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Stakeholder perceptions of the effectiveness and efficiency of agri-environment schemes in enhancing pollinators on farmland

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ABSTRACT

In parts of the northern hemisphere, many pollinator species are in decline, with potential adverse implications for pollination and the ecosystem service of food production. It is therefore important to understand how habitats primarily orientated towards food production can be managed in an efficient way to enhance pollinator populations for current and future food security. In Europe, agri-environment schemes are a well-established method for promoting nature conservation on farmland. Some previous studies indicate that certain agri-environment schemes may be beneficial to pollinator populations by promoting increased floristic diversity in agricultural habitats. However, there has been no analysis of the efficiency or cost-effectiveness of these interventions. We used an online survey to evaluate the perceptions of growers in England following the Conservation Grade environmentally-sensitive farming protocol, regarding the effectiveness of different agri-environment scheme options in enhancing pollinators on their farms and the costs of implementation. Options within the agri-environment schemes that were perceived as most effective in enhancing pollinators were those related to improving floristic diversity of field headlands and enhancing or restoring semi-natural grassland. However, these options were not generally the most efficient, due to their high cost. Hedgerow management interventions were shown to be the most efficient, despite being perceived as relatively ineffective, due to the low costs of these options. We have therefore found that there is often a mis-match between effectiveness and efficiency of interventions for enhancing pollinators. Trade-offs are likely to be necessary when making decisions on implementing interventions, and farm size as well other local differences should be taken into account in this decision-making process.

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Introduction

Many pollinator species are declining across the northern hemisphere. (Biesmeijer et al., 2006; Potts et al., 2010; Cameron et al., 2011). This decline is a consequence of a number of different factors including, land use change, changes in farming practices, disease and contamination of the environment with fertilisers and pesticides (Vanbergen et al., 2012). These factors can affect pollinators both directly and indirectly through changes to the ecosystem, particularly food supplies (Carvell et al., 2006; Potts et al., 2010; Sutherland et al., 2011). While declines in some species may have slowed recently in some European countries (Carvalheiro et al., 2013), any decline in pollinators is likely to have an adverse impact on pollination. Pollination underpins the functioning of many ecosystems (Kremen et al., 2007; Potts et al., 2010; Vanbergen et al., 2012), as well as having a direct impact on the ecosystem service of food production (Klein et al., 2007). In the light of increasing concerns about food security in both developed and developing nations (Tscharntke et al., 2012), it is important to understand how habitats primarily orientated towards food production can be managed in an efficient way to enhance pollinator populations for current and future food security.

In recognition of the important ecosystem services that pollinators provide, many countries are investing resources in interventions to enhance pollinator populations, either in terms of encouraging bee-keeping (Aizen and Harder, 2009) or encouraging the management of landscapes in ways that are considered to be more beneficial to pollinators. In Europe, conservation-orientated interventions in agricultural landscapes are encouraged by agri-environment schemes, which are voluntary agreements entered into by farmers who are then provided with payments to manage their land according to certain prescriptions to enhance their conservation value (Kleijn & Sutherland, 2003). There has been much debate over the effectiveness of agri-environment schemes

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for biodiversity and conservation in England (Kleijn & Sutherland, 2003; Whittingham, 2011; Courtney et al., 2013), including in relation to pollinators (Carvell et al., 2007, 2011; Pywell et al., 2006, 2011a,b). These authors concluded that specific targeted interventions were significantly more beneficial for bee and butterfly populations than more general conservation management options. A list of possible interventions to benefit wild bee populations has been provided by Dicks et al. (2010). Although the effectiveness of some of these interventions has been measured in terms of species richness and diversity, few studies have tested the effectiveness on population responses of pollinators (Scheper et al., 2013). An assessment of effectiveness that is uniform and comparable across all these agri-environment interventions has not yet been implemented.

In England, agri-environment schemes operate currently at two main levels: Entry Level Stewardship (ELS) and High Level Stewardship (HLS). The ELS is a basic scheme offering farmers over 60 options to choose from (Natural England, 2010a). The Higher Level Stewardship (HLS) is focused on priority areas and demands more complex management from farmers with more specific conservation goals (Natural England, 2010b). Although there is a diversity of agri-environment management options available under both the ELS and HLS, uptake by farmers tends to be biased towards the lowest-cost options (Hodge and Reader, 2010). Despite the importance of cost as a driver of decisions concerning implementation, there is a very little information about the economic efficiency of the agri-environment scheme policies that enhance ecosystem services on farmlands (Kleijn and Sutherland, 2003).

The importance of evaluating the effectiveness and efficiency of conservation measures has received increasing recognition in recent years, as policy-makers seek evidence of successful returns on investment (Ferraro and Pattanayak, 2006; Kapos et al., 2008; Shwiff et al., 2013). For many conservation projects, although outcomes can be quantified, they cannot be expressed in monetary terms. In these circumstances, cost-effectiveness analysis can be used to assess the change in units of conservation output relative to the cost invested in an intervention to produce these outputs. Financial efficiency can be expressed in terms of cost per unit of conservation effectiveness, with programmes with a low cost per unit of conservation output having a high efficiency (Cullen et al., 2001, 2005; Laycock et al., 2009, 2011).

Here we evaluate the cost, effectiveness and efficiency of a selection of management interventions under the ELS and HLS thought to enhance pollinators on farms in England. We use the perceptions of farmers to obtain information on the effectiveness of different interventions for enhancing pollinators and explore the relationship between effectiveness and efficiency for these interventions. The interventions that are considered to be most effective may not necessarily be the most cost-effective and trade-offs may often be necessary when implementing interventions to enhance pollinators with limited financial resources. Farm size and other factors may also have an impact on cost and effectiveness of the interventions and therefore these factors are also explored using both quantitative and qualitative data.

Methods

Questionnaire of farmers and growers

We designed an online survey targeted at farmers in England who followed the Conservation Grade protocol (Conservation Grade, 2012). Conservation Grade seeks to promote farming methods that will help to halt and reverse declines in farmland biodiversity. Farmers who follow the Conservation Grade protocol are required to adopt certain farming practices, including creating a wildlife area on at least 10% of their farm and maintaining pollen and nectar mixes on at least 4% of their farm. Two pollen and nectar habitats should normally be provided: (1) grass and wildflower mixtures and (2) grass and legume mixtures. However, existing pollen and nectar habitats (naturally occurring or sown) can count towards the total habitat area. The Conservation Grade protocol has been designed with other Environmental Stewardship options in mind such as ELS and HLS. However, the Protocol is not necessarily compliant with any particular scheme or intervention under these schemes (Conservation Grade, 2013).

Within the Conservation Grade group of farmers, we targeted our survey at those farmers who had implemented an ELS or HLS intervention on their farms for a minimum of 2 years, whether currently or in the past. Farmers that follow the Conservation Grade protocol are granted premium prices for their crops each year. However, cost is still likely to be important in determining which of the ELS or HLS options are implemented by farmers on their farms.

We included a total of 22 interventions in the questionnaire, 14 from ELS and 8 from HLS (Table 1). Interventions were selected on the basis of evidence provided in Carvell et al. (2007), Pywell et al. (2012), Sutherland et al. (2011) and Bumblebee Conservation Trust (2012) regarding their potential benefits to pollinators (Table 1).

Table 1
List of ELS and HLS agri-environment scheme interventions included in the questionnaire with an explanation of how they are thought to benefit pollinators. Sources for information on benefits: Carvell et al. (2007, 2011); Natural England (2010a); Pywell et al. (2005, 2006); Bumblebee Conservation Trust (2012).

Details of management intervention	Agri-environment scheme option code	Benefits to pollinators
Hedgerow management on both sides of a hedge, on one side of the hedge and enhanced management.	EB1, EB2, EB3	Nesting and pollen and nectar source
Management of woodland edges	EC4	Rearing, nesting and hibernation
2 m, 4 m and 6 m wide buffer strips on cultivated land	EE1, EE2, EE3	Nesting and pollen and nectar source
Management of field corners	EF1	Nesting
Nectar flower mixture	EF4	Pollen and nectar source
Beetle banks	EF7	Nesting
Unharvested cereal headlands	EF10	Nesting and hibernation
Uncropped cultivated margins for rare plants	EF11	Pollen and nectar source
Undersown spring cereals	EG1	Pollen source
Permanent grassland with very low input	EK3	Pollen and nectar source
Management of hedgerows of very high environmental value	HB12	Pollen and nectar source and nesting
Floristically enhanced grass buffer strips (non-rotational)	HE10	Pollen and nectar source
Unharvested, fertilizer-free conservation headland	HF14	Nesting and hibernation
Cultivated fallow plots or margins for arable plants (rotational or non-rotational)	HF20	Pollen and nectar source
Maintenance, restoration and creation, respectively, of species-rich, semi-natural grassland	HK6, HK7, HK8	Pollen and nectar source
Enhanced buffer strips	HE11	Nesting and pollen & nectar source

Table 2
Summary of the questionnaire for Conservation Grade farmers.

Question	Response option	Response type
Farm region	Midlands, East of England, Greater London, North East England, North West England, South East England, South West England, Yorkshire and Humber	Multiple choice question with single answer option
Farm size	Size in hectares or acres	Open-ended question
Farm type	Wheat, barley, oats, rye, oilseed rape, linseed, potatoes, sugar beet, maize, field beans, vegetables grown outdoors, outdoors plant and flowers, orchard fruits, soft fruits and vine grapes, pigs, poultry, sheep and lambs, dairy cattle, beef cattle, biofuel, other (please specify)	Multiple choice question with multiple answer option and open-ended question
ELS or HLS options implemented	EB1, EB2, EB3, EC4, EE1, EE2, EE3, EF1, EF4, EF7, EF10, EF11, EG1, EK3, HB12, HE10, HF14, HF20, HK6, HK7, HK8, HE11	Multiple choice question with multiple answer option, followed by an open-ended question
Intervention cost in £	<5, 6–20, 21–35, 36–50, 51–65, 66–80, 81–95, >95	Drop-down boxes
Effect of interventions on pollinators	From “Very negative” to “Very positive”	Six-point scale
Comments about study and additional information		Open-ended question

The survey was designed and implemented using Sawtooth SSI Web Survey software version 7 (Sawtooth Software Inc. 2013). Following piloting and evaluation by Conservation Grade, the survey was distributed to all 81 qualifying farmers on 25th June 2012. These farmers received the link to the survey directly from Conservation Grade, together with an explanatory covering letter. To increase the response rate, one reminder was sent out on 3rd July, 2012 and the survey was closed on the 8th July, 2012.

Following the guidelines of Dillman et al. (2008), the questionnaire was short (only six questions) with a relatively simple design that did not require the participants to give any personal details (Table 2). The questionnaire started with a brief introduction providing details about project, an assurance of confidentiality and a note about eligibility. The main part of the questionnaire comprised three sections. In the first section, participants were asked general questions about their farms such as the regional location, the size of the farm and the type of crops grown. In the second section of the questionnaire, farmers were asked to select all ELS and HLS options that were implemented on their farm. They were then asked to estimate the cost for each option per hectare (or acre) per year. Participants were given the choice of seven price ranges (£); <5, 6–20, 21–35, 36–50, 51–65, 66–80, 81–95 and >95. These ranges were based on approximate price estimations whereby the annual cost of implementation and management of an intervention usually does not exceed £100 per hectare (B. Hughes, personal communication). When estimating the costs, participants were asked to include establishment costs such as ground preparation, cost of buying seeds, fertilizers, various sprays, labour costs, and machinery costs such as fuel for the machinery, costs for any specialized equipment, irrigation and water costs (Redman, 2011). However they were asked not to include potential costs such as loss of revenue from the land no longer being used for arable crops, since this cost would vary due to different agricultural prices that change each year (Redman, 2011). The final section of the questionnaire focused on pollination. For the ELS and HLS options that they had selected previously, participants were asked to use their experience to evaluate the effectiveness of each option on pollinators by choosing the appropriate position on a scale that ranged from “very negative” to “very positive”. At the end of the questionnaire, participants were given an opportunity to provide any other information they considered to be relevant to the study, including details of any biodiversity surveys that had been done on their farms in the past.

Statistical analysis and calculation of efficiency

Data analysis was conducted only for those interventions that were implemented on more than five farms. We calculated the efficiency of each agri-environment intervention for enhancing pollinators by dividing the mean average cost of implementing interventions by the mean average perceived effectiveness score to give a cost per unit of effectiveness. This was conducted on those interventions with an average positive effectiveness score (greater than 3.5) only. Greater efficiency is indicated by a lower cost per unit of effectiveness. For the five interventions that were implemented most frequently, we used Spearman's rank to assess correlations of cost, effectiveness and cost per unit effectiveness with farm size and frequency of implementation. All statistical analysis was conducted using SigmaPlot version 12.0 (Systat Software Inc. 2013).

Results

Characteristics of case study farms

From a total of 81 Conservation Grade farmers, we received 28 valid responses to the survey. This response rate of 35% is close to the average response rate for internet surveys of 39.6% reported by Cook et al. (2000). Eighteen additional responses were discarded for being incomplete. The majority of these incomplete responses stopped at the question about the costs of implementing interventions.

The highest number of complete responses came from South East of England including London (39%), followed by East of England (29%) and the Midlands (25%). None of the respondents were from North East and North West of England. This corresponds with the pattern of farm coverage across England, where the North East and North West of England have the lowest coverage percentage (6.4% and 9.9%, respectively; DEFRA, 2010).

The average farm size was 471.3 ha, which is considerably larger than the average farm size in England of 85 ha (DEFRA, 2012). The most common crop grown was wheat, which occurred on all 28 farms (Fig. 1). Other common crops were oilseed rape, barley and oats. Twelve of the farms also farmed livestock, most commonly sheep and beef cattle. None of the survey farms were farming poultry or pigs at the time of survey (Fig. 1).

Of the 22 interventions presented in the survey, the most frequently-adopted were hedgerow management on one side of the hedge (EB2; 26 out of 28 farms) and hedgerow management on both sides of the hedge (EB1; 25 out of 28 farms). The use of 4-m buffer strips on cultivated land (EE3) was the third most frequently-adopted option, being used on 24 farms. The least frequently-implemented interventions were under-sowing of spring cereals (EG1) and enhanced buffer strips (HE11), which were only implemented on one farm each (Fig. 2)

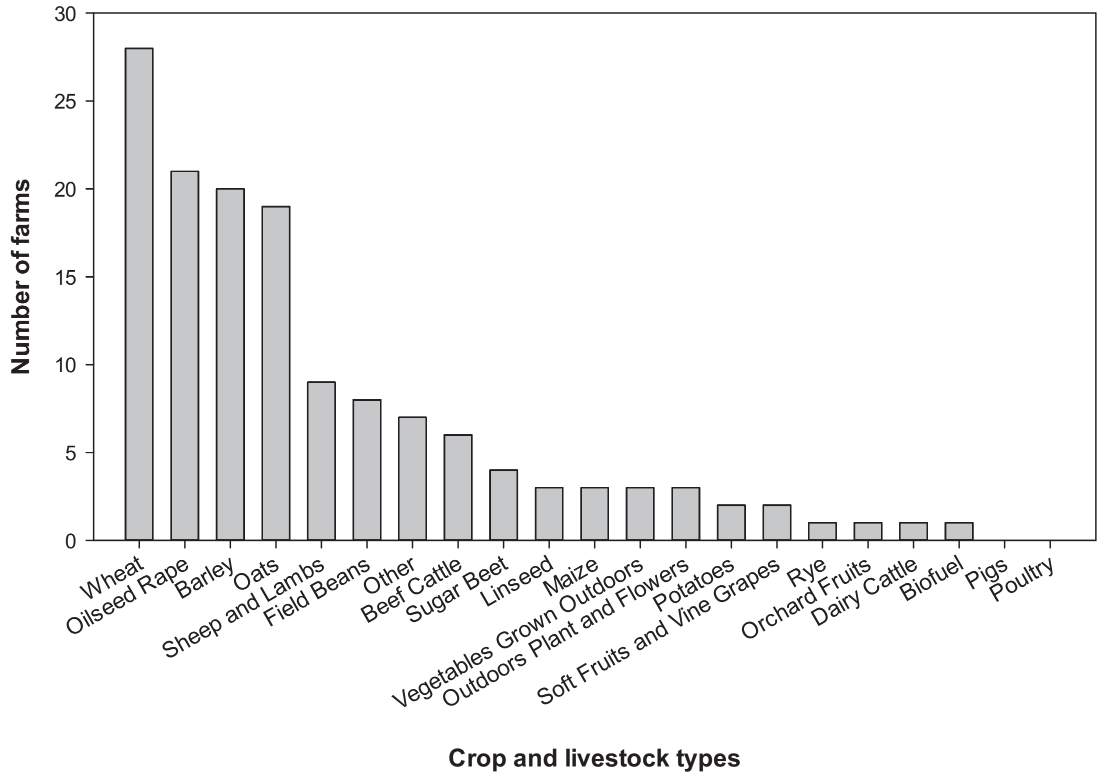

Fig. 1. Frequency of survey farms with different kinds of crops and livestock ($n = 28$). *Other farm activities include: grass, woodland, horses and contract reared heifers.

Cost, effectiveness and efficiency of interventions

On average, the most costly interventions (out of the interventions adopted on more than five farms) were floristically enhanced grass buffer strips (non-rotational) (HE10) and nectar flower mixture (EF4) (Table 3). The least costly interventions were hedgerow management on one side of a hedge (EB2) and hedgerow management on both sides of the hedge (Table 3). The interventions perceived to be most effective were nectar flower mixture (EF4) and floristically enhanced grass buffer strips (non-rotational) (HE10). The intervention perceived to be least effective was cultivated fallow plots or margins for arable plants (rotational or non-rotational) (HF20) (Table 3). The five most economically efficient interventions, with the lowest cost per unit of perceived effectiveness in enhancing pollinators, were hedgerow management on one side of a hedge (EB2), hedgerow management on both sides of a hedge (EB1), enhanced hedgerow management (EB3) and management of woodland edges (EC4). The least efficient intervention

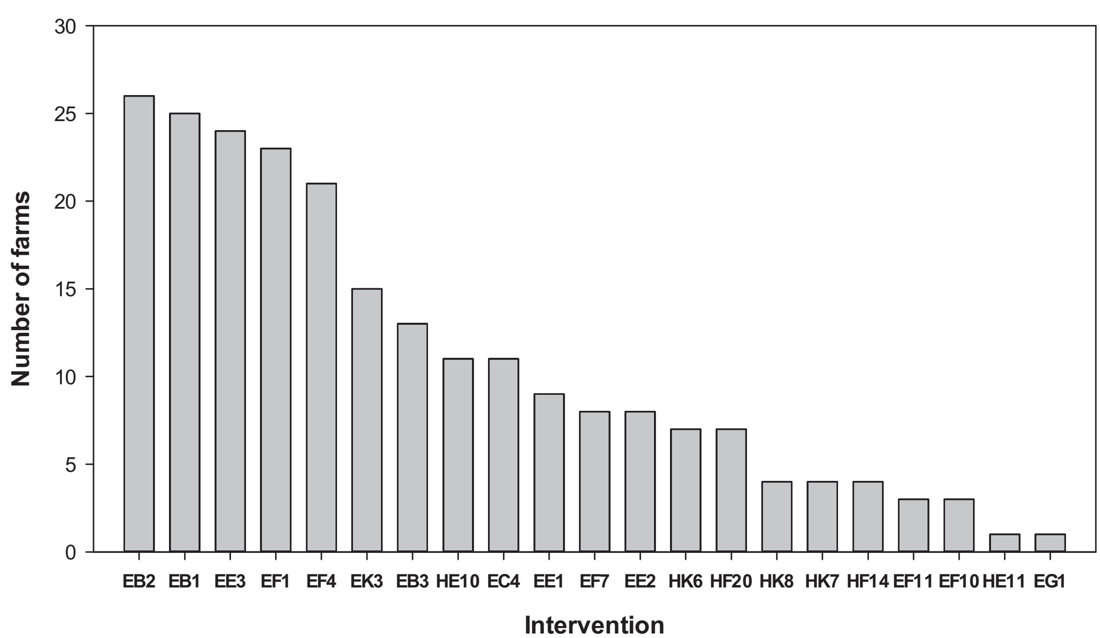

Fig. 2. Frequency of interventions implemented on the study farms ($n = 28$). Interventions listed by code numbers; for details of interventions see Table 1.

Table 3
Perceived cost, effectiveness and cost per unit effectiveness for different interventions on Conservation grade farms. Values for costs and effectiveness are means taken across farms for that specific intervention. Units of measurement for cost and effectiveness are explained in Table 2 Interventions conducted on five or fewer farms are not shown.

Intervention	Cost (scored 1–7)	Effectiveness (scored 1–6)	Cost per unit of effectiveness
EB1	1.2	3.8	0.3
EB2	1.1	3.8	0.3
EB3	1.6	4.7	0.3
EC4	1.3	3.8	0.3
EE1	1.6	3.8	0.4
EE2	2.3	4.1	0.6
EE3	3	4.5	0.7
EF1	3.1	4.5	0.7
EF4	4.8	5.8	0.8
EF7	4	4.5	0.9
EK3	2.5	4	0.6
HE10	5.3	5.6	0.9
HF20	4.2	3.6	1.2
HK6	2.3	5.3	0.4

Table 4
Correlations of cost, effectiveness and cost per unit effectiveness of different interventions with farm size. Correlations are Spearman rank correlations; *n* shown in brackets.

Size of farms implementing interventions	Cost	Effectiveness	Cost per unit effectiveness
EB1	−0.0566 (17)	0.272 (25)	−0.492* (20)
EB2	0.153 (17)	0.197 (26)	−0.474* (21)
EE3	0.0699 (15)	0.00499 (24)	0.234 (20)
EF1	0.171 (20)	−0.184 (23)	0.302 (22)
EF4	0.545* (18)	0.0924 (21)	0.552* (20)

* $P < 0.05$.

was cultivated fallow plots or margins for arable plants (HF20) (Table 3).

There were no significant relationships between the frequency of implementation and the average cost, effectiveness or efficiency of the intervention (Spearman's rank correlations).

Relationship of cost, effectiveness and efficiency of most common interventions with farm size

The cost of implementing nectar flower mixtures (EF4) was positively correlated with farm size (Table 4), but the costs of implementing the other selected interventions had no significant relationship with farm size. The cost per unit of effectiveness of implementing hedgerow management on both sides of a hedge (EB1) and hedgerow management on one side of a hedge (EB2) were negatively correlated with farm size (Table 4), suggesting that cost-effectiveness increases with farm size for these interventions. In contrast, the cost per unit of effectiveness of implementing nectar flower mixtures (EF4) was correlated positively with farm size (Table 4), suggesting that cost-effectiveness decreases with farm size, most likely due to the significantly increasing costs associated with this intervention.

Discussion

This research has presented the first analysis of the perceptions of farmers of the effectiveness and efficiency of interventions under the ELS and HLS to enhance pollinators on farms. Informal knowledge from experts, stakeholders and landowners is being used increasingly in the assessment of conservation programmes (Cullen, 2013). While other methods may be available on which to base a subjective score of effectiveness, the questionnaire approach used in this study allowed us to sample across a wide range of landscapes and farm types and as a consequence, the results are likely to be more robust and potentially transferable. Moreover, we have used farmer perceptions in order to gain relevant local knowledge of the schemes but also to encourage stakeholder participation in the decision-making process.

Local conditions and different contexts are often overlooked and yet changes to policies based on information provided by stakeholder participation can improve the likelihood of implementation and, in some cases, the effectiveness of those policies if adapted to local conditions (Prager and Freese, 2009). In the case of agri-environment schemes, the costs of implementation, especially maintenance, vary considerably with context, affecting the ability to deliver certain agri-environmental benefits on some farms compared to others (Scheper et al., 2013). Thus, it is likely that individual farmers make their implementation decisions based on their own assessment of the likely costs of implementation, including maintenance. We have therefore used cost data collected directly from our participants in this analysis in order to reflect the variation in costs incurred and to ascertain whether these costs affect the individual decisions made on which interventions to implement. Nevertheless, our results are based on stakeholder perceptions and not empirically derived data and this should be considered when interpreting the results.

Our results show that some of the interventions that are perceived to be most effective at improving pollination on English farms are also the most costly according to the costs obtained from our study population. For example, the use of nectar flower mix (EF4) is considered as the intervention most directly aligned to improving pollinator populations by providing foraging resources for pollinators (Carvell et al., 2011; Pywell et al., 2005; Natural England, 2010a,b). In line with these previous studies, the farmers in this study ranked this intervention as most effective too but also relatively costly when compared to other interventions. The relatively high cost may be due to the lengthy preparation process involved in the implementation of this intervention: the costs associated with preparation of the seed bed, buying the appropriate sow mix for successful establishment, and if needed, re-establishment and regular maintenance such as cutting and herbicide use (Natural England, 2010a).

Many of the interventions that were ranked as effective were relatively low in terms of their efficiency, usually due to their high implementation costs. This was the case for nectar flower mix (EF4) as mentioned above, but similar patterns can be seen with other interventions such as floristically enhanced grass buffer strips (HE10). In contrast, the hedgerow management options were ranked relatively low in terms of their effectiveness (a finding that is echoed in previous work, e.g. Dicks et al., 2010) but scored highly in terms of their cost effectiveness due to the relatively low cost of these options. This was not necessarily the case for all of the relatively ineffective options however, and the least effective intervention, cultivated fallow plots for arable plants (HE20), was also relatively costly, making it the least cost-effective intervention in the study.

While cost is clearly having an impact on efficiency, our study did not find any correlation between the frequency of implementation of interventions on farms and their associated cost or effectiveness. Nevertheless, these are likely to be key considerations for farmers when determining which intervention to implement. Indeed, there is likely to be a complex set of ecological and socio-economic drivers affecting the implementation of interventions, as seen with many natural resource management situations (for example see: Austin et al., 2013). Understanding the motivation behind land management decisions and which management interventions are effective in terms of ecological objectives are important considerations when assessing which interventions will be successful, efficient and most likely to be widely implemented.

Our study found correlations between farm size and the associated cost and efficiency of implementing certain interventions, but the direction of these correlations was affected by the requirements of the intervention. For example, for hedgerow management, cost-effectiveness increased with increasing farm size but for nectar flower mixtures, cost-effectiveness decreased with farm size. Thus, economies of scale were evident for hedgerow management but not for the use of nectar flower mixes. This may reflect the large preparation costs involved with nectar flower mixes, which may increase dramatically for larger farms devoting a higher percentage of land cover to this intervention. Despite these general patterns, it is important to consider that other factors may also affect the success and costs of interventions in different parts of the country. For example, Critchley et al. (2004) suggested that different soil properties could affect establishment and re-establishment costs of interventions, and these factors are likely to be especially important for certain interventions such as the use of nectar flower mix.

Conclusions

In this study we have used stakeholder-derived data to consider the cost, effectiveness and efficiency of specific agri-environment schemes that are thought to be beneficial for pollinators. We have found that there is often a mis-match between effectiveness and efficiency of interventions for enhancing pollinators and that the interventions that are thought to be most effective may not necessarily be the most efficient. Trade-offs are likely to be necessary when making decisions on implementing interventions to enhance pollinators, and farm size as well other local differences should be taken into account in this decision-making process.

Cost-effectiveness analysis can be a useful decision support tool when assessing where best to implement certain interventions to enhance pollinators when financial resources are limited. The method used in this study is applicable to other agri-environment schemes where specific benefits and costs can be defined.

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