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STEP

Deliverable 4.3:

Analysis of the effectiveness of measures mitigating pollinator loss

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NON TECHNICAL SUMMARY

Flower-visiting insects provide vital pollination services to crops and wild plants. Accumulating evidence for declining populations of pollinators has increased the urgency to identify and implement measures that effectively mitigate pollinator loss. This report presents the results of a quantitative review of the effectiveness of potential measures to mitigate pollinator loss. All investigated agri-environmental measures effectively enhanced species richness and abundance of pollinators. Supplementing pollinator food resources through the establishment of sown flower strips displayed the most pronounced enhancing effect and appears to be a particularly effective mitigation measure. In addition, effectiveness of mitigation measures for promoting pollinators is probably highest when implemented in cropland rather than grassland habitats and in structurally simple rather than structurally complex landscapes. Results of a narrative literature review stress the importance of protected natural areas as source habitats for pollinators.

POLICY RELEVANCE

Reported losses of pollinators and pollination services call for policy that addresses the development and implementation of mitigating measures. Analysis of the effectiveness of different potential mitigation measures shows that establishing sown flower strips is a particularly effective measure to enhance species richness and abundance of wild pollinators. As most current flower strip measures are not specifically targeted at pollinators, the incorporation of flower strips specifically targeted at pollinators in national agri-environment schemes may even further increase the effectiveness of these types of measures.

Establishment of flower strips is a potentially effective tool for policy that aims to enhance biodiversity for the provision of ecosystem services, such as the pollination of crops. Sown flower strips are expected to be most effective in cropland habitats located in structurally simple landscapes, which are exactly the locations where pollination deficits are expected to be largest. Increased pollinator species richness and abundance induced by flower strips promote the effective pollination of insect-pollinated crops.

Halting biodiversity loss is a key international priority, enshrined in the CBD and EU policy, and requires policies for enhancing biodiversity, not only for the provisioning of ecosystem services, but also for the intrinsic values of biodiversity. Policy that aims to enhance intrinsic biodiversity values requires measures that positively affect overall landscape-wide pollinator populations. Although population-level positive effects of flower strips may be expected, the species richness and abundance data analyzed in this report do not merit unambiguous conclusions about effects of flower strips on landscape-wide populations of pollinators. Assessing the effectiveness of flower strips for promoting intrinsic biodiversity values calls for studies investigating population-level responses of pollinators. This type of research is currently unavailable and could therefore not be included in this review, but is the topic of ongoing research in WP5 of STEP.

STEP Deliverable 4.3

Analysis of the effectiveness of measures mitigating pollinator loss

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1. Introduction

Flower-visiting insects such as bees, hoverflies and butterflies play a vital functional role in the pollination of both wild plants (Ashman et al., 2004) and crops (Klein et al., 2007). Circa 88% of all angiosperms (Ollerton et al., 2011) and 76% of the main global food crops (Klein et al., 2007) rely upon pollination by animals, mainly insects. In Europe, 84% of crops grown for human consumption, livestock consumption, green manure or essential oils are pollinated by insects (Williams, 1994), and the annual economic value of pollination of food crops alone has been estimated to be € 22 billion (Gallai et al., 2009). However, the last decades have witnessed declining populations of both wild and managed pollinators (Patiny et al., 2009; Potts et al., 2010a; Potts et al., 2010b), giving rise to increasing concern about a potential pollination crisis (Steffan-Dewenter et al., 2005). Consequently, there is an urgent need for better insights into the main drivers for pollinator loss and to identify measures that effectively mitigate the impact of these drivers (Potts et al., 2011).

Among the drivers for pollinator decline are the dramatic changes in land use that have taken place since the second half of the 20th century in developed countries (Potts et al., 2011). Agricultural intensification and the re-allotment of farmland have resulted in the loss and fragmentation of habitat, accompanied by increased pesticide and fertilizer use. The loss and fragmentation of habitat is generally thought to be the most important factor underlying pollinator decline (Brown and Paxton, 2009). A recent quantitative review (meta-analysis) investigating the effects of different types of disturbances on bee communities identified habitat loss and fragmentation as the most import negative disturbances for bees (Winfree et al., 2009). Both habitat loss and increased pesticide use negatively affect pollinators through repercussions on the direct factors (sensu Roulston and Goodell, 2011) that regulate pollinator populations, such as the availability of food resources, the availability of nesting, mating and overwintering sites, and incidental risk factors (i.e. biotic and abiotic sources of mortality).

In general, the adverse effects of land use change on pollinator communities may be mitigated by measures that prevent further loss of pollinator habitats and by measures that create or restore pollinator habitat. Protected (semi-)natural areas, which cover about 13% of the terrestrial area in the EU-25 (Eurostat), represent measures of the first class. Protecting remaining natural areas from conversion to crop and pasture land, managed forest or settlement may play an important role in supporting pollinator populations in intensively managed landscapes. Although few protected areas are specifically targeted at pollinators, they often provide food and nesting resources that may be limiting in the surrounding agricultural matrix, and therefore may serve as source habitats for pollinators (Öckinger and Smith, 2007; Kohler et al., 2008).

Agri-environmental measures compose the second class of mitigation measures. Agriculture, covering about 40% of land area in the EU (Eurostat), has an important impact on the natural environment, including pollinators. A wide variety of measures are available that can potentially create or improve habitat for pollinators in agricultural environments through either directly or indirectly enhancing the availability of floral resources, the availability of nesting sites and/or reducing sources of mortality (i.e. the use of insecticides). These measures include for instance incentives to farmers to restrict farming intensity and incentives to promote the creation or maintenance of non-cropped farmland habitat such as field margins, hedges and wildflower strips (Rundlöf et al, 2011). However, few agri-environmental measures specifically aim to promote pollinators, and the effectiveness of agri-environmental measures at conserving biodiversity in general has been questioned (Kleijn and Sutherland, 2003). Whether and to what extent agri-environmental measures benefit pollinator communities has been shown to depend on the type of measures and where they are implemented (Kleijn et al., 2006; Kohler et al., 2007), what pollinator taxa are being targeted (Kohler et al., 2007) and landscape context (Holzschuh et al., 2007; Rundlöf et al., 2008). In view of the ongoing declines in pollinators there is a pressing need for a quantitative synthesis that assesses what measures are effective where for what pollinators.

The main objectives of Work Package 4 (WP4) are to (1) give an insight into what mitigation measures are effective for which pollinator taxa, (2) provide information on where mitigation measures should be implemented, and (3) formulate recommendations for improving the efficacy of mitigation strategies. Within WP4, the objective of Task 4.2a is to assess the effectiveness of mitigation measures for pollinator loss that have so far been implemented throughout Europe. To this end, we review and synthesize the results of all available European studies examining the effects of conservation measures such as protected areas and agri-environmental measures on wild and managed pollinators. Focussing on the most important pollinator taxa, namely bees (Apiformes), hoverflies (Syrphidae) and butterflies and moths (Lepidoptera), we will address the following questions:

- Are mitigation measures in general effective at promoting pollinator species richness and abundance?
- Does effectiveness of mitigation measures vary across the pollinator taxa of interest?
- Does effectiveness of measures vary across the habitat types in which they are located?
- To what extent do individual measure-types differ in effectiveness?
- To what extent is effectiveness of mitigation measures affected by landscape context?

2. Material & methods

2.1 Meta-analysis

We addressed our research questions using a meta-analysis. In contrast to qualitative and descriptive traditional reviews, meta-analysis allows the quantitative synthesis, analysis, and summary of a set of multiple independent studies (Hedges and Olkin, 1985; Gurevitch and Hedges, 1999). When several studies examine essentially the same particular effect, meta-analysis offers the tools to examine the overall magnitude of the effect and the consistency of the effect among studies. To this end, the results of separate studies are placed onto a common scale using a metric of effect size, so that they can be compared and averaged. Contemporary meta-analyses is a valuable method to increase power, explore heterogeneity, identify large-scale patterns and facilitate evidence-based decision making (Stewart, 2010).

2.2 Data collection

We conducted an extensive systematic survey for literature on effects of potential mitigation measures on pollinators. ISI Web of Science, SCOPUS and OvidSP (CAB abstracts, Biological abstracts, AGRICOLA, AGRIS) were searched until April 1st 2010 using the following search terms: (pollinat*

OR apoidea OR bee OR butterfl* OR Lepidoptera OR hoverfl* OR Syrphidae) AND (agri-environment* OR mitigation OR "organic farming" OR management OR conservation OR restoration OR "field margin" OR "nature reserve" OR "flowering crop" OR "protected area" OR "field edge" OR set-aside). In May 2011 we re-ran the database search to check for studies that had been published since April 2010. In addition, the websites of the EU, IEEA, EEA and Google were searched for relevant so-called "grey literature" (reports, non-peer reviewed articles). Finally, late June 2010, a letter was sent to various contacts (STEP partners, authors of publications on pollinators and/or agri-environment schemes, nature conservation organisations) in several European countries requesting less accessible or unpublished reports addressing mitigation of pollinator loss. In total the literature search delivered more than 16,000 entries (including duplicates).

We initially screened all studies for relevance based on title and abstract and subsequently screened potentially relevant studies for fulfilment of our selection criteria for inclusion. We included only those studies that:

(1) Compared the species richness (species diversity (log-series diversity index, α) in case of Merckx et al., 2009) and/or abundance of the focal pollinator taxa (Apiformes, Lepidoptera, Syrphidae) between sites where mitigation measures were applied and conventionally managed control sites. Some studies did not strictly include a conventionally managed control. In such cases we used the treatment most closely resembling conventional practice as control (e.g. in case of Kells et al., 2001 we used the cropped field margin managed as conservation headland as control for the uncropped naturally regenerated field margin treatment);
(2) Reported means, standard deviations (s.d.), standard errors of means (s.e.m.) or confidence intervals (CI) and sample sizes for both treatment and control (in the text, tables, graphs or after requesting the authors) to allow calculation of effect sizes;
(3) Included at least four spatial replicates;
(4) Were geographically restricted to Europe.

In individual studies, observations on different pollinator taxa and/or in different geographical regions or landscape types were considered to be independent and were included as separate cases in the dataset. As a result, some studies contributed more than one entry to the dataset. If a study examined more than one treatment of a particular measure-type or covered multiple years we selected the treatment and year with the largest sample size; in case of equal sample sizes we selected the treatment with the highest ecological contrast (sensu Kleijn et al., 2011) vis-à-vis conventional management and used the results of the most recent study year. When studies presented results for several lower order taxonomic groups (e.g. solitary bees, bumblebees, butterflies, moths) within the focal taxa, or if results were presented for different locations within the studied habitat (e.g. crop field centre and crop field edge), we considered the results to be dependent and used the data that was based on the largest sample size. We randomly selected cases when sample sizes were equal. Some studies presented observations on effects of measures in different habitat-types (grassland and cropland) or on effects of multiple measure-types. In overall analyses we randomly selected one of the observations; in analyses examining the effects of habitat-types or measure-types we included all appropriate observations.

Altogether, we found 106 observations of 49 case studies for species richness (Appendix I) and 132 observations of 61 case studies for abundance (Appendix II), all concerning agri-environmental measures. These studies covered 10 countries, with the majority of studies conducted in the United Kingdom (27 studies). We found too few studies to assess the effects of Protected Areas on pollinator species richness or abundance. Studies investigating the effectiveness of protected areas are scarce (Dicks et al., 2010; but see Hodgson et al., 2010). There are however several studies that address the relationship between the proportion of (semi-)natural habitats in a landscape and species richness and abundance of pollinators, but definitions of semi-natural habitats are unclear or inconsistent among studies, and few studies provide the required statistics to calculate (correlation data) effect sizes. Consequently, our meta-analysis only includes agri-environmental mitigation measures. We initially intended to investigate potential moderating effects of landscape structure on effectiveness of mitigation measures. However, a meta-analytic study on landscape-moderated effects of agri-environmental management has recently been published by Batáry et al. (2011), which included separate analyses on pollinators. We found too few suitable studies in addition to those used by Batáry et al. (2011) to warrant a re-analysis of landscape-moderated effects.

2.3 Calculation of effect sizes

We used Hedge's unbiased estimate of the standardized mean difference (Hedge's *d*) as the metric of effect size in our meta-analyses. Hedges *d* effect sizes and their non-parametric estimates of variance were calculated for each treatment-control pair in the dataset. The non-parametric estimates of variance are less constrained by the assumptions of large sample theory (Rosenberg et al., 2000). Using the treatment and control means (*X*), standard deviations (*s*) and sample sizes (*n*), Hedges *d* is calculated as (Rosenberg et al., 2000):

$$d = \frac{(\overline{X}_T - \overline{X}_C)}{S_{pooled}} \times J$$

where the pooled standard deviation S_{pooled} is:

$$S_{pooled} = \sqrt{\frac{(n_T - 1)(s_T)^2 + (n_C - 1)(s_C)^2}{n_T + n_C - 2}}$$

and where the correction term for small sample size *J* is:

$$J = 1 - \frac{3}{4(n_C + n_T - 2) - 1}$$

As can be seen from the equations above, Hedges *d* expresses the magnitude of an effect (i.e. a difference between treatment and control) in number of standard deviation units. The rule of thumb proposed by Cohen (1988) is that a standardized mean difference of 0.20 indicates a small effect, a standardized mean difference of 0.50 suggests a medium indicates and a standardized mean difference of 0.80 indicates a large effect.

2.4 Analyses

We calculated mean effect sizes in MetaWin 2.1 using random categorical models (i.e. mixed effects models). Random effects models assume that differences among studies are not only due to sampling error but also due to true random variation resulting from biological or environmental differences between organisms and studies, and are therefore the preferred models for ecological data (Gurevitch and Hedges, 1999). Bias-corrected 95% bootstrap confidence intervals (CI) of effect sizes were calculated using resampling procedures (4,999 iterations). In contrast to parametric methods, nonparametric resampling tests do not assume that the data used to calculate effect sizes for each individual study (i.e. the authors' original data) are normally distributed (Adams et al., 1997; Gurevitch and Hedges, 1999), which is often not the case for species richness and abundance data. A mean effect size was considered significant when its 95% CI did not contain zero. For each categorical comparison we tested whether mean effect sizes differed between the categories by assessing the significance of the between-group heterogeneity (Q_B) with a randomization test (Adams et al., 1997).

We performed several separate mixed effects analyses on species richness and abundance data. First, we performed an overall analysis using the different pollinator taxa as categorical variable to test whether the implementation of agri-environmental measures in general, regardless of measure-type, had a significant positive effect on species richness and abundance of pollinators and whether the effect differed among pollinator taxa. Second, for all pollinators combined and for each taxon separately, we assessed whether effects of agri-environmental measures deployed in cropland differed significantly from those in grassland. For these analyses we distinguished between measures applied within arable farming systems (cropland) and measures applied within livestock systems (permanent grasslands for grazing or hay making). Third, based on the nature of the different agri-environmental measures covered by the studies in the species richness and abundance datasets, we divided the studies into five categories of measure-types: (1) sown flower strips (uncroppped farmland habitats such as field margins, set-aside or other patches sown with insect-pollinated herb species), (2) extensive grassland (pasture or meadow under an extensification scheme), (3) organic farming, (4) grass-sown or naturally regenerated uncropped farmland habitats such as field margins and set-aside, and (5) woody elements (hedges and hedgerow trees). In each analysis, where differences in effects between habitat-types and measure-types were examined for the different pollinator groups separately, we assessed the resulting *p*-values against sequential Dunn–Sidák adjusted alpha levels to correct for multiple testing. The experimental design of some studies allowed us to compare the sown flower measure-type and the grass-sown/natural regeneration measure-type directly, rather than by comparing their effects against controls. For this direct comparison we calculated effect sizes using the grass-sown/natural regeneration measures as control and the sown flower measures as treatment, and assessed the mean effect size for species richness and abundance in mixed models with pollinator taxon as categorical variable.

Meta-analysis may produce biased results when studies showing statistically significant findings are more likely to be published than studies showing non-significant results. We calculated Rosenthal's fail-safe numbers and inspected normal quantile plots to assess the presence of publication bias in the datasets. Rosenthal's fail-safe numbers represent the number of non-significant, unpublished studies that need to be added to a summary analysis in order to change the results from significant into non-significant (Rosenthal, 1979). If a fail-safe number is larger than five times the sample size plus 10, the number can be considered robust with regard to publication bias.

After inspection of normal quantile plots we identified some studies with extreme effect size values for pollinator abundance (d = 6.551, d = 9.128, d = -6.042); these outliers were excluded from the analysis.

3. Results

3.1 Overall effects of agri-environmental measures

In general, the implementation of agri-environmental measures had a significant positive effect on both pollinator species richness (weighted-mean effect size = 1.035, 95% CI = 0.820 to 1.278) and pollinator abundance (weighted-mean effect size = 0.881, 95% CI = 0.707 to 1.081). Mixed effects models incorporating the different pollinator taxa as grouping variable revealed that these observed overall effects were consistent with the observed effects of agri-environmental measures on the different pollinator taxa: within each taxon, species richness and abundance were significantly higher at sites with agri-environmental measures than at control sites (Fig. 1a, 1b). The magnitude of the effects did not differ between the pollinator taxa (species richness between-group heterogeneity Q_B = 0.718, p = 0.738; abundance Q_B = 2.552, p = 0.294).

Rosenthal's fail-safe numbers were robust for the abundance (fail-safe number 3292 > 545 (5n + 10) as well as the species richness analysis (2780 > 455), indicating that the observed results can be treated as reliable estimates.

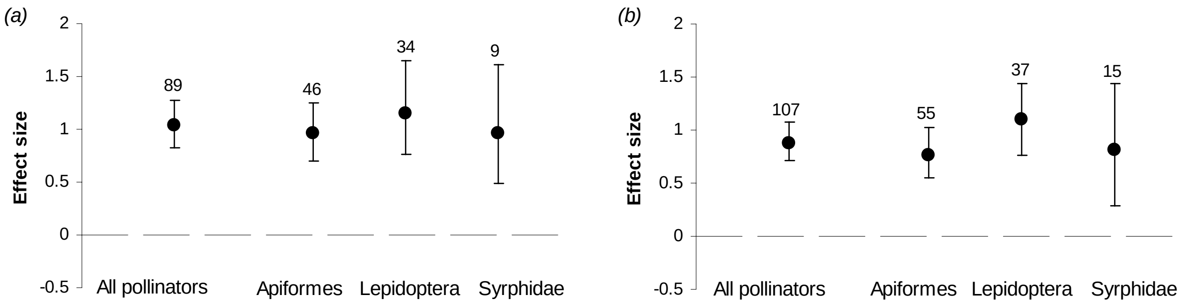

Figure 1. Overall effects of agri-environmental measures on species richness (a) and abundance (b) of pollinators. Indicated are mean Hedges' *d* effect sizes ± 95% bias corrected bootstrap CI. A mean effect size is considered significant when its 95%-confidence interval does not include zero. Numbers indicate sample sizes.

3.2 Effects of agri-environmental measures in cropland and grassland habitats

Agri-environmental measures increased pollinator species richness in croplands as well as in grasslands. In both habitat types, standardized mean effect sizes for species richness of Apiformes, Lepidoptera, Syrphidae and all pollinator taxa combined were significantly larger than zero (Fig. 2a). For all pollinator taxa combined, the effect of agri-environmental measures on species richness was larger in croplands than in grasslands (croplands weighted-mean effect size = 1.308, 95% CI = 0.993 to 1.672; grasslands weighted-mean effect size = 0.643, 95% CI = 0.407 to 0.905; Q_B = 9.646, p = 0.004 tested against sequential Dunn–Sidák corrected α = 0.013). The same pattern of larger effect sizes in cropland than in grassland was observed for the separate pollinator taxa, although the between-group heterogeneity statistics were not significant in these cases.

The abundance of all pollinator taxa combined was significantly enhanced by agri-environmental schemes in both croplands (weighted-mean effect size = 1.028, 95% CI = 0.777 to 1.297) and grasslands (weighted-mean effect size = 0.484, 95% CI = 0.246 to 0.752) and, in line with the results for species richness, the effect of agri-environmental measures was larger in cropland habitats than in grassland habitats (Q_B = 7.315, p = 0.008 tested against sequential Dunn–Sidák corrected α = 0.013) (Fig. 2b). Separate results for Apiformes and Lepidoptera also showed significant effect sizes in both croplands and grasslands and suggested larger effects in croplands than in grasslands, although differences between habitat types were not significant. With respect to Syrphidae a significant effect of agri-environmental measures was only detected in grasslands and not in croplands, but between-group heterogeneity was not significant.

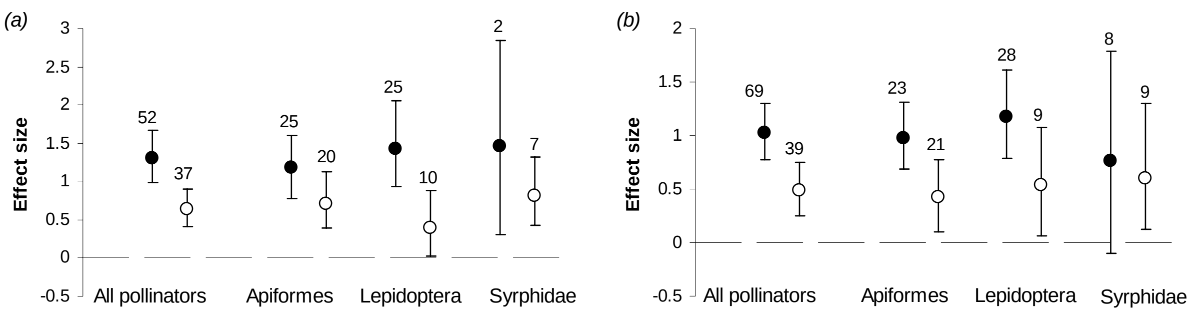

Figure 2. Overall effects of agri-environmental measures on species richness (a) and abundance (b) of pollinators in cropland (filled circles) and grassland (open circles). Indicated are mean Hedges' *d* effect sizes ± 95% bias corrected bootstrap CI. A mean effect size is considered significant when its 95%-confidence interval does not include zero. Numbers indicate sample sizes.

Failsafe-numbers indicated no publication-bias, except for the analyses of the separate Syrphidae data. The low fail-safe numbers for the analysis of Syrphidae species richness and abundance data (respectively 27 < 55 and 20 < 95) means that we can not rule out the possibility of publication-bias, which should be kept in mind when considering the results for Syrphidae. However, random-effects model fail-safe numbers are usually smaller than their fixed-effects model equivalents (Rosenberg, 2005) and normal quantile plots of Syrphidae species richness and abundance data did not suggest publication bias.

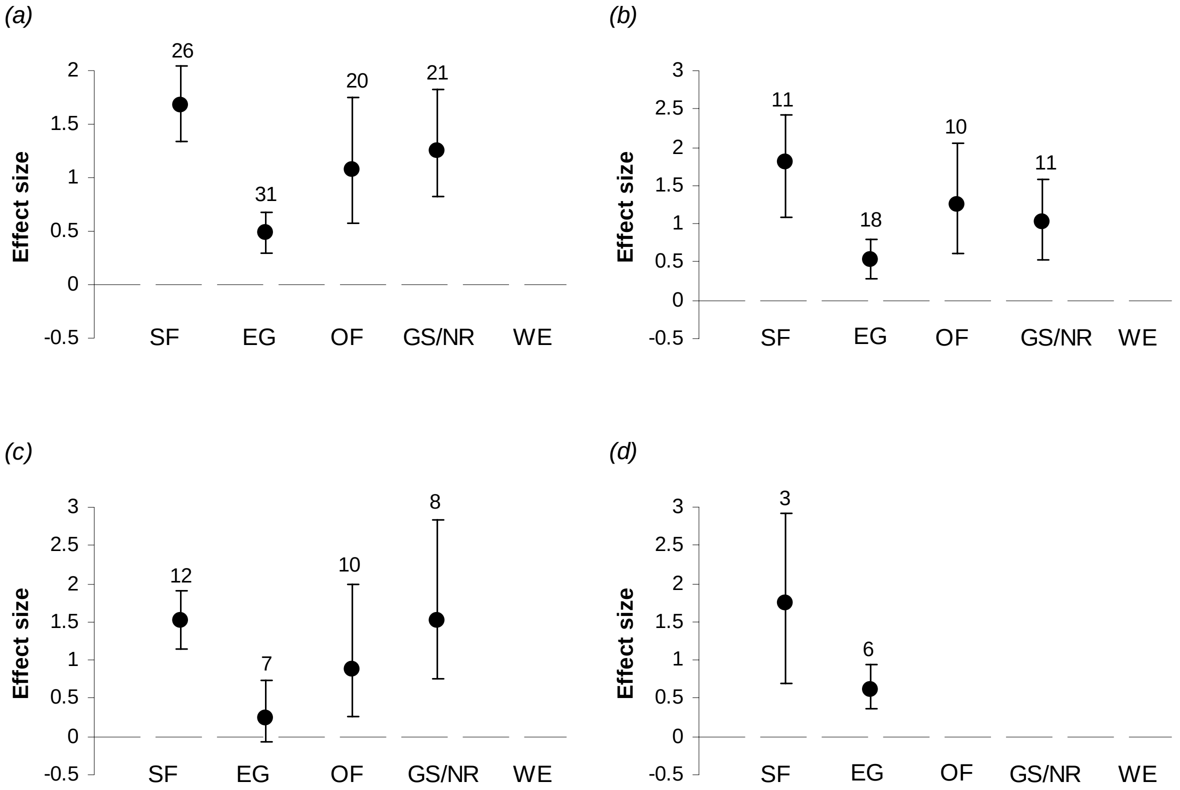

Figure 3. Effects of different types of agri-environmental measures on species richness of (a) all pollinators, (b) Apiformes, (c) Lepidoptera and (d) Syrphidae. Indicated are mean Hedges' *d* effect sizes ± 95% bias corrected bootstrap CI. A mean effect size is considered significant when its 95%-confidence interval does not include zero. Numbers indicate sample sizes. SF = sown flower strips, EG = extensive grassland, OF = organic farming, GS/NR = grass-sown or naturally regenerated field margin/set-aside, WE = woody element. Blank categories indicate insufficient number of samples to calculate effect size.

3.3 Effects of different types of agri-environmental measures

Species richness of pollinators was increased by all considered types of agri-environmental measures: for species richness of all pollinator taxa combined, weighted-mean effect sizes of sown flower measures, extensive grassland, organic farming and grass-sown/natural regeneration measures were significantly greater than zero (Fig. 3a). The magnitude of the effect differed significantly among the measure-types (Q_B = 26.052, $p <$ 0.001 tested against sequential Dunn–Sidák corrected α = 0.013), with sown flowers displaying the largest effect and extensive grasslands the smallest. Separate analyses for the individual pollinator taxa revealed that the pattern of all taxa combined was reflected in the patterns for Apidae (Q_B = 14.396, p = 0.006 tested against sequential Dunn–Sidák corrected α = 0.017, Fig. 3b). Although the pattern for Lepidoptera was broadly similar, no significant effect of extensive grassland on Lepidoptera was found, and between-group heterogeneity was not significant (Q_B = 9.507, p = 0.065, Fig. 3c). For Syrphidae only observations in sown flower strips and extensive grassland were available in sufficient numbers to merit analysis. Sown flower strips and extensive grassland displayed significant effects on species richness of Syrphidae; the magnitude of the effect sizes did not significantly differ between both measure-types ($Q_B = 4.669$, $p = 0.052$, Fig. 3d).

Pollinator abundance was also significantly enhanced by each of the measure-types. For all pollinators combined, more individuals were observed at sites with sown flower strips, extensive grassland, organic farming, grass-sown/natural regeneration and woody elements than at control sites (Fig. 4a). As was the case with pollinator species richness, significant differences in effectiveness were found among the different measure-types ($Q_B = 30.2505$, $p < 0.001$ tested against sequential Dunn–Sidák corrected $\alpha = 0.013$), with sown flower strips again displaying the largest effect and extensive grasslands the smallest. These differences were also found in the separate analyse of data on Apiformes abundance ($Q_B = 16.476$, $p = 0.001$ tested against sequential Dunn–Sidák corrected $\alpha = 0.017$) and in this case the effect of extensive grassland on abundance was not significant (Fig. 4b). Results on Lepidoptera abundance resembled the general pattern of the combined pollinator taxa, though between-group heterogeneity was not significant ($Q_B = 7.225$, $p = 0.179$, Fig. 4c). Results for Syrphidae displayed varying standardized mean effect sizes among measure-types, with sown flower strips and extensive grasslands having a significant positive effect, organic farming a significant negative effect and field margin/set-aside no significant effect on abundance of Syrphidae (Fig. 4d). However, sample sizes were small and the differences between measure-types were not significant ($Q_B = 11.350$, $p = 0.040$ tested against sequential Dunn–Sidák corrected $\alpha = 0.025$).

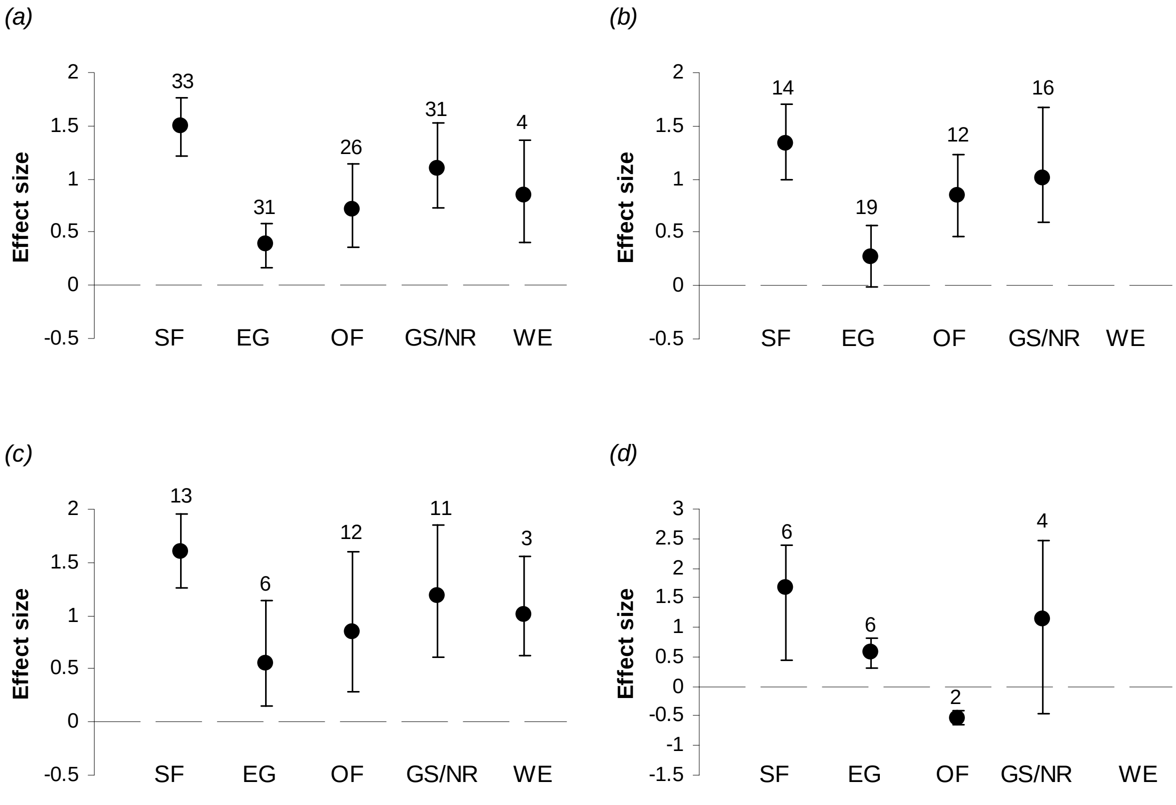

Figure 4. Effects of different types of agri-environmental measures on abundance of (a) all pollinators, (b) Apiformes, (c) Lepidoptera and (d) Syrphidae. Indicated are mean Hedges' *d* effect sizes ± 95% bias corrected bootstrap CI. A mean effect size is considered significant when its 95%-confidence interval does not include zero. Numbers indicate sample sizes. SF = sown flower strips, EG = extensive grassland, OF = organic farming, GS/NR = grass-sown or naturally regenerated field margin/set-aside, WE = woody element. Blank categories indicate insufficient number of samples to calculate effect size.

The direct comparison between the sown flower strips and grass-sown/natural regeneration measures showed that species richness of all pollinator taxa combined did not differ significantly between uncropped farmland habitats that had been established by sowing flower mixtures on one hand and those established by natural regeneration or sowing grass on the other (Fig. 5a). A significant difference was only observed for Syrphidae, but only two studies contributed to the mean effect size. In contrast, abundance results revealed significant differences between the two measure-types. Significant positive mean effect sizes indicated higher abundance of Apiformes, Syrphidae and aggregated pollinator taxa, but not of Lepidoptera, for sown flower strips than for grass-sown/natural regeneration measures (Fig. 5b).

Rosenthal's failsafe-numbers were robust for all categorical analyses on the different measure-types, with the exception of the fail-safe numbers for Syrphidae data. However, although the fail-safe numbers for the analyses of Syrphidae data did not strictly meet Rosenthal's suggested critical value of 5n + 10, the numbers deviated relatively little from the critical value (species richness: 53 < 55; abundance 92 < 100) and random-effects model fail-safe numbers are usually smaller than their fixed-effects model equivalents (Rosenberg, 2005). Moreover, normal quantile plot of Syrphidae species richness and abundance data did not indicate publication bias. The fail-safe number for the direct comparison between sown flowers and grass-sown/natural regeneration measure-types was extremely low for the species richness data (4 < 95) and also did not meet Rosenthal's critical value of 5n +10 for the abundance data (73 < 130), but inspection of the normal quantile plots did not indicate publication bias.

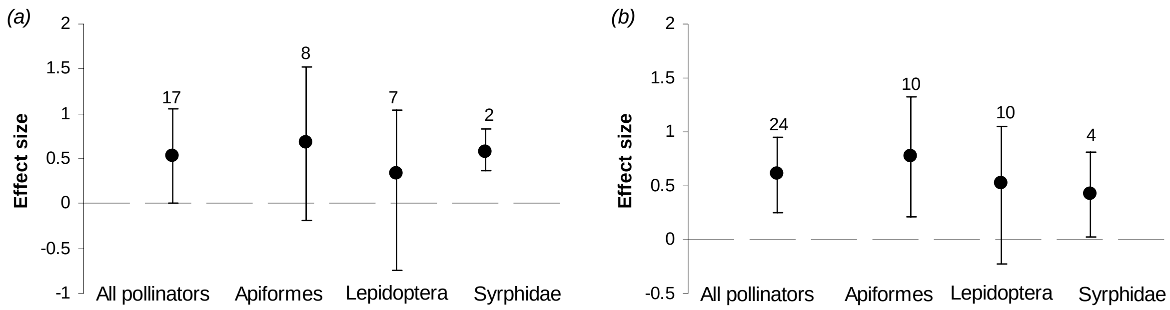

Figure 5. Mean effect sizes for the direct comparison of the effect of sown flowers measures (treatment) and grass-sown or natural regeneration measures (control) on species richness (a) and abundance (b) of pollinators. Indicated are mean Hedges' *d* effect sizes ± 95% bias corrected bootstrap CI. A mean effect size is considered significant when its 95%-confidence interval does not include zero. Numbers indicate sample sizes.

4. Discussion

4.1 Overall patterns of effectiveness of agri-environmental measures

The effectiveness of agri-environmental schemes for promoting overall biodiversity has in many cases not lived up to the intentions of their introduction (Kleijn and Sutherland, 2003), and results of studies specifically assessing the effectiveness of these measures for enhancing pollinators have often been mixed (e.g. Kleijn et al., 2006). In contrast, our meta-analysis clearly indicates that even though the vast majority of available agri-environmental measures do not specifically target pollinators (Rundlöf et al., 2011), generally their implementation has positive side-effects on species richness and abundance of pollinators. The observed significant effect sizes were consistent across all investigated pollinator taxa and thus did not differ between the central-place foragers (bees) and non-central-place foragers (butterflies and hoverflies). However, within taxa, responses of individual species to agri-environmental measures may vary according to life-history traits. Agri-environmental measures mainly benefit common, generalist species (Kleijn et al., 2006; Holzschuh et al., 2007; Aviron et al., 2010) but may often not meet the specific habitat requirements of rare and/or specialized species (Wenzel et al., 2006; Larsson and Franzén, 2007; Konvicka et al., 2008; Rotheray et al., 2009). The dataset did not allow us to investigate these potential differences in response between common/generalist species and rare/specialist species.

The farmland habitat in which the agri-environmental measures were deployed affected the magnitude but not the significance of the observed effectiveness of agri-environmental measures: effect sizes were significant in both croplands and grasslands, but implementation of agri-environmental measures in croplands resulted in larger contrasts vis-à-vis control sites than implementation in grasslands. This finding contradicts results of a recent meta-analysis conducted by Batáry et al. (2011), which showed that the magnitude of the effect of agri-environmental measures on species richness and abundance of plants and animals, including pollinators, did not differ between croplands and grasslands. Yet, only 23% (25/109) of cases of species richness and 22% (25/114) of cases of abundance used by Batáry et al. concerned pollinators, so a possible difference in effect size for pollinators in cropland and grassland may have been masked by effect sizes for the other taxa. In contrast, the large number of pollinator specific observations on species richness and abundance that were used in our analyses of habitat effects provide strong support for the observed differences in effect sizes between cropland and grassland habitats in our meta-analysis.

The larger effect sizes found in croplands compared to grasslands may result from the creation of larger ecological contrasts (i.e. the extent to which agri-environmental measures improves habitat conditions for pollinators relative to conventionally managed habitats, Kleijn et al., 2011) in croplands compared to grasslands after implementation of agri-environmental measures. Compared to croplands, grasslands are often situated in more extensive landscapes (e.g. uplands) with more surrounding semi-natural habitats, are generally less intensively managed in terms of nitrogen input, pesticide applications and agricultural disturbances (Herzog et al., 2006) and generally support higher biodiversity (Andow, 1991). The relative habitat improvement induced by agri-environmental measures may therefore be smaller in grasslands than in croplands.

4.2 Effectiveness of different types of agri-environmental measures

Our meta-analysis indicated that each of the considered types of agri-environmental measures significantly enhanced pollinator species richness and abundance compared to control sites. The factors that directly regulate pollinator populations are most likely food resources, nesting resources (and mating and hibernation sites) and incidental risk factors such as e.g. pesticide-induced mortality (Roulston and Goodell, 2011). The availability of floral resources is a major determinant of pollinator species richness and abundance (Müller et al., 2006; Ockinger and Smith, 2007; Franzen and Nilsson, 2010; Fründ et al., 2010; Radmacher and Strohm, 2010; Carvalheiro et al., 2011) and the positive effects of the agri-environmental measures on pollinators appear to be predominantly mediated by direct or indirect enhancement of flower resource availability (Kleijn et al., 2001; Gabriel and Tscharntke, 2007; Holzschuh et al., 2007; Kohler et al., 2007; Holzschuh et al., 2008; Rundlöf et al., 2008; Potts et al., 2009; Aviron et al., 2010). The measure-type that directly increased flower resource availability consistently displayed the largest mean effect sizes in our categorical analyses, and was more effective at enhancing pollinator abundance when directly compared to the grass-sown or naturally regenerated field margins and set-aside.

However, availability of nesting sites may be equally important for pollinator populations (Tscharntke et al., 1998; Potts et al., 2005; Steffan-Dewenter and Schiele, 2008). Nest site availability is probably enhanced in at least some of the measure-types. For instance, uncropped, little disturbed field margins and set-asides provide hibernation and nesting resources for bees (Banaszak 1992, Westrich 1996) and many bumblebee species may find suitable nesting sites in sown or naturally regenerated uncropped farmland habitats that contain tussocky grasses (Carvell et al., 2007). Furthermore, woody elements, which are preferred habitats for rodents (Scheper and Smit, 2011), may benefit below-ground nesting bumblebees who depend on the abundance of abandoned rodent nests (Svensson and Lundberg,1977). In addition, woody elements may provide pithy stems (e.g. *Rubus* spp.) and nesting facilities in dead wood that promote populations of cavity-nesting solitary bee species (Tscharntke et al., 1998; Potts et al., 2005).

Another mechanism through which some of the studied measure-types may benefit pollinators is by reducing pesticide-induced mortality. Insecticides can cause mortality by direct intoxication (Alston et al., 2007) and can affect wild bee diversity and abundance (Brittain et al., 2010). Reduced pesticide use in organic farming and in farmland habitats withdrawn from intensive farming (field margin prescriptions and set-aside) may therefore be expected to be beneficial for pollinators.

4.3 Landscape- and land-use-moderated effectiveness of mitigation measures

The potential influence of landscape variables on the effectiveness of pollinator mitigation measures has not been included in our quantitative analysis. However, it has been hypothesized that the effectiveness of conservation measures is moderated by landscape structure. Tscharntke et al. (2005) argued that the relationship between effectiveness of conservation measures and landscape structure is hump-shaped, with measures being less effective in complex landscapes (<80% cropland) where the availability of sufficient semi-natural source habitats allows pollinator populations to persist without mitigation measures. In simple landscapes (80-99% cropland) where pollinator source habitats are still present but are not enough to subsidize pollinator colonization of intensively managed farmland measures are hypothesized to be most effective. In cleared landscapes (>99% cropland) where pollinators have largely disappeared and few sources for re-colonization are present measures are again thought to be less effective. Several studies, reviewed by Kleijn et al. (2011), provide evidence for landscape-moderated effects of agri-environmental measures on biodiversity in general. Batáry et al. (2011) observed that pollinator species richness and abundance in particular were consistently significantly enhanced by agri-environmental measures in homogeneous, simple landscapes but not in heterogeneous, complex landscapes. Part of the studies that were included in the meta-analysis of Batáry et al. (2011) were also part of the current study. In addition, a meta-analyis investigating the effect of human disturbance on pollinators revealed that the effect of habitat loss on pollinators was only significant in landscapes with severe habitat loss (i.e. simple landscapes) and not in landscapes with moderate habitat loss (i.e. more complex landscapes, Winfree et al., 2009). This suggests that mitigating the effects of habitat loss would probably be more effective in the landscapes with more extreme habitat loss.

In addition to being affected by landscape structure, effectiveness of mitigation measures is also affected by factors operating at the scale of within-field processes. Kleijn and Sutherland (2003) hypothesized that effectiveness of conservation measures is moderated by land-use intensity. Extensively managed farmland, characterized by high within-field spatial heterogeneity (Benton et al., 2003) and low rates of agricultural disturbances can support viable populations of many species. In contrast, agricultural intensification results in reduced spatial heterogeneity due to increased specialization, increased use of external inputs and increased rates of disturbances, thereby supporting fewer species. Because of the exponential decline of farmland biodiversity with increasing land-use (Kleijn et al., 2009), it is suggested that agri-environmental measures will be most effective in extensively farmed areas where the potential measure-induced biodiversity increase per extensification unit will be highest (Kleijn and Sutherland, 2003; Kleijn et al., 2009).

Ultimately, the effectiveness of pollinator mitigation measures depends on the interaction between landscape structure, land-use intensity and the ecological contrast created by measures (Kleijn et al., 2011).

4.4 Effectiveness of protected areas

The lack of sufficient suitable studies on protected (semi-)natural areas did not allow a quantitative review on the effectiveness of this class of conservation measures. However, narrative review of studies investigating the effects of nature reserves and semi-natural habitats provides support for beneficial effects on pollinator communities. The only study (to our knowledge) that directly assessed the effectiveness of protected areas for pollinator conservation is the study of Hodgson et al. (2010). These authors studied butterfly densities on organic farms, conventional farms and in grassland nature reserves (designated a “Site of Special Scientific Interest” conservation status) in 16 landscapes, and found that nature reserves supported higher densities of butterflies than either organic or conventional farms. In addition, several studies have shown that pollinator species richness and/or abundance in farmland is higher in the proximity of (semi-)natural areas such as e.g. deciduous forest or semi-natural grassland (Ricketts et al., 2008), particularly in intensively farmed landscapes (Hendrickx et al., 2007; Kohler et al., 2008; Jauker et al., 2009). Other findings indicate that pollinator species richness and abundance is positively related to the proportion of (semi-) natural area in the landscape (Bergman et al., 2004; Franzen and Nilsson, 2008), although the effect may be scale-dependent (Steffan-Dewenter et al., 2002; Bergman et al., 2008), may vary among and within taxa (Steffan-Dewenter et al., 2002; Le Féon et al., 2010; Williams et al., 2010) and depends on the type of habitat (Carré et al., 2009). Interestingly, Dormann et al. (2007) found that a decrease in the amount of semi-natural habitat in landscapes led to an increased similarity of bee communities, indicating that when the proportion of semi-natural habitat decreases local communities are increasingly being dominated by the same common, generalist species: loss of semi-natural habitat often favours the dominance of generalist species while decreasing that of rare and specialized ones (Warren et al., 2001; Williams et al., 2010). Thus, although (semi-)natural areas may provide foraging, nesting and/or hibernation resources for both generalist and specialist pollinators, they appear to be especially important for providing the resources that limit the more rare and specialized pollinators in the agricultural environments.

Apart from the study of Hodgson et al. (2010), above-mentioned studies did not measure directly the responses of pollinators to specific measures protecting (semi-)natural habitat. Nevertheless, as habitat loss and fragmentation have been shown to negatively affect pollinators (Winfree et al., 2009) it seems evident that measures that prevent further habitat loss and fragmentation by protecting or even creating (semi-) natural areas (i.e. nature development projects) are beneficial for the conservation of pollinators.

4.5 Limitations of the meta-analysis

A few limitations associated with the studies included in the dataset should be born in mind when interpreting the results of our meta-analysis.

First, the studies included in our dataset covered only a limited number of all European countries, with 25 out of a total of 63 studies originating from the United Kingdom. Results should therefore be interpreted bearing this geographical bias in mind.

Second, although quite some studies that were part of our meta-analysis measured responses of pollinators to implementation of agri-environmental measures over multiple years, none of the studies used a replicated before–after control-impact (BACI) design. Examining the in situ effectiveness of agri-environmental measures can best be performed by comparing trends in biodiversity on treatment sites and control sites both before and after implementation of the measures (i.e. by using a replicated BACI study design; Kleijn et al., 2006). Comparing treatment and control sites without measuring base-line conditions before implementation of measures does not distinguish between initial site differences and differences induced by the treatments. This may bias results of evaluations of agri-environmental measures, for example, when farmers preferentially locate agri-environmental schemes on their least productive fields that are supporting higher levels of biodiversity to begin with (Kleijn and Sutherland, 2003).

A more fundamental problem associated with the methodologies of most studies is the use of species richness and/or abundance variables to assess effectiveness of agri-environmental measures. Only 8 of the 63 studies (13%) included in our dataset involved measurements on population dynamical variables such as colony growth or reproductive success, besides measurements on species richness and/or abundance. Increased species richness and abundance of pollinators in sites with agri-environmental measures may indicate positive effects on pollinator populations, but as population dynamical variables such as reproductive success and mortality rate are not measured, the actual effects on pollinator populations remains unclear. Measurements of species richness and abundance may either overestimate or underestimate the effects of agri-environmental measures on pollinator populations when species richness and abundance responses are influenced by ecological phenomena such as source-sink dynamics, buffer effects, spill-over effects, concentration responses and extinction debt (see Kleijn et al., 2011). The extent to which the drawbacks of species richness and abundance measurements limit interpretation of evaluation studies depends on the objectives of the agri-environmental measures. Measures that aim to enhance biodiversity for its intrinsic values should be evaluated by studying population dynamical variables, as species richness and abundance responses may not be representative for the actual population level responses. On the other hand, measures that aim to enhance biodiversity for the provision of ecosystem services, such as pollination of crops, can be evaluated using species richness and abundance responses. After all, for the pollination of crops it does not matter whether increased availability of pollinators in crop fields originates from a spatial redistribution of the existing pool of pollinators in the landscape (concentration effect) or from and increased total pool of pollinators in the landscape (Kleijn et al., 2011).

5. Conclusion

In view of the growing evidence for declines in both wild and domesticated pollinators there is an urgent need to identify and implement effective mitigation measures for pollinator loss. Our narrative review stresses the importance of protecting (semi-) natural areas that act as source habitats of pollinators. Regarding the agri-environmental measures, our meta-analysis clearly shows that all investigated measures were effective at enhancing species richness and abundance of the studied pollinator taxa. Given the relatively large proportion of area under agricultural land use compared to the proportion of area under nature protection (respectively ca. 40% and 13% of the terrestrial area in the EU), agri-environmental pollinator mitigation measures can potentially cover a larger area than protected areas. The extent of the effectiveness of agri-environmental measures varies among different measure-types: directly enhancing pollinator food resources through the sowing of flower seed mixtures displayed the most pronounced enhancing effect and appears to be a particularly effective mitigation measure, while the beneficial effect of extensified grasslands was least pronounced. Based on both the present meta-analysis and the recent meta-analysis by Batáry et al. (2011) it is suggested that effectiveness of mitigation measures for promoting pollinators is highest when implemented in cropland habitats situated in simple landscapes. However, due to the methodological limitations associated with evaluations of mitigation measures on the basis of species richness and abundance data, inferences from the results for conservation policy should be made with caution, particularly if conservation goals involve enhancing intrinsic values of biodiversity.

Acquiring a more in-depth understanding of the effectiveness of pollinator mitigation measures which can be translated to both ecosystem services objectives and objectives for intrinsic values of biodiversity requires field studies that deploy replicated BACI designs, measure population dynamical variables and are performed at the landscape scale. In Work Package 5, we will conduct such studies in four European countries to further assess and understand the effectiveness of the most promising mitigation measure identified here: the direct enhancement of floral resources through sown flower strips.

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Appendix I. Summary information for each of the included observations in the abundance analyses.

Case no.	Study no.	Source	Country	Region / landscape	Order / family	Species / group	Habitat	Measure-type	Hedges *d*	NP var (*d*)
1	1	Alanen et al. 2011	Finland	-	Apiformes	Bumblebees	Cropland	Sown flower strips	0.195	0.500
2	1	Alanen et al. 2011	Finland	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	0.087	0.500
3	2	Albrecht et al. 2007a	Switzerland	-	Apiformes	All bees	Grassland	Extensive grassland	1.622	0.154
4	2	Albrecht et al. 2007a	Switzerland	-	Lepidoptera	Butterflies	Grassland	Extensive grassland	0.524	0.154
5	2	Albrecht et al. 2007a	Switzerland	-	Syrphidae	Hoverflies	Grassland	Extensive grassland	1.018	0.154
6	3	Albrecht et al. 2007b	Switzerland	-	Apiformes	Solitary bees	Grassland	Extensive grassland	0.711	0.154
7	4	Albrecht et al. 2010	Switzerland	-	Apiformes	All bees	Grassland	Extensive grassland	1.086	0.083
8	5	Aviron et al. 2010	Switzerland	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	2.227	0.084
9	6	Batary et al. 2010	Hungary	Alkali	Apiformes	All bees	Grassland	Extensive grassland	0.134	0.286
10	6	Batary et al. 2010	Hungary	Meadow	Apiformes	All bees	Grassland	Extensive grassland	-0.294	0.286
11	6	Batary et al. 2010	Hungary	Heves	Apiformes	All bees	Grassland	Extensive grassland	0.015	0.286
12	7	Belfrage et al. 2005	Sweden	-	Apiformes	Bumblebees	Cropland & Grassland	Organic farming	0.668	0.333
13	7	Belfrage et al. 2005	Sweden	-	Lepidoptera	Butterflies	Cropland & Grassland	Organic farming	1.998	0.333
14	8	Blake et al. 2011a	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	0.951	0.333
15	9	Blake et al. 2011b	United Kingdom	-	Apiformes	Bumblebees	Cropland	Sown flower strips	1.412	0.333
16	10	Brittain et al. 2010	Italy	-	Apiformes	Solitary bees	Cropland	Organic farming	1.675	0.333

17	10	Brittain et al. 2010	Italy	-	Lepidoptera	Butterflies	Cropland	Organic farming	1.077	0.333
18	11	Buys et al. 1997	The Netherlands	-	Apiformes	Bumblebees & honeybees	Cropland	Sown flower strips	1.358	0.041
19	11	Buys et al. 1997	The Netherlands	-	Apiformes	Bumblebees & honeybees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.609	0.077
20	11	Buys et al. 1997	The Netherlands	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	1.245	0.041
21	11	Buys et al. 1997	The Netherlands	-	Lepidoptera	Butterflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.139	0.077
22	11	Buys et al. 1997	The Netherlands	-	Syrphidae	Hoverflies	Cropland	Sown flower strips	2.199	0.077
23	11	Buys et al. 1997	The Netherlands	-	Syrphidae	Hoverflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	3.067	0.142
24	12	Carvell et al. 2007	United Kingdom	-	Apiformes	Bumblebees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.497	0.333
25	12	Carvell et al. 2007	United Kingdom	-	Apiformes	Bumblebees	Cropland	Sown flower strips	3.216	0.333
26	13	De Snoo & DeLeeuw 1996	The Netherlands	-	Apiformes	All bees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.512	0.200
27	13	De Snoo & DeLeeuw 1996	The Netherlands	-	Lepidoptera	Moths	Cropland	Grass-sown or naturally regenerated field margin/set-aside	-0.598	0.250
28	13	De Snoo & DeLeeuw 1996	The Netherlands	-	Syrphidae	Hoverflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.553	0.200
29	14	De Snoo et al. 1998	The Netherlands	-	Lepidoptera	Butterflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.102	0.143
30	15	Dover 1999	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Woody element	0.731	0.333
31	16	Dover et al. 2000	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Woody element	1.554	0.194
32	17	Ekroos et al. 2008	Finland	-	Apiformes	Bumblebees	Cropland	Organic farming	0.341	0.092
33	17	Ekroos et al. 2008	Finland	-	Lepidoptera	Diurnal macrolepidoptera	Cropland	Organic farming	-0.191	0.092
34	18	Feber et al. 1996	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	2.380	0.250

35	18	Feber et al. 1996	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.099	0.250
36	19	Feber et al. 2007	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Organic farming	0.593	0.200
37	20	Gabriel et al. 2010	United Kingdom	Coldspot	Apiformes	Solitary bees	Cropland	Organic farming	6.551	0.042
38	20	Gabriel et al. 2010	United Kingdom	Coldspot	Apiformes	Solitary bees	Grassland	Organic farming	9.128	0.042
39	20	Gabriel et al. 2010	United Kingdom	Hotspot	Apiformes	Solitary bees	Grassland	Organic farming	-6.042	0.043
40	20	Gabriel et al. 2010	United Kingdom	Coldspot	Syrphidae	Hoverflies	Cropland	Organic farming	-0.661	0.042
41	20	Gabriel et al. 2010	United Kingdom	Coldspot	Syrphidae	Hoverflies	Grassland	Organic farming	-0.389	0.042
42	20	Gabriel et al. 2010	United Kingdom	Hotspot	Syrphidae	Hoverflies	Cropland	Organic farming	-0.414	0.042
43	20	Gabriel et al. 2010	United Kingdom	Hotspot	Syrphidae	Hoverflies	Grassland	Organic farming	-0.172	0.043
44	21	Gathmann et al. 1994	Germany	-	Apiformes	Solitary bees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.555	0.500
45	21	Gathmann et al. 1994	Germany	-	Apiformes	Solitary bees	Cropland	Sown flower strips	0.847	0.500
46	22	Goulson et al. 2002	United Kingdom	-	Apiformes	Bombus terrestris	Cropland	Grass-sown or naturally regenerated field margin/set-aside	-0.079	0.222
47	23	Haenke et al. 2009	Germany	-	Syrphidae	Hoverflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.212	0.286
48	23	Haenke et al. 2009	Germany	-	Syrphidae	Hoverflies	Cropland	Sown flower strips	2.012	0.286
49	24	Harwood et al. 1994	United Kingdom	-	Syrphidae	Hoverflies	Cropland	Sown flower strips	2.450	0.333
50	25	Heard et al. 2007	United Kingdom	-	Apiformes	Bumblebees	Cropland	Sown flower strips	1.260	0.167
51	26	Hodgson et al. 2010	United Kingdom	Coldspot	Lepidoptera	Butterflies	Cropland	Organic farming	-0.259	0.250
52	26	Hodgson et al. 2010	United Kingdom	Coldspot	Lepidoptera	Butterflies	Grassland	Organic farming	-0.751	0.250

53	26	Hodgson et al. 2010	United Kingdom	Hotspot	Lepidoptera	Butterflies	Cropland	Organic farming	0.176	0.250
54	26	Hodgson et al. 2010	United Kingdom	Hotspot	Lepidoptera	Butterflies	Grassland	Organic farming	0.454	0.268
55	27	Holzschuh et al. 2007	Germany	G	Apiformes	All bees	Cropland	Organic farming	0.889	0.286
56	27	Holzschuh et al. 2007	Germany	S	Apiformes	All bees	Cropland	Organic farming	1.080	0.286
57	27	Holzschuh et al. 2007	Germany	M	Apiformes	All bees	Cropland	Organic farming	1.513	0.286
58	28	Holzschuh et al. 2010	Germany	-	Apiformes	Solitary bees	Cropland	Organic farming	0.424	0.087
59	29	Hopkins & Feber 1997	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	1.518	0.400
60	30	Kells et al. 2001	United Kingdom	-	Apiformes	Bumblebees & Honeybees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	4.790	0.300
61	31	Kleijn et al. 1999	The Netherlands	-	Apiformes	All bees	Grassland	Extensive grassland	0.179	0.286
62	31	Kleijn et al. 1999	The Netherlands	-	Lepidoptera	Butterflies	Grassland	Extensive grassland	0.198	0.286
63	31	Kleijn et al. 1999	The Netherlands	-	Syrphidae	Hoverflies	Grassland	Extensive grassland	0.290	0.286
64	32	Kleijn et al. 2004	The Netherlands	Clay	Apiformes	All bees	Grassland	Extensive grassland	0.840	0.182
65	32	Kleijn et al. 2004	The Netherlands	Peat	Apiformes	All bees	Grassland	Extensive grassland	0.507	0.125
66	32	Kleijn et al. 2004	The Netherlands	Sand	Apiformes	All bees	Grassland	Extensive grassland	-0.086	0.200
67	32	Kleijn et al. 2004	The Netherlands	Clay	Syrphidae	Hoverflies	Grassland	Extensive grassland	0.115	0.182
68	32	Kleijn et al. 2004	The Netherlands	Peat	Syrphidae	Hoverflies	Grassland	Extensive grassland	0.784	0.125
69	32	Kleijn et al. 2004	The Netherlands	Sand	Syrphidae	Hoverflies	Grassland	Extensive grassland	0.723	0.200
70	33	Kleijn et al. 2006	The Netherlands	E	Apiformes	All bees	Grassland	Extensive grassland	-0.732	0.286

71	33	Kleijn et al. 2006	The Netherlands	H	Apiformes	All bees	Grassland	Extensive grassland	0.667	0.286
72	33	Kleijn et al. 2006	The Netherlands	V	Apiformes	All bees	Grassland	Extensive grassland	-0.208	0.286
73	33	Kleijn et al. 2006	Spain	R	Apiformes	All bees	Crop	Extensive grassland	-0.500	0.286
74	33	Kleijn et al. 2006	Spain	H	Apiformes	All bees	Crop	Extensive grassland	0.769	0.286
75	34	Knop et al. 2006	Switzerland	Ruswill	Apiformes	All bees	Grassland	Extensive grassland	-0.895	0.286
76	34	Knop et al. 2006	Switzerland	Bauma	Apiformes	All bees	Grassland	Extensive grassland	-0.574	0.286
77	34	Knop et al. 2006	Switzerland	Fluhli	Apiformes	All bees	Grassland	Extensive grassland	0.367	0.286
78	35	Kohler et al. 2008	The Netherlands	-	Apiformes	All bees	Grassland	Sown flower strips	2.039	0.220
79	35	Kohler et al. 2008	The Netherlands	-	Syrphidae	Hoverflies	Grassland	Sown flower strips	2.817	0.220
80	36	Kruess & Tscharntke 2002	Germany	-	Apiformes	All bees	Grassland	Extensive grassland	0.426	0.367
81	36	Kruess & Tscharntke 2002	Germany	-	Lepidoptera	Butterflies & Burnet moths	Grassland	Extensive grassland	1.927	0.333
82	37	Kuussaari et al. 2011	Finland	-	Apiformes	Bumblebees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	2.174	0.500
83	37	Kuussaari et al. 2011	Finland	-	Lepidoptera	Butterflies & diurnal moths	Cropland	Grass-sown or naturally regenerated field margin/set-aside	3.479	0.500
84	38	Kvarnback 2009	Sweden	-	Apiformes	Bumblebees	Cropland	Sown flower strips	0.625	0.400
85	38	Kvarnback 2009	Sweden	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	1.164	0.400
86	39	Lagerlof & Wallin 1993	Sweden	-	Apiformes	All bees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.755	0.500
87	39	Lagerlof & Wallin 1993	Sweden	-	Apiformes	All bees	Cropland	Sown flower strips	-0.214	0.500
88	39	Lagerlof & Wallin 1993	Sweden	-	Lepidoptera	Butterflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.530	0.500

89	39	Lagerlof & Wallin 1993	Sweden	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	1.433	0.500
90	39	Lagerlof & Wallin 1993	Sweden	-	Syrphidae	Hoverflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	-0.936	0.500
91	39	Lagerlof & Wallin 1993	Sweden	-	Syrphidae	Hoverflies	Cropland	Sown flower strips	-1.186	0.500
92	40	Littlewood et al. 2008	United Kingdom	-	Lepidoptera	Nocturnal moths	Grassland	Extensive grassland	0.723	0.333
93	41	Lye et al. 2009	United Kingdom	-	Apiformes	Bumblebees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.543	0.400
94	41	Lye et al. 2009	United Kingdom	-	Apiformes	Bumblebees	Cropland & Grassland	Woody element	0.275	0.400
95	42	MacLeod 1999	United Kingdom	-	Syrphidae	Episyrphus balteatus	Cropland	Sown flower strips	0.951	0.250
96	43	Mand et al. 2001	Estonia	-	Apiformes	Bumblebees	Cropland & Grassland	Organic farming	0.789	0.167
97	44	Marshall et al. 2004	United Kingdom	S	Apiformes	All bees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.228	0.286
98	44	Marshall et al. 2004	United Kingdom	I	Apiformes	All bees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.214	0.286
99	44	Marshall et al. 2004	United Kingdom	O	Apiformes	All bees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.466	0.286
100	45	Meek et al. 2002	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.703	0.500
101	45	Meek et al. 2002	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	3.096	0.500
102	46	Merckx et al. 2009	United Kingdom	-	Lepidoptera	Larger moths	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.225	0.500
103	46	Merckx et al. 2009	United Kingdom	-	Lepidoptera	Larger moths	Cropland	Woody element	0.562	0.500
104	47	Muchow et al. 2007	Germany	-	Apiformes	All bees	Cropland	Sown flower strips	1.970	0.278
105	47	Muchow et al. 2007	Germany	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	1.488	0.278
106	48	Potts et al. 2009	United Kingdom	-	Apiformes	Bumblebees	Grassland	Grass-sown or naturally regenerated field margin/set-aside	0.407	0.167

107	48	Potts et al. 2009	United Kingdom	-	Apiformes	Bumblebees	Grassland	Sown flower strips	1.705	0.167
108	48	Potts et al. 2009	United Kingdom	-	Lepidoptera	Butterflies	Grassland	Grass-sown or naturally regenerated field margin/set-aside	0.566	0.167
109	48	Potts et al. 2009	United Kingdom	-	Lepidoptera	Butterflies	Grassland	Sown flower strips	1.712	0.167
110	49	Pywell et al. 2005	United Kingdom	-	Apiformes	Bumblebees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.199	0.125
111	49	Pywell et al. 2005	United Kingdom	-	Apiformes	Bumblebees	Cropland	Sown flower strips	1.149	0.071
112	50	Pywell et al. 2006	United Kingdom	-	Apiformes	Bumblebees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.818	0.063
113	50	Pywell et al. 2006	United Kingdom	-	Apiformes	Bumblebees	Cropland	Sown flower strips	1.216	0.075
114	51	Pywell et al. 2007	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.448	0.333
115	51	Pywell et al. 2007	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	1.605	0.333
116	52	Risberg 2004	Sweden	-	Apiformes	Bumblebees	Cropland	Organic farming	1.589	0.400
117	53	Rundlof & Smith 2006	Sweden	Heterogeneous	Lepidoptera	Butterflies & Burnet moths	Cropland	Organic farming	1.293	0.333
118	53	Rundlof & Smith 2006	Sweden	Homogeneous	Lepidoptera	Butterflies & Burnet moths	Cropland	Organic farming	4.212	0.333
119	54	Rundlof et al. 2008a	Sweden	Heterogeneous	Apiformes	Bumblebees	Cropland	Organic farming	0.626	0.333
120	54	Rundlof et al. 2008a	Sweden	Homogeneous	Apiformes	Bumblebees	Cropland	Organic farming	2.072	0.333
121	55	Rundlof et al. 2008b	Sweden	Organic landscape	Lepidoptera	Butterflies & Burnet moths	Cropland	Organic farming	0.596	0.286
122	55	Rundlof et al. 2008b	Sweden	Conventional landscape	Lepidoptera	Butterflies & Burnet moths	Cropland	Organic farming	1.554	0.286
123	56	Saarinen 2002	Finland	-	Lepidoptera	Butterflies	Grassland	Extensive grassland	0.039	0.236
124	57	Sjodin et al. 2008	Sweden	-	Apiformes	Bees	Grassland	Extensive grassland	0.484	0.250

125	57	Sjodin et al. 2008	Sweden	-	Lepidoptera	Butterflies & Burnet moths	Grassland	Extensive grassland	0.011	0.250
126	57	Sjodin et al. 2008	Sweden	-	Syrphidae	Hoverflies	Grassland	Extensive grassland	0.436	0.250
127	58	Steffan-Dewenter & Tscharntke 1997	Germany	-	Lepidoptera	Butterflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	3.365	0.500
128	58	Steffan-Dewenter & Tscharntke 1997	Germany	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	1.603	0.500
129	59	Steffan-Dewenter & Tscharntke 2001	Germany	-	Apiformes	Bees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.545	0.500
130	59	Steffan-Dewenter & Tscharntke 2001	Germany	-	Apiformes	Bees	Cropland	Sown flower strips	1.148	0.500
131	60	Weibull et al. 2003	Sweden	-	Lepidoptera	Butterflies	Cropland	Organic farming	-0.468	0.268
132	61	Wickramasinghe et al. 2004	United Kingdom	-	Lepidoptera	Nocturnal moths	Cropland & Grassland	Organic farming	0.482	0.083

References for Appendix I

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Appendix II. Summary information for each of the included observations in the species richness analyses.

Study no.	Source	Country	Region / landscape	Order / family	Species / group	Habitat	Measure type	Hedges d	NP var (d)
1	Alanen et al. 2011	Finland	-	Apiformes	Bumblebees	Cropland	Sown flower strips	0.704	0.500
1	Alanen et al. 2011	Finland	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	0.150	0.500
2	Albrecht et al. 2007a	Switzerland	-	Apiformes	All bees	Grassland	Extensive grassland	1.615	0.154
2	Albrecht et al. 2007a	Switzerland	-	Lepidoptera	Butterflies	Grassland	Extensive grassland	0.517	0.154
2	Albrecht et al. 2007a	Switzerland	-	Syrphidae	Hoverflies	Grassland	Extensive grassland	1.279	0.154
3	Albrecht et al. 2007b	Switzerland	-	Apiformes	Solitary bees	Grassland	Extensive grassland	0.456	0.154
4	Albrecht et al. 2010	Switzerland	-	Apiformes	All bees	Grassland	Extensive grassland	1.271	0.083
5	Aviron et al. 2009	Switzerland	Grassland and mixed arable-grassland region	Lepidoptera	Butterflies	Grassland	Extensive grassland	0.149	0.008
5	Aviron et al. 2009	Switzerland	Arable region	Lepidoptera	Butterflies	Cropland	Sown flower strips	0.811	0.027
6	Aviron et al. 2010	Switzerland	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	2.686	0.084
7	Batary et al. 2010	Hungary	Alkali	Apiformes	All bees	Grassland	Extensive grassland	0.312	0.286
7	Batary et al. 2010	Hungary	Meadow	Apiformes	All bees	Grassland	Extensive grassland	0.134	0.286
7	Batary et al. 2010	Hungary	Heves	Apiformes	All bees	Grassland	Extensive grassland	-0.196	0.286
8	Blake et al. 2011a	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	1.170	0.333
9	Brittain et al. 2010	Italy	-	Apiformes	Solitary bees	Cropland	Organic farming	1.165	0.333
9	Brittain et al. 2010	Italy	-	Lepidoptera	Butterflies	Cropland	Organic farming	0.834	0.333
10	Buys et al. 1997	The Netherlands	-	Apiformes	Bumblebees & honeybees	Cropland	Sown flower strips	1.599	0.041

10	Buys et al. 1997	The Netherlands	-	Apiformes	Bumblebees & honeybees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.385	0.077
10	Buys et al. 1997	The Netherlands	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	1.399	0.041
10	Buys et al. 1997	The Netherlands	-	Lepidoptera	Butterflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.482	0.077
10	Buys et al. 1997	The Netherlands	-	Syrphidae	Hoverflies	Cropland	Sown flower strips	0.693	0.077
10	Buys et al. 1997	The Netherlands	-	Syrphidae	Hoverflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.303	0.142
11	Carvell et al. 2007	United Kingdom	-	Apiformes	Bumblebees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.845	0.333
11	Carvell et al. 2007	United Kingdom	-	Apiformes	Bumblebees	Cropland	Sown flower strips	3.560	0.333
12	De Snoo et al. 1998	The Netherlands	-	Lepidoptera	Butterflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.318	0.143
13	Dover et al. 2000	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Woody element	3.888	0.194
14	Ekroos et al. 2008	Finland	-	Apiformes	Bumblebees	Cropland	Organic farming	0.539	0.092
14	Ekroos et al. 2008	Finland	-	Lepidoptera	Butterflies	Cropland	Organic farming	-0.040	0.092
15	Feber et al. 1996	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	1.610	0.250
15	Feber et al. 1996	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.600	0.250
16	Feber et al. 2007	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Organic farming	0.425	0.200
16	Feber et al. 2007	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Organic farming	0.876	0.200
17	Gathmann et al. 1994	Germany	-	Apiformes	Solitary bees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.000	0.500
17	Gathmann et al. 1994	Germany	-	Apiformes	Solitary bees	Cropland	Sown flower strips	0.000	0.500

18	Haenke et al. 2009	Germany	-	Syrphidae	Hoverflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	2.851	0.286
18	Haenke et al. 2009	Germany	-	Syrphidae	Hoverflies	Cropland	Sown flower strips	2.909	0.286
19	Hodgson et al. 2010	United Kingdom	Coldspot	Lepidoptera	Butterflies	Cropland	Organic farming	-0.253	0.250
19	Hodgson et al. 2010	United Kingdom	Coldspot	Lepidoptera	Butterflies	Grassland	Organic farming	-0.271	0.250
19	Hodgson et al. 2010	United Kingdom	Hotspot	Lepidoptera	Butterflies	Cropland	Organic farming	0.000	0.250
19	Hodgson et al. 2010	United Kingdom	Hotspot	Lepidoptera	Butterflies	Grassland	Organic farming	0.450	0.268
20	Holzschuh et al. 2007	Germany	G	Apiformes	All bees	Cropland	Organic farming	3.133	0.286
20	Holzschuh et al. 2007	Germany	S	Apiformes	All bees	Cropland	Organic farming	0.653	0.286
20	Holzschuh et al. 2007	Germany	M	Apiformes	All bees	Cropland	Organic farming	1.764	0.286
21	Holzschuh et al. 2010	Germany	-	Apiformes	Solitary bees	Cropland	Organic farming	0.347	0.087
22	Hopkins & Feber 1997	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	1.730	0.400
23	Kleijn et al. 1999	The Netherlands	-	Apiformes	All bees	Grassland	Extensive grassland	-0.086	0.286
23	Kleijn et al. 1999	The Netherlands	-	Lepidoptera	Butterflies	Grassland	Extensive grassland	-0.269	0.286
23	Kleijn et al. 1999	The Netherlands	-	Syrphidae	Hoverflies	Grassland	Extensive grassland	0.171	0.286
24	Kleijn et al. 2004	The Netherlands	Clay	Apiformes	All bees	Grassland	Extensive grassland	0.867	0.182
24	Kleijn et al. 2004	The Netherlands	Peat	Apiformes	All bees	Grassland	Extensive grassland	0.740	0.125
24	Kleijn et al. 2004	The Netherlands	Sand	Apiformes	All bees	Grassland	Extensive grassland	0.957	0.200
24	Kleijn et al. 2004	The Netherlands	Clay	Syrphidae	Hoverflies	Grassland	Extensive grassland	0.378	0.182
24	Kleijn et al. 2004	The Netherlands	Peat	Syrphidae	Hoverflies	Grassland	Extensive grassland	0.697	0.125

24	Kleijn et al. 2004	The Netherlands	Sand	Syrphidae	Hoverflies	Grassland	Extensive grassland	0.361	0.200
25	Kleijn et al. 2006	The Netherlands	E	Apiformes	All bees	Grassland	Extensive grassland	-0.577	0.286
25	Kleijn et al. 2006	The Netherlands	H	Apiformes	All bees	Grassland	Extensive grassland	0.141	0.286
25	Kleijn et al. 2006	The Netherlands	V	Apiformes	All bees	Grassland	Extensive grassland	0.000	0.286
25	Kleijn et al. 2006	Spain	R	Apiformes	All bees	Crop	Extensive grassland	-0.238	0.286
25	Kleijn et al. 2006	Spain	H	Apiformes	All bees	Crop	Extensive grassland	0.373	0.286
26	Knop et al. 2006	Switzerland	Ruswill	Apiformes	All bees	Grassland	Extensive grassland	0.650	0.286
26	Knop et al. 2006	Switzerland	Bauma	Apiformes	All bees	Grassland	Extensive grassland	0.560	0.286
26	Knop et al. 2006	Switzerland	Fluhli	Apiformes	All bees	Grassland	Extensive grassland	0.985	0.286
27	Kohler et al. 2008	The Netherlands	-	Apiformes	All bees	Grassland	Sown flower strips	1.411	0.220
27	Kohler et al. 2008	The Netherlands	-	Syrphidae	Hoverflies	Grassland	Sown flower strips	2.071	0.220
28	Kruess & Tscharntke 2002	Germany	-	Apiformes	All bees	Grassland	Extensive grassland	1.218	0.367
28	Kruess & Tscharntke 2002	Germany	-	Lepidoptera	Butterflies & burnet moths	Grassland	Extensive grassland	1.473	0.333
29	Kuussaari et al. 2011	Finland	-	Apiformes	Bumblebees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.780	0.500
29	Kuussaari et al. 2011	Finland	-	Lepidoptera	Butterflies & diurnal moths	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.439	0.500
30	Kvarnback 2009	Sweden	-	Apiformes	Bumblebees	Cropland	Sown flower strips	1.046	0.400
30	Kvarnback 2009	Sweden	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	1.225	0.400
31	Littlewood et al. 2008	United Kingdom	-	Lepidoptera	Nocturnal moths	Grassland	Extensive grassland	0.255	0.333
32	Mand et al. 2001	Estonia	-	Apiformes	Bumblebees	Grassland &	Organic farming	0.821	0.167

						cropland			
33	Marshall et al. 2004	United Kingdom	S	Apiformes	All bees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	-0.447	0.286
33	Marshall et al. 2004	United Kingdom	I	Apiformes	All bees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.767	0.286
33	Marshall et al. 2004	United Kingdom	O	Apiformes	All bees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	0.632	0.286
34	Meek et al. 2002	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	-0.037	0.500
34	Meek et al. 2002	United Kingdom	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	0.971	0.500
35	Merckx et al. 2009	United Kingdom	-	Lepidoptera	Larger moths	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.369	0.500
35	Merckx et al. 2009	United Kingdom	-	Lepidoptera	Larger moths	Cropland	Woody element	1.553	0.500
36	Muchow et al. 2007	Germany	-	Apiformes	All bees	Cropland	Sown flower strips	1.995	0.278
36	Muchow et al. 2007	Germany	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	2.054	0.278
37	Potts et al. 2009	United Kingdom	-	Apiformes	Bumblebees	Grassland	Grass-sown or naturally regenerated field margin/set-aside	0.357	0.167
37	Potts et al. 2009	United Kingdom	-	Apiformes	Bumblebees	Grassland	Sown flower strips	3.141	0.167
37	Potts et al. 2009	United Kingdom	-	Lepidoptera	Butterflies	Grassland	Grass-sown or naturally regenerated field margin/set-aside	0.716	0.167
37	Potts et al. 2009	United Kingdom	-	Lepidoptera	Butterflies	Grassland	Sown flower strips	1.893	0.167
38	Pywell et al. 2005	United Kingdom	-	Apiformes	Bumblebees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	2.725	0.125
38	Pywell et al. 2005	United Kingdom	-	Apiformes	Bumblebees	Cropland	Sown flower strips	2.334	0.071
39	Pywell et al. 2006	United Kingdom	-	Apiformes	Bumblebees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.363	0.063

39	Pywell et al. 2006	United Kingdom	-	Apiformes	Bumblebees	Cropland	Sown flower strips	2.888	0.075
40	Risberg 2004	Sweden	-	Apiformes	Bumblebees	Cropland	Organic farming	-0.361	0.400
41	Roth et al. 2008	Switzerland	-	Lepidoptera	Butterflies	Grassland & cropland	Several_combined	0.448	0.048
42	Rundlof & Smith 2006	Sweden	Heterogeneous	Lepidoptera	Butterflies & burnet moths	Cropland	Organic farming	1.158	0.333
42	Rundlof & Smith 2006	Sweden	Homogeneous	Lepidoptera	Butterflies & burnet moths	Cropland	Organic farming	5.089	0.333
43	Rundlof et al. 2008a	Sweden	Heterogeneous	Apiformes	Bumblebees	Cropland	Organic farming	1.118	0.333
43	Rundlof et al. 2008a	Sweden	Homogeneous	Apiformes	Bumblebees	Cropland	Organic farming	3.869	0.333
44	Rundlof et al. 2008b	Sweden	Organic landscape	Lepidoptera	Butterflies & burnet moths	Cropland	Organic farming	0.658	0.286
44	Rundlof et al. 2008b	Sweden	Conventional landscape	Lepidoptera	Butterflies & burnet moths	Cropland	Organic farming	1.300	0.286
45	Saarinen 2002	Finland	-	Lepidoptera	Butterflies	Grassland	Extensive grassland	-0.210	0.236
46	Sjodin et al. 2008	Sweden	-	Apiformes	All bees	Grassland	Extensive grassland	0.081	0.250
46	Sjodin et al. 2008	Sweden	-	Lepidoptera	Butterflies & burnet moths	Grassland	Extensive grassland	-0.111	0.250
46	Sjodin et al. 2008	Sweden	-	Syrphidae	Hoverflies	Grassland	Extensive grassland	0.652	0.250
47	Steffan-Dewenter & Tscharntke 1997	Germany	-	Lepidoptera	Butterflies	Cropland	Grass-sown or naturally regenerated field margin/set-aside	5.942	0.500
47	Steffan-Dewenter & Tscharntke 1997	Germany	-	Lepidoptera	Butterflies	Cropland	Sown flower strips	2.341	0.500
48	Steffan-Dewenter & Tscharntke 2001	Germany	-	Apiformes	All bees	Cropland	Grass-sown or naturally regenerated field margin/set-aside	1.425	0.500
48	Steffan-Dewenter & Tscharntke 2001	Germany	-	Apiformes	All bees	Cropland	Sown flower strips	-0.464	0.500
49	Weibull et al. 2003	Sweden	-	Lepidoptera	Butterflies	Cropland	Organic farming	0.259	0.268

References for Appendix II

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