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# Regenerative Agriculture in Cropping Systems: Knowledge gaps, research needs and how to address them

## Challenge 1 (of 6): Standardisation of regenerative agriculture

Julia Cooper
Organic Research Centre

Elizabeth Stockdale
NIAB

Belinda Clarke
Agritech E

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# Thank You

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# Backround/Introduction

Although the term regenerative agriculture was coined in the late 1980s, the term was not widely used in the agricultural or scientific community until the late 2000s. Since then the term 'regen ag' has become commonplace in UK agriculture. Although much emphasis has been placed on the adoption of key principles by farmers, this has not always been supported by scientific knowledge and understanding. This series of reports was commissioned to provide a quick overview of the state of knowledge and research activity on a number of topics important for the development of regenerative agriculture in the UK, with a particular emphasis on priorities for farmers. The goal was to prioritise research topics and identify where the current gaps in knowledge exist so that future funding can be targeted towards topics that have previously been insufficiently studied.

This report was produced as a result of a Rapid Evidence Assessment (REA). To conduct this REA a list of research priorities was drafted based on informal conversations with key stakeholders and reviews of prior research prioritisation exercises. In addition an online workshop with stakeholders (19 in total) was used to rank the priorities and discuss best approaches to conduct the research. This was followed by a detailed scoping study of ongoing and past projects in the UK which were mapped to the list of research priorities. In parallel, searches of published academic literature were conducted and a selection of papers on each topic were rapidly reviewed and synthesised.

The results were briefly presented at the Cambridge Future of Agriculture Conference (held in March 2024), which served as a unique platform for farmers, farmer organisation representatives, and scientists to openly discuss and shape future research needs; these are reflected in this report.

It is important to keep in mind that this study was not done in isolation. There have been several reviews on similar topics conducted in the past few years. These include the rapid evidence review by Albanito et al (2022) (1) that was commissioned by the Committee on Climate Change to assess the role of agroecological farming in the UK transition to Net Zero; the DEFRA-commissioned study on the impacts of agroecological compared to conventional farming systems published by Burgess et al (2023) (2) ; and most recently, the assessment of farmer priorities for research conducted by the Agricultural Universities Council. Regenerative systems and carbon sequestration have been identified through that process as new priorities while soil health and crop breeding have persisted from previous assessments.

This project focused specifically on challenges relating to implementing regenerative agriculture in cropping systems, with a particular emphasis on soil health. This makes it slightly more focused than these other studies and the information gathered complements the outcomes of these three recent studies.

1. https://www.theccc.org.uk/publication/agroecology-a-rapid-evidence-review-university-of-aberdeen/
2. See all three reports from: Evaluating the productivity, environmental sustainability and wider impacts of agroecological compared to conventional farming systems project SCF0321 for DEFRA. 20 February 2023

# Key Findings

Detailed summaries of the outcomes of the survey and discussion during the workshop along with the knowledge gaps listed above, were synthesised into 6 challenges and 34 sub-challenges. Because of the diverse topics and range of study types identified in the peer-reviewed literature, a narrative synthesis approach was used to summarise the findings for each topic. This focussed on descriptive (rather than numerical) summaries of the findings highlighting themes where the research results appeared to converge or diverge.

## The six challenge areas identified were:

1. Standardisation of regenerative agriculture
2. Advice and Guidance or “How to…”
3. Crop genetic resources
4. Soil health
5. Wider system considerations
6. Socio-economics

**This publication presents the findings of Challenge 1: Standardisation of Regenerative Agriculture. The findings of the other challenges can be found in the associated series of publications available at www.organicresearchcentre.com.**

# 1.1 Identification of metrics to support the definition

A major concern raised by researchers is the lack of a clear definition for the term “regenerative agriculture” which makes it difficult to conduct robust studies. Robert Rodale, son of the founder of the organic movement in the United States, coined the term “regenerative organic” in the late 1980s to refer to a holistic approach to farming that encourages continuous innovation and improvement of environment, social and economic measures (Sumption 2023), but the term was not widely used in the agricultural or scientific community until the 2000s.

A literature search conducted during Phase 1 of this project identified just one article

published before 1990 that used the term “regenerative agriculture” and only two during the 1990s. The first time the phrase appears in the academic literature in a form similar to the commonly understood definition of the term, with direct reference to soil health, is in a conference paper published in the journal Applied Soil Ecology in 2000, that argues the need for a focus on soil health research for sustainable food production from relatively less land (Sherwood and Uphoff 2000).

A Web of Science search of peer-reviewed literature was conducted in March 2024, looking specifically for publications addressing the definition of the term. Globally there are 331 papers using the term regenerative agriculture, but only 18 of those cover definition, meaning or metrics. A further screening found 6 of those papers not relevant to definitions of regen ag, leaving 12 that cover this topic. These 12 papers represent a fascinating spectrum of perspectives on regenerative agriculture covering a range of disciplines. Most recently, Jayasinghe et al. (2023) published a review of definitions of regenerative agriculture. They identified a wide range of definitions reporting that it is a “framework consisting of principles, practices, or outcomes aimed at improving soil health, biodiversity, climate resilience, and ecosystem function”. Their findings reflected those of Newton et al. (2020) who categorised definitions into two broad groups: those based on a set of practices and those that emphasise outcomes.

Jayasinghe et al. (2023) finally proposed a lengthy definition that recognises the importance of integrating knowledge of local landholders and indigenous people (see box to the below). While this is a highly inclusive definition, it lacks specific details necessary for distinguishing between different production systems in real-world applications. These specifics are crucial for gathering strong evidence about the effects of regenerative agriculture on the ecosystem services it aims to enhance.

Sands et al. (2023) argue that the current debate which focuses on practices, principles and outcomes does not acknowledge the importance of social justice, relational values and the contribution of indigenous knowledge within regenerative agriculture. Page and Witt (2022) explain that the range of definitions and “competing discourses” is because regen ag has not “matured sufficiently for a clear definition to have emerged”.

**RA is an agricultural and transdisciplinary approach that integrates local and indigenous knowledge of landscapes, as well as their management, with established scientific knowledge. It combines a range of adoptable principles with context-specific practices, focusing on soil conservation as the initial step to restore soil health, enhance ecosystem functions, and promote improved socioeconomic outcomes (Jayasinghe et al. 2023).**

Their study (although with a limited number of participants) is useful in identifying the different perspectives of farmers, some of whom dismiss regenerative agriculture as just another term for sustainable agriculture versus other groups who strongly identify with the term; interestingly, the regenerative group displays some scepticism towards science and technology while the other two perspectives (productive and environmentally conscious) see science and technology positively and agree that intensive agriculture is needed to feed the growing world population.

Various reports produced in the UK have also addressed definitions of regen ag, including Hurley et al. (2023), Burgess et al. (2023), Brunyee and Semple (2021), Magistrali et al. (2022) and Albanito et al. (2022). These have all focused on the practice or outcome-based definitions referred to above.
The GREAT (Gloucestershire Regenerative Environmental Agricultural Transition) Project in South Gloucestershire, which offers support to farmers to transition to regenerative agriculture, summarised some of the pros and cons of defining regenerative agriculture (Table 1).

**Table 1 Benefits and disadvantages of an open definition for regenerative agriculture** (Brunyee and Semple 2021)

| Benefits | Disadvantages |
|---|---|
| A regenerative system can be defined as an evolving and holistic mix of principles, practises and outcomes. | When the term is used within policy and strategy, the lack of a clear definition can result in lack of depth and/or focus, and ineffective delivery. |
| It recognises that in differing climates, environments and soils, different practises can be used to achieve the same goal, or through adopting the same practise, results can occur at different speeds. | A loose meaning can get lost and corrupted (watered down) over time. |
| It can flex to suit the farm, farmer or enterprise (the 6th principle), optimising outcomes. | Regenerative claims can be mis-used, co-opted and overstated in marketing campaigns by farm businesses and associated industries i.e. green wash. |
| With the right information and tools, it can be adopted anywhere in the world. | Consumers may struggle to identify, understand and trust regenerative claims and brands. |
| It grows from the bottom up. | Researchers lack a clear framework or single-issue focus to follow when seeking evidence. |

They ultimately synthesised various definitions from global organisations into this definition:

> Farming principles and practices that increase biodiversity, build better soils, improve water catchment and enhance nutrient cycling, with the aim of capturing carbon in the soil and increasing aboveground biomass; thereby helping to reverse the current global trends of atmospheric accumulation

A general consensus from this review and discussions with stakeholders is that the preoccupation with defining regenerative agriculture is coming from the research community; actors along the supply chain who are benefitting from a loose definition of the term are not particularly eager to see it clearly defined.(3) However, when standards are discussed (see below) a clear definition of regenerative agriculture is viewed as essential (Elrick et al. 2022; Landers et al. 2021). Newton et al. (2020) also list a series of problems with the lack of a definition, including challenges for researchers trying to conduct comparative studies of systems, confusion among consumers, dilution or corruption of the value of the term over time, and difficulties with developing laws, policies and programmes to evaluate and promote this type of agriculture.

**The lack of a clear definition of regen ag limits the potential to conduct robust studies into regenerative agriculture systems; practice-based or outcomes-based definitions (with clear metrics to differentiate systems) are needed to design trials or surveys that compare regenerative practices with business-as-usual farming. Until this is resolved, the potential to build the scientific evidence base for regenerative agriculture will be limited.**

3. This sentiment was articulated by Mike Gooding, Farming Systems Director, AHDB, in a meeting about this project

# 1.2 Regenerative agriculture standards/certification (pros and cons)

There is currently no legal definition of regenerative agriculture and no restrictions on the use of the term by the UK government. This contrasts with organic foods which must meet organic production standards to be marketed as organic(4). There has been limited analysis of the issues around regenerative agriculture certification in the peer-reviewed literature. A Web of Science search in May 2024 identified only 5 papers(5) discussing the issues surrounding regenerative agriculture certification systems (the search term included “regulation” which resulted in many papers discussing regulation of climate or water processes in regenerative agriculture which were excluded).

There have not been any studies in the UK that explicitly look into the industry attitudes towards a certification scheme for regenerative agriculture, but an Australian study provides some useful insights drawing on experiences from the organic sector (Elrick et al. 2022). The authors interviewed a range of key informants in Australia on the future for a regen ag certification label. Despite offering many criticisms of the organic certification system, the informants still felt strongly that regulation of the term “regenerative agriculture” was needed to avoid “false marketing”. They advocated a centralised RA regulatory body while cautioning against too much bureaucracy or expense for farmers. A recurrent theme in the interviews was that regenerative agriculture is an inclusive movement and that any certification scheme should be built around principles of support, education and collaboration. Participatory Guarantee Schemes (PGS) were proposed as an alternative to third-party certification. These schemes have been trialled in the organic sector and include the exchange of advice and knowledge as a key element of inspections (Kaufmann et al. 2023). This approach would be in line with the general sentiment expressed by the informants that “a future RA certification model should put a focus on principles that support and help the

4. Including organically grown, organically produced, grown or produced using organic principles or grown or produced using organic methods

5. Elrick et al. (2022), Newton et al. (2020), Lemke et al. (2024),Marks (2020), Mooney et al. (2024)

producer to transition along a continuum of RA farming approaches and practices, rather than imposing dichotomous rules" (Elrick et al. 2022) Lemke et al. (2024) also viewed the issues around certification of regenerative agriculture through the lens of experiences of certification in the organic sector. In their small survey of organic farmers, the need for an outcome-based certification scheme in regenerative agriculture (versus the process-based schemes used in organic farming) was suggested. To be viable the scheme would need to be flexible, with a list of practices specific to local conditions, a clear list of certification requirements, a third-party verification system, and tied to a premium. This was reflected in interviews with farmers in the United Kingdom, Ireland and France, who expressed concerns about future dilution of the meaning of terms like regenerative, in the absence of clear standards (Mooney et al. 2024).

Within the organic sector there is an interest in developing a set of practices that go beyond organic; these have been demonstrated in the Regenerative Organic Certified® scheme led by the Regenerative Organic Alliance(6) The scheme uses the USDA organic production standards as a baseline and then builds in additional standards relating to soil health, animal welfare and social justice. The objectives of regenerative agriculture espoused by the scheme are outcomes-based, but the standards are principally process-based (Newton et al. 2020).

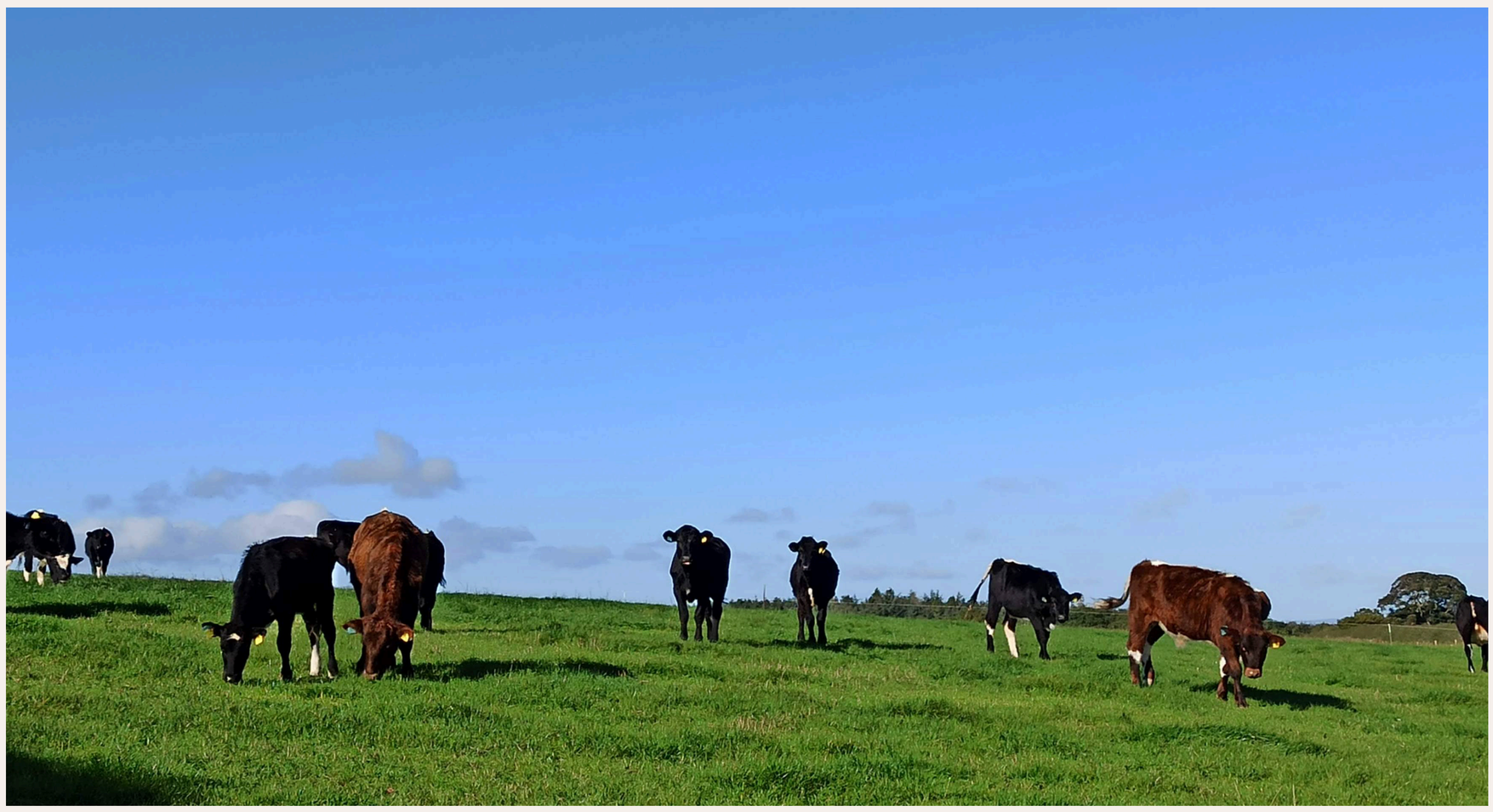
The Savory Institute is developing an outcome-based certification programme(7) which is part of the Land to Market initiative that links regenerative farmers to brands seeking to improve their environmental credentials through Corporate Social Responsibility (CSR) investments.

6. https://regenorganic.org/

7. https://savory-institute.gitbook.io/eov-manual-public

This Ecological Outcome Verified™ programme baselines environmental indicators (e.g. soil health, biodiversity) on regenerative farms and collects more detailed data every five years to monitor status of the metrics; if improvement is not detected, farmers may lose their certification (Newton et al. 2020). In the UK, Regenerate Outcomes(8) is running a similar program with links to the Savory Institute and Gabe Brown's Understanding Ag(9). This programme includes free mentoring and training for members which reflects the ethos of the Participatory Guarantee Schemes referred to above.

Newton et al. (2020) explain that outcome-based programs may be more expensive to administer due to the additional costs associated with monitoring and advice.



**The debate about certification schemes is not really a research question. The pros and cons of different types of schemes are outlined above. It is more important that the industry decides if they want to continue to allow ue of the term "regenerative" in marketing with no restrictions, or if they would like to move towards an "organic" system where the term is regulated and certain criteria need to be met for it to be used in marketing.**

8. https://www.regenerateoutcomes.co.uk/
9. https://understandingag.com/

# Project Summary

Appendix A summarises the results of the gap analysis based on the evidence reviewed in this project. To be considered a high priority for research, topics needed to have received more than 10 votes in the critical or high-importance categories in the initial stakeholder workshop. Topics were also considered priorities if there were few peer-reviewed papers found on the Web of Science (<20 indicating minimal research activity globally on this topic) and a low number of UK projects and reports (fewer than five are shaded green to indicate a deficiency of activity in this area).

Impacts of the production system on product quality and end-market use (5.4), particularly with reference to wheat and effects on the feed vs. bread wheat market，ranks as a high-priority area for further applied research: few academic papers on this topic exist, and only three current and past projects were assessed as relevant to this topic. Multidisciplinary work across the supply chain, including nutritionists and food system modellers, is necessary to fully understand the implications of changes in product quality on markets and food security.

A key factor affecting uptake of regenerative agriculture is its impact on farm economics, and a better understanding of socio-economic factors constraining uptake of regenerative agriculture (6.2) is of critical importance to many stakeholders. This ties in with topic 6.1, The impact of regenerative agriculture systems on farm livelihoods, which workshop participants ranked as the top research priority. More information on the economic impacts of adopting regenerative agriculture practices is necessary, and this could be accomplished through farmer clusters e.g. Groundswell Agronomy or AHDB's Monitor Farm approaches.

"How to…" implement regenerative agriculture featured as a top priority, with the need for regionally adapted cover crops (2.6) of high importance to stakeholders and relatively few ongoing projects. However, some existing reports on cover crops should be referred to when developing future research activities. The Cover Crop Guide, recently developed by the Yorkshire Agricultural Society, has laid much of the groundwork for further work in this area.

Other “How to…” topics that were considered important included: 2.1 Growing root crops in regenerative systems, 2.2 Intercropping arable crops successfully, 2.5 Effective termination of cover crops; without herbicides, 2.7 Impacts of cover crops on weeds, pests and diseases, 2.8 Reducing herbicide use in regenerative systems, and 2.9 Integration of livestock into arable regenerative systems. The latter two topics emerged during discussions at the workshop and the Future of Farming conference. Some of these topics already have a large body of scientific information to support the development of applied research in the UK, e.g. root crops in regenerative (low disturbance tillage) systems are discussed in more than 100 academic papers. The same is true for intercropping, which has been researched extensively and would benefit from an applied/KE approach. Termination of cover crops is also discussed in many academic studies, but since its success is so dependent on the local environment, it will still be important to conduct research under UK conditions. Livestock are recognised as integral to regenerative agriculture but can present challenges to arable farmers; more applied research is needed to overcome the barriers to including animals in regenerative farming systems. All of these topics are best suited to applied research on farms, recognising that implementation of these diversified cropping approaches is highly context-dependent.

The identification of metrics to support the definition of regenerative agriculture (1.1) was identified as important by workshop attendees, and there are few academic papers or projects on this topic. There is a recognition that the main drive to define regenerative agriculture comes from researchers and a solid definition and metrics will be important if robust research on regenerative agriculture’s effects is to be conducted. A few UK projects have attempted to define regenerative agriculture and a consensus could be reached on a definition by collecting stakeholder input. It does seem key to decide if a practice-based definition (which is conducive to the development of standards and a certification system) or an outcomes-based definition (more inclusive of a range of practices and aligned with Defra targets like the Environmental Improvement Plan) is the way forward for the movement in the UK. An inclusive definition based on outcomes could facilitate more rapid uptake of practices and ultimately have a wider impact but may not allow niche access to markets that compensate farmers adequately for any loss in production.

Wider system impacts of regenerative agriculture need to be better documented to demonstrate the benefits of these practices. Impacts particularly on the water cycle (both flood risk and drought resilience; 5.1) need to be studied and understood. In addition, the net effects on greenhouse gas emissions are not known. Integrating legumes into rotations (5.2) can have a range of knock-on effects on emissions in the field and beyond the farm gate. A slightly broader statement on the wider impacts of regenerative agriculture on the environment also ranked highly (5.3 Practice and options to be assessed in terms of wider impacts), but it should be noted that there have been many papers published globally on environmental impacts of regenerative agriculture which should be reviewed before designing UK studies; various projects are ongoing that will also address these topics in the UK.

There is a perception that more crop breeding efforts should be targeted at traits important for regenerative farming. Variety evaluation and breeding for low N and pesticide inputs (3.3) was a high priority among workshop participants and has also been identified as important to levy payers in the recent AHDB Recommended List review process. Variety evaluation and breeding for weed competitiveness (3.4) and performance in reduced tillage systems (3.5) emerged as important topics at the workshop. These topics have been covered in peer-reviewed studies, but there have been few projects in the UK.

In addition, this study has highlighted the predominance of cereals, particularly wheat, in most breeding efforts. There is tremendous scope to extend breeding programmes to the less dominant arable crops (e.g. pulses, minor cereals like oats, spelt) and cover crops to help facilitate the transition to regenerative agriculture in the UK.

Among the topics within the Soil Health challenge, the need to understand the impacts of changes in soil biology on weeds (4.2) was particularly highly scored. There is some basic knowledge on the underlying mechanisms (a moderate number of peer-reviewed papers relating to the topic) but further basic soil science and applied research is needed. We did not identify any relevant projects on this topic and only one report from the grey literature. The impacts of strategic (occasional) tillage vs glyphosate on soil health (4.5) garnered significant interest among stakeholders at the workshop and was also identified in discussions at the Future of Agriculture conference.

There have not been many papers published that explicitly address this topic, however, there are several past and current experiments in the UK that include rotations, tillage and herbicide use as factors that could be used to begin to address this research topic.

# Authors' Recommendations

This study has clearly mapped out the status of the research needed to support the transition to regenerative agriculture in the UK. It has showcased the extensive knowledge accumulated from past projects and the expertise of scientists, industry experts, and farmers in the sector. The detailed report and database are key resources that can be used to build an action plan to tackle the obvious knowledge gaps. The database could be made publicly accessible and maintained as a living resource for anyone looking for information on past and current projects and research relating to regenerative agriculture.

The next steps should be to develop a strategy to tackle each of the six challenge areas by forming working groups with the key individuals and organisations identified in the database. These groups could develop action plans that include accessing the Farming Futures funding opportunities that are currently live and partnering with research organisations and farmer groups (clusters) to develop local solutions to production challenges. In addition, the report can be used as evidence to lobby Defra and UKRI to support research programmes in these high-priority areas. Many of the priority areas reflect actions within the Sustainable Farming Incentive. Research on these topics will help build the evidence base for the SFI and other future farming and land management policies.

Key to the success of new programmes to support regenerative agriculture will be efficient and targeted use of resources. This means not reinventing the wheel and building on past experiences and knowledge. This study has helped to develop the resources needed to do this effectively.

**The full report on this project (including full bibliography and appendices) and the database listing projects and reports can be found at www.organicresearchcentre.com.**

# Appendix A

Summary table of top priority research topics based on outcomes of the stakeholder workshop, Future of Agriculture Conference and scoping of past and ongoing research. Projects included are only UK-based activities. Code numbering relates to the Challenges identified in this series of publications. "Grey literature" refers to reports from UK government and industry bodies, e.g. AHDB, NIAB. Colour shading is provided to indicate highest priority/largest gap (green), moderate priority/gap (amber) and lower priority/smaller gap (putty). Topics with the most "green" shading can be interpreted as top priorities.

| | | Workshop Outcomes | | Scoping Study Outcomes | | | |
|---|---|---|---|---|---|---|---|
| Code | Description | Critical+High Votes >10 | Research Type | Peer-reviewed papers | Ongoing projects (total 27) | Past projects (total 28) | Grey literature (total 76) |
| **High priority with few academic papers or UK projects** | | | | | | | |
| 5.4 | Impact of regenerative agriculture on product quality and end-market use | 13 | Applied | <20 | 1 | 2 | 0 |
| 6.2 | Socio-economic factors constraining uptake of regenerative agriculture | 11 | Policy | <20 | | 1 | 6 |
| 2.6 | Regional adaptation of cover crops, particularly for cool, wet, temperate climates | 11 | Applied | <20 | 2 | 2 | 13 |
| 1.1 | Identification of metrics to support definition | 10 | Policy | <20 | | 1 | 6 |
| **High priority, some academic papers, some UK projects** | | | | | | | |
| 6.1 | Impact (and the factors affecting it) of regenerative agriculture systems on farm livelihoods | 19 | Applied/KE | 20-100 | 11 | 2 | 7 |
| 5.1 | Impacts of regenerative agriculture systems on the water cycle (flood risk, drought) | 13 | Applied | 20-100 | 3 | 2 | 3 |
| 3.3 | Variety evaluation and breeding for low N and pesticide inputs | 12 | Applied | 20-100 | 3 | 3 | 7 |
| 2.7 | Impacts of cover crops on weeds, pest and diseases | 11 | Applied | 20-100 | 3 | 3 | 4 |
| 4.2 | Impact of changes in soil biology on weeds, particularly blackgrass | 11 | Basic/Applied | 20-100 | | | 1 |
| **High priority, many academic papers, some UK projects** | | | | | | | |
| 2.2 | Intercropping arable crops successfully | 12 | Applied/KE | >100 | 2 | 4 | 7 |
| 2.5 | Effective termination of cover crops; without herbicide; impacts on the following crop | 13 | Applied | >100 | 3 | 2 | 8 |
| 5.2 | Impacts of integration of legumes throughout the cropping system on N cycling including GHG emissions | 12 | Applied | >100 | 7 | 3 | |
| 5.3 | Practice and options for regenerative agriculture to be assessed in terms of wider impacts | 12 | Applied | >100 | 8 | 3 | 13 |
| 2.1 | Growing root crops in regenerative systems | 11 | Applied | >100 | 3 | | 2 |
| **Topics not ranked during the stakeholder workshop** | | | | | | | |
| 2.8* | Reducing herbicide use in regenerative systems | NA | NA | 20-100 | 1 | | 9 |
| 2.9* | Integration of livestock into arable regenerative systems | NA | NA | <20 | 2 | 1 | 2 |
| 3.4* | Variety evaluation and breeding for weed competitiveness | NA | NA | >100 | 1 | | 3 |
| 3.5* | Variety evaluation and breeding for performance in reduced tillage systems | NA | NA | >100 | 1 | 1 | |
| 4.5* | Impacts of strategic (occasional) tillage vs glyphosate on soil health | NA | NA | 20-100 | 7 | 4 | 7 |

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**Organic Research Centre**, Trent Lodge, Stroud Road, Cirencester, Gloucestershire. GL7 6JN

**01488 658 298** | **hello@organicresearchcentre.com** | **organicresearchcentre.com**

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