents that greater farmer involvement in recording would result in positive outcomes for biodiversity. This positive feedback assumption was not found by the empirical study Alblas & van Zeben 2023, but further research would be needed to determine whether the results of that study are more generally applicable. We believe that this is a key assumption from the survey respondents, and we recommend that further research is commissioned to determine whether farmer engagement in environmental monitoring does support beneficial

management for environmental condition, and how this is moderated, e.g. through experiential learning or data interpretation.

4. Participatory Stakeholder Workshop

4.1 Workshop approach and structure

Citizen science scheme coordinators (and those involved with schemes who had completed the UKCEH digital survey) were invited to attend an online participatory workshop. Also attending were members of project steering group representing Natural England, from JNCC and from research organisations / universities. There were 45 participants from across 17 organisations including the UKCEH project team. Most respondents to the online survey asked to be invited to the workshop, so there was cross-over in participants for the two forms of engagement.

There were four short talks were at the start of the workshop, to set the scene. The first introduced the project and relevant Natural England initiatives, the other three talks each described an example of a citizen science activity or pilot project that involves farmers in different ways:

- *Facilitation of Participation: pursuing inclusive and scientific environmental survey and monitoring*, Natural England
- *A Very Muddy Farm Walk – helping farmers understand how to help the wildlife on their land through individual farm survey reporting*, RSPB
- *An introduction to the Healthy Hedgerows rapid assessment app*, Peoples Trust for Endangered Species (link to app).
- *Citizen Science on farmland: A butterfly recording case study*, University of Reading

Following the talks, participants split into smaller discussion groups with a facilitator from the UKCEH project team in each. For each group, four questions were presented on a concept board and participants could add virtual 'post-it' notes with their personal comments and ideas.

1. Why do you think farmers need or want data, e.g. biodiversity, environmental or productivity data?
2. Why do you think policy makers /scientists / scheme co-ordinators want to know about farmland?
3. What are our opportunities to develop farmers & citizen science/participatory monitoring? (What can we do more of, or do differently?)
4. What might limit our ability to achieve this?

Participants were asked first to address Questions 1 and 2 on different sections of the same discussion board, and then Questions 3 and 4. There was also time for verbal discussion, though the majority of participant input was through the written notes.

4.2 Post workshop analysis

After the workshop, we identified broad themes using all the comments. Each note was read once, then again and assigned a theme by the facilitator of the group immediately after the workshop. A member of the project team then assigned all comments across the three workshop groups to common themes. All notes from all answers to questions were considered and the number of comments per theme counted. Themes were as broad as they could be to contain a mix of comments but specific enough to be meaningful; if there was a long comment that could be split (each part fitting a different theme) then it was counted more than once. Tables 12 to 15 list the themes; the total number of comments that contributed to that theme being identified; and a good example comment selected from all responses. Full copies of the concept boards with all notes are in Appendix 2.

4.3 Results from the participatory workshop

4.3.1 Question 1. Why do you think farmers need or want data, e.g. biodiversity, environmental or productivity data?

Table 12: Themes identified from a question to workshop participants – Why do you think farmers need or want data, e.g. biodiversity, environmental or productivity data?

Theme	Number of 'post-it notes'	Examples of comments
Business reasons/financial	22	*"To challenge/confirm or provide evidence for changes to SFI/CSS [sustainable farming incentive/countryside stewardship] payments"* *"To baseline biodiversity — could be important for green financing going forward"* *"To have control over their land, assessment of its value, and the grants they may be entitled to."*
Personal interest	14	*"From my limited crossover with farmers and landowners I get the impression many see themselves as care-takers of their land and have a genuine interest in, and concern for, its wellbeing."* *"Love of nature/biodiversity (e.g. particular charismatic birds or fish)"* *"For interest or comparison with neighbours"*

Understanding impact of management	22	*"To tell a story to their customers and local community of their impact. To broaden the dialogue beyond farming vs nature towards farming with nature"* *"To help them to understand (and provide evidence of) the biodiversity impact of any interventions/changes in management practices on farmland."* *"To find out what species they have on their land so they can adopt appropriate management to help conserve them."* *"To get direct advice about management options"*

4.3.2 Question 2. Why do you think policy makers /scientists / scheme co-ordinators want to know about farmland?

The responses to this question followed more diverse themes than the responses about what farmers might want to know.

Table 13: Themes identified from a question to workshop participants – Why do you think policy makers /scientists / scheme co-ordinators want to know about farmland?

Theme	Number of 'post-it notes'	Example of comments
Farmland makes up large proportion of UK	10	*"Farming is c. 70% UK land area — if you don't [survey] there then you don't know much"* *"we can't achieve our goals on nature recovery without farmland""* *Farmland covers a huge proportion of the country — if we want to understand biodiversity trends nationally then we need to understand what's going on in farmland"*
Understand the direct impact of changes in land management	25	*"To inform management and assess impact of practices"* *"They want to know if the interventions are making an impact on environmental factors"* *"To test/demonstrate that recommendations/ trial conservation methods are effective"* *"To see the benefits of agri-environment and other habitat management"*

For understanding/research e.g. trends, predictions	6	*"New research topics — identify problems early on"* *"To assess national trends in biodiversity loss (or otherwise)"* *"What's the trend overall? Are things improving or getting worse? What's the case for action?"* *"To make predictions about what might happen in the future, based on what has happened in the past. i.e. biodiversity effects of new pesticides, farmland responses to climate, projected soil productivity"*
To engage farmers, help farmers understand	2	*"Ideally should be to fund monitoring to help inform farmer's understanding"* *"engage farmers in understanding better what they have to conserve and Love of enhance on their land"*
Other	1	*"probably to reduce cost of collecting data"*

4.3.3 Question 3. What are our opportunities to develop farmers & citizen science/participatory monitoring? (What can we do more of, or do differently?)

Table 14: Themes identified from a question to workshop participants –What are our opportunities to develop farmer citizen science participatory monitoring?

Theme	Number of 'post-it notes'	Example of comments
Develop and use technology – data collection	14	*"Developing monitoring objectives that focus on simple, single species monitoring e.g. yellowhammers with associated data recording through an App to be as convenient as possible"* *"Energy savings renewables and continuous monitoring e.g. using webcams or CCTV at the farm."* *"Clear signposting of apps and recording schemes/volunteer recorders to farmers"* *"Simple, repeatable in-field methods"*
Develop and use of infrastructure – data processing	6	*"Development of infrastructure (guidance on methods, data recording and storage tools) to facilitate monitoring at any scale."*

		"Ease of transfer of data from citizen science submission format to that required for stewardship applications etc." *"Provide services back to farmers as part of surveys (e.g. detailed habitat mapping) to keep them engaged and onboard".* *"Make all data collected on farms as widely available as possible (collect once, use many times)"*
Financial incentives for monitoring / surveying	16	*"Making participation a requirement of public/ private schemes or markets".* *"Payments by results scheme where surveying by farmers/volunteers is a requirement".*
New incentives for participation	2	*"The ability to 'show off'? Some apps have leaderboards for participation or achievements — this could trigger competitive urges, positive reinforcement or even just to create a forum for likeminded farmers attempting similar positive change? Peer engagement is more powerful than many other incentivization"*
Training/skills development	5	*"Opportunities for running training/workshops at farms; Expand Open Farm scheme? — so chance to link more members of public with farmers."* *"Funding for regional support. Particularly in person meets and training, support and follow up"*
Linking biodiversity with production/other aspects of farm business	2	*"Farmers must be appropriately paid for monitoring and recording they undertake. With the best will in the world, they are extremely time poor and lengthy surveying does not work."* *"Useful within their business model"*
Better links between farmers and Cit Sci / volunteers	10	*"Joined-up thinking. Working together to share citizen data or coordinate data/sample collection so that farmers are not being bombarded with requests or overwhelmed by the number of citizen science projects there are to participate in."* *"Opportunity for linking to pest control / IPM i.e. for some suitable species groups such as ladybirds (great for citizen science), carabids (more difficult but very useful), etc — i.e. so that the recording is more useful for farmers, potentially linking to farming practice."* *"Better linking/facilitating conversations/bridging the communication gaps between biological recorders*

		(national schemes, ad hoc recording via apps etc) and farmers. Also better communication of results of surveys and scientific analysis to farmers/landowners, which doesn't always happen." *"Local community participation to ensure farmers and others work together, e.g. rewilding."* *"Regional networks of farms/farmers for long term monitoring (thus helping long-term biodiversity trends data)"* *"Famers and volunteers need appreciation of other projects going on — gets confusing with many different methods"*
Expand volunteer outreach/reach different audiences	3	*"Tap into public interest in food production and encourage members of the public to record biodiversity on farmland".* *"Outreach to different types of farmers (gender, age, type of farm)"*

4.3.4 Question 4. What might limit our ability to achieve this?

Table 15: Themes identified from a question to workshop participants –What are our opportunities to develop farmer citizen science participatory monitoring?

Theme	Number of 'post-it notes'	Example of comments
Trust (between scheme and farmer) **Data exchange**	8	*"Understandable nervousness about giving away some data that might, in some way, come back to cause them headaches (fear of RPA etc)".* *"Farmers being concerned about rare species being found on their land and this limiting their activities."* *"Need to be very clear about the use of the data to the farmers — can include data that are confidential (rare species or commercially sensitive data)"* *"Fear that analysis of data collected will then lead to landowners being obliged to put land into schemes or reserves where they then are more restricted in how they can manage the land in question, or are obliged to increase the level of public access on this land or on their adjoining land."*
Trust (between scheme and farmer) **Data quality**	8	*"Farmers wanting to underestimate present biodiversity status before biodiversity net gain kicks in".* *"Concerns from farmers over data quality leading to concerns over the value of allowing volunteers on their land (common perception that citizen science isn't as high quality as professional even though not true much of the time)".* *"Volunteer capacity. Also the skills of the volunteers/farmers will dictate the quality of data that can be collected and the purpose they can be used for".*
Trust (between scheme and farmer) **Access**	5	*"Allowing citizen scientists onto land. Experience from our projects range from farmers being extremely keen to those who are overtly and aggressively opposed to the activity".* *"Bridging the gap between landowning farmers and tenants. Landowners may say 'yes, of course', whereas tenants can be more opposed."*
Time (farmers)	19	*"Farmers actually having time to engage and get out on the farms to look at biodiversity."* *"The many other asks / drains on farmers time"*

		"Farmer time — farmers work long hours so how can this fit in with their day job? Farmers' time, priorities changing through year, unpredictability of weather etc!"
Time (citizen science schemes)	9	*"Volunteer fatigue is a real problem — having a person that citizen scientists, farmers and others can speak to, maybe just to commiserate with or to tell about success can help to mitigate this. This requires long term funding and support."* *"Engage more volunteers to prevent volunteer fatigue".* *"Need for volunteer scientists/surveyors to have a certain level of skill from outset — offering training or buddying up might help increase volunteers?"*
Methods and equipment/tools	6	*"The proliferation of different technology platforms/apps/websites for recording and survey projects can be both positive and negative — it can be very confusing and potentially overwhelming for people (including farmers?) to get involved with citizen science or perhaps decide which survey to choose to engage with, especially when people have limited time".* *"Generation of too much data. So it's too daunting to actually do useful analysis. Too many different types of survey so analysis difficult to make"*
Funding	13	*"Appropriate funding and overcomplicating the requirements or desired outcomes of the monitoring ...it must be super simple to undertake and continue with"*
Communication	5	*"How farmers identify with the purpose / organisation providing the platform / particular environmental angle"* *"Create a survey or 'calculator' to input farmer goals and farmer needs to limit and narrow the key cit sci projects that are most relevant".* *"Too much duplication of effort across projects—so much citizen science occurring that is asking for attention".* *"Multiple platforms doing similar things or need to use multiple platforms to get a summary of how a farm is doing".*
Differences in need/aims between scheme and farmer	2	*"'telling' farmers what they must do, rather than facilitating this as a bottom-up approach. If farmers are interested enough to monitor a species and have the tools, funding and support available then they will."*

4.4 Verbal contributions to discussions

Note takers were present in each of the breakout groups and recorded verbal discussions. However, most information was captured by written record. Discussions were much more fluid and less structured than the written questions and so are presented as bullet points.

- Biodiversity related monitoring most common. Other agencies and science areas were mentioned that carry out citizen science activities on farmland e.g. archaeology. Citizen science workshop participants were not aware of other monitoring outside of environmental science and especially the biodiversity schemes present.
- There was a need identified for collaboration of partnerships between citizen science and farmers to understand the needs of farmer and come together as citizen science schemes to address these needs collectively.
- Monitoring across scales, looking at areas where there are priorities that merge between what a farmer is interested in and what citizen science schemes are interested in at a national scale and merge these where possible.
- There is an anxiety about volunteer fatigue and the problem of maintaining long term relationships between farmer and volunteer or scheme coordinators.
- Long-term farmer engagement is difficult regardless of how interested farmers are.
- There is a need to understand that success rates will be variable – some schemes, despite much travel time, input and enthusiasm still don't actually get any data.

4.5 Discussion and summary of participatory workshop

It is important to note that workshop participants were mainly citizen science co-ordinators, policy-makers and a few researchers (farmer viewpoints consulted in the parallel citizen science project *Farmer Engagement with Citizen Science and Environmental Data Collection*). Whilst this workshop was from the viewpoint of coordinators of citizen science activities, reflections and comparisons are needed with the sister project which engaged with farmers directly. Comparisons of the themes emerging and crossover between the two projects would be informative, especially for the first question on farmer needs, in order to identify gaps and differences between the two stakeholder groups.

Farmers needs for data

Three themes emerge from workshop participants' answers to the question of why farmers would want to know about environmental data:

- Business need (22 comments). There may be a financial need for farmers to collect environmental data. Providing evidence and proof of management done through an agri-environment scheme, supermarket assurance scheme or other grant/business mechanism. Accounting for or completing an audit of environmental impact may be required. Or submitting records as part of a baseline prior to work commencing.
- Understanding impact of management (22 comments). When farmers implement management either directly to influence nature or as a consequence of business as usual, they may wish to learn what the outcomes of those actions are on farm

biodiversity or other elements impacted by farming practices e.g. soil condition/water quality.
- Personal interest (14 comments). Farmers may have a personal interest, love of or a curiosity for recording and monitoring what is on their land. This may be as their role as custodian of the countryside or a genuine concern for its wellbeing.

Researchers needs for data from farmland

Identified themes for citizen scientist and researchers needs for data included:

- Understand impact of management (25 comments). Similar to the need for farmers, the consequences of farmland management on species/environment need to be understood, and therefore data are needed to demonstrate the effects of that management.
- Farmland makes up a large proportion of the UK (10 comments). Given that so much land area is covered by agricultural land in England it makes knowing what is going on within these areas important, almost vital in understanding all data.
- For understanding/research (6 comments). Data collected are needed to understand trends in populations, e.g. identifying biodiversity losses or improvements at a national scale, as well as identifying areas for future research.
- To engage farmers (2 comments). Data collection can be used as a means to engage farmers and enthuse them in nature conservation and improve understanding and the need for favourable management.
- To reduce cost of collecting data (1 comments). Using volunteers negates the need for paying ecological surveyors to collect data.

Whilst there is some cross-over with question one, there are key differences in the themes which emerged. Interestingly, the theme of personal interest was not raised here. Understanding direct management impacts was considered important for both stakeholder groups and this could be important in identifying, understanding and building mutual policies across these two groups for environmental benefit.

4.5.1 Opportunities to develop farmer involvement in citizen science and what might limit them

We have combined the discussion of responses to Question 3, on opportunities and gaps within farmer involvement and citizen science schemes, with responses to Question 4. on barriers to those opportunities. They have been brought together to enable greater understanding of the opportunities that are feasible and gaps that were identified during the workshop. Within this section some additional comments from verbal discussions have also been incorporated. However, the majority of content on opportunities, gaps and barriers came from written post-it notes within the virtual white board approach of the workshop.

Incentives for monitoring / surveying

Finding novel or existing but effective ways of incentivising farmers with environmental management techniques was considered to be important. Participants suggested financial incentives through the likes of agri-environment schemes. Suggestions included paying directly for environmental data collection, payment by results or making collection of data a requirement of participation. However, some novel approaches such as gamification of app use were made to appeal to different motivations of farmers for participation. Some concerns were also raised about the reliability of the data (trust in data), and difficulties and consistency in collection methods available for farmers if financial incentivisation of data collection was pursued.

Improving links between citizen science and farming

There were strong feelings that better links and communication are needed between the citizen science community and farming community. There is a recent substantial increase in interest from farmers and farmer clusters to undertake their own monitoring, or coordinate additional volunteer monitoring, especially with regards to the impact of interventions on biodiversity and ecosystems. There are many schemes collecting a wide range of data, this can be overwhelming for farmer clusters or farmers looking for a monitoring methodology or citizen science scheme. However, they lack access to information on suitable methodologies and data infrastructures, and how to link to existing citizen science schemes.

Sustained funding for the creation and ongoing maintenance of a citizen science hub would help to address this need. Citizen science volunteer and coordinator fatigue was raised as a risk however, given the increased interest.

There was also discussion on how citizen science schemes could cooperate between themselves as this is a growing area, and come together as a collection of partnerships to explore how citizen science could deliver for farmers and farmland.

However, from the survey (Section 3) improving links with farmland was not priority for some of the larger national schemes, whose focus remains on national and higher-level reporting for taxa distribution atlases and national trend data for official statistics.

Develop and use technology for data collection and for data processing

Technology and the introduction of technology was a strong theme emerging in order to facilitate both collection, and post collection processing, of data. These were strong themes to compensate for the barriers that were identified in Question 4, principally of limited time for farmers participating and time limitations for citizen science scheme coordination.

Technology may also facilitate the building of trust in data quality, through either direct reporting of results to farmers (e.g. Heathy hedgerows app) or recording equipment that

farmers themselves can set out (e.g. audio recorders), alleviating access restrictions for strangers.

Issues may persist with trust in terms of data sharing, data exchange and confidentiality by use of technology (as well as traditional approaches). Citizen scheme coordinators expressed views and experiences of farmers not engaging, for example as they do not want to know if there is rare or threatened species on sites because they are fearful about what this would mean for their business (e.g. in terms of selling land for development or in terms of having to implement hard and difficult management at their own cost for conservation measures), or for fear of twitchers/enthusiasts descending on land when a rarity is found. There is a need to explore such challenges in trust in further detail between schemes and farmers.

There is also a disconnect that could potentially arise from increased use of technology, farmers recording but not engaging with nature directly and therefore not altering management. There is a clear perception amongst many citizen science coordinators that increased nature connectedness by farmers will lead to improved management, and a concern that if technology negates the need for connection does this limit the engagement of farmers to improve direct management? However, it is also recognised that a technological approach may incentivise some farmers to participate and improve management through interest in the technology and use of it directly.

Training/skills development

The training and skills development of participating in a monitoring activity may in itself be an excellent tool for increasing farmer engagement and knowledge exchange. Enthusiastic volunteers visiting farms and discussing recording was shown to result in a positive relationship in one of the opening talks of the workshop (pers. Comm. Stuart Edwards, Uni. of Reading). Events such as Open Farm Sunday were suggested as an opportunity for linking members of the volunteering community with farmers. Participants also recognised that funding regional support and local level coordination helps sustain engagement.

Linking biodiversity with production/other aspects of farm business

Participants at the workshop felt it was important to try to link biodiversity with other aspects of the farm business, in order to enhance farmer engagement and involvement. An example was given of the potential for integrating beetle (ladybird/carabid) monitoring with integrated pest management plans and solutions as well as considering aspects such as soil health. However, from the survey such integration was not currently happening.

5. Discussion and summary

We developed conclusions and summarise the gaps and opportunities for next steps for farmland citizen science and farmer participatory monitoring based on: our rapid assessment of evidence; the survey with 37 respondents to assess the state of play in England and the rest of the UK; the workshop with 45 participants to understand their perspectives on gaps and opportunities (Section 4); and reflections from our own experience.

5.1 Discussion

5.1.1 How might farmers and farmland be involved in citizen science?

Based on our reflections from the evidence review, our survey results, and early enhanced engagement conversations with stakeholders, we classified the range of 'citizen science involving farmers' activities into a spectrum of five categories (Figure 6.1). These categories vary in the degree of the involvement of the farmer, the type of person who undertakes the recording (public volunteers, or the farmer/their representative) and whether they come under the more traditional definition of citizen science as volunteer monitoring, or the broader definition that includes voluntary sharing of data collected for other purposes.

Early conversations with stakeholders identified an example of a National Park authority asking farmers to voluntarily share data that they had been paid to collect for their individual farms, through Sustainable Farming Incentive (SFI) monitoring payments. This enabled the National Park to collate a larger database across multiple farms, to inform their conservation initiatives. We did not come across other examples of this type of voluntary sharing of data collected for non-voluntary reasons, but it represents an opportunity for adding value to existing data collection at the farm level.

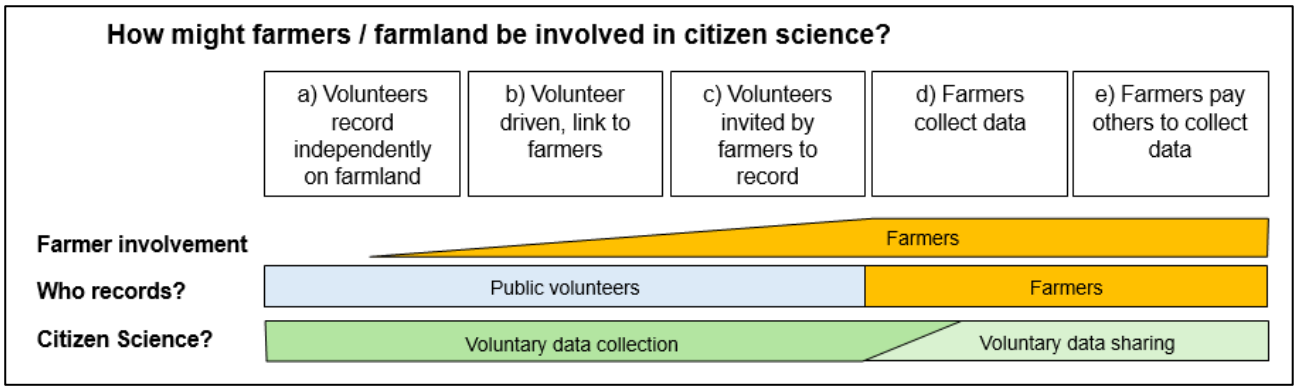

Figure 6: A broad classification of citizen science involving farmers and farmland, as described above.

The five categories in Figure 7 are:

a) **Volunteers record independently on farmland.** Many national biodiversity citizen science schemes encourage recording of biodiversity across the countryside including on farmland, i.e. in areas with public access. In some citizen science on farmland, volunteers are independent from farmers and often may undertake recording without the knowledge of the landowner or farmer (e.g. from public footpaths or rights of access). These include both ad hoc, opportunistic records of species (e.g. via iRecord) and systematic, repeated monitoring along public rights of way (e.g. Breeding Bird Survey, Wider Countryside Butterfly Survey). Some of these schemes deliver high-quality statistics on the trends in biodiversity across a region or nationally, although most are usually limited in their ability to report trends specifically on farmland, or evaluate the impact of farming practices or interventions.

b) **Volunteer-driven, link to farmers.** Some large-scale projects encourage public volunteers to engage with the farmers on whose land they wish to record, both by requesting access and potentially providing feedback on data collected (e.g. species lists). This category links to the schemes in the 'passive farmer involvement' category in the online survey results (Section 3.3). Examples include the National Pollinator Monitoring Scheme.

c) **Volunteers invited by farmers to record.** Some projects are led by farmers, but invite volunteers to record on their land. These will tend to be more nature-friendly farmers who are willing to receive advice or evaluation of the impact of their agri-environment schemes, for instance, or farmer clusters initiating volunteer monitoring across a group of farms.

d) **Farmers collect data.** Projects in which farmers collect their own data as 'citizen science' (i.e. voluntarily collecting data and sharing them) are scarcer, and often regional rather than national in scope (Section 3.3). Examples include the Wensum Farmers (www.wensumfarmers.co.uk). Our workshop provided some indication why this might be the case and how there may be opportunities to grow in this area (Section 4.3).

e) **Farmers pay others to collect data.** If the data are voluntarily shared even in situations where the farmers pay others to collect these data, e.g. productivity or pest data, or mandatory agri-environment reporting, then we consider that it falls within scope of this project. We came across only one example of this, with farmers voluntarily sharing SFI monitoring data with a National Park authority. This sharing of data from individual farms to datasets that cover larger spatial areas represents a potential opportunity.

Few of the published studies reviewed (Section 2) or the citizen science activities characterised (Section 3) directly measured impacts of farmland management or

conservation initiatives on environmental outcomes. This was identified as an opportunity (Section 4). Realising this opportunity would require sharing of farmland management and conservation data from across multiple farms, which may be limited by the themes of trust also raised in the workshop (Section 4.3; Wittman et al. 2020).

Reflecting on the expectation of many stakeholders that monitoring by farmers on their own farmland might lead to adaptive management leading to improved environmental outcomes (Sections 3.3 and 4.5), and the potential for voluntary sharing of data collected at the farm-scale to create larger-scale databases, we devised a conceptual model to illustrate approaches to data and evidence among farmers vs policy-makers / researchers / conservation organisations (Section 4.3) and how these could interlink (Figure 8). We suggest this may differ for farmers, some of whom prefer anecdotal data / shared experience from their own or similar farms communicated via peer networks and demonstration days (Burgess et al. 2023), compared to researchers and policy makers who prioritize evidence based on empirical data (Turbé et al. 2019). Expectations of timescales for results can also differ between farmers and researchers (van Etten et al. 2019a); the longer timescales over which research outputs become available has been identified as a barrier to farmer engagement with research.

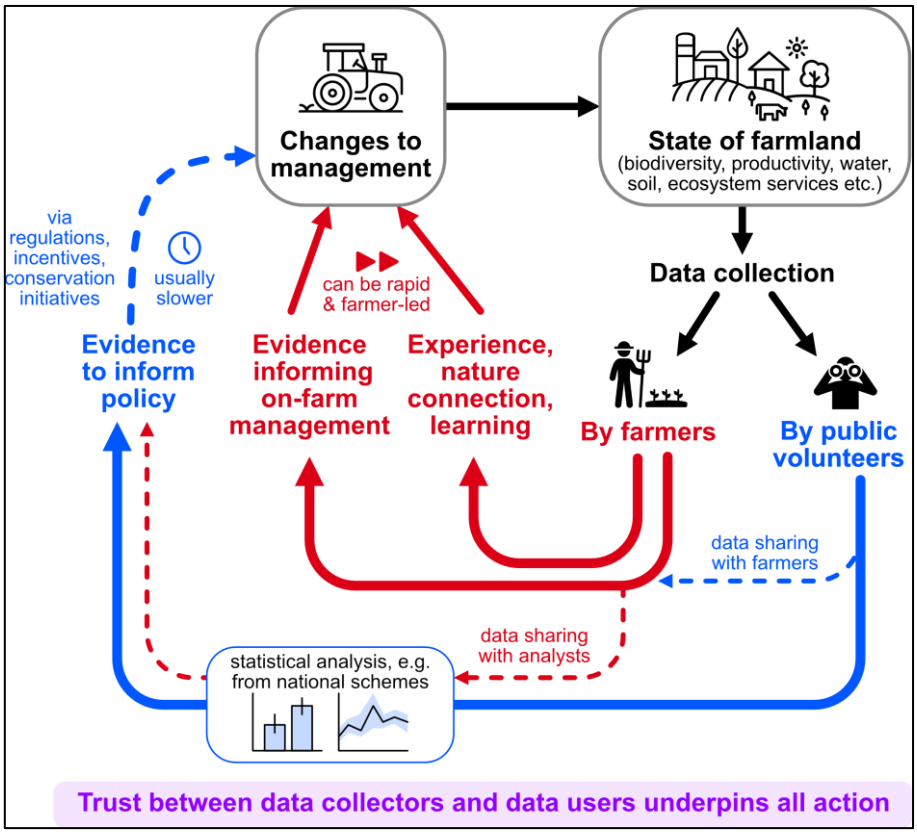

Figure 7: Our proposed understanding of how citizen science on farms can impact on management / practices of farmland and support adaptive management. (Icons by Prosymbols, Design Circle, Adrien Coquet and Luis Prado from Noun Project – open access).

5.1.2 Research gaps and barriers to the involvement of farmers and farmland in citizen science

There are gaps in evidence for some of the links illustrated in Figure 8. For example, as discussed above, the only published study we found suggested that in this one example, farmer monitoring did not improve agri-environment management outcomes (Alblas & van Zeben 2023). This result may have been unique to the specific context of this study, and we did not find other empirical evidence relating to this. Given multiple stakeholders expectation that farmer monitoring would lead to beneficial management, this needs further research to explore the contexts and approaches that might strengthen this link.

Previous reviews suggest farmers may be more engaged with monitoring that directly impacts their farm business (e.g. soil quality, ecosystem services such as pest control) than for wider biodiversity monitoring. This was challenged by a study that found time requirements were more important than monitoring focus (Garratt et al. 2019), and by several examples of ongoing citizen science activities that involve farmers in biodiversity data collection (Section 3.3). Farmer engagement with different types of monitoring may vary with farm attributes such as agricultural sector, size, and also with farmer motivations and experience. Further research could help elucidate the drivers behind farmer engagement with different types of citizen science.

Many of the stakeholders consulted raised a lack of clarity around citizen science opportunities and methodology, especially in the context of substantially increased interest in biodiversity monitoring by farmer clusters and individual farmers. Coordinators of established citizen science schemes raised volunteer and coordinator fatigue as a concern, linked to this increased demand for biodiversity monitoring.

The short-term nature of many projects set up to trial farmer engagement with citizen science or participatory research was also raised as a barrier to expanding this type of monitoring, both in the survey (Section 3) and the participatory workshop (Section 4). These short projects were felt to be missed opportunities, as many of them involved bringing together a community of stakeholders including farmers without continued engagement once the project ended.

5.2 Summary – opportunities, priorities and research gaps

Here, we summarise next steps in relation to priorities, opportunities to further support farmer involvement in citizen science and research gaps, using evidence drawn from the project activities (reported in Sections 2 to 4 above). We identify the sources of evidence for each: evidence review, survey, workshop, or project team.

Priority - maintain national citizen science monitoring schemes

Many national volunteer-led biodiversity monitoring schemes successfully report on the state of biodiversity across the wider countryside including on farmland. Natural England and related bodies should continue to support them. Some of these national schemes run related projects to explore monitoring on farmland (e.g. Volunteer Monitoring of Farm Wildlife), and sometimes these schemes may find it challenging to gain sufficient coverage on farmland. Data from these schemes contribute to key national indicators (Environment Improvement Plan, Defra 2023). [survey, project team]. It remains important to balance a priori statistical design (e.g. having a clear question, undertaking power analysis to calculate the required sample size and having a balanced, representative sample) against the potential to re-use data to address questions that the scheme was not specifically designed for (e.g. the use of Breeding Bird Survey data to explore impacts of agri-environment schemes, although re-use may be limited by the lack of experimental design).

Opportunity - add value to existing citizen science initiatives

A few existing initiatives provide farmers with individual feedback on biodiversity or habitats within their farm, without the collated data being analysed or reported across a larger scale (e.g. Healthy Hedgerows app). Relatively small amounts of additional funding would add value to these data that are already being collected and collated, for example through analyses that could inform regional and national estimates and conservation targeting. [survey]

Opportunity - share data currently held at individual farm scale

Sharing and collation of farm management data across larger spatial scales (i.e. beyond farm boundaries) would allow intervention and management impacts to be assessed using citizen science data. Understanding direct impacts of changes in land management on environmental outcomes was identified as a key priority both for policy-makers / researchers and for farmers. [survey, workshop]. Concerns over data sharing and a lack of trust are barriers that would need to be overcome [workshop, review].

Monitoring data being collected at the individual farm scale for mandatory reporting or incentives (e.g. monitoring funded through SFI, Landscape Recovery or for Biodiversity Net Gain assessment) are not currently being collated into central databases and made available for conservation or research. These data could be shared voluntarily, if concerns over data use and privacy can be alleviated [workshop, review]. The complexity of biodiversity and environmental data flows in the UK remains a substantial challenge that needs to be addressed to avoid confusion or data being siloed, and to allow effective data sharing and data re-use.

Opportunity – building citizen science capacity to support farmer involvement

There is a recent substantial increase in interest from farmers and farmer clusters to undertake their own monitoring, or coordinate additional volunteer monitoring, especially with regards to the impact of interventions on biodiversity and ecosystems. However, they lack access to information on suitable methodologies and data infrastructures, and how to link to existing citizen science schemes. Citizen science volunteer and coordinator fatigue was raised as a risk, given the increased interest. Sustained funding for the creation and ongoing maintenance of a citizen science hub would help to address this need. [survey, workshop]

Sustained funding for facilitators and coordinators, e.g. within regions or farm clusters and between farm clusters and researchers, would support greater engagement of farmers and farmland in monitoring. Several stakeholders identified short-term project funding as a barrier to sustained engagement in this area. [survey, workshop]

Opportunity – wider stakeholder engagement

Stakeholder consultation of citizen science involving farmers and farmland and environmental data has focussed on farmers, scientists / researchers, policy makers and conservation organisations (often NGOs). Given the expanding markets / opportunities for income for services evidenced by biodiversity data, future stakeholder consultations should include commercial stakeholders and explore the potential for greater sharing of data. [survey]

Stakeholder consultation of upland farmer clusters on citizen science. Limited regional-scale responses to our online survey may show a gap in engagement of upland farmers with citizen science [survey]. This needs further exploration, and would need to be conducted both in terms of what the farm wants to know, what other data users (e.g. researchers or policy-makers) want to know, what is feasible for the recorder, and what leads to statistically rigorous evidence addressing policy-relevant questions.

Research / evidence gaps

Research to understand the potential link between farmer engagement in citizen science / monitoring and changes to their land management that benefit biodiversity and other environmental outcomes. Anecdotally many of the stakeholders consulted expected such a link to be present, though the only empirical study did not find one [review, survey], Research in this area could include the ways in which farmer behaviour is influenced, and the value of experiential and place-based knowledge (of the farmer) versus statistically rigorous analysis that informs farm-scale decisions and informs policy.

Research is needed to understand farmer motivations in relation to different types of citizen science data, and how this relates to barriers such as time taken for monitoring. The linked project includes surveys and interviews of farmers which may address this gap.

Appendix

1. Survey questions

Understanding Citizen Science and farmer involvement

Understanding Citizen Science, and both current and future involvement of farmers

Who is this survey for?

This survey is for co-ordinators of Citizen Science activities collecting biodiversity and / or agricultural productivity data, with a focus on those that include farmland or farmers. Results of this survey will be used to inform Natural England's policies and activities, for example landscape-scale nature recovery and climate resilience.

Please respond to let us know about your Citizen Science activity (one entry per scheme),and circulate the survey to others co-ordinating Citizen Science.

Background

This survey is being run by UK Centre for Ecology and Hydrology and funded by Natural England. We will use the data collected to understand the characteristics of Citizen Science activities, including those that involve farmers and farmland. In addition, we would appreciate your thoughts on what the gaps and future opportunities are for farmer involvement in Citizen Science.

For this survey, we consider Citizen Science to be the intentional involvement of volunteers in science and monitoring. Whilst we focus on activities in the UK, information on Citizen Science from elsewhere in Europe is also welcome.

Filling in the survey should take around 20 minutes.

Your response will form part of a database of Citizen Science activities for Natural England, and an anonymised summary of the responses will be included in the final report for this project.

If you have any queries about the survey or research project, please email Morag.

Ethics, privacy notice and consent

This survey has undergone ethical consideration and has been reviewed by Natural England Ethics Committee. If you wish to make a complaint or talk to a member of UKCEH about the research who is not part of the research team, please email ukcehresearchethics@ceh.ac.uk.

No statement will be directly attributed to a specific individual in reports or publications from this project. The data will be anonymised for reporting. Any use of personal data will

adhere to the principles expressed in the UK Centre for Ecology and Hydrology privacy notice.

Your participation in this survey is completely voluntary. It is possible to withdraw or change your response at any time prior to publication, by emailing Morag McCracken (memcc@ceh.ac.uk).

Please confirm your consent to this study using the box below.

1. **I am happy to continue to the survey** *Required*

- Yes

About your Citizen Science activity or scheme

2. **What is the name of the Citizen Science activity or scheme?**

[Text box]

2.a. **Please give the website if you are happy to share it.**

[Text box]

3. **What is the main purpose of the Citizen Science activity? (Tick all that apply)**

- To measure general trends or changes in biodiversity, for individual species or groups of species
- To measure trends or changes in biodiversity on farmland, for individual species or groups of species
- To measure how a farming-related activity affects biodiversity, either for individual species or groups of species
- To measure soil characteristics including soil biodiversity
- To measure productivity
- To measure profit
- To engage farmers, or test methods with farmers
- Other

3.a. **If you selected Other, please specify:**

[Text box]

4. **What is your role in the Citizen Science activity? (Tick all that apply)**

- Designing or co-designing the activity
- Recruiting or training Citizen Scientists
- Co-ordinating or managing the activity
- Data entry design, support and / or quality assurance
- Data analysis
- Reporting or summarising results

- Publicity and marketing
- Applying for funding
- Other

4.a. **If you selected Other, please specify:**

[Text box]

5. **How do farmers participate in this Citizen Science activity? (Tick all that apply. By farmers we include all those directly connected with the farm business, including landowners & managers, farm staff, contractors.)**

- Farmers are not currently involved in the activity
- Farmers helped to design or co-design the activity
- Farmer(s) co-ordinate the activity
- Farmers voluntarily collecting environmental data, samples or information
- Farmers share existing environmental data (originally collected for other purposes)
- Farmers recruit and co-ordinate volunteers for the activity (including other farmers)
- Farmers permit access to their farmland for other volunteers to survey
- Farmers contribute information about farming practices, agri-environment or conservation management for their farmland
- Other

5.a. **If you selected Other, please specify:**

[Text box]

5.b. **If farmers are involved in the activity, can you estimate approximately how many?**

- <5
- 6-25
- 26-100
- More than 100
- Don't know
- Other

5.b.i. **If you selected Other, please specify:**

[Text box]

6. **Please indicate what type(s) of funding your activity has received? (Tick all that apply)**

- Self-funded
- Farming industry
- Commercial enterprise / business
- UK government - Defra, JNCC or related agencies
- UK research councils
- National Lottery

- Charity / Non-government organisation
- International funding - EU
- International funding - rest of the world
- Other

6.a. **If you selected Other, please specify:**

[Text box]

Data collection in your Citizen Science activity or scheme

7. **What types of data are collected by the activity? (Tick all that apply)**

- Biodiversity (see next question for more detail)
- Crop pests
- Natural enemies of pests (predators or parasitoids)
- Undesirable plant species or weeds
- Habitat type
- Habitat quality
- Physical soil characteristics, e.g. structure, organic matter
- Chemical soil data, e.g. carbon or nitrogen
- Water quality
- Farm productivity / yield (crop or livestock)
- Profit / economic data
- Other

7.a. If you selected Other, please specify:

[Text box]

7.b. **If biodiversity data are collected, which species or groups are recorded? (Tick all that apply)**

- Plants
- Higher plants
- Bryophytes (mosses and liverworts)
- Birds
- Mammals
- Reptiles
- Amphibians
- Invertebrates
- Pollinating insects
- Butterflies
- Moths
- Carabids (ground beetles)
- Soil invertebrates including earthworms
- Other

7.b.i. **If you selected Other, please specify:**

[Text box]

7.c. **Please add any further detail on the types of data collected.**

[Text box]

8. How long has data been collected within this Citizen Science activity? (Tick one)

- Less than a year
- 1-5 years
- 6-20 years
- 21-50 years
- More than 50 years
- Other

8.a**. If you selected Other, please specify:**

[Text box]

9. **At how many sites are data collected, in a typical year? (Tick one answer)**

- 5 or fewer
- 6-20
- 21-50
- 51-100
- More than 100
- Other

9.a. **If you selected Other, please specify:**

[Text box]

10. **Who collects data? (Tick all that apply)**

- Volunteer Citizen Scientists (non-farmers)
- Volunteer farmer Citizen Scientists
- Professional (paid) surveyors
- Agronomists
- Other

11. **What geographical area does your Citizen Science activity operate over? (Tick one)**

- Single farm
- Region or landscape within England
- Nationally - all of England
- Nationally - all of UK

- Internationally outside the UK
- Other (if you ticked region or landscape, please give further details here)

11.a. **If you selected Other, please specify:**

[Text box]

12. **How would you describe a 'survey site' within your activity? (Tick all that apply)**

- Sampling location or individual plot (within a field)
- Field
- Whole farm
- Multiple farms
- Habitat type
- Transect or other survey route across multiple habitat types
- Monad / 1km survey square
- Landscape
- Other

12.a. **If you selected Other, please specify:**

[Text box]

13. **What broad approaches are used to collect data? (Tick all that apply, and please add any further details under Other)**

- Participants record data on site
- Samples are collected for later analysis or identification
- Data are collected through technology (e.g. agricultural machinery)
- Other

13.a. **If you selected Other, please specify:**

[Text box]

14. **What monitoring methods are used for data collection? (Tick all that apply, and please add any further details under Other)**

- Transect or similar survey route walked (set locations, with repeat visits over time)
- Quadrats surveyed (set locations, with repeat visits across time)
- Trapping methods in set location (e.g. pan traps for pollinating insects, moth light traps, small mammal traps etc)
- Timed counts using standard method
- Fixed fields or land parcels surveyed
- Automated recording of data (e.g. acoustic recording, temperature)
- Ad hoc records of species
- Samples sent for analysis (e.g. soil cores or water samples)
- Other

14.a**. If you selected Other, please specify:**

[Text box]

15. **How are data captured? (Tick all that apply)**

- Entered into App in field
- Entered online in field via another route
- Recorded on paper form in field and entered online later
- Automatic data capture
- Photographs
- Other

15.a. **If you selected Other, please specify:**

[Text box]

16. **How many visits are there to each site in a year? (Tick all that apply)**

- 1 visit
- 2-5 visits
- 6-20 visits
- More than 20 visits
- Number of visits varies across sites (please tick all that apply above)
- Other

16.a. **If you selected Other, please specify:**

[Text box]

17. **Are data publicly available, shared with either the farming community or Citizen Scientists?**

- Publicly available data, freely and openly available to everyone
- Limited availability of data (e.g. for a fee, with a restricted license)
- Data not publicly available (e.g. only released to research users, or government departments)
- Other

17.a. **If you selected Other, please specify:**

[Text box]

18. **Have you published or circulated any results from your Citizen Science activity? (tick all that apply)**

- Yes - the results are free to access for everyone
- Yes - the results are circulated to Citizen Science volunteers and/or farmers
- Yes - published in scientific journals / literature
- Yes - the results are circulated internally to project partners and funders

- Not yet, but we do intend to make the results available
- No, we do not intend to publish or circulate the results
- Other

18.a**. If you selected Other, please specify:**

[Text box]

18.b. **If you have experienced barriers to circulating or publishing results from your activity, please let us know what they are.**

[Text box]

19. **What aspirations do you have for your Citizen Science activity looking forward? (Tick all that apply).**

- The activity will maintain its current focus.
- Develop and grow to include more Citizen Scientist volunteers
- Develop and grow to include more farmers
- Develop and grow to include more partner organisations
- Strengthen and expand knowledge exchange and wider engagement
- Apply for funding to continue or expand
- Other

19.a. **If you selected Other, please specify:**

[Text box]

19.b. **Please expand on these future aspirations if you would like to.**

[Text box]

20. **What is important for you to achieve these future aspirations?**

[Table with options: Very important, Fairly important, Not important, No opinion]

- Longer-term funding
- Additional funding
- Improved connections with farmers and landowners
- Improved tools or skills for recording and data capture
- More links to researcher networks or policy holders
- Other

20.a. **Please add any further details on what would help you to achieve the aspirations.**

[Text box]

21. **Can you briefly describe your opinion on the value and the opportunities for involving farmers more in Citizen Science activities?**

[Text box]

21.a. **Can you briefly describe any important gaps in what is currently being done to engage farmers in Citizen Science?**

[Text box]

22. **We plan to run an online workshop to explore gaps and future opportunities for Citizen Science activities involving farmers in January / February 2024. If you would like to be sent details of the workshop, and a summary of the project findings, please enter your email address here. (Note this is an optional question).**

[Text box]

2. Workshop concept boards

Group 1

Figure 8: Example screenshot of online workshop concept board.

Selected text from the post it notes from Group 1:

Why do you think farmers need or want data?

- To help steer effective land management for biodiversity.
- To use as indicators for SFI etc.
- To implement biodiversity-friendly interventions.
- To gain information on what is on their farm for management, visitor information, personal interest, and applications.
- To identify what biodiversity is present in order to make changes.
- To find out what species they have on their land so they can adopt appropriate management to help conserve them.
- To get direct advice about management options.
- To show that farmland can support wildlife and contribute to conservation.

- To understand the state of natural processes such as hydrology, soils, biodiversity, and how they are changing in response to pressures or interventions.
- From my limited crossover with farmers and landowners, I get the impression many see themselves as caretakers of their land and have a genuine interest in, and concern for, its wellbeing.
- Find out the impact they are making on the wider catchment/landscape.
- Adding to the points about non-biodiversity related natural capital, soil health is likely to be a key interest for farmers that could be supported by environmental citizen science.
- There is a lot of interest in the species linked with eco-services such as pollination and pest control, and species recording can inform this, although other types of recording may be needed to demonstrate outcomes.
- Competition with other farmers, be able to demonstrate the greatest biodiversity outcomes in their community.
- To measure change and understand how different approaches are impacting a baseline survey.
- Logging their own personal/farm scale impacts.
- Contribute towards stewardship grants.

Why do you think policy makers, scientists, scheme co-ordinators want to know about farmland?

- Farmland covers a huge proportion of the country - if we want to understand biodiversity trends nationally then we need to understand what's going on in farmland.
- Farm land covers 70% of the nation, so has a huge impact on the domestic environmental and biodiversity targets we have committed ourselves to. There is a need to measure and respond to this accordingly. Policy making is an iterative process that needs data to drive its change.
- To understand the state of natural processes such as hydrology, soils, biodiversity, and how they are changing in response to pressures or interventions.
- Assess the impact of AES interventions.
- To enable monitoring of the outcomes from policies.
- Understand efficacy of agricultural policies such as SFI, Landscape Recovery.

- To test/demonstrate that recommendations/trial conservation methods are effective.
- To improve the countryside for wildlife, understand what is there and target conservation action, implement monitoring, assess change positive and negative.
- Agricultural land dominates UK landscape, so is potentially very important for biodiversity.
- To encourage environmentally friendly farming practice in the interests of a particular target species group.
- To study long term changes in distribution/abundance changes.
- Encouragement of local public close to farmland to engage in the natural world.
- Farmland is a vital part of understanding broader scale biodiversity.
- There's lots of farmland so need to include.
- As well as 'why', can we ask 'what do we want to know?' From the point of view of running a Citizen Science project, we want to know who owns land, so we can help our volunteers approach landowners to gain the necessary permission.
- To ensure resource security through continued provision of ecosystem services essential to farming.
- What's the trend overall? Are things improving or getting worse? What's the case for action?
- Identify trends or learnings.
- To make predictions about what might happen in the future, based on what has happened in the past. i.e., biodiversity effects of new pesticides, farmland responses to climate, projected soil productivity.

What are our opportunities to develop farmers & citizen science / participatory monitoring? (What can we do more of, or do differently?)

- There is broadening opportunity for more people to contribute to our understanding of biodiversity, ecosystems, and natural functions on which we rely.
    1. Technology is lowering the technical and skill levels required for people to detect and identify important information.
    2. The broadening interest of natural systems and processes that biodiversity is a part of has more direct relevance for broader societal interests - soil health, flood resilience, recreation, clean water, clean air, etc.

- More of the kind of infrastructural developments that support the Citizens 'Tracking the Impact' project - using existing Citizen Science methods/volunteer bases to measure change at landscape scales.

- Development of infrastructure (guidance on methods, data recording, and storage tools) to facilitate monitoring at any scale.

- Development and test the statistical power farmland-specific I&O methods.

- The ability to show 'off-farm apps that have leaderboards for participation or achievements - creates more competition by urges, positive reinforcement, even turning data into a forum for wider farmland-based change.

- Peer engagement is more powerful than many other incentivization tools.

- Incentive for opportunities: Biodiversity monitoring (in the wider sense) being a condition of receiving AES support.

- Training and workshops: Opportunities for running training/workshops at farms.

    - Expand Open Farm Scheme - so chance to link to more members of the public with farmers.

    - Regional networks of farms/farmers for long-term monitoring (thus helping long-term biodiversity trend data).

- Improve data exchange and infrastructure: Ability to link datasets within farm clusters, catchment, or landscape-level areas to monitor collectively to a specific environmental or conservation target.

    - E.g. A farm cluster group in a Dorrowmore area might choose to share data to work towards creating numerous corridors of connectivity between various woodland patches locally.

- The DECIDE tool can be used to target under-recorded areas, and farmers could be informed of the importance of gap-filling - could they start to use the tool to improve recording coverage?

- Opportunity for linking to pest control/IPM i.e., for some suitable species groups such as ladybirds (great for Citizen Science), carabids (more difficult but very useful), etc. - i.e., so that the recording is more useful for farmers, potentially linking to farming practice.

- Monitoring across scales - creating data infrastructure and collaboration opportunities to allow for data sharing between projects with common aims, e.g., a local project also feeding data up to help us understand national trends.

- Provide services back to farmers as part of surveys (e.g., detailed habitat mapping) to keep them engaged and onboard.

- Feedback to farmers from the monitoring.

What might limit our ability to achieve this?

- Allowing citizen scientists onto land. Experience from our projects ranges from farmers being extremely keen to those who are overtly and aggressively opposed to the activity.
- Access to land - public rights of way sometimes blocked especially in Wales.
- Bridging the gap between landowning farmers and tenants. Landowners may say yes, of course, whereas tenants can be more opposed.
- Understandable nervousness about giving away some data that might, in some way, come back to cause them headaches (fear of RPA etc).
- Farmers being concerned about rare species being found on their land and this limiting their activities.
- Species monitoring projects such as POMS are often designed to monitor change at national or regional levels, and it is often difficult to interpret them for single farms/sites.
- Differences in reasons for needing the data.
- Having the time to engage.
- Farmers having the time to engage.
- Farmers actually having time to engage and get out on the farms to look at biodiversity.
- Coordinated and sustained support for volunteer participation at a practical scale that can engage and support interested people to enable and align helpful approaches and demonstrate impact locally as well as nationally (collect, integrate, analyze, use - circle).
- Challenge of continued engagement throughout a botanical trial. When trialing new farm management methods, we need 3 years - to see any changes to plant diversity, ideally much longer. It is very difficult to keep a farm committed for that long, even when engaging them.
- Time and money to find willing participants (from both the farmer and Citizen Science side).
- Sustaining long-term interest so that citizens do sampling over multiple years.
- Trust: Concerns from farmers over data quality leading to not valuing the value of allowing volunteers on their land (common perception of Citizen Science is that data quality is diluted even for specialist schemes most of the time).
- Not a limitation, but a consideration: If possible, we need to involve a wider group of farmers, not just typical 'hobby-level' farmers. (i.e., avoid preaching to the converted) for greater impact.
- Balance between simplicity/complexity of methodology - i.e., need to have simple and relatively easy-to-follow instructions but also need quality data, so avoid it being over-simplistic.

- Method - some farmers might not feel confident using an app, for example.
- Methods and equipment: Money for simple monitoring equipment such as sweep nets (i.e., some species groups are not best sampled through observation alone). Issue here of providing access to equipment that we want back (or other Citizen Science later). A local farm hub (e.g., where the kit is stored) may be a solution.

3. Citizen science survey participants

Below is a list of all the citizen science initiatives that responded to the survey and are part of the database connected to this report. Additional citizen science projects are likely to be launching all the time, given this is a rapidly growing area. This list was collected in November 2023.

UK Ladybird Survey

BTO/JNCC/RSBP Breeding Bird Survey (BBS)

Wader Calendar

Nurturing Nature

Bioacoustic Wader Monitoring Trials (not an officially named project!)

UK pollinator monitoring scheme also Butterfly transects and https://ukbms.org

Fresh Water Watch, Soil Health Tool Kit, Biodiversity Tool Kit (Earthwatch)

National Honey Monitoring Scheme

Nurturing Nature - part of the Chase & Chalke Partnership Scheme

Freshwater Watch

National Harvest Mouse Survey

English Winter Bird Survey

British Bryological Society recording scheme

Wider Countryside Butterfly Survey (part of UKBMS)

Healthy Hedgerows

BeeWalk

Carabid monitoring scheme

FAB Farmers EU Interreg Project

Farm Nature Discovery

E-surveyor

Farmland Bird Aid Network

GWCT Big Farmland Bird Count

GWCT Partridge Count Scheme

Breeding Waders of Wet Meadows

Farming with Nature

Wensum Farmers

Fenland SOIL Landscape Opportunity Mapping

iRecord

Cairngorms Mob Grazing Trails

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