Collaboration for Environmental Evidence

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Systematic Map Protocol

Title
What evidence exists on how biodiversity is affected by the adoption of carbon footprint reducing agricultural practices?

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Agroecosystem, Evidence Synthesis, Farming, Net Zero, Wildlife.

Background
Land used for agriculture covers 70% of United Kingdom (UK) landmass (1), therefore the management of agricultural land has a significant role in the UK government's environmental targets to reach carbon Net Zero by 2050 (2) and halt the decline in nature by 2030 (3). However, as an industry, agriculture produces 11% of all UK greenhouse gas emissions (4) and has contributed to the decline of nature through incentivised environmentally damaging farming practices (5). The main greenhouse gas emissions from agriculture are methane, nitrous oxide and carbon dioxide which account for 55%, 32% and 16% of agricultural greenhouse gas emissions respectively (6). For agriculture to support the target of carbon Net Zero, the United Kingdom Committee for Climate Change (UKCCC) (7) suggests that UK agriculture must reduce its emissions by 64% through the adoption of low carbon techniques and improving farm efficiency (8, 9, 10, 11). Unavoidable emissions will need to be offset through carbon sequestration or offsetting which can be achieved through adoption of practices such as regenerative farming techniques, agroforestry and renewable energy generation (7, 12). Interventions that reduce the carbon footprint of a farm involving land management change or land use change needs to be assessed in terms of its impact on biodiversity. Decisions at a farm and policy level are reliant on this to ensure both UK government environmental targets can be met. This knowledge will also be fundamental to accurately measure how agricultural land management can impact biodiversity. A systematic mapping approach will find evidence relating to low carbon farming methods and their impact on biodiversity. Where there are clusters of knowledge this could be synthesised in systematic reviews of interventions to further understanding of their impact on biodiversity. Conversely, knowledge gaps can highlight areas for further research.

Theory of change or causal model
The assumption of this research is a farm reducing its carbon footprint through changing its land use or management will impact on-farm biodiversity. An example of this is a farm converting open, arable land into a silvoarable system (planting rows of trees within a cropped field). This is designed to reduce a farms carbon footprint but may also provide a diversified habitat, benefiting some species albeit to the potential detriment of species that require large open fields. To fully understand the biodiversity impact of carbon footprint reducing interventions, studies on a variety of species are required.

Stakeholder engagement
This protocol was developed as part of a research project funded by WM Morrisons Supermarkets Limited to understand how their supply chain can affect biodiversity because of moving towards carbon Net Zero farming. The systematic map title and research question was presented at a stakeholder meeting where the stakeholder group discussed the purpose and importance of the research in the context of the wider research project. The stakeholder group will be updated on the progress of the research during regular meetings and will have the opportunity to provide input regarding the interpretation of results and potential recommendations derived from the research.

Objectives and review question
The objective of this review is to identify and systematically map research investigating how agricultural practices that lower greenhouse gas emissions or increase carbon sequestration impact biodiversity on agricultural land and associated agroecosystems. The map is restricted in geographic scope to temperate climates and farming systems that are similar to the United Kingdom.

Definitions of the question components
Primary Question – What evidence exists that the adoption of agricultural practices to reduce a farm's carbon footprint impact on-farm biodiversity? Population – Organisms on agricultural land and surrounding agroecosystems (e.g. watercourses such as ponds, ditches, streams and rivers). Intervention - Adoption of practices on temperate agricultural land that are designed to reduce greenhouse gas emissions or increase carbon sequestration and involves land use change or land management change. Comparator - Before adoption of low carbon farming practices or increased sequestration. A control site where such changes have not been applied, a comparison of different types of carbon reduction/carbon sequestration practices, or a comparison of different levels (e.g. intensity/area etc.) of carbon reduction/sequestration practices. A time series on the same site after adoption of low carbon farming practices or increased sequestration. Outcome – Measured or observed change to organism abundance and diversity.

Search strategy
A database of publications will be created using the methods described here which will document relevant literature to answer the research question. The methodology will follow the guidelines set out by James, Randall and Haddaway (13) and Collaboration for Environmental Evidence (2022) (14). ROSES reporting standards for evidence synthesis (15) have been followed, which can be seen appended in Additional file 1. Searches for peer reviewed articles and grey literature will use a search string that has been developed using a scoping process, the details on how the final search string was developed can be seen in Additional file 2. The search terms have been identified by the PICO analysis, from benchmarking articles and discussions within the stakeholder group. Search terms for carbon footprint reducing interventions were developed from the UKCCC's Land Use Policy framework (7), the majority of which are cited as being identified in the National Farmers Union (NFU) publication 'Achieving Net Zero Farming's 2040 goal' (16). Synonyms and interpretation of generic interventions to be included in the search string were discussed in a meeting of authors. When the search for articles is conducted, the date and time of each search will be recorded. All searches will be conducted in English. This restriction is due to the resources available to the research team. There will be no date restrictions applied to the searches.

Bibliographic databases
The following bibliographic search platforms will be searched using Harper Adams University subscriptions for articles that are relevant to the research question: 1. Web of Science (WoS) All Databases (conducted as a topic search) 2. CAB abstracts. The string to be used is; ((“low input farming” OR “reduced input farming” OR “regen* farm*” OR “precision agriculture” OR “precision fertili*” OR “direct fertili*” OR “alternative fertili*” OR “cover crop” OR “catch crop” OR “direct

drill*” OR “min* till*” OR “no till*” OR “controlled traffic farm*” OR “hedge* management” OR “hedge* lay*” OR "farm woodland" OR agroforestry OR silvopastur* OR silvoarab* OR "increase* soil carbon" OR “enhance* soil carbon” OR “residu* incorp*” OR “manure incorp*” OR liming OR “lime application” OR paludiculture OR “peat restor*” OR "energy crop*" OR “bioenergy” OR miscanthus OR agrivol* OR "solar grazing" OR "wind farm" OR "slurry acidi*" OR "acidi* slurry") AND (abundance OR biodiversity OR ecolog* OR ecosystem* OR wildlife OR “natural habit*” OR animal* OR fauna OR vertebrat* OR mammal* OR bird* OR reptile* OR amphibia* OR fish OR invertebrat* OR arthropo* OR insec* OR arachni* OR microbi* OR bacteri* OR microorganism OR fung* OR flora OR vegetation)). A meeting of authors decided the databases to be used that took into consideration resource constraints and current Harper Adams University subscription to databases.

Web-based search engines
We investigated using Google Scholar to identify relevant literature that may not be found by the search string however the search string is too large for the algorithm to work. A scoping exercise was undertaken to see if simplifying the search string would work and it did not. Also, tests of the search string in the databases was comprehensive which is discussed in section 8.4.

Organisational websites
Relevant websites will be trawled using key words relating to each intervention to search for relevant publications including: AHDB, BES, CIEEM, Gov.uk, GWCT, RSPB, UKCEH, USDA, CORDIS. This list was determined during a meeting of the authors.

Comprehensiveness of the search
The comprehensiveness of the search was determined by testing whether ten known relevant articles (listed in Additional file 3), would be found by the search string. When articles were missing, the search string was altered to include relevant search terms to capture the benchmarking articles. The search string shown above found all ten articles in the WoS database. The comprehensiveness of the search will be improved by the inclusion of a trawl of relevant websites for grey literature (defined as research or information that is not controlled by commercial publishing).

Search update
A search update is not planned unless Scopus becomes available through a Harper Adams University subscription.

Screening strategy
The results from each search will be imported into EndNote (17), where duplicates will be removed using the automatic function, and then to EPPI reviewer (18) where the results will be screened at three levels: firstly to identify any missed duplicates (the number of which will be recorded), then title and abstract together and lastly, full text. Where necessary, full text versions of non-open-source articles will be accessed using the Harper Adams University Online Library. Where necessary an inter-library loan for the full text will be requested. If the full text is not available and the information in the abstract satisfies the inclusion criteria it will be included in the systematic map. Secondary research including reviews and meta-analysis will be recorded in a separate section and will be used to identify additional primary research by examining the references and including those that meet the inclusion criteria. Should the quantity of studies exceed the limitations of the timeframe, the priority screening function within EPPI reviewer will be utilised to identify relevant material quicker. Once the inclusion percentage of 200 papers out of 1,000 falls below 5%, the subset will be defined.

Eligibility criteria
Relevant subjects - Temperate regions as defined by the following Köppen-Geiger climate

classification zones (19) Cfa [warm temperate]; Cfb and Cfc [maritime temperate or oceanic]. Relevant interventions – Adoption of practices on temperate agricultural land that are designed to reduce greenhouse gas emissions or increase carbon sequestration involving land use change or land management change within farming systems that are currently adopted or trialed in the UK. Relevant comparators - Before adoption of low carbon farming practices or increased sequestration. A control site where such changes have not been applied, a comparison between low carbon farming practices or increased sequestration, a comparison of differing levels of a practice. A time series on the same site after adoption of low carbon farming practices or increased sequestration. Relevant outcomes - Measured or observed change to organism diversity or abundance. Relevant types of study design – Only primary studies that have involved experimental observations and manipulations will be included. Only studies that have quantified biodiversity change on agricultural land and associated agroecosystems will be included. Reviews and meta-analyses will be recorded in a separate database. Relevant languages: All studies translatable to English as this is the linguistic capability of the review team. Excluded articles will be listed in a separate database along with reasons for their exclusion.

Consistency checking
A random sub-set of 5% of articles from the search results will be used for consistency checking against the inclusion criteria with a second reviewer to abstract level only. Cohen's Kappa coefficient will be carried out to examine the similarity in screening between reviewers. If the score is less than 0.6 then disagreements will be discussed in detail and the inclusion criteria will be adjusted accordingly. If the number of studies is too large for the timeframe available, then fewer will be selected for the second reviewer.

Reporting screening outcomes
A ROSES flow diagram will report the results from the screening process. Two files will record lists of articles that are excluded from the systematic map for title and abstract screening and those excluded at full text with explanations for their exclusion.

Study validity assessment
Critical appraisal will not be undertaken in accordance with guidelines for systematic maps (14). However, discrepancies or inconsistencies will be noted to highlight potential areas for further research.

Consistency checking
N/A

Data coding strategy
If the timeframe, quantity of articles and access allows, full texts will be used for data extraction. Should the volume of articles at abstract level mean that it is unfeasible to extract and code data at full text, we will code basic key information at abstract level from all articles included at that stage, and select a subsection (eg a subgroup of interventions) to code in full detail at full text. If this is necessary, the decision on which interventions to choose for detailed coding will be decided by the author team and Morrisons stakeholder group based on the included abstracts.

Meta-data to be coded
All studies will have the following meta-data recorded: Bibliographic information, basic study details (including Population, Intervention, Comparator, Outcome). For field studies location and farming system will be recorded. If other ecosystem services are studied, then this will also be recorded. The coding strategy can be seen in Additional file 4.

Consistency checking
Coding will be performed by the first author, with a subset of 5% of articles checked for coding consistency by another reviewer. Should substantial disagreement arise then the coding criteria will be reviewed and a further 5% of studies will be checked for consistency. This will be repeated until the consistency reaches a minimum of 90% similarity. Missing information will be coded as “Not specified”, because the timeframe does not allow for contacting authors for information. Information that does not apply to a specific study will be coded as “N/A”.

Type of mapping
A full written report will be produced to document the methods and results of the research and will accompany the systematic map database. The searchable database will be produced using Microsoft Excel and will contain a data dictionary, all included studies and all available details from the coding strategy. This will be published as a supporting file with the systematic map report.

Narrative synthesis methods
Descriptive statistics, geographical maps and heat maps will be used to characterise the systematic map.

Knowledge gap identification strategy
The systematic map database will enable clusters to be identified. The final report will detail any gaps or clusters identified using heat maps: tables of two variables showing the number of studies examining their interaction.

Demonstrating procedural independence
SR and SK do not have any previous publications. The random subset of articles JC will check for consistency will not include papers published by JC. NR and ML will not be involved in the screening or coding process.

Competing interests
The authors declare that they have no competing interests.

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SR received funding to carry out a research degree from WM Morrisons Supermarkets Limited who have had no role in any aspect of the study design, collection, analysis, or interpretation of data or in writing the manuscript.

Author’s contributions
SR and NR conceptualised the primary question. NR, as the methods expert refined the PICO terms and discussed, guided and reviewed the study design and methodology. SR drafted the initial protocol, performed the scoping study and wrote the final manuscript. All authors read and approved the manuscript.

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