Extended Abstract
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Paper/Poster Title	**Improving the ecological and economic performance of agri-environment schemes: payment by modelled results versus payment for actions.**

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Abstract	***200 words max***
Researchers and policy designers have become increasingly interested in re-designing agri-environmental policy to improve both economic efficiency and ecological effectiveness. One idea within this debate has been payments for outcomes (results) rather than payment for actions. Payment for outcome policies have been argued to have some important advantages, but two key disadvantages are the higher risks faced by land owners, leading to low participation rates; and the costs of monitoring outcomes. In a recent paper, Bartkowski et al (2021) propose an alternative policy design of payment for modelled results, which claims to avoid these two problems. Our paper provides the first empirical test of the economic and ecological consequences of applying such a payment for modelled results policy to farmland biodiversity in England; we also compare results with a hybrid scheme which uses spatial variation in payments for actions. Key insights from the work are that payment for modelled results delivers superior ecological outcomes for the same budget as either of the payment for action outcomes, whilst surpluses to farmers are also higher. However, payments for modelled results does not allow farmers to make use of private information on how best to deliver target biodiversity outcomes.	

Keywords	Agri-environmental policy; biodiversity; ecological-economic modelling.
JEL Code	Q15; Q57 see: www.aeaweb.org/jel/guide/jel.php?class=Q)

Introduction	***100 – 250 words***
Agri-Environment Schemes (AES) have been mainstreamed in agricultural policies across the globe as a means to financially incentivise farmers to undertake nature-protecting activities and to support rural development and mitigate environmental damage (Batary et al, 2015; Prager, 2015). At their core, they aim to compensate land managers for additional costs and income foregone incurred in abiding with higher environmental and ecological quality standards (Tyllianakis & Martin-Ortega 2021). However, evidence is emerging world-wide that the dominant design of AES – namely payment for actions – often fails to achieve desired environmental outcomes, such as halting the decline of farmland biodiversity (Bertoni et al., 2020; Pe'er et al, 2020; although see Walker et al, 2018).	

Within the general class of incentive-based agri-environment schemes (AES), two main policy design alternatives have been analysed: action-based and result-based payments (Derissen and Quaas 2013; Wuepper and Huber, 2021). Payment for action schemes offer farmers a (typically uniform) payment for adopting specific management practices within a specified region or nation state (Engel 2016). In contrast, results-based payment schemes offer payment conditional on achieving a specified ecological outcome, creating an incentive for those farmers who can provide the ecological benefit at a low cost to join the AES (Chaplin et al, 2021; Birge et al, 2017; Gibbons et al 2011). Within Europe, interest is growing in the use of results-based incentives as part of the on-going reforms of the Common Agricultural Policy (Herzon et al, 2018; Wuepper and Huber, 2021; Hasler et al, 2022).

Methodology	***100 – 250 words***

We use an integrated ecological-economic modelling approach to understand the landscape-scale outcomes of alternative AES policies, comparing payment for actions with payment for modelled results. Our landscape is divided into 1 by 1 km land parcels (100 ha), and each landowner is assumed to manage a single parcel. We assume that the landowner is a profit maximiser. The model follows a two-stage approach. Firstly, ecological regression models are used to predict changes in the distribution and abundance of species based on the prescribed AES policy (i.e., payment for actions, payment for modelled results, or spatially-varying payments for actions). The baseline for this modelling is the current landscape. Secondly, economic simulation models integrate data on agricultural values within the landscape to determine the profitability of each land parcel under the alternative AES policies. From this, we can determine which farmers would sign up for (i) a payment for actions scheme ii) a spatially targeted payment for actions scheme and iii) a payment for results scheme. We then analyse these decisions spatially to understand the resulting impacts on both habitats and species, and the economic effects on farmers.

We apply our model to a UK case study region known as the Tees Valley, Pennine Uplands and North York Moors (Figure 1), to compare the ecological and economic outcomes of three simulated policies: a uniform payment for action (grassland creation), a spatially-differentiated set of payments for actions to reflect differences in ecological productivity, and Bartkowski et al's new "payment for modelled results" policy. We designed the simulations so that all three policy options have a similar budgetary cost to the taxpayer.

Results	***100 – 250 words***

Our payment for actions scheme was the restoration of agricultural land to low-intensity grassland. Farmers were paid a uniform subsidy of £585 per hectare of agricultural land restored to low-intensity grassland. By uniform payment recall that

all farmers are offered the same standard payment rate, regardless of location throughout the case study region. We find that under this scheme, 39 farmers would choose to restore agricultural land parcels. This results in the restoration of 2792 hectares of low-intensity grassland at a cost to the policy maker of £1.6 million. Under this scheme, there is a 2.8% increase in the number of lapwings above the current predicted abundance on agricultural land parcels. Under the spatially weighted payments for action, 37 farmers choose to sign up to the scheme. This results in the restoration of 2721 hectares of low-intensity grassland and a 1.6% increase in the abundance of lapwing compared to the current landscape. Our payment for modelled results scheme was based on predicted increases in lapwing for an agricultural land parcel switched to low-intensity grassland from its current use. Using our ecological-economic modelling framework we were able to derive a farmer's opportunity cost for increasing the abundance of a single lapwing and rank these from lowest to highest for all land parcels that could restore agricultural land parcels to improved grassland. Under payment for modelled results, we find higher ecological benefits and higher farmer surpluses for those farmers choosing to enrol than for either of the other two policies modelled.

Discussion and Conclusion	***100 – 250 words***

For the same overall budgetary cost, the payment for modelled results schemes yields superior outcomes in terms of biodiversity indicators than either the uniform or spatially-differentiated payment for action schemes. Fewer hectares of low intensity grassland are created under payment for modelled outcomes, but the gains in lapwing, oystercatcher and curlew populations are greater, since the ecological model enables the targeting of restoration actions where the biodiversity pay-off is greater. However, there are also, as a result, large differences in where restoration occurs under the three schemes. Under payment for action, restoration occurs where the opportunity costs of changing land use are lowest. Under payment for modelled results, these opportunity costs are effectively weighted by the ecological model to reflect differences in the costs per predicted increase in the target species across space, which in itself depends on a large number of factors taken into account in the ecological model. This set of results would seem to offer evidence in favour of the payment for modelled results suggestion put forward by Bartkowski et al (2021). Whilst we were unable to compare outcomes with actual ecological results (since the schemes we simulate are hypothetical), it would also seem likely that payment for modelled results will encourage higher levels of participation than payment for monitored, actual, results, since the latter transfers risks from the regulator to the farmer. If farmers are risk averse, then this will reduce participation, other things being equal.