Executive Summary: Synthesising evidence in the economics of farm environmental biodiversity

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Abstract: Robust ecosystems play important roles in supporting productive landscapes and food security. Our literature synthesis estimates that pollinators' economic value to UK agriculture is between £189 and £379 million per year. However, mounting evidence shows that fragmentation due to land use change threatens pollinator communities and that the UK places towards the bottom in European comparisons of pollinator stock capacity. Applying a species distribution model to citizen records of the Western honeybee, we find that agricultural land scores significantly lower on habitat suitability than woodland and grassland. As part of this project, we propose an environmental land management scheme allowing farmers to coordinate with neighbours to create ecological corridors across farm boundaries. Surveying 309 English farmers in a discrete choice experiment, we estimate the required bonus payment for coordination with two neighbours to be approximately £5.40, while the requirement to coordinate with one neighbour was negligible. Previous participation in agri-environment schemes, higher educational attainment, and sharing farm equipment with neighbours were significant predictors of uptake.

Introduction

Effective agri-environmental policies are needed to ensure the sometimes opposing---but crucially important goals---of sustaining productive agriculture while meeting landscape biodiversity and ecosystem services targets. The planned reform of UK agricultural policies following Brexit should support these goals, while wrestling with the consequences for the sector from leaving the single market and the growing threat of climate change.

This research project focuses on factoring biodiversity values and designing cost-effective and spatially targeted agri-environmental schemes (AES). We achieve this by focusing on farmers' commitment to supporting ecosystem services where they have the most significant impact. We use data-driven tools to estimate the multifunctional value of natural landscapes and design contracts supporting biodiversity and flood management. By providing schemes that encourage and reward farmers for collaborating with their neighbours to maximise habitat gains from relatively small individual commitments, we propose ways to limit the costs to the sector and ensure the greatest return on future public spending. Our interdisciplinary research will interest a broad spectrum of stakeholders in agri-environmental- and ecological economics, ecology, environmental management, and land use policy as we address both cost- and benefit estimates.

Background

To support our empirical research, we present a literature synthesis of the research on economic biodiversity values to date. The literature on biodiversity values has grown rapidly, from negligible output, since the early 2000s. Among empirical valuation research, analyses attributing crop yields to biodiversity and the use of contingent valuation methods are most common. Discrete choice experiments and revealed preference methods, such as travel cost methods, are rare, accounting for only about 2% of sampled articles.

We limited the research scope to insect pollinators and the economic value of pollination. We motivate this restriction on the following grounds: a) Pollination is a key ecosystem service contingent on biodiversity and a determinant of ecosystem function [1]; b) a previous UK study links changes in land use to a decline in pollinator populations [2], and c) we model the impact of our proposed AES on honeybees in the UK using species distribution modelling.

Analysis of cropland in the UK since 1984 indicates that insect-pollinated crop area has risen by 57.5%, covering 848,946 hectares of UK cropland in 2007, growing at an average rate of 21,250 ha per year. This represents 20.4% of the 2007 UK cropland. Recent research suggests that the occupancy of bee and hoverfly species has declined by an average of 25% across Britain since 1980 [3] and that while there were honeybee deficits (insufficient stocks to supply 90% of national demands) in 22 countries in 2010, only the UK and Moldova had a pollinator stock capacity below 25%. [4] The causes of pollinator decline include the indiscriminate use of pesticides, biological invasions, genetically modified (GM) crops, intensification and expansion of agricultural practices and parasites [5] [6], as well as habitat loss and fragmentation associated with farming and urbanisation [7].

The total contribution of pollinators to UK agricultural value is estimated between £188.7M and £379M per year. This represents between 1.7% and 3.5% of total crop values in 2021 [8]. In a 2020 synthesis of the international pollination values, the economic benefits of pollination services have not yet translated into targeted policymaking [9]. Targeted AES provide measurable improvement in fragmented landscapes [10]. Understanding how land management affects pollinator abundance and diversity in combination with other drivers is necessary to design more targeted, adaptive management strategies at national scales [11].

Empirical method

We followed two separate but complementary methodological approaches within the scope of this grant. First, we conducted two discrete choice experiments (DCE) with a sample of 309 farmers in northern England. A DCE is a survey in which respondents are asked to choose their preferred option from a set of discrete alternatives. Each option is associated with a set of characteristics, or attributes, that differentiate it from the other options. [12] The DCEs aimed to estimate farmers' willingness to participate in an environmental land management scheme to create habitat patches in agricultural landscapes. Our proposed scheme is conceptually similar to the proposed Landscape Recovery scheme planned to launch in 2024. The scheme will fund long-term, large-scale projects that "restore priority habitats, improve habitat quality, and increase species abundance" in England by building or linking nature reserves, creating woodlands, or improving habitat connectivity [13]. Additionally, on top of an annual grant payment, our scheme features a bonus for coordinating with one or more neighbouring farmers to connect habitats with strips of set-aside land that improve connectivity [14]. Second, we estimate the effect of land use choices on honeybee abundance through species distribution modelling. By estimating which land use categories are suitable for pollinators, we can better target the scheme to deliver ecosystem services.

Results

Our DCEs reveal that the location of the natural features is considered more important than the quality of land retired. Respondents require, on average, £232 less compensation per year when offered a scheme with features along field boundaries compared within the middle of fields; and £271 less per year with features along river edges. Comparatively, high-quality land (high-yield cropland, prime grazing) is only valued at £36 per year over low-quality land. Controlling for location, land quality, and feature type, the average marginal compensation required to retire land is £1.80 per square metre. Participation in a real AES is associated with lower costs and a higher likelihood of opting into our proposed schemes than a status quo alternative.

Similarly, higher educational attainment lowers the barrier to uptake by £212 to £359 annually, depending on education level. As expected, coordinating with two neighbours was perceived as more costly than no coordination. However, the estimated shift in required compensation was smaller than expected, with no significant preference for no coordination requirements over coordination with only one neighbour. The average respondent required more compensation (£157 per year) to consider a scheme requiring wider corridors (20m over 10m), as well as features of planted trees over natural regeneration (£117).

Self-rated community participation (assessed with a Likert scale rating respondents' degree of social engagement in the local community) was not very influential. Instead, sharing farm equipment with neighbouring farmers made respondents more willing to opt into the scheme. These results indicate that unlike the scheme without collaboration, willingness to coordinate to improve habitat connectivity is not driven by general ties to the community but by lower coordination costs from having previously collaborated with individual farmer neighbours.

A maximum entropy model was run on occurrence data for the Western honeybee based on the following predictors: Monthly maximum and minimum temperatures, precipitation [15], land use categories, distance to rivers and streams, population density, and air pollution. The raster resolution was 25m, and data for 2019 were used. Land use produces the best prediction on its own and reduces accuracy the most when left out of the model. Farmland is considerably less suitable to the species than broadleaved woodland and acid grassland. Urban- and semi-urban uses are also identified as suitable, but lose some significance when controlling for population density. This could be attributed to higher sampling intensity in populated urbanised areas. These results indicate converting arable farmland to broadleaved (planted) woodland or grassland.

Conclusion

Initial results from our project have found that rewilding farmland can have a quantifiable effect on pollinator habitats. An annual payment of between £200 and £500 could incentivise farmers in the north of England to create natural features of 500-1000 square metres, and that a one-off coordination bonus can facilitate coordination between neighbours that results in improved habitat connectivity. To encourage uptake and flexibility for farmers, such corridors should be as narrow as possible while maintaining connectivity benefits. On average, younger, more educated farmers and those with previous exposure to government ELM schemes were more likely to participate. Farmers who share farm equipment with their neighbours were more likely to also agree to connect features with a neighbour and required lower compensation. On the cost side, schemes involving natural regeneration along field edges will likely require the smallest government transfers.

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