Extended Abstract
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Paper/Poster Title	The costs of delivering environmental outcomes with land sharing and land sparing

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Abstract	***200 words max***
The biodiversity and climate crises demand ambitious policies for lowering the environmental impacts of farming. Most current interventions incentivise land sharing by compensating yield-reducing measures that encourage wildlife or reduce net emissions within farmed land. Here, we present the first detailed quantification of the likely costs of land sharing compared with land sparing, in which interventions remove large areas from production altogether. We used a choice experiment to explore farmer preferences and estimate the cost of contrasting agri-environment schemes that delivered populations of well-studied farmland birds and reduced net carbon emissions in England. We included capital, administration and monitoring costs, and lost food production. Sparing delivered the target outcomes at 71% of the food production cost and 48% of the taxpayer cost of sharing. The difference in subsidy payments required by farmers roughly tracked lost food production but other costs favoured sparing even more strongly. The cost-related merits of sparing would increase further by considering the costs of food imports and of conserving the many species and ecosystem services not deliverable on farmland.	

Keywords	Environmental economics; agri-environment schemes; choice experiment; biodiversity; climate mitigation
JEL Code	Q57 Ecological economics

Introduction	***100 – 250 words***

Globally, agriculture is the greatest threat to biodiversity, accounts for 34% of annual anthropogenic carbon emissions and covers 50% of all inhabitable land. This vast area under production offers huge opportunity for interventions that deliver biodiversity and carbon storage. To date, most policies for reconciling food production and environmental outcomes have promoted a land-sharing approach where wildlife-friendly measures are implemented on farmed land, usually at the cost of yield. However, 15 years of empirical data from five continents suggests that the same quantity of food could be produced at substantially lower cost to biodiversity and the climate if it was instead met through land sparing, with higher yields on already-cleared land freeing-up land elsewhere for the retention or restoration of natural habitats. Despite these relatively clear-cut natural science results, there has been no attempt to estimate and compare the financial costs, particularly to taxpayers, of pursuing these alternative approaches to reducing the environmental footprint of farming.

Scheme costs are dominated by the payments made to farmers to secure their participation in these voluntary schemes. Other important costs are the once-off capital costs of altering

management, administration costs and monitoring costs. All may differ between sharing and sparing schemes, but none have been compared in a like-for-like manner. Therefore, we present a novel comparison of the financial and food production costs of delivering environmental outcomes with sharing and sparing in England, where Brexit presents an opportunity to redefine current policy.

Methodology

100 – 250 words

We identified outcomes that could be delivered by both sharing and sparing - bullfinches, lapwings and yellowhammers and carbon sequestration - and identified sharing and sparing interventions by which they could be delivered. Sharing interventions were measures implemented within the field that reduced yields. Sparing interventions involved creation of 10-50ha areas of (semi)-natural habitat. We used existing literature to estimate the per-area benefit of these interventions for the target outcomes.

We conducted a discrete choice experiment to estimate the payments required by farmers to implement the studied interventions. Options varied in terms of the interventions, area requirement, contract duration and payment rate. Each participant answered 12 choice questions, which presented sharing and sparing interventions plus the option not to adopt any of the offered contracts. The survey was conducted online using Qualtrics and received responses from 118 farmers in England.

We analysed the responses using mixed logit modelling. Using posterior estimates of each individual's sensitivities, we estimated individuals' willingness to accept payment to implement each intervention over varying areas and durations. We used these estimates to simulate the cost of fixed-price schemes, which paid all participants at the rate of the least-willing enrolled farmer, that delivered fixed quantities of our target outcomes (300 yellowhammers, bullfinches and lapwings and 1500tC/yr). We estimated the associated once-off capital costs and administration costs based on the literature. Finally, we used a utility-theory approach to estimate the costs of compliance monitoring.

Results

100 – 250 words

Our discrete choice experiment found that farmers required, on average, more compensation to participate in any contract relative to opting out, with larger areas and longer durations requiring greater payments. On average, sharing options required less compensation than sparing options. However, significant heterogeneity existed between farmers in attitudes towards all interventions studied.

Taking into account the benefit delivered by each of the studied interventions, and using estimates of the payments required by each individual farmer, our simulated fixed-price schemes found the target outcomes (bullfinches, lapwings, yellowhammers and carbon) were delivered at less cost with sparing than sharing in terms of all costs considered. Amalgamating the taxpayer costs (payments to farmers, capital costs, administration costs

and compliance monitoring costs), we found sparing cost only 48% of the taxpayer cost of sharing.

We found that financial costs were dominated by the maintenance payments made to farmers to participate in the schemes each year; these approximately tracked the value of lost production for both sharing and sparing. All other costs - capital, administration, and monitoring - were also cheaper under sparing and by a greater margin. Whilst monitoring costs were a small portion of overall costs, insufficient monitoring could see total costs escalate since, under our model, compliance falls with little monitoring so more farmers must be paid to enter the scheme to make-up the benefit lost to non-compliance.

Finally, based on information given by the participant farmers about their farms, we calculated the food production forgone in delivering our target outcomes; sparing resulted in loss of 71% of the food production lost under sharing.

Discussion and Conclusion

100 – 250 words

We have shown, for the first time, that sparing delivers a range of environmental outcomes at less than half the cost to the taxpayer of sharing. This is largely because sparing typically delivers greater benefit per-unit area, so despite the average farmer being more willing to participate in sharing, fewer farmers - and therefore only the relatively more willing - are required in a sparing scheme.

Crucially, our study underestimates the costs of sharing in two key ways. First, we studied outcomes that are deliverable on farmed land; this biased the studied in favour of sharing since many outcomes can only be delivered on the unfarmed land that is directly lost to land sharing. Second, we did not estimate the costs of recovering the production lost in delivering our outcomes which was higher under sharing. A loss in domestic production would likely be compensated with increased imports with consequences for biodiversity, carbon sequestration and people elsewhere.

In conclusion, we believe our work presents a major challenge to the predominantly land-sharing policy approach in the UK. Prolonging the current predominance of land-sharing interventions risks delivering environmental outcomes at a greater cost to the taxpayer, potentially increasing environmental damages in food-exporting countries and depriving wild species that do not tolerate conditions on farmed land of adequate conservation effort.