A global synthesis of the effects of diversified farming systems on arthropod diversity within fields and across agricultural landscapes

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Abstract: Agricultural intensification is a leading cause of global biodiversity loss, which can reduce the provisioning of ecosystem services in managed ecosystems. Organic farming and plant diversification are farm management schemes that may mitigate potential ecological harm by increasing species richness and boosting related ecosystem services to agroecosystems. What remains unclear is the extent to which farm management schemes affect biodiversity components other than species richness, and whether impacts differ across spatial scales and landscape contexts. Using a global meta-dataset, we quantified the effects of organic farming and plant diversification on abundance, local diversity (communities within fields), and regional diversity (communities across fields) of arthropod pollinators, predators, herbivores, and detritivores. Both organic farming and higher in-field plant diversity enhanced arthropod abundance, particularly for rare taxa. This resulted in increased richness but decreased evenness. While these responses were stronger at local relative to regional scales, richness and abundance increased at both scales, and richness on farms embedded in complex relative to simple landscapes. Overall, both organic farming and in-field plant diversification exerted the strongest effects on pollinators and predators, suggesting these management schemes can facilitate ecosystem service providers without augmenting herbivore (pest) populations. Our results suggest that organic farming and plant diversification promote diverse arthropod meta-communities that may provide temporal and spatial stability of ecosystem service provisioning. Conserving diverse plant and arthropod communities in farming systems therefore requires sustainable practices that operate both within fields and across landscapes.

A global synthesis of the effects of diversified farming systems on arthropod diversity within fields and across agricultural landscapes

Running head: Effects of diversified farming on arthropods

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DC, CMK, CK, and EML designed the study with support from FB, PB, RB, NAB-P, LGC, WES, NW, and RW; EML, DC, and CMK collected, prepared, and analyzed data and wrote the manuscript; all authors except CMK and EML contributed empirical field data; all authors revised the manuscript.

ABSTRACT

Agricultural intensification is a leading cause of global biodiversity loss, which can reduce the provisioning of ecosystem services in managed ecosystems. Organic farming and plant diversification are farm management schemes that may mitigate potential ecological harm by increasing species richness and boosting related ecosystem services to agroecosystems. What remains unclear is the extent to which farm management schemes affect biodiversity components other than species richness, and whether impacts differ across spatial scales and landscape contexts. Using a global meta-dataset, we quantified the effects of organic farming and plant diversification on abundance, local diversity (communities within fields), and regional diversity (communities across fields) of arthropod pollinators, predators, herbivores, and detritivores. Both organic farming and higher in-field plant diversity enhanced arthropod abundance, particularly for rare taxa. This resulted in increased richness but decreased evenness. While these responses were stronger at local relative to regional scales, richness and abundance increased at both scales, and richness on farms embedded in complex relative to simple landscapes. Overall, both organic farming and in-field plant diversification exerted the strongest effects on pollinators and predators, suggesting these management schemes can facilitate ecosystem service providers without augmenting herbivore (pest) populations. Our results suggest that organic farming and plant diversification promote diverse arthropod meta-communities that may provide temporal and spatial stability of ecosystem service provisioning. Conserving diverse plant and arthropod communities in farming systems therefore requires sustainable practices that operate both within fields and across landscapes.

INTRODUCTION

Simplification of agricultural landscapes, and increased use of fertilizers and pesticides, threaten arthropod communities worldwide (Matson *et al.*, 1997; Tscharntke *et al.*, 2005; Potts *et al.*, 2016). This could impair agricultural sustainability because declines in arthropod abundance and diversity are often associated with reduced provisioning of ecosystem services including pollination, pest control, and nutrient cycling (Kremen & Miles, 2012; Oliver *et al.*, 2015). Two strategies purported to mitigate this ecological harm are organic farming and in-field plant diversification (Table S1). We refer to these strategies as farm management schemes, both of which include a host of practices that promote biological diversification (Kremen & Miles, 2012; Puech *et al.*, 2014). We refer to organic farming, conventional farming, high in-field plant diversification, and low in-field plant diversification as separate field types. Mounting evidence indicates that arthropod communities are more diverse and abundant in fields lacking synthetic fertilizers and pesticides, and in those with greater plant diversity (e.g., intercropped or having non-crop vegetation like hedgerows or floral strips) (Letourneau *et al.*, 2011; Crowder *et al.*, 2012; Kennedy *et al.*, 2013; Garibaldi *et al.*, 2014; Batáry *et al.*, 2015; Fahrig *et al.*, 2015).

The benefits of diversified farming practices may manifest at different scales, such as within individual fields (local diversity) or across multiple fields in a landscape (regional diversity) (Table S1). One observational study of 205 farms across Europe and Africa, for example, found that although organic farming provided strong benefits for local richness of plants and pollinators, these benefits faded at regional scales (Schneider *et al.*, 2014). This suggests that while farmers may promote local diversity on their field(s) by using organic practices, their efforts may not enhance biodiversity across multiple fields. Conversely, the addition of hedgerows to crop fields has been shown to increase community heterogeneity and species turnover (measures of local diversity), which are important components of regional diversity (Ponisio *et al.*, 2016). The effects of farm management for particularly mobile arthropods, such as pollinators, may also transcend individual fields if the improved quality of habitats on one field boosts abundance, with organisms spilling over to nearby fields (Tscharntke *et al.*, 2012; Kennedy *et al.*, 2013). While increases in local diversity have been shown to provide the strongest benefits to individual ecosystem services (i.e., pollination and biological control), regional diversity can support the simultaneous provision of multiple ecosystem services over space and time (Pasari *et al.*, 2013). Thus, to mitigate the effects of biodiversity loss across agroecosystems, farm management schemes should ideally benefit both local and regional diversity.

Research on the impacts of organic farming and in-field plant diversity has primarily focused on beneficial functional groups such as natural enemies and pollinators (Crowder *et al.*, 2010; Kennedy *et al.*, 2013) across intensively sampled regions of Europe and North America (Shackelford *et al.*, 2013; De Palma *et al.*, 2016). Moreover, almost all studies rely on richness (the number of taxa; Table S1) as a proxy for biodiversity but ignore metrics such as evenness (the relative abundances among species; Table S1) (e.g., Bengtsson *et al.*, 2005; Tuck *et al.*, 2014). Yet, richness poorly reflects overall community diversity (Duncan *et al.*, 2015; Loiseau & Gaertner, 2015), and its measurement is strongly confounded by abundance (Chao & Jost, 2012). Variation in richness has also been shown to have minimal impacts on ecosystem functioning when richness increases are driven primarily by rare species that contribute little to ecosystem services (Kleijn *et al.*, 2015; Winfree *et al.*, 2015). While common species may provide the majority of ecosystem services on some farms (Schwartz *et* *al.*, 2000; Kleijn *et al.*, 2015), rare species can provide redundancy (Kleijn *et al.*, 2015) or support provisioning of multiple ecosystem services (Soliveres *et al.*, 2016). Assessing evenness can help determine whether richness increases are driven by rare or common species. Richness, evenness, and abundance can also independently or interactively affect ecosystem function (Wilsey & Stirling, 2006; Wittebolle *et al.*, 2009; Crowder *et al.*, 2010; Northfield *et al.*, 2010; Winfree *et al.*, 2015). Thus, teasing apart the effects of farm management schemes on abundance and each diversity metric is critical. While existing studies find that organic farming and in-field plant diversification tend to boost abundance and richness of certain taxa, whether these effects are consistent for other biodiversity components such as evenness, for functional groups other than pollinators and natural enemies, and for less-well studied regions of the world (e.g., the tropics and Mediterranean) remains unclear.

Here, we present a comprehensive synthesis of studies that explore how organic farming and in-field plant diversification influence arthropod communities across global agroecosystems. We determine whether community responses to these management schemes vary based on different metrics (abundance, local richness and evenness, regional richness and evenness) and arthropod functional groups (detritivores, herbivores, pollinators, and predators). We investigate if these responses depend on landscape complexity (i.e., the proportion of natural and semi-natural habitat surrounding the farm; Fig. S1, Table S1), because landscape heterogeneity has been shown to influence the effectiveness of farm management schemes (Batáry *et al.*, 2011; Kleijn *et al.*, 2011; Kennedy *et al.*, 2013; Tuck *et al.*, 2014). We also explore whether farm management schemes have similar impacts on relatively rare compared to common taxa. Our results demonstrate whether local and regional diversity and abundance of different functional groups are similarly affected by on-farm management and landscape complexity, and the extent of covariance between biodiversity within and across fields in a landscape. Broadly, our findings further reveal the role of farm management in mitigating biodiversity loss and maintaining healthy arthropod communities in agroecosystems under global change.

MATERIALS AND METHODS

Literature survey

We compiled data from studies on arthropod diversity in agroecosystems that compared one or both of the farm management schemes of interest: (1) organic vs. conventional farming and (2) high vs. low in-field plant diversity. We defined organic agriculture as fields that were organically certified or met local certification guidelines (Table S1). These guidelines involve, at minimum maintaining production systems free of synthetic pesticides and fertilizers. We defined conventional agriculture as fields or farms that used recommended rates of synthetic, or a mix of synthetic and organic, pesticides and fertilizers. Other types of farming systems, such as integrated, which fit neither category where excluded from the analysis. Fields were defined as having high in-field plant diversity if they had diverse crop vegetation or managed field margins to include non-crop vegetation (e.g., hedgerows, border plantings, flower strips) (Table S1). We also classified small (< 4 ha) fields as diverse because they yield small-scale crop diversity (across several fields) even if the target field is a monoculture (Pasher *et al.*, 2013). Fields were defined as having low in-field plant diversity if they had none of these features. Studies that compared these schemes were identified by (1) searching the reference lists of recent meta-analyses (Batáry *et al.*, 2011; Chaplin-Kramer *et al.*, 2011; Crowder *et al.*, 2012; Garibaldi *et al.*, 2013; Kennedy *et al.*, 2013; Scheper *et al.*, 2013; Shackelford *et al.*, 2013), (2) searching ISI Web of Knowledge (April and May 2013) using the terms “evenness or richness” and “organic and conventional” or “local diversity”, and (3) directly contacting researchers who study arthropods in agricultural systems.

We identified 235 relevant studies that we examined for inclusion based on five criteria: (1) sampling was performed in the same crop or crop type (e.g., cereals) for organic and conventional fields, or fields with high and low in-field plant diversity; (2) sampling was conducted at the scale of individual crop fields rather than using plots on experiment stations; (3) the study included at least two fields of each type; (4) all organisms collected were identified to a particular taxonomic level (i.e., order, family, genus, species, or morphospecies), such that no taxa were lumped into groups such as “other”; and (5) at least three unique taxa were collected. We use “taxon” to refer to a single biological type (e.g., species, morphospecies, genus, family), determined as the finest taxonomic resolution to which each organism was identified in a particular study (see examples in Table S1). A total of 60 studies met our criteria, representing 43 crops, 21 countries, and 5 regions (Asia, Europe, North and Central America, South America, Oceania) (Fig. S2, Table S2). For studies that investigated both management scheme comparisons, we included the data in both analyses only when the field types were independently assigned (Table S3); otherwise we selected the scheme that the authors indicated the study was designed to address (Table S2). Across these 60 studies, our meta-analysis included 110 unique data points: 81 comparing organic and conventional fields and 29 comparing fields with high vs. low in-field plant diversity (Fig. S2, Tables S2, S4, archived data). Among organic vs. conventional studies, the number with high in-field plant diversity, low in-field plant diversity, and both levels of plant diversity was independent of organic vs. conventional management ($\chi^2_2 = 0.47$, $p = 0.79$).

Calculation of effect sizes

Unlike traditional meta-analyses that extract summary statistics from studies, we gathered and manipulated raw data, which enabled us to calculate evenness and classify taxa into functional groups. For each study, we compiled data on the abundance of all taxa in each field. For studies conducted across multiple years or crop types, separate values were compiled for each year and crop. To avoid pseudoreplication, for multi-year studies we selected a single year to analyze based on maximizing the number of (1) sites that met the evenness criterion (at least three taxa), (2) fields, or (3) individuals (in decreasing priority order; Garibaldi *et al.*, 2013). Each collected taxon was classified into one of four functional groups: detritivore, herbivore, pollinator, or predator (see Supporting Methods for details). These taxon-level data were used to calculate effect sizes for abundance, local diversity, and regional diversity in paired organic vs. conventional or high vs. low in-field plant diversity systems. For local and regional calculations, we defined diversity as both richness and evenness, and treated each functional group separately (Fig. S1).

Local diversity reflects the average diversity within each field, and was calculated using individual crop fields as the sampling unit (Fig. S1, Table S1). In studies with sub-samples at a scale smaller than a field (i.e., plots within fields), values across these sub-samples were averaged before calculating local diversity. Abundance was the number of arthropods, and richness the number of unique taxa, in a field. Evenness was calculated using the metric E_{var}, which ranges from 0 (one taxon dominant) to 1 (uniform abundance for all taxa). This metric was chosen for its desirable statistical properties, particularly independence from richness, and its use in similar previous meta-analyses (Crowder *et al.*, 2012). After calculating abundance, richness, and evenness for each field, we averaged values across all fields of a particular type in a study to obtain the values for effect size calculations.

Regional diversity values were calculated based on individuals pooled across all fields in a study (Fig. S1, Table S1). Thus, regional richness and evenness are measures of diversity of meta-communities across fields in a landscape, while local diversity measures communities in a single field (Wang & Loreau, 2014). We note that regional diversity is not a direct indication of spatial scale, as the geographical extent of sampling varied among studies. Some studies were not designed to assess regional diversity specifically, and sampled unequal numbers of fields of each type. To correct for this sampling bias, we used sample-based rarefaction with 1,000 random samples taken from the set of fields in a given study to determine pooled species assemblages (Gotelli & Colwell, 2011). For example, if a study had 10 conventional and 6 organic fields, regional diversity values for the conventional management schemes would be based on the average pooled community taken from 1,000 random draws of 6 field sites. Regional abundance is simply local abundance multiplied by the number of sites, thus we reported only one abundance value per study.

To compare effects of farm management schemes on diversity and abundance, we used the log-response ratio as an effect size metric (Hedges *et al.*, 1999). We used this metric, rather than a weighted effect size, for three reasons. First, weighted effect sizes could not be calculated for regional diversity because these calculations were based on a single value (without replication) from each study, such that there was no estimate of variability. Second, our studies classified arthropods at varying levels of taxonomic resolution. Studies classified at the family level had less variability than studies classified at the species level, so using a weighted metric would give studies conducted at a coarser taxonomic resolution greater weight. Finally, preliminary analysis showed weighted and unweighted analyses of local diversity and abundance were qualitatively similar (Table S5). In the Results, we back-transformed log response-ratio effect sizes to percentages.

We assessed funnel plot asymmetry to test for publication bias. Because we used an unweighted effect size metric, we plotted effect sizes against sample sizes (i.e., number of fields; Figs. S3, S4) (Sterne & Egger, 2001), and visually assessed asymmetry since formal statistical tests require effect size variances (Jin *et al.*, 2015) and measures of regional diversity had no variance component. Visual assessment looked for, and did not find, areas of missing non-significant results, a directional bias to effects, or a strong relationship between effect and sample sizes. We did not detect any sign of publication bias; funnel plots were sufficiently symmetrical. Finally, we ensured the sampling method (active versus passive sampling techniques) did not influence results (see Supporting Information, Table S6). We calculated abundance and diversity values with R v. 3.1.1 (R Core Team, 2014), using packages BiodiversityR (Kindt & Coe, 2005), doBy (Højsgaard & Halekoh, 2013), and reshape (Wickham, 2007).

Study variables

We gathered data on three categorical variables and assessed whether they mediated arthropod responses to farm management schemes: (1) landscape complexity (simple, complex), (2) biome (boreal, Mediterranean, temperate, tropical), and (3) crop cultivation period (annual, perennial). Landscape complexity (see Fig. S1, Table S1) was determined from land cover data on the percentage of natural and semi-natural habitat within 1 km of sampled fields. Natural and semi-natural habitat was defined as areas dominated by forest, grassland, shrubland, wetlands, ruderal vegetation, or non-agricultural plantings (i.e., previously-cultivated areas where vegetation is regenerating, hedgerows, field margins, and vegetation along roadways or ditches). For each study, we calculated the mean percentage of natural habitats across fields using locally-relevant land cover databases. Landscapes were classified as simple if they averaged ≤ 20% natural habitat, and complex if they averaged > 20% natural habitat, following Tscharntke et al. (2005) and common practice (e.g., Batáry *et al.*, 2011; Scheper *et al.*, 2013) (see Supporting Methods for additional details). Biome was based on the geographic location of the study. Crop cultivation periods were derived from several sources (FAO AGPC, 2000; Garibaldi *et al.*, 2013). Table S4 shows the distribution of data points across each of these descriptive variables.

Data analyses

Table S7 summarizes specific questions we addressed and the approach we used to test each one. We first used one-sample *t*-tests (Crowder & Reganold, 2015) to determine if the mean effect sizes for abundance, local richness and evenness, and regional richness and evenness differed significantly from 0. For each management scheme comparison (organic vs. conventional or high vs. low in-field plant diversity), these analyses were conducted for the overall arthropod community and for each functional group separately. We also explored correlations between local and regional richness, and between local and regional evenness, to determine if these metrics responded similarly to each of the management schemes. We used $\alpha = 0.10$, to describe effect sizes that appeared ecologically important but did not meet the somewhat arbitrary $\alpha = 0.05$. This accords with a recent policy statement by the American Statistical Association (Wasserstein & Lazar, 2016), which notes that reliance on arbitrary alpha values can lead to erroneous conclusions.

In subsequent analyses, we used meta-regression to examine whether effect sizes were influenced by functional group and other study characteristics. We excluded studies lacking landscape complexity data (see archived data) from meta-regressions. For each management scheme and response, we ran a linear mixed model (lme4 package; Bates *et al.*, 2014) that included eight fixed effect variables: (1) functional group (detritivore, herbivore, predator, pollinator), (2) diversity scale (local, regional), (3) landscape complexity (simple, complex), (4) biome (boreal, Mediterranean, temperate, tropical), (5) crop cultivation period (annual, perennial), (6) functional group×diversity scale interaction; (7) functional group×landscape complexity interaction; and (8) diversity scale×landscape complexity interaction. These models included study ID as a random effect. We used information-theoretic model selection to determine the set of best-fit models for each response variable (MuMIn package; Barton, 2014), which contained models with AICc values within 2 of the smallest value (Burnham & Anderson, 1998). We examined significance of the fixed effects in each model in the best-fit set ($\alpha = 0.10$) with likelihood ratio tests, and used post-hoc planned contrasts (with *p*-values adjusted to control the overall Type I error rate using Holm's sequential Bonferroni procedure; see Supporting Methods) (phia package; Rosario-Martinez, 2013) to test for (1) differences in effect size among functional groups and biomes, (2) differences in effect size between the local and regional scales within each functional group, and (3) landscape complexity differences between each pair of functional groups.

We also tested whether abundance and richness effect sizes differed for rare and common taxa. Following Kleijn et al. (2015), within each study we classified taxa as common if their relative abundance was at least 5% of the total community; other species were categorized as rare. We then calculated local abundance and richness as well as regional abundance and richness separately for rare and common taxa. We used one-sample *t*-tests to determine if mean effect sizes differed significantly from zero, and paired *t*-tests to determine whether mean effect sizes differed between rare and common taxa.

RESULTS

Effects of management schemes on overall arthropod communities

Organic farming increased arthropod abundance (45% change), local richness (19%), and regional richness (11%) (Fig. 1a, Table S8). These positive effects were stronger for local compared to regional richness (Fig. 1a, Tables S9, S10). Arthropod communities on organic farms had significantly but only moderately lower local evenness (-6%) and regional evenness (-8%) than on conventional farms (Fig. 1a, Table S8). Fields with high in-field plant diversity increased local richness (23%) and regional richness (19%), with similar magnitude (Fig. 1b, Tables S8, S11, S12). In-field plant diversity did not significantly affect abundance (27%), local evenness (-6%) or regional evenness (-13%) (Fig. 1b, Table S8). Overall, there were strong positive correlations between local and regional richness (r = 0.87), and between local and regional evenness (r = 0.57; Fig. S5).

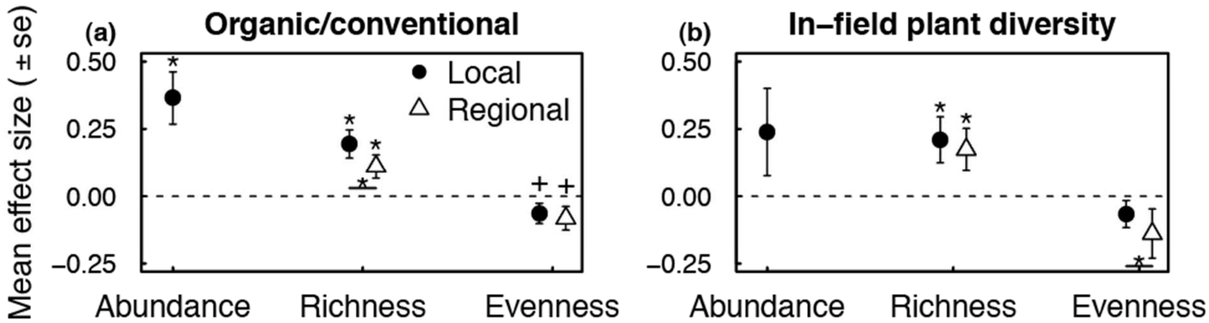

Figure 1. Effects of farm management schemes on arthropod abundance, local diversity, and regional diversity. Values shown are for the entire arthropod community, and represent the mean log-response ratio (± SE) of (a) adopting organic farming and (b) promoting in-field plant diversity on abundance, richness, and evenness. A "*" ($p < 0.05$) or "+" ($0.05 \leq p < 0.1$) above a mean denotes a significant difference from zero (determined via one-sample *t*-tests; statistical details in Table S8), while one below a pair of means indicates a significant difference between local and regional diversity (determined via linear mixed models; Tables S9-S12).

Organic farming increased abundance and richness of both rare and common arthropods at the local and regional scales (Fig. S6a,c, Table S13). At the local scale, organic farming increased arthropod richness by promoting rare taxa (27% increase) more strongly than common taxa (14% increase) (Fig. S6c, Table S14). In-field plant diversification also had differential effects on rare and common taxa, increasing richness of both at the local scale, but only of rare taxa at the regional scale (Fig. S6d, Table S13). Fields with higher in-field plant diversity increased abundance of common arthropods, but not of rare arthropods (Fig. S6b, Table S13).

Effects of management schemes on arthropod functional groups

Organic farming substantially increased the abundance (90%), local richness (55%), and regional richness (32%) of pollinator communities, but did not impact pollinator evenness (Fig. 2a, Table S15). For predator communities, organic farming increased abundance (38%) and local richness (14%), lowered local (-9%) and regional (-14%)

evenness (Fig. 2c, Table S16), but did not affect regional richness (Fig. 2c, Table S16). Organic farming also did not impact abundance, local or regional richness, or local or regional evenness for herbivore (Fig. 2e, Table S17) or detritivore (Fig. 2g, Table S18) communities. For all biodiversity components and functional groups, effect sizes in response to organic farming did not differ between the local and regional scales (Fig. 2a,c,e,f, Tables S9, S10). The diversity scale×landscape complexity interaction was never retained in a best-fit model (Tables S9, S11).

High in-field plant diversity promoted the abundance (45%), local richness (44%), and regional richness (29%) of pollinator communities, but decreased local pollinator evenness (-11%) (Fig. 2b, Table S15). In-field plant diversity did not affect regional pollinator evenness (Fig. 2b, Table S15). In addition, in-field plant diversity did not alter abundance, local or regional richness, or local or regional evenness for predator (Fig. 2d, Table S16) or herbivore (Fig. 2f, Table S17) communities. In-field plant diversity increased the regional richness (69%) of detritivores and lowered regional detritivore evenness (-65%), but did not impact detritivore abundance, local richness, or local evenness (Fig. 2h, Table S18). The low sample size for detritivores, however, limits our ability to make inferences about this group.

Effects of landscape complexity, biome, and crop cultivation period on arthropod communities

Landscape complexity did not mediate the influences of organic farming or in-field plant diversity on arthropod abundance or evenness (Fig. 3, Tables S9-S12). However, both management schemes had stronger positive effects on local and regional arthropod richness in complex relative to simple landscapes: organic farming 26% vs. 9%, in-field plant diversification 29% vs. 11%, respectively (Fig. 3c,d, Tables S9-S12). The effects of landscape complexity were similar in both direction and magnitude for local and regional diversity (Fig. 3c-e, Tables S9-S12). Organic farming promoted herbivore richness to a greater extent in simple than complex landscapes (Table S10), but other effects of landscape complexity on abundance and diversity were similar across functional groups (Tables S9-S12).

Stronger richness gains in complex than simple landscapes were driven predominantly by rare taxa (Fig. 4). In complex landscapes, both organic farming and in-field plant diversification had stronger positive effects on local richness of rare (organic 44%, plant diversification 68%) than of common (organic 21%, plant diversification 18%) arthropod taxa (Fig. 4c,d, Table S19). Organic farming within complex landscapes also increased local abundance and regional richness of rare taxa (78% and 17%, respectively) to a greater extent than common taxa (33% and 4%, respectively) (Fig. 4a, Table S19). Neither management scheme differentially affected abundance or richness of rare and common taxa in simple landscapes (Fig. 4, Table S19).

Biome mediated the impacts of in-field plant diversity on arthropod richness (pooled across local and regional scales) (Tables S11, S12). Post-hoc tests failed to indicate significant differences among biomes when considering all studies; but when the single boreal study was removed from the analysis, high in-field plant diversity more strongly promoted richness in Mediterranean (53%) than in temperate studies (-2%) (Table S12). Biome did not mediate the effects of organic farming or in-field plant diversification on arthropod abundance or evenness (Tables S9-S12). Organic farming increased arthropod abundance to a greater extent in annual (70%) than in perennial (1%) crops (Tables S9, S10). The effects of in-field plant diversification on abundance and diversity were consistent across crop cultivation periods (Tables S11, S12).

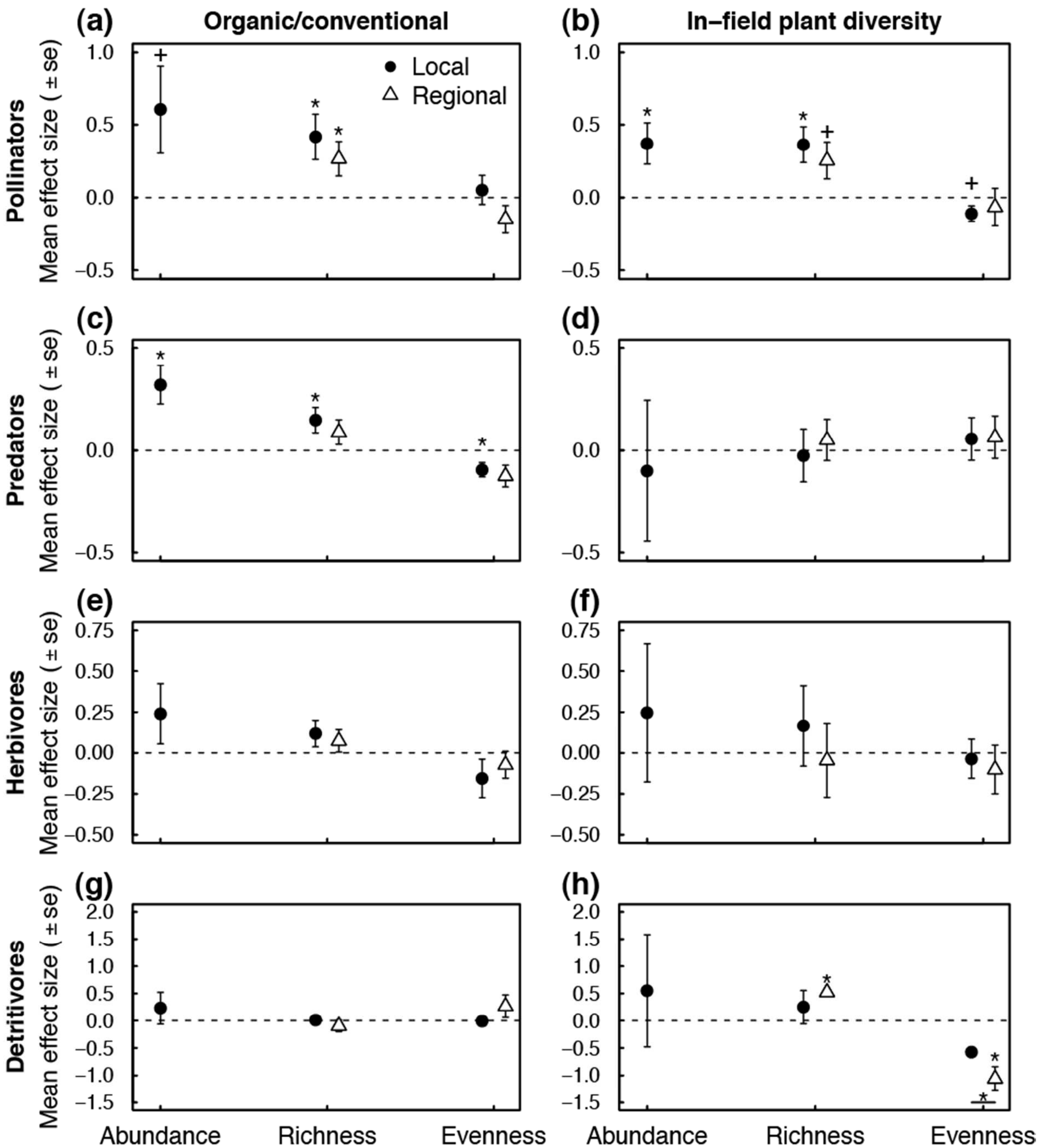

Figure 2. Effects of farm management schemes on abundance, local diversity, and regional diversity of arthropod functional groups. Mean log-response ratios (± SE) of (left column) adopting organic farming and (right column) promoting in-field plant diversity for (a-b) pollinators, (c-d) predators, (e-f) herbivores, and (g-h) detritivores. A "*" ($p < 0.05$) or "+" ($0.05 \leq p < 0.1$) above a mean denotes a significant difference from zero (determined via one-sample *t*-tests; Tables S15-S18). Meta-regressions indicated that differences between local and regional values did not vary with functional group (Tables S9-S12).

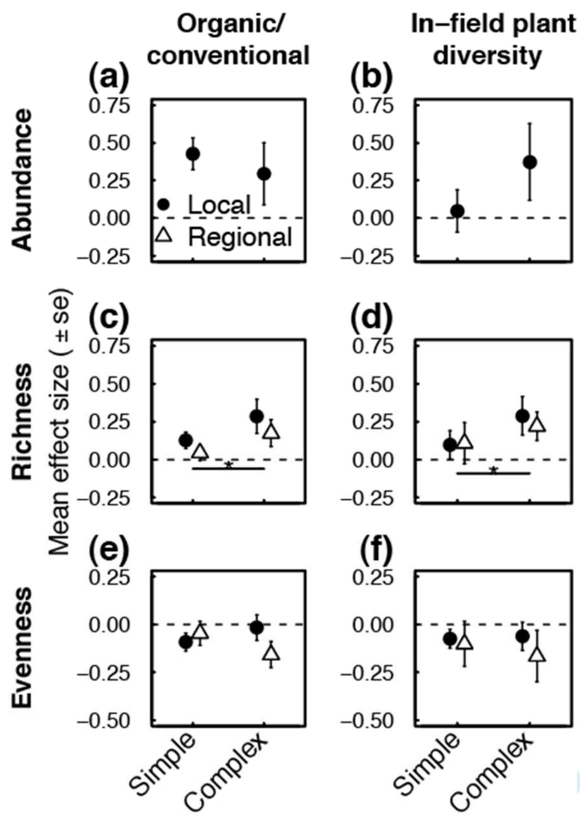

Figure 3. Effects of landscape complexity on the entire arthropod community in organic vs. conventional farms (left column) and fields with high vs. low in-field plant diversity (right column). Each graph shows the mean log-response ratio (± SE) for studies in simple (≤ 20% natural habitat) or complex (>20% natural habitat) landscapes for (a,b) abundance, (c,d) richness, and (e,f) evenness. A "*" ($p < 0.05$) or "+" ($0.05 \leq p < 0.1$) below a set of means indicates a significant difference between means at the habitat complexity levels (Tables S9-S12).

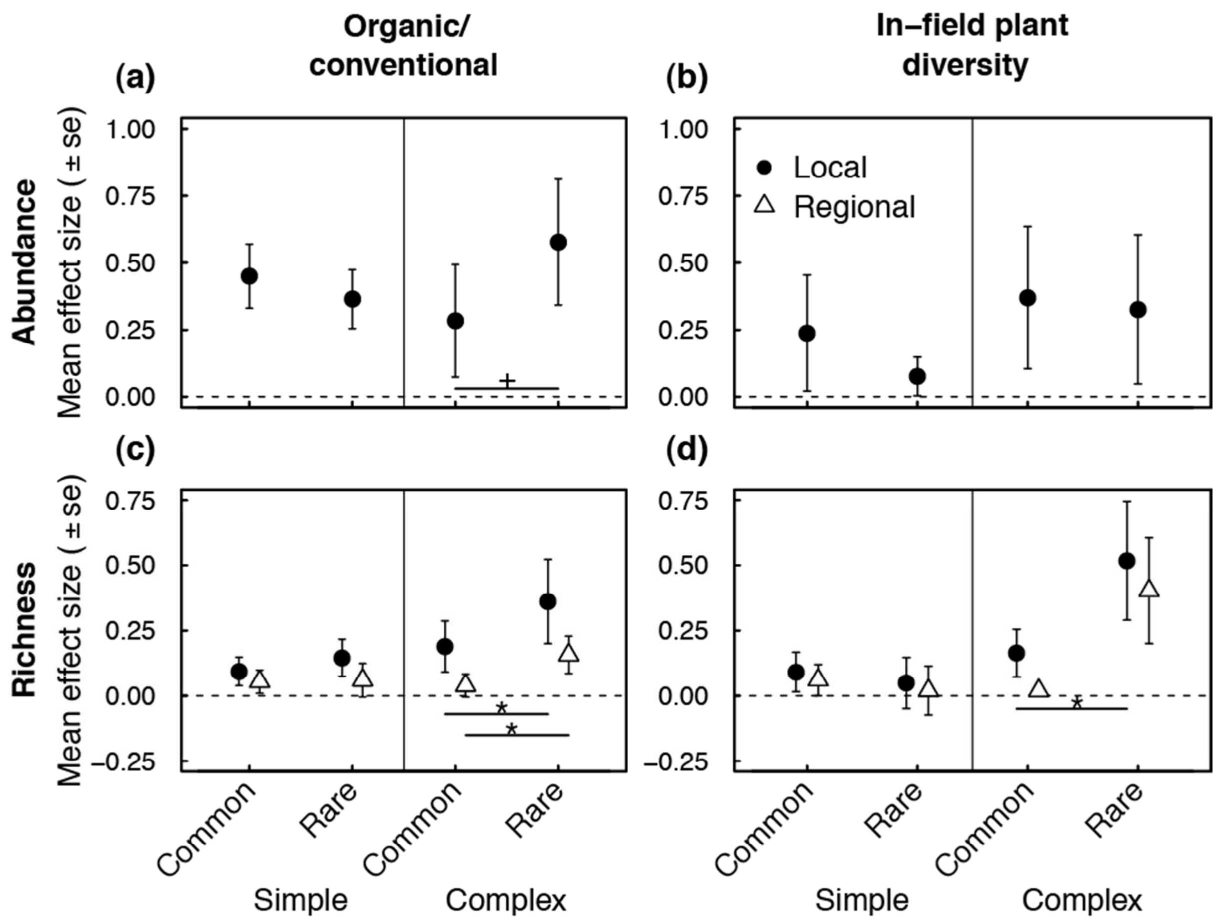

Figure 4. Effects of farm management schemes on abundance (a, b) and richness (c, d) of common vs. rare taxa in simple and complex landscapes. Mean log-response ratios (±SE) of (left column) adopting organic farming and (right column) promoting in-field plant diversity. A "*" ($p < 0.05$) or "+" ($0.05 \leq p < 0.1$) below a pair of means indicates a significant difference between rare and common taxa within a landscape complexity category (determined via paired *t*-tests; Table S19).

DISCUSSION

Our global meta-analysis showed that both organic farming and in-field plant diversification strongly increased arthropod abundance and richness, but had weaker effects on evenness. The minimal evenness decreases on diversified farms reflected the presence of more rare taxa. Emerging evidence suggests that rare taxa contribute to individual ecosystem services less than common taxa (Schwartz *et al.*, 2000; Kleijn *et al.*, 2015), although they may be important for maintenance of multiple ecosystem services across time and space (Isbell *et al.*, 2011; Soliveres *et al.*, 2016). Thus, while organic farming and plant diversification promote arthropod biodiversity conservation goals, their impacts on ecosystem services may be nuanced. The positive effects of both organic farming and in-field plant diversification were greatest for two groups of beneficial arthropods: pollinators and predators. Thus, both schemes may increase agroecosystem sustainability by promoting key ecosystem service providers without boosting pest (herbivore) densities.

Previous meta-analyses have investigated how organic farming and, to a lesser extent, in-field plant diversification, affect arthropod abundance and richness (e.g., Bengtsson *et al.*, 2005; Batáry *et al.*, 2011; Chaplin-Kramer *et al.*, 2011; Scheper *et al.*, 2013; Shackelford *et al.*, 2013; Tuck *et al.*, 2014). Our study extends upon this work by (1) combining data on multiple arthropod functional groups (but see Shackelford *et al.*, 2013), and (2) examining the type and scale of diversity across a variety of crop types. As such, we offer a more comprehensive understanding of when and how farm management schemes alter arthropod biodiversity. Our findings caution that the frequent use of richness as the sole proxy for biodiversity fails to reflect the full impacts of farming practices on biologic communities. While multiple studies have shown that organic farming boosts richness (e.g., Bengtsson *et al.*, 2005; Tuck *et al.*, 2014), we found that evenness decreased, an outcome that was due mainly to promotion of rare species. Species richness might be increased by conservation practices that target specific taxa, but the promotion of evenness requires practices that can simultaneously balance the abundances of many taxa (Crowder *et al.*, 2010, 2012). Finally, our results highlight the necessity of targeting farm management within the context of local conditions (Cunningham *et al.*, 2013; Saunders *et al.*, 2016). For example, our results suggest that farmers in Mediterranean biomes might see greater arthropod richness gains by increasing in-field plant diversity than by farming organically, while farmers growing annual crops may be more likely to boost arthropod abundance with organic farming.

Disentangling relationships between biodiversity components at local and regional scales can inform patterns of community assembly and mechanisms that shape community structure (Gering & Crist, 2002; Wang & Loreau, 2014). We found that regional diversity positively correlated with local diversity under both management schemes. Further, organic farming increased richness at both scales, although local effects were stronger than regional ones. One possible explanation is that diversified farming practices increase the heterogeneity of local communities (e.g., Ponisio *et al.*, 2016), which could lead to greater regional diversity. Another possibility is that diversified fields serve as source habitats within a matrix of crop and non-crop habitats across farming landscapes (M'Gonigle *et al.*, 2015). Further, the benefits of diversification practices on local communities in fields can be strongly mediated by regional species pools across farming landscapes (Gering & Crist, 2002).

Our results, in combination with another recent meta-analysis (Schneider *et al.*, 2014), suggest that mobility of organisms can determine whether the benefits of farm diversification accrue at both local and regional scales. While we show that organic farming can boost arthropod diversity at local and regional scales, Schneider et al. (2014) found that organic farming increased plant, earthworm, and spider richness at field but not regional scales. These groups of organisms tend to have limited dispersal capacity, particularly plants and earthworms. Thus, their local communities may be structured more by competition than long-distance dispersal (Gering & Crist, 2002), which would limit the similarity between communities within and across fields. At the same time, Schneider et al. (2014) found that organic farming boosted the richness of bees, a more mobile group of organisms, by approximately 25% at the local scale and 15% at the regional scale. We likewise found that diversified farming increased abundance, and local and regional richness, of mobile pollinators, but had less impact on detritivores that tend to have lower mobility (Sattler *et al.*, 2010).

Overall, our results are consistent with mounting evidence that farm management and landscape complexity interactively affect arthropod biodiversity (e.g., Rusch *et al.*, 2010; Batáry *et al.*, 2011; Kennedy *et al.*, 2013; Tuck *et al.*, 2014), although results across studies have found sometimes conflicting patterns (Kleijn *et al.*, 2011; Tscharntke *et al.*, 2012; Tuck *et al.*, 2014). For example, agri-environment schemes that promote low input, low disturbance, and diverse farms are sometimes most effective in fostering biodiversity in structurally simple landscapes (Batáry *et al.*, 2011; Scheper *et al.*, 2013). This presumably occurs because simple landscapes fail to satisfy the resource needs of many species, such that these species may disperse into diverse farms to seek resources (Tscharntke *et al.*, 2005; Kremen & Miles, 2012). In contrast, we found that impacts of organic farming and plant diversification on arthropod richness were heightened for fields embedded in complex landscapes. This could occur if complex landscapes support more diverse species pools that can respond positively to farm management (Duelli & Obrist, 2003; Hillebrand *et al.*, 2008; Kennedy *et al.*, 2013). Consistent with this hypothesis, we showed that organic farming in complex landscapes preferentially increased richness of rare taxa locally (i.e., in fields) and regionally (i.e., across landscapes). Importantly, the interactive effects of landscape complexity and on-farm management may differ across arthropod functional groups with varying capacity to move across landscapes (Tscharntke *et al.*, 2005; Chaplin-Kramer *et al.*, 2011). However, the only interaction between landscape complexity and management schemes we found was for richness of herbivores, a group with considerable variation in mobility among taxa (Sattler *et al.*, 2010).

Ideally, increases in abundance and diversity of arthropods on farms would enhance the provisioning of ecosystem services (Kremen & Miles, 2012). However, empirical studies have provided mixed evidence. In-field plant diversification and increased landscape complexity have been found to promote predator abundance and diversity with no change in pest control levels (Chaplin-Kramer *et al.*, 2011; Rusch *et al.*, 2016) or reduced crop damage (Letourneau *et al.*, 2011). The relationship between biodiversity and ecosystem services on farms is thus likely strongly mediated by species' abundances and functional roles. For example, Northfield *et al.* (2010) found that greater predator richness increased pest control, but only with high predator densities where complementarity among predator species was fully realized. Increases in pollinator richness can have minimal impacts on ecosystem services when richness gains are associated with rare species that contribute little to pollination (Kleijn *et al.*, 2015; Winfree *et al.*, 2015). Increasing wild pollinator richness on large farms (> 14 ha) only increases fruit set when wild pollinator density is also high (Garibaldi *et al.*, 2016). Higher predator species evenness on organic farms has also been shown to translate to increased pest control, with the potential to reduce yield gaps compared with conventional agriculture (Crowder *et al.*, 2010). However, models suggest that decreased evenness could also lead to greater ecosystem services when abundance of common species that are effective ecosystem services providers increases at the expense of rare species that are functionally less important (Crowder & Jabbour, 2014), a result seen with pollinators in agricultural systems (Kleijn *et al.*, 2015; Winfree *et al.*, 2015). The combination of context-specific responses to farm management schemes shown by this study and biodiversity-ecosystem functioning relationships that depend on species' abundances and functional traits suggest that the effects of diversified farming on ecosystem services are likely to depend on biome, landscape, and crop characteristics.

By promoting biodiversity and abundance of arthropods, diversified agriculture could provide a multitude of other benefits (Oliver *et al.*, 2015). Biodiversity can help maintain stability of ecosystem processes through mechanisms such as response diversity and functional redundancy (Cardinale *et al.*, 2012; Mori *et al.*, 2013). Arthropod richness gains in response to organic farming and plant diversification, such as those documented here, could guard against the loss of ecological function by supporting multiple species that occupy similar functional niches (functional redundancy) or that are functionally similar but respond differentially to environmental change (response diversity; Elmqvist *et al.*, 2003). The abundance and richness increases we detected for pollinators and predators but not for herbivores suggest that the two former groups may benefit more from these stabilizing processes. Resilient systems must also exhibit multiple ecosystem functions (multifunctionality) as environmental conditions and arthropod populations fluctuate. Increases in rare taxa, as detected in this study, may be critical for multifunctionality (Isbell *et al.*, 2011; Soliveres *et al.*, 2016) and even for single ecosystem functions (Zavaleta & Hulvey, 2004; Mouillot *et al.*, 2013). Thus, regional-scale refuges for rare species may ensure resilient agricultural systems.

Overall, our results suggest that organic farming and in-field plant diversification both promote biodiversity on farms. Moreover, these two schemes might have interactive effects on farm productivity. Practices such as multi-cropping (plant diversification) and longer, more diverse, crop rotations can reduce the yield gaps between organic and conventional agriculture (Ponisio *et al.*, 2015), and increase the profitability of organic relative to conventional systems (Crowder & Reganold, 2015). Diversified small farms are increasingly being replaced by large, simplified, and intensive monoculture production systems (Tscharntke *et al.*, 2005; Bennett *et al.*, 2012). This is problematic because intensified farming reduces the long-term sustainability of agroecosystems, thereby threatening global food security (Ray *et al.*, 2012). One of the greatest challenges of the 21st century is meeting the food, fiber, and energy needs of a growing human population while maintaining farm sustainability and ecosystem functioning (Tilman *et al.*, 2011). Our study underscores that adopting organic farming or in-field plant diversification practices might aid society in attaining these goals.

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DATA ACCESSIBILITY

Data and scripts available at: [insert DOI for Zenodo repository]

REFERENCES

Barton K (2014) *MuMIn: Multi-model inference.* R package v. 1.13.14. https://cran.r-project.org/web/packages/MuMIn/MuMIn.pdf.

Batáry P, Báldi A, Kleijn D, Tscharntke T (2011) Landscape-moderated biodiversity effects of agri-environmental management: a meta-analysis. *Proceedings of the Royal Society B: Biological Sciences*, **278**, 1894–1902.

Batáry P, Dicks LV, Kleijn D, Sutherland WJ (2015) The role of agri-environment schemes in conservation and environmental management. *Conservation Biology*, **29**, 1006–1016.

Bates D, Mächler M, Bolker B, Walker S (2014) Fitting linear mixed-effects models using lme4. *arXiv:1406.5823*.

Bengtsson J, Ahnström J, Weibull A-C (2005) The effects of organic agriculture on biodiversity and abundance: a meta-analysis. *Journal of Applied Ecology*, **42**, 261–269.

Bennett AJ, Bending GD, Chandler D, Hilton S, Mills P (2012) Meeting the demand for crop production: the challenge of yield decline in crops grown in short rotations. *Biological Reviews*, **87**, 52–71.

Burnham KP, Anderson DR (1998) *Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach*, 2nd edn. Springer-Verlag, New York, 488 pp.

Cardinale BJ, Duffy JE, Gonzalez A et al. (2012) Biodiversity loss and its impact on humanity. *Nature*, **486**, 59–67.

Chao A, Jost L (2012) Coverage-based rarefaction and extrapolation: standardizing samples by completeness rather than size. *Ecology*, **93**, 2533–2547.

Chaplin-Kramer R, O'Rourke ME, Blitzer EJ, Kremen C (2011) A meta-analysis of crop pest and natural enemy response to landscape complexity. *Ecology Letters*, **14**, 922–932.

Crowder DW, Jabbour R (2014) Relationships between biodiversity and biological control in agroecosystems: Current status and future challenges. *Biological Control*, **75**, 8–17.

Crowder DW, Reganold JP (2015) Financial competitiveness of organic agriculture on a global scale. *Proceedings of the National Academy of Sciences*, **112**, 7611–7616.

Crowder DW, Northfield TD, Strand MR, Snyder WE (2010) Organic agriculture promotes evenness and natural pest control. *Nature*, **466**, 109–112.

Crowder DW, Northfield TD, Gomulkiewicz R, Snyder WE (2012) Conserving and promoting evenness: organic farming and fire-based wildland management as case studies. *Ecology*, **93**, 2001–2007.

Cunningham SA, Attwood SJ, Bawa KS et al. (2013) To close the yield-gap while saving biodiversity will require multiple locally relevant strategies. *Agriculture, Ecosystems & Environment*, **173**, 20–27.

De Palma A, Abrahamczyk S, Aizen MA et al. (2016) Predicting bee community responses to land-use changes: Effects of geographic and taxonomic biases. *Scientific Reports*, **6**, 31153.

Duelli P, Obrist MK (2003) Regional biodiversity in an agricultural landscape: the contribution of seminatural habitat islands. *Basic and Applied Ecology*, **4**, 129–138.

Duncan C, Thompson JR, Pettorelli N (2015) The quest for a mechanistic understanding of biodiversity–ecosystem services relationships. *Proceedings of the Royal Society B: Biological Sciences*, **282**, 20151348.

Elmqvist T, Folke C, Nyström M, Peterson G, Bengtsson J, Walker B, Norberg J (2003) Response diversity, ecosystem change, and resilience. *Frontiers in Ecology and the Environment*, **1**, 488–494.

Fahrig L, Girard J, Duro D et al. (2015) Farmlands with smaller crop fields have higher within-field biodiversity. *Agriculture, Ecosystems & Environment*, **200**, 219–234.

FAO AGPC (2000) Ecocrop. http://ecocrop.fao.org/ecocrop/srv/en/cropFindForm.

Garibaldi LA, Steffan-Dewenter I, Winfree R et al. (2013) Wild pollinators enhance fruit set of crops regardless of honey bee abundance. *Science*, **339**, 1608–1611.

Garibaldi LA, Carvalheiro LG, Leonhardt SD et al. (2014) From research to action: enhancing crop yield through wild pollinators. *Frontiers in Ecology and the Environment*, **12**, 439–447.

Garibaldi LA, Carvalheiro LG, Vaissière BE et al. (2016) Mutually beneficial pollinator diversity and crop yield outcomes in small and large farms. *Science*, **351**, 388–391.

Gering JC, Crist TO (2002) The alpha–beta–regional relationship: providing new insights into local–regional patterns of species richness and scale dependence of diversity components. *Ecology Letters*, **5**, 433–444.

Gotelli NJ, Colwell RK (2011) Estimating species richness. In: *Biological Diversity* (eds Magurran AE, McGill BJ), pp. 39–54. Oxford University Press, New York.

Hedges LV, Gurevitch J, Curtis PS (1999) The meta-analysis of response ratios in experimental ecology. *Ecology*, **80**, 1150–1156.

Hillebrand H, Bennett DM, Cadotte MW (2008) Consequences of dominance: a review of evenness effects on local and regional ecosystem processes. *Ecology*, **89**, 1510–1520.

Højsgaard S, Halekoh U (2013) *doBy: doBy - Groupwise summary statistics, LSmeans, general linear contrasts, various utilities*. R package v. 4.5-11. https://cran.rstudio.com/web/packages/doBy/index.html.

Isbell F, Calcagno V, Hector A et al. (2011) High plant diversity is needed to maintain ecosystem services. *Nature*, **477**, 199–202.

Jin Z-C, Zhou X-H, He J (2015) Statistical methods for dealing with publication bias in meta-analysis. *Statistics in Medicine*, **34**, 343–360.

Kennedy CM, Lonsdorf E, Neel MC et al. (2013) A global quantitative synthesis of local and landscape effects on wild bee pollinators in agroecosystems. *Ecology Letters*, **16**, 584–599.

Kindt R, Coe R (2005) *Tree diversity analysis. A manual and software for common statistical methods in ecology and biodiversity studies*. World Agroforestry Centre (ICRAF), Nairobi, 196 pp.

Kleijn D, Rundlöf M, Scheper J, Smith HG, Tscharntke T (2011) Does conservation on farmland contribute to halting the biodiversity decline? *Trends in Ecology & Evolution*, **26**, 474–481.

Kleijn D, Winfree R, Bartomeus I et al. (2015) Delivery of crop pollination services is an insufficient argument for wild pollinator conservation. *Nature Communications*, **6**, 7414.

Kremen C, Miles A (2012) Ecosystem services in biologically diversified versus conventional farming systems: benefits, externalities, and trade-offs. *Ecology and Society*, **17**, 40.

Letourneau DK, Armbrecht I, Rivera BS et al. (2011) Does plant diversity benefit agroecosystems? A synthetic review. *Ecological Applications*, **21**, 9–21.

Loiseau N, Gaertner J-C (2015) Indices for assessing coral reef fish biodiversity: the need for a change in habits. *Ecology and Evolution*, **5**, 4018–4027.

Matson PA, Parton WJ, Power AG, Swift MJ (1997) Agricultural intensification and ecosystem properties. *Science*, **277**, 504–509.

M’Gonigle LK, Ponisio LC, Cutler K, Kremen C (2015) Habitat restoration promotes pollinator persistence and colonization in intensively managed agriculture. *Ecological Applications*, **25**, 1557–1565.

Mori AS, Furukawa T, Sasaki T (2013) Response diversity determines the resilience of ecosystems to environmental change. *Biological Reviews*, **88**, 349–364.

Mouillot D, Bellwood DR, Baraloto C et al. (2013) Rare species support vulnerable functions in high-diversity ecosystems. *PLOS Biology*, **11**, e1001569.

Northfield TD, Snyder GB, Ives AR, Snyder WE (2010) Niche saturation reveals resource partitioning among consumers. *Ecology Letters*, **13**, 338–348.

Oliver TH, Isaac NJB, August TA, Woodcock BA, Roy DB, Bullock JM (2015) Declining resilience of ecosystem functions under biodiversity loss. *Nature Communications*, **6**, 10122.

Pasari JR, Levi T, Zavaleta ES, Tilman D (2013) Several scales of biodiversity affect ecosystem multifunctionality. *Proceedings of the National Academy of Sciences*, **110**, 10219–10222.

Pasher J, Mitchell SW, King DJ, Fahrig L, Smith AC, Lindsay KE (2013) Optimizing landscape selection for estimating relative effects of landscape variables on ecological responses. *Landscape Ecology*, **28**, 371–383.

Ponisio LC, M’Gonigle LK, Mace KC, Palomino J, Valpine P de, Kremen C (2015) Diversification practices reduce organic to conventional yield gap. *Proceedings of the Royal Society B: Biological Sciences*, **282**, 20141396.

Ponisio LC, M’Gonigle LK, Kremen C (2016) On-farm habitat restoration counters biotic homogenization in intensively managed agriculture. *Global Change Biology*, **22**, 704–715.

Potts SG, Imperatriz-Fonseca VL, Ngo HT et al. (eds.) (2016) *Summary for policymakers of the assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production.* Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany, 36 pp.

Puech C, Baudry J, Joannon A, Poggi S, Aviron S (2014) Organic vs. conventional farming dichotomy: Does it make sense for natural enemies? *Agriculture, Ecosystems & Environment*, **194**, 48–57.

R Core Team (2014) *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna.

Ray DK, Ramankutty N, Mueller ND, West PC, Foley JA (2012) Recent patterns of crop yield growth and stagnation. *Nature Communications*, **3**, 1293.

Rosario-Martinez H de (2013) *phia: Post-Hoc Interaction Analysis*. R package v. 0.2-0. https://cran.rstudio.com/web/packages/phia/index.html.

Rusch A, Valantin-Morison M, Sarthou J-P, Roger-Estrade J (2010) Biological control of insect pests in agroecosystems: effects of crop management, farming systems, and seminatural habitats at the landscape scale: a review. In: *Advances in Agronomy*, Vol. Volume 109 (ed Donald L. Sparks), pp. 219–259. Academic Press, Cambridge, MA.

Rusch A, Chaplin-Kramer R, Gardiner MM et al. (2016) Agricultural landscape simplification reduces natural pest control: A quantitative synthesis. *Agriculture, Ecosystems & Environment*, **221**, 198–204.

Sattler T, Duelli P, Obrist MK, Arlettaz R, Moretti M (2010) Response of arthropod species richness and functional groups to urban habitat structure and management. *Landscape Ecology*, **25**, 941–954.

Saunders ME, Peisley RK, Rader R, Luck GW (2016) Pollinators, pests, and predators: Recognizing ecological trade-offs in agroecosystems. *Ambio*, **45**, 4–14.

Scheper J, Holzschuh A, Kuussaari M, Potts SG, Rundlöf M, Smith HG, Kleijn D (2013) Environmental factors driving the effectiveness of European agri-environmental measures in mitigating pollinator loss – a meta-analysis. *Ecology Letters*, **16**, 912–920.

Schneider MK, Lüscher G, Jeanneret P et al. (2014) Gains to species diversity in organically farmed fields are not propagated at the farm level. *Nature Communications*, **5**.

Schwartz MW, Brigham CA, Hoeksema JD, Lyons KG, Mills MH, Mantgem PJ van (2000) Linking biodiversity to ecosystem function: implications for conservation ecology. *Oecologia*, **122**, 297–305.

Shackelford G, Steward PR, Benton TG, Kunin WE, Potts SG, Biesmeijer JC, Sait SM (2013) Comparison of pollinators and natural enemies: a meta-analysis of landscape and local effects on abundance and richness in crops. *Biological Reviews*, **88**, 1002-1021.

Soliveres S, Manning P, Prati D et al. (2016) Locally rare species influence grassland ecosystem multifunctionality. *Philosophical Transactions of the Royal Society B: Biological Sciences*, **371**, 20150269.

Sterne JAC, Egger M (2001) Funnel plots for detecting bias in meta-analysis: Guidelines on choice of axis. *Journal of Clinical Epidemiology*, **54**, 1046–1055.

Tilman D, Balzer C, Hill J, Befort BL (2011) Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences*, **108**, 20260–20264.

Tscharntke T, Klein AM, Kruess A, Steffan-Dewenter I, Thies C (2005) Landscape perspectives on agricultural intensification and biodiversity – ecosystem service management. *Ecology Letters*, **8**, 857–874.

Tscharntke T, Tylianakis JM, Rand TA et al. (2012) Landscape moderation of biodiversity patterns and processes - eight hypotheses. *Biological Reviews*, **87**, 661–685.

Tuck SL, Winqvist C, Mota F, Ahnström J, Turnbull LA, Bengtsson J (2014) Land-use intensity and the effects of organic farming on biodiversity: a hierarchical meta-analysis. *Journal of Applied Ecology*, **51**, 746–755.

Wang S, Loreau M (2014) Ecosystem stability in space: α, β and γ variability. *Ecology Letters*, **17**, 891–901.

Wasserstein RL, Lazar NA (2016) The ASA's statement on *p*-values: context, process, and purpose. *The American Statistician*, **70**, 129–133.

Wickham H (2007) Reshaping data with the reshape package. *Journal of Statistical Software*, **21**, 1–20.

Wilsey B, Stirling G (2006) Species richness and evenness respond in a different manner to propagule density in developing prairie microcosm communities. *Plant Ecology*, **190**, 259–273.

Winfree R, W. Fox J, Williams NM, Reilly JR, Cariveau DP (2015) Abundance of common species, not species richness, drives delivery of a real-world ecosystem service. *Ecology Letters*, **18**, 626–635.

Wittebolle L, Marzorati M, Clement L et al. (2009) Initial community evenness favours functionality under selective stress. *Nature*, **458**, 623–626.

Zavaleta ES, Hulvey KB (2004) Realistic species losses disproportionately reduce grassland resistance to biological invaders. *Science*, **306**, 1175–1177.

SUPPORTING METHODS

Functional group classifications

Data providers determined the functional group of each taxon. When functional groups were non-defined or non-standard (e.g., saprophage), or when taxa filled multiple functional roles (e.g., species that serve as both pollinators and herbivores), we assigned taxa to a single functional role based on their most common description in the literature. To maximize data inclusion, we also (1) combined predators and parasitoids, (2) classified all carabids as predators since even the herbivorous species are thought to consume some animal material (e.g., Hengeveld, 1980; Jørgensen & Toft, 1997), and (3) classified a few pollinators as herbivores in studies with few pollinator taxa but many herbivores.

Sampling methods

Studies used a broad range of sampling methods, which we categorized as active or passive. Active sampling methods included beating, netting bees seen at plants, hand-collecting individuals off plants, observational counting, washing plants, taking soil cores, sweep-netting, and vacuum sampling. Passive sampling methods were blue vane traps, light traps, visually-attractive or scented lures, malaise traps, minnow traps, pan traps, pitfall traps, and sticky cards. However, we did not include sampling method in our meta-regressions because preliminary analyses indicated that sampling method negligibly affected effect sizes (Table S5).

Landscape complexity

The "simple" landscape complexity category combined Tscharntke et al.'s (2005) "cleared" and "simple" categories because we had only two "cleared" studies. We were unable to categorize landscape complexity when we obtained data directly from published articles that lacked GPS coordinates of sampling locations or information on natural habitat surrounding fields (Study IDs drit01, febe01, hesl01, hokk01, and weib01). These five studies all compared organic and conventional farms. In a couple of cases we based landscape complexity on percentage of natural habitat within 500 m (bosq01), or the average of percentages at 500m and 1.5 km (leto01; percentages at the two distances strongly correlated, with $r = 0.8$).

SUPPORTING REFERENCES

Hengeveld R (1980) Polyphagy, oligophagy and food specialization in ground beetles (Coleoptera, Carabidae). *Netherlands Journal of Zoology*, **30**, 564–584.

Jørgensen HB, Toft S (1997) Food preference, diet dependent fecundity and larval development in *Harpalus rufipes* (Coleoptera: Carabidae). *Pedobiologia*, **41**, 307–315.

Kremen C, Miles A (2012) Ecosystem services in biologically diversified versus conventional farming systems: benefits, externalities, and trade-offs. *Ecology and Society*, **17**, 40.

Puech C, Baudry J, Joannon A, Poggi S, Aviron S (2014) Organic vs. conventional farming dichotomy: Does it make sense for natural enemies? *Agriculture, Ecosystems & Environment*, **194**, 48–57.

Tscharntke T, Klein AM, Kruess A, Steffan-Dewenter I, Thies C (2005) Landscape perspectives on agricultural intensification and biodiversity – ecosystem service management. *Ecology Letters*, **8**, 857–874.

Table S2 is in a separate file.

Table 1: Definitions and descriptions of key terms.

Term	**Definition**	**Notes**
Organic farming	Organically certified, or meeting local certification guidelines. While guidelines vary by country, they typically involve, at minimum, maintaining production systems free of synthetic pesticides and fertilizers.	Both organic and conventional farming include a broad range of management strategies and levels of intensity (e.g., pesticide application frequency, monoculture vs. polyculture) (Kremen & Miles, 2012; Puech *et al.*, 2014).
Conventional farming	Fields or farms that used recommended rates of synthetic, or synthetic and organic, pesticides and fertilizers.	
In-field plant diversification	This includes various schemes that increase small-scale plant diversity, including intercropping, managing field margins to include non-crop vegetation (e.g., hedgerows, border plantings, flower strips), and use of small (< 4 ha) fields.	
Taxon	A single biological type (e.g., species, morphospecies, genus, family), determined as the finest taxonomic resolution to which each organism was identified.	Examples: *Apis mellifera* (species), *Halictus* sp. 1 (morphospecies), *Lasioglossum* spp. (genus), Formicidae (family). We assigned each taxon to a functional group (detritivore, herbivore, pollinator, predator), but calculated abundance and diversity from taxon-level data.
Abundance	The number of total individuals, of all taxa together, sampled.	We calculated abundance, richness, and evenness separately for each field type (e.g., conventional farming), crop, year, and arthropod functional group within each study.
Richness	The number of taxa sampled.	
Evenness	How individuals are distributed across taxa in the sample. The evenness measure that we used, E_{var}, range from 0 (completely uneven, one taxon dominates) to 1 (completely even, with each taxon represented by an equal number of individuals.	
Region	A large spatial extent that contains multiple communities and habitats. We defined each study's region as	

	all of the fields sampled in the study.	
Rare taxon	A taxon with relative abundance less than 5% of all individuals sampled across the region.	We determined rarity separately for each management scheme comparison (organic vs. conventional, high vs. low in-field plant diversity), crop, year, and function within a study, but did not further separate by field type.
Local diversity	Diversity (here, richness and evenness) of a community within a field.	We estimated local abundance and diversity by first calculating abundance and diversity values within each field, then averaging these values across fields. For example, assume species A, B, C, D, and E were found in field 1; species A, E, and F in field 2; species B, C, D, and E in field 3; and species A, B, E, F, G, and H in field 4. Each field's richness would be 5, 3, 4, and 6, respectively. Local richness would be 4.5, the average of each field's richness value.
Regional diversity	Diversity (here, richness and evenness) of the meta-community that spans all fields in a region.	We estimated regional diversity by pooling individuals sampled in all fields within a landscape, then calculating diversity of taxa in this one regional sample. In the above example, the regional species pool would include species A through H and regional richness would be 8.
Landscape complexity	The proportion of natural and semi-natural habitat (areas dominated by forest, grassland, shrubland, wetlands, ruderal vegetation, or non-agricultural plantings including previously-cultivated areas where vegetation is regenerating, hedgerows, field margins, and vegetation along roadways or ditches) surrounding a farm.	We determined landscape complexity separately for each management scheme comparison, crop, and year within a study, by averaging proportions across fields.

Table S3. Fisher exact tests for studies with variation in both management (organic vs. conventional) and in-field plant diversity (high vs. low). These tests were used to determine whether sites were assigned independently to management types across the two management schemes. I-f=in-field plant diversity

	Number of sites with:					
Study ID	**Organic & high i-f**	**Organic & low i-f**	**Conventional & high i-f**	**Conventional & low i-f**	***p*-value**	**Management scheme(s) used**
bomm01	8	16	22	53	0.80	Both
bosq01	7	10	10	10	0.74	Both
clou01	15	6	10	11	0.21	Both
danf01	2	0	3	5	0.44	Both
eige01	3	0	0	3	0.10	Organic/ conventional
ekro01	7	8	12	4	0.15	Both
frei01	0	2	2	0	0.33	I-f
frei02	2	0	0	2	0.33	I-f
holz01	16	5	10	11	0.11	Both
krem01	8	1	8	12	<0.0001	Organic/ conventional
leto01	5	0	0	5	0.0080	Organic/ conventional
ober01	3	2	0	3	0.20	Both
otie01	4	1	5	2	1.00	Both
rose01	0	12	9	0	<0.0001	Organic/ conventional
saun01	5	0	0	10	0.0003	I-f
weis01	1	6	3	22	1.00	Both

Table S4. Number of data points grouped by several categories used in the analysis.

(a) Arthropod functional group				
Management scheme	**Detritivore**	**Herbivore**	**Pollinator**	**Predator**
Organic/conventional	8	17	20	36
In-field plant diversity	3	5	13	8
(b) Landscape complexity				
Management scheme	**Simple**	**Complex**	**No data**	
Organic/conventional	44	30	7	
In-field plant diversity	12	17	0	
(c) Biome				
Management scheme	**Boreal**	**Mediterranean**	**Temperate**	**Tropical**
Organic/conventional	2	14	58	7
In-field plant diversity	1	9	13	6
(d) Cultivation period				
Management scheme	**Annual**	**Perennial**		
Organic/conventional	59	22		
In-field plant diversity	20	9		

Table S5. Correlations between unweighted (log-response ratio) and weighted (Hedges' *d*) effect sizes with various metrics. Weighted metrics could not be calculated at the regional scale (see Methods in main text)

Management scheme	Metric	Pearson's correlation coefficient	*t*	df	*p*-value
Organic vs. conventional	Abundance	0.66	7.88	79	<0.0001
Organic vs. conventional	Local richness	0.77	10.7	77	<0.0001
Organic vs. conventional	Local evenness	0.70	7.99	66	<0.0001
In-field plant diversity	Abundance	0.90	10.7	27	<0.0001
In-field plant diversity	Local richness	0.81	7.26	27	<0.0001
In-field plant diversity	Local evenness	0.83	7.01	22	<0.0001

Table S6. Effects of sampling method on effect size (log-response ratio) estimates. ANOVAs testing whether sampling method affected effect sizes were significant in only 4% of cases, which is within the amount expected by chance. Means are average untransformed log-response ratios comparing organic to conventional, or high to low in-field plant diversity, data. Effect sizes transformed to percentage change are in parentheses.

Organic vs. conventional												
Functional group	**Metric**	**N active**	**N passive**	**N both**	**Mean active**	**Mean passive**	**Mean both**	**SE active**	**SE passive**	**SE both**	**F**	***p*-value**
All	Abundance	32	39	10	0.56 (75%)	0.19 (21%)	0.43 (54%)	0.22	0.08	0.14	1.63	0.20
All	Local richness	32	39	10	0.29 (33%)	0.14 (15%)	0.11 (12%)	0.12	0.04	0.07	1.06	0.35
All	Local evenness	28	35	10	-0.07 (-6%)	-0.04 (-4%)	-0.12 (-12%)	0.07	0.05	0.05	0.22	0.80
All	Regional richness	32	39	10	0.16 (17%)	0.08 (9%)	0.07 (7%)	0.09	0.05	0.07	0.41	0.66
All	Regional evenness	32	39	10	-0.22 (-20%)	-0.00 (0%)	0.04 (5%)	0.08	0.05	0.06	3.62	0.031
Detritivore	Abundance	3	2	3	-0.37 (-31%)	0.83 (130%)	0.43 (54%)	0.51	0.63	0.29	1.70	0.27
Detritivore	Local richness	3	2	3	0.00 (0%)	0.17 (19%)	-0.09 (-9%)	0.14	0.17	0.07	1.00	0.43
Detritivore	Local evenness	3	1	3	0.20 (23%)	-0.04 (-4%)	-0.21 (-19%)	0.13	NA	0.07	4.15	0.11
Detritivore	Regional richness	3	2	3	0.00 (0%)	-0.38 (-32%)	0.00 (0%)	0.11	0.31	0.16	1.26	0.36
Detritivore	Regional evenness	3	2	3	0.22 (24%)	0.66 (94%)	0.05 (5%)	0.11	0.96	0.08	0.60	0.58
Herbivore	Abundance	8	6	3	0.29 (34%)	0.09 (10%)	0.39 (47%)	0.36	0.20	0.28	0.17	0.85
Herbivore	Local richness	8	6	3	0.04 (4%)	0.16 (17%)	0.24 (27%)	0.16	0.09	0.05	0.41	0.67

Herbivore	Local evenness	7	4	3	-0.23 (-20%)	-0.17 (-15%)	0.03 (3%)	0.21	0.19	0.09	0.32	0.73
Herbivore	Regional richness	8	6	3	-0.05 (-5%)	0.18 (20%)	0.19 (21%)	0.11	0.10	0.05	1.53	0.25
Herbivore	Regional evenness	8	6	3	-0.25 (-22%)	0.06 (6%)	0.12 (13%)	0.14	0.07	0.13	2.42	0.13
Pollinator	Abundance	12	7	1	0.98 (166%)	-0.10 (-9%)	1.06 (187%)	0.45	0.26	NA	1.56	0.24
Pollinator	Local richness	12	7	1	0.50 (64%)	0.28 (32%)	0.41 (51%)	0.25	0.15	NA	0.20	0.82
Pollinator	Local evenness	10	6	1	0.02 (2%)	0.18 (20%)	-0.39 (-33%)	0.09	0.24	NA	0.90	0.43
Pollinator	Regional richness	12	7	1	0.26 (30%)	0.25 (29%)	0.36 (44%)	0.19	0.11	NA	0.02	0.98
Pollinator	Regional evenness	12	7	1	-0.16 (-15%)	-0.11 (-10%)	-0.25 (-22%)	0.15	0.11	NA	0.06	0.94
Predator	Abundance	9	24	3	0.54 (72%)	0.24 (28%)	0.27 (31%)	0.30	0.08	0.20	0.95	0.40
Predator	Local richness	9	24	3	0.32 (38%)	0.09 (10%)	0.08 (8%)	0.20	0.05	0.12	1.35	0.27
Predator	Local evenness	8	24	3	-0.13 (-12%)	-0.08 (-8%)	-0.10 (-9%)	0.11	0.04	0.06	0.17	0.85
Predator	Regional richness	9	24	3	0.26 (30%)	0.04 (5%)	-0.07 (-7%)	0.17	0.06	0.09	1.63	0.21
Predator	Regional evenness	9	24	3	-0.42 (-34%)	-0.04 (-4%)	0.06 (7%)	0.15	0.04	0.10	7.14	0.003
In-field plant diversity												
Functional group	**Metric**	**N active**	**N passive**	**N both**	**Mean active**	**Mean passive**	**Mean both**	**SE active**	**SE passive**	**SE both**	**F**	***p*-value**
All	Abundance	13	11	5	0.22 (25%)	0.20 (22%)	0.37 (45%)	0.15	0.39	0.24	0.07	0.94
All	Local richness	13	11	5	0.29 (34%)	0.09 (10%)	0.26 (30%)	0.13	0.16	0.06	0.60	0.56

All	Local evenness	12	9	5	-0.03 (-3%)	-0.09 (-9%)	-0.11 (-10%)	0.07	0.11	0.05	0.25	0.78
All	Regional richness	13	11	5	0.25 (28%)	0.08 (9%)	0.19 (20%)	0.13	0.14	0.09	0.44	0.65
All	Regional evenness	13	11	5	-0.08 (-8%)	-0.25 (-22%)	-0.04 (-4%)	0.13	0.17	0.16	0.44	0.65
Detritivore	Abundance	1	2	0	0.03 (3%)	0.81 (125%)	NA	NA	1.73	NA	0.07	0.84
Detritivore	Local richness	1	2	0	-0.07 (-7%)	0.41 (51%)	NA	NA	0.45	NA	0.39	0.65
Detritivore	Local evenness	0	1	0	NA	-0.57 (-44%)	NA	NA	NA	NA	NA	NA
Detritivore	Regional richness	1	2	0	0.41 (50%)	0.58 (79%)	NA	NA	0.06	NA	2.55	0.36
Detritivore	Regional evenness	1	2	0	-0.84 (-57%)	-1.17 (-69%)	NA	NA	0.33	NA	0.32	0.67
Herbivore	Abundance	1	3	1	-0.04 (-4%)	0.30 (35%)	0.37 (45%)	NA	0.76	NA	0.03	0.97
Herbivore	Local richness	1	3	1	0.12 (13%)	0.15 (17%)	0.24 (27%)	NA	0.45	NA	0.01	0.99
Herbivore	Local evenness	1	2	1	0.21 (23%)	-0.17 (-16%)	0.00 (0%)	NA	0.19	NA	0.71	0.64
Herbivore	Regional richness	1	3	1	-0.06 (-6%)	-0.10 (-10%)	0.15 (16%)	NA	0.40	NA	0.05	0.95
Herbivore	Regional evenness	1	3	1	0.09 (10%)	-0.25 (-22%)	0.15 (17%)	NA	0.21	NA	0.61	0.62
Pollinator	Abundance	10	0	3	0.37 (46%)	NA	0.36 (43%)	0.15	NA	0.44	0.00	0.96
Pollinator	Local richness	10	0	3	0.40 (49%)	NA	0.26 (29%)	0.16	NA	0.12	0.22	0.65
Pollinator	Local evenness	10	0	3	-0.09 (-9%)	NA	-0.17 (-16%)	0.07	NA	0.07	0.39	0.55

Pollinator	Regional richness	10	0	3	0.28 (32%)	NA	0.17 (18%)	0.16	NA	0.16	0.13	0.73
Pollinator	Regional evenness	10	0	3	-0.05 (-5%)	NA	-0.10 (-10%)	0.15	NA	0.28	0.03	0.88
Predator	Abundance	1	6	1	-0.87 (-58%)	-0.05 (-5%)	0.40 (50%)	NA	0.44	NA	0.37	0.71
Predator	Local richness	1	6	1	-0.22 (-20%)	-0.05 (-5%)	0.30 (36%)	NA	0.16	NA	0.47	0.65
Predator	Local evenness	1	6	1	0.40 (49%)	0.01 (1%)	-0.03 (-3%)	NA	0.13	NA	0.71	0.54
Predator	Regional richness	1	6	1	0.08 (8%)	0.01 (1%)	0.27 (31%)	NA	0.13	NA	0.30	0.75
Predator	Regional evenness	1	6	1	0.23 (25%)	0.06 (6%)	-0.04 (-4%)	NA	0.14	NA	0.17	0.85

Table S7: Questions investigated in this study, and statistical tests that addressed each one. Q2, Q4, Q7, and Q8 were tested with the same meta-regression.

Question	**How tested**
(Q1) Does diversified farming differentially alter abundance, richness, and evenness?	One sample *t*-tests: Does each metric's mean effect size differ from zero?
(Q2) Diversified farming differentially alters local and regional diversity (richness, evenness).	(a) One-sample *t*-tests: Are patterns of difference from zero the same at the local and regional scales? (b) Meta-regression: Does scale affect mean effect size?
(Q3) Diversified farming differentially alters abundance and diversity of arthropods in different functional groups	One-sample *t*-tests: Within each functional group (detritivores, herbivores, pollinators, predators), does each metric's mean effect size differ from zero?
(Q4) Landscape complexity mediates responses of arthropod communities to diversified farming.	Meta-regression: Do effect sizes differ in simple and complex landscapes?
(Q5) Diversified farming differentially affects the abundance and diversity of relatively rare and relatively common taxa.	(a) One-sample *t*-tests: Does each metric's mean effect size for a given rarity category (rare, common) differ from zero? (b) Paired *t*-tests: Within a metric, do mean effect sizes for rare taxa differ from those of common taxa?
(Q6) Landscape complexity mediates the degree to which diversified farming differentially affects the abundance and diversity of rare vs. common taxa.	Paired *t*-tests: Within each metric and landscape complexity category (simple, complex), do mean effect sizes for rare taxa differ from those of common taxa?
(Q7) A crop's cultivation period (annual, perennial) mediates responses of arthropod communities to diversified farming.	Meta-regression: Do effect sizes differ for crops grown as annuals and perennials?
(Q8) Biome mediates responses of arthropod communities to diversified farming.	Meta-regression: Do effect sizes differ among boreal, Mediterranean, temperate, and tropical biomes?

Table S8. Results of one-sample *t*-tests testing whether organic farming and in-field plant diversification impacted overall arthropod communities (pooled across functional groups). Means are average untransformed log-response ratios comparing organic to conventional, or high to low in-field plant diversity, data. Effect sizes transformed to percent change are in parentheses.

Management scheme	**Metric**	**N**	**Mean**	**SE**	***t***	***p*-value**
Organic vs. conventional	Abundance	81	0.36 (45%)	0.10	3.76	0.0003
Organic vs. conventional	Local richness	81	0.19 (21%)	0.05	3.75	0.0003
Organic vs. conventional	Local evenness	73	-0.06 (-6%)	0.04	-1.69	0.095
Organic vs. conventional	Regional richness	81	0.11 (10%)	0.04	2.52	0.014
Organic vs. conventional	Regional evenness	81	-0.08 (-9%)	0.04	-1.87	0.065
In-field plant diversity	Abundance	29	0.24 (27%)	0.16	1.48	0.15
In-field plant diversity	Local richness	29	0.21 (23%)	0.08	2.49	0.019
In-field plant diversity	Local evenness	26	-0.07 (-6%)	0.05	-1.31	0.20
In-field plant diversity	Regional richness	29	0.17 (19%)	0.08	2.24	0.033
In-field plant diversity	Regional evenness	29	-0.14 (-13%)	0.09	-1.51	0.14

Table S9. Best-fit models, with ΔAICc < 2, and global models explaining arthropod abundance, richness, and evenness in fields managed organically vs. conventionally. *K* is the number of estimated model parameters (fixed plus random effects). Parameters are: F=functional group, D=diversity scale (local, regional), LC=landscape complexity (simple, complex), A=cultivation period (annual, perennial), B=biome. A "*" indicates an interaction and both of its main effects. Detritivores were excluded from meta-regressions due to low sample size.

Abundance					
Model ID	**Parameters**	***K***	**AICc**	**ΔAICc**	**weight**
2	A	4	178.1	0	0.40
6	F + A	6	178.6	0.41	0.32
14	F + A + LC	7	178.8	0.69	0.28
Global	F×D + F×LC + D×LC + A + B	12	191.4	13.26	
Richness					
Model ID	**Parameters**	***K***	**AICc**	**ΔAICc**	**weight**
61	D + F×LC	9	148.1	0	0.57
45	F×LC	8	148.6	0.54	0.43
Global	F×D + F×LC + D×LC + A + B	16	163.2	15.1	
Evenness					
Model ID	**Parameters**	***K***	**AICc**	**ΔAICc**	**weight**
1	intercept only	3	82.5	0	0.52
17	D	4	84.0	1.5	0.25
2	A	4	84.0	1.5	0.24
Global	F×D + F×LC + D×LC + A + B	16	102.7	20.2	

Table S10. Regression details for best-fit models listed in Table S7 that explain arthropod abundance, richness, and evenness in fields managed organically vs. conventionally. We significance of fixed effects with likelihood ratio tests (LRTs), and used post-hoc planned contrasts (with *p*-values adjusted via Holm's sequential Bonferroni procedure) to test for (1) differences in effect size among functional groups, and (2) differences in effect size between the local and regional scales within each functional group. Parameters are: F=functional group (h=herbivore, po=pollinator, pr=predator), D=diversity scale (r=regional), LC= landscape complexity (c=complex, s=simple), A=cultivation period (p=perennial), B=biome (b=boreal, M=Mediterranean, te=temperate, tr=tropical). A ":" indicates an interaction. Detritivores were excluded from meta-regressions due to low sample size.

Abundance (detritivores excluded)									
Model ID	**Parameter**	**Coefficient (SE)**	**LRT χ^2**	**LRT df**	**LRT *p*-value**	**Contrast**	**Contrast χ^2**	**Contrast df**	**Contrast *p*-value**
2	Intercept	0.54 (0.13)	NA						
	A, p	-0.50 (0.24)	4.48	1	0.034				
6	Intercept	0.41 (0.24)	NA			F, h-po	2.96	1	0.18
	F, po	0.52 (0.30)	4.36	2	0.11	F, h-pr	0.01	1	0.91
	F, pr	0.03 (0.28)				F, po-pr	3.51	1	0.18
	A, p	-0.62 (0.24)	6.11	1	0.014				
14	Intercept	0.09 (0.33)	NA			F, h-po	4.87	1	0.075
	F, po	0.75 (0.34)	6.41	2	0.041	F, h-pr	0.23	1	0.63
	F, pr	0.14 (0.28)				F, po-pr	5.04	1	0.074
	LC, s	0.36 (0.25)	2.22	1	0.14				
	A, p	-0.57 (0.24)	5.68	1	0.017				
Richness (detritivores excluded)									
Model ID	**Parameter**	**Coefficient (SE)**	**LRT χ^2**	**LRT df**	**LRT *p*-value**	**Contrast**	**Contrast χ^2**	**Contrast df**	**Contrast *p*-value**
61	Intercept	-0.46 (0.21)	NA			F, h-po	10.23	1	0.004
	F, po	0.88 (0.20)	18.46	4	0.001	F, h-pr	8.14	1	0.009
	F, pr	0.68 (0.20)				F, po-pr	1.81	1	0.18
	S, r	-0.09 (0.06)	2.85	1	0.092	F:LC, c-s in h	6.88	1	0.026
	LC, s	0.61 (0.23)	10.66	3	0.014	F:LC, c-s in po	0.31	1	1
	F:LC, po	-0.75 (0.32)	10.64	2	0.005	F:LC, c-s	0.42	1	1

						in pr			
	F:LC, pr	-0.72 (0.22)							
45	Intercept	-0.51 (0.21)	NA			F, h-po	10.13	1	0.004
	F, po	0.88 (0.20)	17.95	4	0.001	F, h-pr	7.94	1	0.010
	F, pr	0.68 (0.21)				F, po-pr	1.82	1	0.18
	LC, s	0.61 (0.24)	10.30	3	0.016	F:LC, c-s in h	6.77	1	0.028
	F:LC, po:s	-0.75 (0.32)	10.27	2	0.006	F:LC, c-s in po	0.32	1	1
	F:LC, pr:s	-0.72 (0.23)				F:LC, c-s in pr	0.41	1	1
Evenness (detritivores excluded)									
Model ID	**Parameter**	**Coefficient (SE)**	**LRT χ^2**	**LRT df**	**LRT *p*-value**				
17	Intercept	-0.08 (0.05)	NA						
	S, r	-0.04 (0.05)	0.65	1	0.42				
2	Intercept	-0.12 (0.06)	NA						
	A, p	0.07 (0.10)	0.61	1	0.43				

Table S11. Best-fit models, with ΔAICc < 2, and global models explaining arthropod abundance, richness, and evenness in fields managed with high vs. low in-field plant diversity. *K* is the number of estimated model parameters (fixed plus random effects). Parameters are: F=functional group, D=diversity scale (local, regional), LC=landscape complexity (simple, complex), A=cultivation period (annual, perennial), B=biome. A "*" indicates an interaction and both of its main effects.

Abundance					
Model ID	**Parameters**	***K***	**AICc**	**ΔAICc**	**weight**
1	intercept only	3	70.4	0	0.67
2	A	4	71.7	1.4	0.33
Global	F×D + F×LC + D×LC + A + B	14	96.7	26.3	
Richness					
Model ID	**Parameters**	***K***	**AICc**	**ΔAICc**	**weight**
5	F	6	42.2	0	0.36
45	F×LC	10	42.2	0.04	0.36
7	F + B	9	42.7	0.5	0.28
Global	F×D + F×LC + D×LC + A + B	19	54.1	11.9	
Evenness					
Model ID	**Parameters**	***K***	**AICc**	**ΔAICc**	**weight**
85	F×D	10	21.8	0	1
Global	F×D + F×LC + D×LC + A + B	19	48.5	26.7	

Table S12. Regression details for best-fit models listed in Table S9 that explain arthropod abundance, richness, and evenness in fields managed with high vs. low in-field plant diversity. We significance of fixed effects with likelihood ratio tests (LRTs), and used post-hoc planned contrasts (with *p*-values adjusted via Holm's sequential Bonferroni procedure) to test for (1) differences in effect size among functional groups, (2) differences in effect size between the local and regional scales within each functional group, and (3) landscape complexity differences among each pair of functional groups. Parameters are: F=functional group (d=detritivore, h=herbivore, po=pollinator, pr=predator), D=diversity scale (l=local, r=regional), LC= landscape complexity (c=complex, s=simple), A=cultivation period (p=perennial), B=biome (b=boreal, M=Mediterranean, te=temperate, tr=tropical). A ":" indicates an interaction.

Abundance									
Model ID	**Parameter**	**Coefficient (SE)**	**LRT χ^2**	**LRT df**	**LRT *p*-value**				
2	Intercept	0.06 (0.20)	NA						
	A, p	0.40 (0.36)	1.33	1	0.25				
Richness									
Model ID	**Parameter**	**Coefficient (SE)**	**LRT χ^2**	**LRT df**	**LRT *p*-value**	**Contrast**	**Contrast χ^2**	**Contrast df**	**Contrast *p*-value**
5	Intercept	0.25 (0.16)	NA			F, d-h	6.24	1	0.075
	F, h	-0.30 (0.12)	9.57	3	0.023	F, d-po	0.10	1	1
	F, po	0.06 (0.19)				F, d-pr	4.13	1	0.21
	F, pr	-0.24 (0.12)				F, h-po	4.02	1	0.21
						F, h-pr	0.31	1	1
						F, po-pr	3.17	1	0.23
45	Intercept	0.19 (0.20)	NA			F, d-h	10.37	1	0.008
	F, h	-0.03 (0.14)	20.36	6	0.002	F, d-po	0.07	1	1
	F, po	0.19 (0.25)				F, d-pr	7.16	1	0.037
	F, pr	-0.21 (0.14)				F, h-po	2.74	1	0.39
	LC, s	0.32 (0.34)	11.00	4	0.027	F, h-pr	0.43	1	1
	F:LC, h:s	-0.67 (0.23)	10.57	3	0.014	F, po-pr	1.82	1	0.53
	F:LC, po:s	-0.49 (0.40)				F:LC, c-s in d	0.93	1	1
	F:LC, pr:s	-0.18 (0.23)				F:LC, c-s in h	1.28	1	1
						F:LC, c-s in po	0.52	1	1

						F:LC, c-s in pr	0.24	1	1
7	Intercept	0.30 (0.38)	NA			F, d-h	6.54	1	0.064
	F, h	-0.31 (0.12)	11.30	3	0.010	F, d-po	0.29	1	0.84
	F, po	0.10 (0.18)				F, d-pr	3.49	1	0.19
	F, pr	-0.23 (0.12)				F, h-po	5.67	1	0.086
	B, M	0.17 (0.40)	7.61	3	0.054	F, h-pr	0.65	1	0.84
	B, te	-0.28 (0.39)				F, po-pr	3.93	1	0.19
	B, tr	0.09 (0.41)				B, b-M	0.18	1	1
						B, b-te	0.51	1	1
						B, b-tr	0.05	1	1
						B, M-te	5.54	1	1
						B, M-tr	0.14	1	1
						B, te-tr	3.56	1	1
Richness, boreal data excluded									
Model ID	**Parameter**	**Coefficient (SE)**	**LRT χ^2**	**LRT df**	**LRT *p*-value**	**Contrast**	**Contrast χ^2**	**Contrast df**	**Contrast *p*-value**
7	Intercept	0.47 (0.20)	NA			F, d-h	6.36	1	0.070
	F, h	-0.31 (0.12)	10.90	3	0.012	F, d-po	0.29	1	0.85
	F, po	0.10 (0.19)				F, d-pr	3.40	1	0.20
	F, pr	-0.23 (0.12)				F, h-po	5.45	1	0.087
	B, te	-0.45 (0.19)	7.23	2	0.027	F, h-pr	0.64	1	0.85
	B, tr	-0.08 (0.22)				F, po-pr	3.92	1	0.19
						B, M-te	5.54	1	0.056
						B, M-tr	0.14	1	0.71
						B, te-tr	3.56	1	0.12
47	Intercept	0.41 (0.22)	NA			F, d-h	10.56	1	0.007
	F, h	-0.03 (0.14)	21.29	6	0.002	F, d-po	0.01	1	0.95
	F, po	0.18 (0.27)				F, d-pr	6.55	1	0.052
	F, pr	-0.19 (0.14)				F, h-po	4.04	1	0.18
	LC, s	0.31 (0.36)	10.55	4	0.032	F, h-pr	0.68	1	0.82
	B, te	-0.43 (0.21)	7.07	2	0.029	F, po-pr	2.55	1	0.33

	B, tr	-0.05 (0.29)				B, M-te	4.39	1	0.11
	F:LC, h:s	-0.69 (0.23)	10.30	3	0.016	B, M-tr	0.03	1	0.86
	F:LC, po:s	-0.39 (0.47)				B, te-tr	2.40	1	0.24
	F:LC, pr:s	-0.22 (0.23)				F:LC, c-s in d	0.73	1	1
						F:LC, c-s in h	1.23	1	1
						F:LC, c-s in po	0.12	1	1
						F:LC, c-s in pr	0.08	1	1
5	Intercept	0.24 (0.17)	NA			F, d-h	6.04	1	0.084
	F, h	-0.30 (0.12)	9.21	3	0.027	F, d-po	0.12	1	1
	F, po	0.07 (0.20)				F, d-pr	4.02	1	0.22
	F, pr	-0.25 (0.12)				F, h-po	3.84	1	0.22
						F, h-pr	0.29	1	1
						F, po-pr	2.98	1	0.25
Evenness									
Model ID	**Parameter**	**Coefficient (SE)**	**LRT χ^2**	**LRT df**	**LRT *p*-value**	**Contrast**	**Contrast χ^2**	**Contrast df**	**Contrast *p*-value**
85	Intercept	-0.08 (0.21)	NA			F, d-h	17.99	1	0.0001
	F, h	0.14 (0.21)	46.79	6	<0.0001	F, d-po	6.45	1	0.045
	F, po	-0.04 (0.23)				F, d-pr	21.60	1	<0.0001
	F, pr	0.13 (0.20)				F, h-po	0.59	1	0.89
	S, r	-0.88 (0.21)	16.44	4	0.003	F, h-pr	0.18	1	0.89
	F:S, h:r	0.79 (0.24)	16.13	3	0.001	F, po-pr	1.21	1	0.81
	F:S, po:r	0.92 (0.22)				F:S, l-r in d	17.44	1	0.0001
	F:S, pr:r	0.89 (0.23)				F:S, l-r in h	0.55	1	1
						F:S, l-r in po	0.44	1	1
						F:S, l-r in pr	0.01	1	1

Table S13. Results of one-sample *t*-tests testing whether organic farming and in-field plant diversification impacted overall arthropod communities (pooled across functional groups) for rare and common taxa. We classified taxa as common if their relative abundance was at least 5% of the total community; other species were categorized as rare. Means are average untransformed log-response ratios comparing organic to conventional, or high to low in-field plant diversity, data. Effect sizes transformed to percent change are in parentheses.

Management scheme	**Metric**	**Relative abundance category**	**N**	**Mean**	**SE**	***t***	***p*-value**
Organic vs. conventional	Abundance	Rare	77	0.44 (55%)	0.45	4.16	<0.0001
Organic vs. conventional	Abundance	Common	82	0.37 (45%)	0.51	3.64	<0.0001
Organic vs. conventional	Local richness	Rare	77	0.24 (27%)	0.38	3.29	0.002
Organic vs. conventional	Local richness	Common	82	0.13 (14%)	0.31	2.75	0.007
Organic vs. conventional	Regional richness	Rare	73	0.12 (12%)	0.31	2.52	0.014
Organic vs. conventional	Regional richness	Common	78	0.05 (6%)	0.29	1.80	0.076
In-field plant diversity	Abundance	Rare	25	0.23 (25%)	1.31	1.33	0.19
In-field plant diversity	Abundance	Common	30	0.31 (37%)	1.10	1.79	0.084
In-field plant diversity	Local richness	Rare	25	0.33 (39%)	0.68	2.24	0.035
In-field plant diversity	Local richness	Common	30	0.13 (14%)	0.31	2.17	0.038
In-field plant diversity	Regional richness	Rare	24	0.24 (28%)	0.69	1.89	0.071
In-field plant diversity	Regional richness	Common	25	0.04 (4%)	0.18	1.45	0.16

Table S14. Results of paired *t*-tests testing whether organic farming and in-field plant diversification impacted arthropod abundance and richness differentially for rare and common taxa. Means are average untransformed log-response ratios comparing organic to conventional, or high to low in-field plant diversity, data. Effect sizes transformed to percent change are in parentheses.

Management scheme	Metric	N common taxa	Mean common taxa	SE common taxa	N rare taxa	Mean rare taxa	SE rare taxa	*t*	*p*-value
Organic vs. conventional	Abundance	82	0.37 (45%)	0.10	77	0.44 (55%)	0.11	-0.76	0.45
Organic vs. conventional	Local richness	82	0.13 (14%)	0.05	77	0.24 (27%)	0.07	-2.40	0.019
Organic vs. conventional	Regional richness	78	0.05 (6%)	0.03	73	0.12 (12%)	0.05	-1.63	0.11
In-field plant diversity	Abundance	30	0.31 (37%)	0.17	25	0.23 (25%)	0.17	1.02	0.32
In-field plant diversity	Local richness	30	0.13 (14%)	0.06	25	0.33 (39%)	0.15	-1.61	0.12
In-field plant diversity	Regional richness	25	0.04 (4%)	0.02	24	0.24 (28%)	0.13	-1.48	0.15

Table S15. Results of one-sample *t*-tests testing whether organic farming and in-field plant diversification impacted pollinator communities. Means are average untransformed log-response ratios comparing organic to conventional, or high to low in-field plant diversity, data. Effect sizes transformed to percent change are in parentheses.

Management scheme	Metric	N	Mean	SE	*t*	*p*-value
Organic vs. conventional	Abundance	20	0.61 (90%)	0.30	2.01	0.058
Organic vs. conventional	Local richness	20	0.42 (55%)	0.16	2.68	0.015
Organic vs. conventional	Local evenness	17	0.05 (5%)	0.10	0.52	0.61
Organic vs. conventional	Regional richness	20	0.27 (32%)	0.12	2.25	0.036
Organic vs. conventional	Regional evenness	20	-0.15 (-15%)	0.10	-1.58	0.13
In-field plant diversity	Abundance	13	0.37 (45%)	0.14	2.62	0.023
In-field plant diversity	Local richness	13	0.36 (44%)	0.12	2.97	0.012
In-field plant diversity	Local evenness	13	-0.11 (-11%)	0.05	-2.07	0.061
In-field plant diversity	Regional richness	13	0.25 (29%)	0.13	2.01	0.068
In-field plant diversity	Regional evenness	13	-0.07 (-6%)	0.13	-0.51	0.62

Table S16. Results of one-sample *t*-tests testing whether organic farming and in-field plant diversification impacted predator communities. Means are average untransformed log-response ratios comparing organic to conventional, or high to low in-field plant diversity, data. Effect sizes transformed to percent change are in parentheses.

Management scheme	**Metric**	**N**	**Mean**	**SE**	***t***	***p*-value**
Organic vs. conventional	Abundance	36	0.32 (39%)	0.09	3.41	0.0020
Organic vs. conventional	Local richness	36	0.15 (14%)	0.06	2.42	0.021
Organic vs. conventional	Local evenness	35	-0.09 (-9%)	0.03	-2.69	0.011
Organic vs. conventional	Regional richness	36	0.09 (6%)	0.06	1.50	0.14
Organic vs. conventional	Regional evenness	36	-0.12 (-14%)	0.05	-2.35	0.024
In-field plant diversity	Abundance	8	-0.10 (-10%)	0.34	-0.29	0.78
In-field plant diversity	Local richness	8	-0.03 (-3%)	0.13	-0.19	0.85
In-field plant diversity	Local evenness	8	0.06 (6%)	0.10	0.54	0.61
In-field plant diversity	Regional richness	8	0.05 (5%)	0.10	0.51	0.63
In-field plant diversity	Regional evenness	8	0.07 (7%)	0.10	0.63	0.55

Table S17. Results of one-sample *t*-tests testing whether organic farming and in-field plant diversification impacted herbivore communities. Means are average untransformed log-response ratios comparing organic to conventional, or high to low in-field plant diversity, data. Effect sizes transformed to percent change are in parentheses.

Management scheme	**Metric**	**N**	**Mean**	**SE**	***t***	***p*-value**
Organic vs. conventional	Abundance	17	0.24 (23%)	0.18	1.30	0.21
Organic vs. conventional	Local richness	17	0.12 (10%)	0.08	1.44	0.17
Organic vs. conventional	Local evenness	14	-0.16 (-14%)	0.12	-1.33	0.21
Organic vs. conventional	Regional richness	17	0.07 (5%)	0.07	1.06	0.30
Organic vs. conventional	Regional evenness	17	-0.07 (-7%)	0.08	-0.89	0.39
In-field plant diversity	Abundance	5	0.25 (28%)	0.42	0.58	0.59
In-field plant diversity	Local richness	5	0.17 (18%)	0.25	0.67	0.54
In-field plant diversity	Local evenness	4	-0.04 (-4%)	0.12	-0.30	0.78
In-field plant diversity	Regional richness	5	-0.04 (-4%)	0.23	-0.20	0.85
In-field plant diversity	Regional evenness	5	-0.10 (-10%)	0.15	0.68	0.53

Table S18. Results of one-sample *t*-tests testing whether organic farming and in-field plant diversification impacted detritivore communities. Means are average untransformed log-response ratios comparing organic to conventional, or high to low in-field plant diversity, data. Effect sizes transformed to percent change are in parentheses.

Management scheme	**Metric**	**N**	**Mean**	**SE**	***t***	***p*-value**
Organic vs. conventional	Abundance	8	0.23 (26%)	0.29	0.79	0.46
Organic vs. conventional	Local richness	8	0.01 (1%)	0.07	0.15	0.89
Organic vs. conventional	Local evenness	7	-0.01 (-1%)	0.09	-0.06	0.95
Organic vs. conventional	Regional richness	8	-0.10 (-9%)	0.11	-0.91	0.39
Organic vs. conventional	Regional evenness	8	0.26 (30%)	0.21	1.28	0.24
In-field plant diversity	Abundance	3	0.55 (74%)	1.03	0.54	0.65
In-field plant diversity	Local richness	3	0.25 (28%)	0.31	0.82	0.50
In-field plant diversity	Local evenness	1	-0.57 (-44%)	NA	NA	NA
In-field plant diversity	Regional richness	3	0.52 (69%)	0.07	7.51	0.017
In-field plant diversity	Regional evenness	3	-1.06 (-65%)	0.22	-4.80	0.041

Table S19. Results of paired *t*-tests testing whether organic farming and in-field plant diversification impacted arthropod abundance and richness differentially for rare and common taxa, in simple and complex landscapes. Means are average untransformed log-response ratios comparing organic to conventional, or high to low in-field plant diversity, data. Effect sizes transformed to percent change are in parentheses.

Management scheme	**Metric**	**Landscape complexity**	**N common taxa**	**Mean common taxa**	**SE common taxa**	**N rare taxa**	**Mean rare taxa**	**SE rare taxa**	***t***	***p*-value**
Organic vs. conventional	Abundance	Simple	45	0.45 (57%)	0.12	43	0.36 (44%)	0.11	0.51	0.61
Organic vs. conventional	Abundance	Complex	30	0.28 (33%)	0.21	28	0.58 (78%)	0.24	-1.90	0.068
Organic vs. conventional	Local richness	Simple	45	0.09 (10%)	0.05	43	0.15 (16%)	0.07	-0.88	0.39
Organic vs. conventional	Local richness	Complex	30	0.19 (21%)	0.10	28	0.36 (44%)	0.16	-2.35	0.027
Organic vs. conventional	Regional richness	Simple	42	0.05 (6%)	0.04	41	0.06 (6%)	0.06	0.10	0.92
Organic vs. conventional	Regional richness	Complex	29	0.04 (4%)	0.04	26	0.16 (17%)	0.07	-2.33	0.028
In-field plant diversity	Abundance	Simple	13	0.24 (27%)	0.22	10	0.08 (8%)	0.07	1.58	0.15
In-field plant diversity	Abundance	Complex	17	0.37 (45%)	0.27	15	0.33 (39%)	0.28	0.05	0.96
In-field plant diversity	Local richness	Simple	13	0.09 (10%)	0.08	10	0.05 (5%)	0.10	1.00	0.35
In-field plant diversity	Local richness	Complex	17	0.16 (18%)	0.09	15	0.52 (68%)	0.23	-2.22	0.044
In-field plant diversity	Regional richness	Simple	10	0.06 (6%)	0.06	10	0.02 (2%)	0.09	-0.04	0.97
In-field plant diversity	Regional richness	Complex	15	0.02 (2%)	0.01	14	0.40 (50%)	0.20	-1.59	0.14

Fig. S1. Data structure and major factors used in the meta-analysis. Each study consisted of a collection of fields (white rectangles, not to scale) situated in simple or complex landscapes. We classified each field as having low or high in-field plant diversity, or being managed organically or conventionally (not shown). Within each study, we divided sampled taxa by functional group (detritivore, herbivore, pollinator, predator). For each sub-group, we calculated local abundance and diversity from field-level taxon pools, and regional diversity from the regional pool.

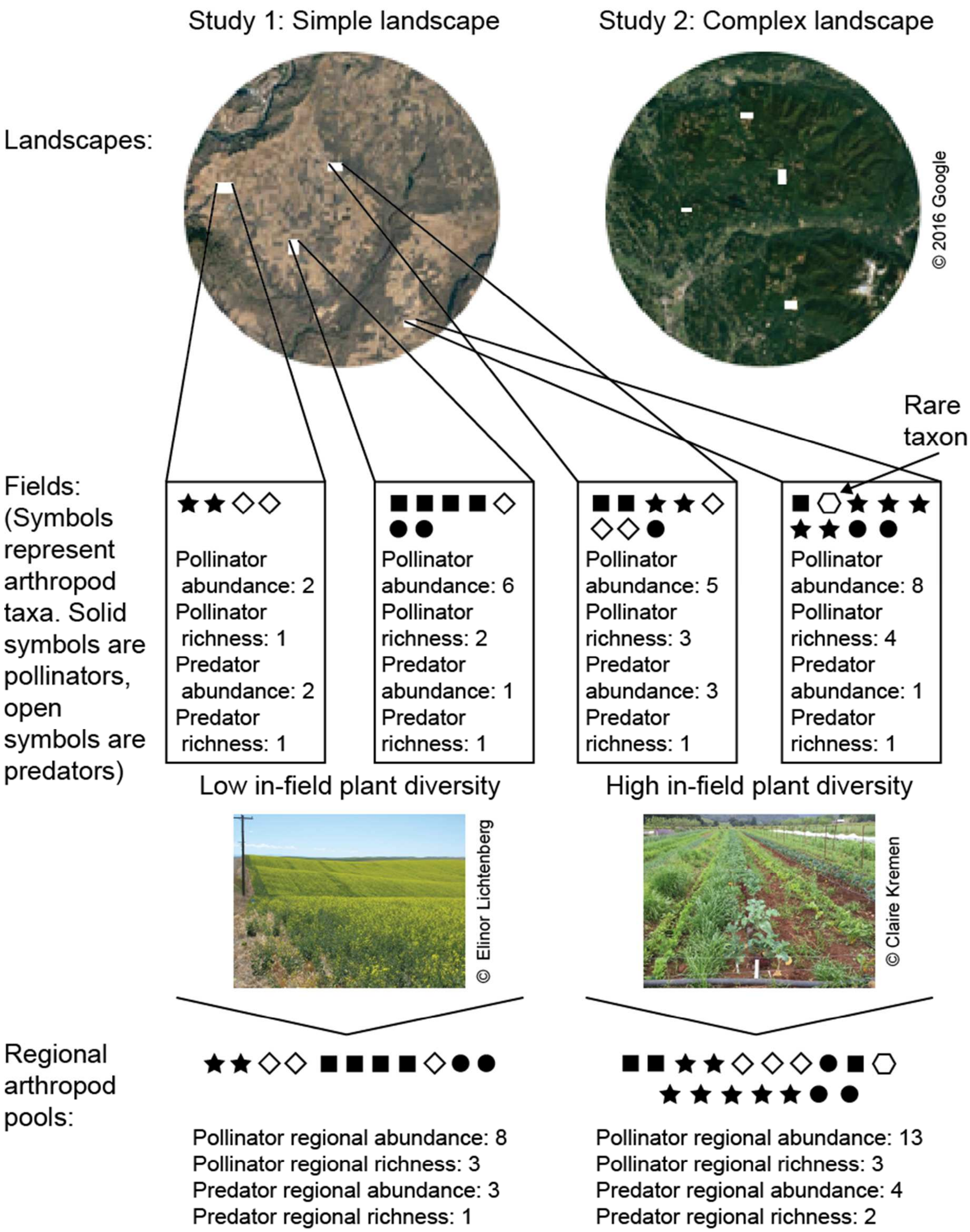


Fig. S2. Map of study sites.

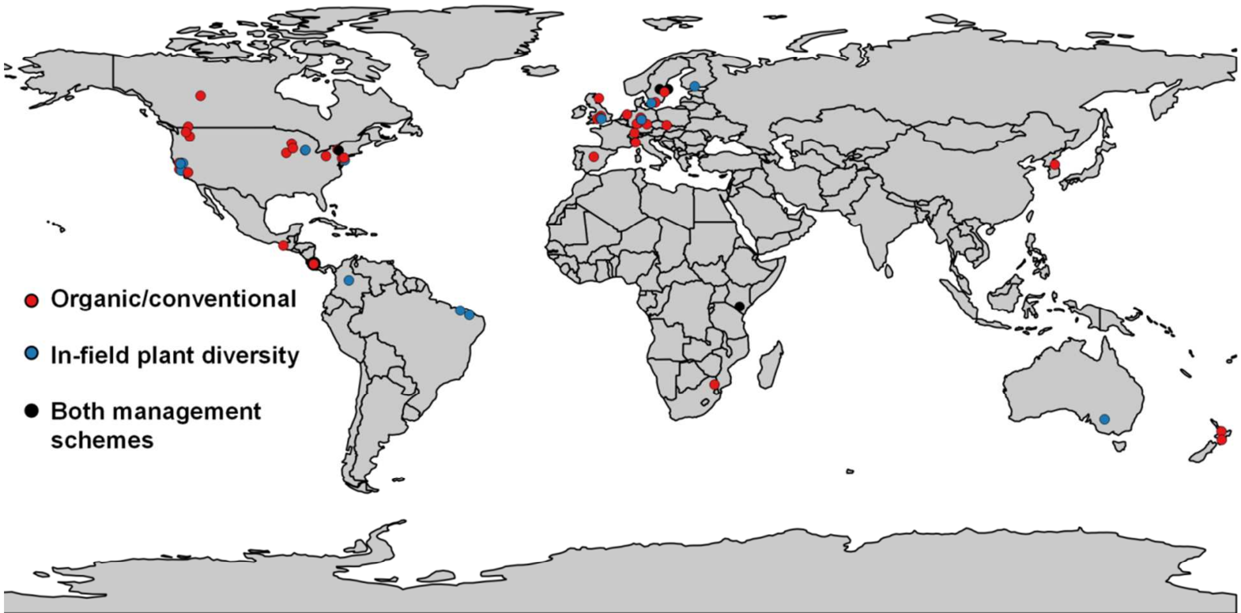


Figure S3. Funnel plots for studies assessing organic vs. conventional farming. All plots are sufficiently symmetrical about their mean (visually assessed) to indicate no publication bias. Effect sizes are log-response ratios.

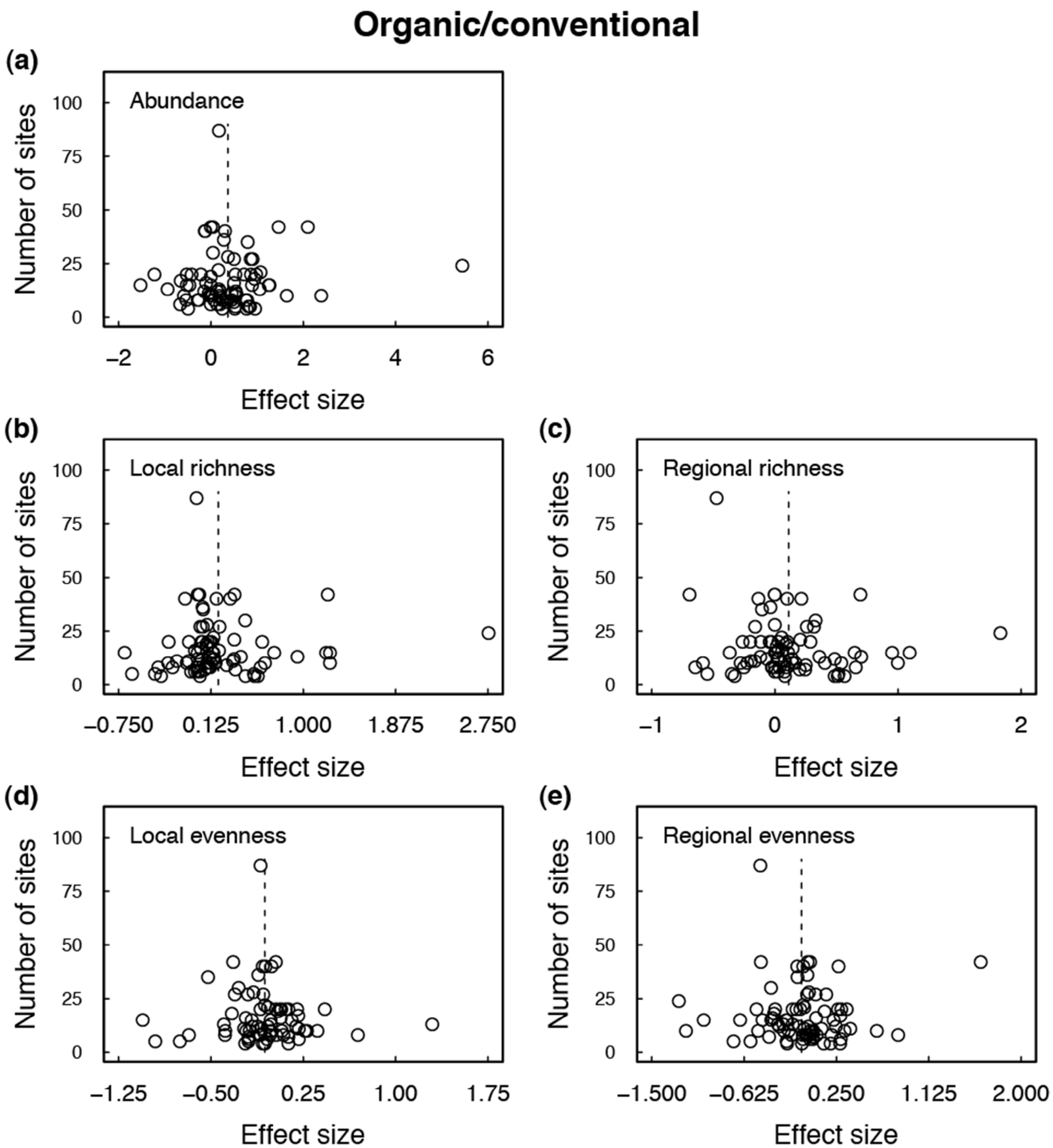


Figure S4. Funnel plots for studies assessing in-field plant diversification. All plots are sufficiently symmetrical about their mean (visually assessed) to indicate no publication bias. Effect sizes are log-response ratios.

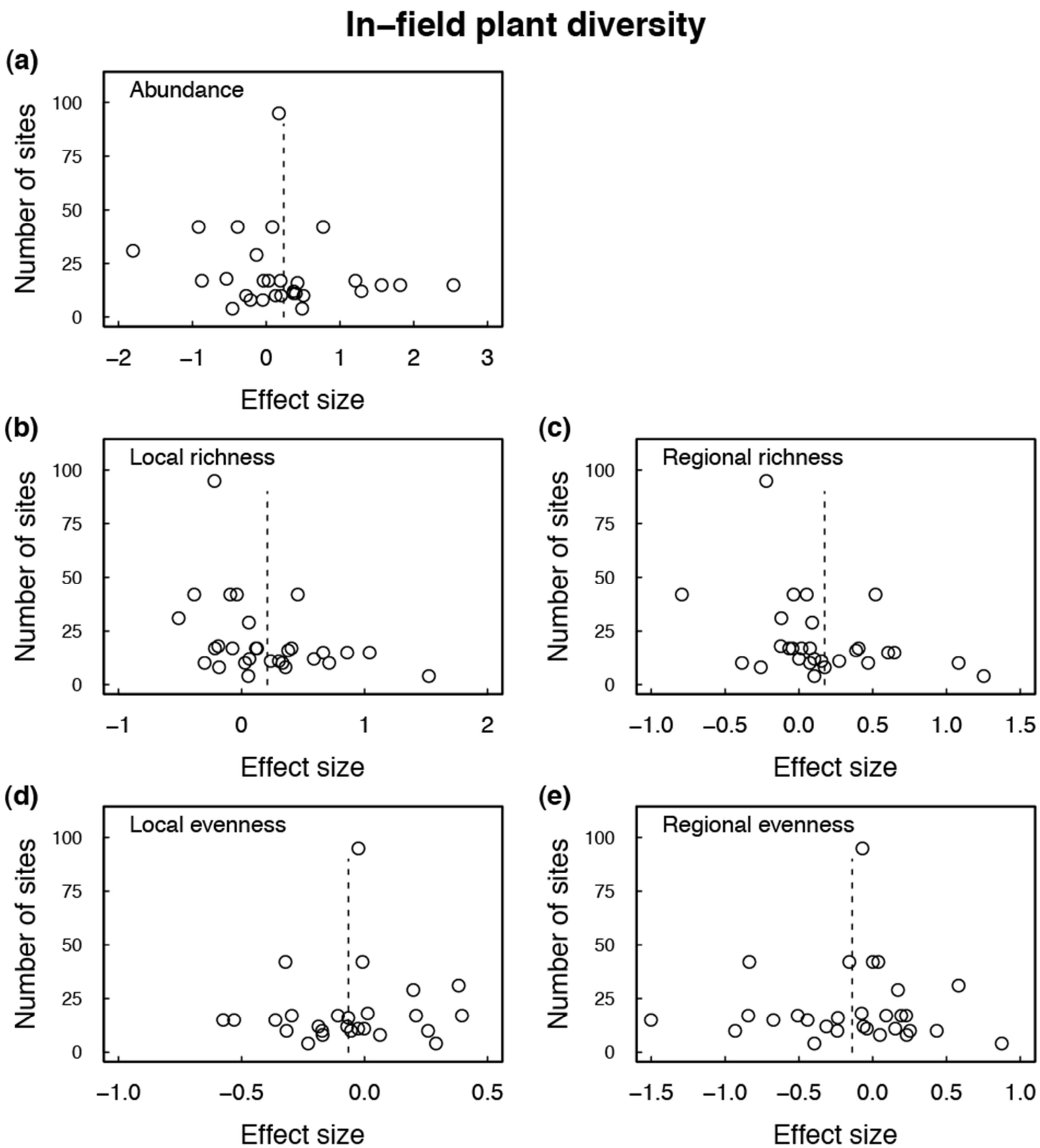


Figure S5. Diversity effects (log-response ratios) strongly correlated at the local and regional scales for both richness (Pearson's correlation: $r = 0.87$, $t_{108} = 18.41$, $p < 0.0001$) and evenness ($r = 0.81$, $t_{97} = 5.83$, $p < 0.0001$).

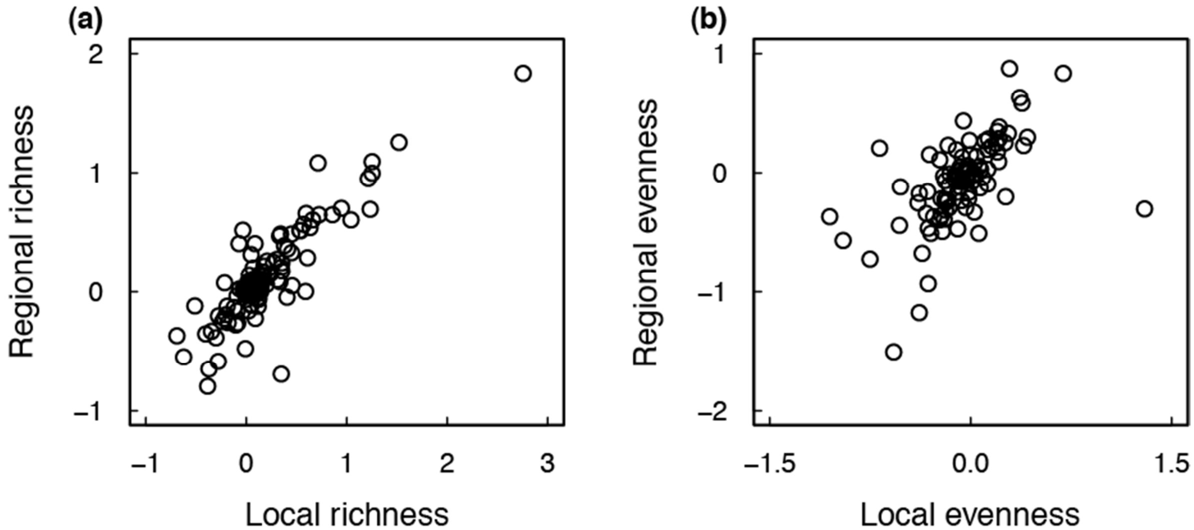


Figure S6. Effects of farm management schemes on abundance (a, b) and richness (c, d) of common vs. rare taxa. Mean log-response ratios (±SE) of (left column) adopting organic farming and (right column) promoting in-field plant diversity. A "*" ($p < 0.05$) or "+" ($0.05 \leq p < 0.1$) above a mean denotes a significant difference from zero (determined via one-sample *t*-tests), while one below a pair of means indicates a significant difference between rare and common taxa (determined via paired *t*-tests).

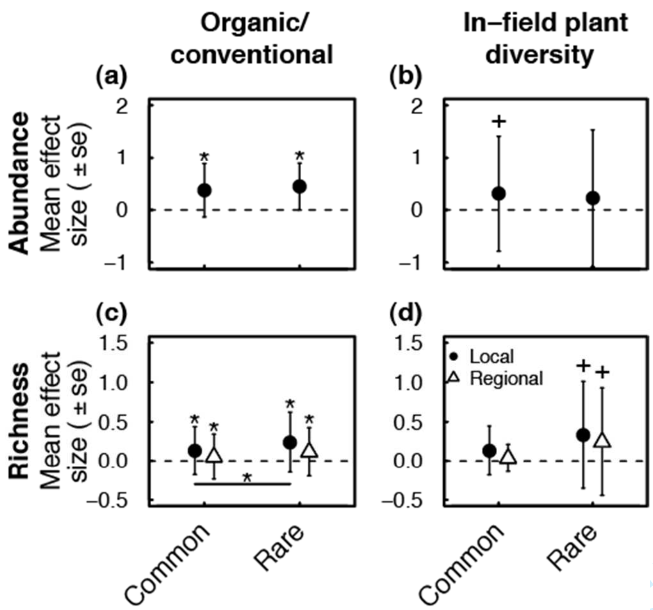


Table S1. Data holders and studies participating. We were unable to categorize landscape complexity when we obtained data directly from published articles that lacked GPS coordinates of sampling locations or information on natural habitat surrounding fields (Study IDs drit01, febe01, hesl01, hokk01, and weib01). These studies were excluded from meta-regressions.

Study ID	**Reference or data holder**	**Crop(s)**	**Study location**	**Functional group(s)**	**Management scheme(s)**	**# sites** (o=organic/ conventional, i-f=in-field plant diversity)	**Year(s)**
arms01	(Armstrong, 1995)	potato	Scotland	predators	organic/ conventional	4	1992
bata01	(Batáry *et al.*, 2012)	wheat	Germany	predators	organic/ conventional	18	2008
benj01	(Cariveau *et al.*, 2013)	blueberry	USA	pollinators	in-field plant diversity	16	2012
bere01	(Winqvist *et al.*, 2011)	wheat	Netherlands	predators	organic/ conventional	35	2007
bomm01	(Winqvist *et al.*, 2011)	wheat	Sweden	predators	organic/ conventional, in-field plant diversity	95	2007
bosq01	Bosque-Perez, Nilsa; Ramos, Mariangie	coffee	Costa Rica	herbivores	organic/ conventional, in-field plant diversity	18 (o), 19 (i-f)	2005
carv01	(Carvalheiro *et al.*, 2010, 2012)	mango	South Africa	herbivores, pollinators, predators	organic/ conventional	15	2009

chap01	(Chaplin-Kramer *et al.*, 2013)	broccoli	USA	detritivores, herbivores, predators	in-field plant diversity	17	2008
clou01	(Clough *et al.*, 2005, 2007a, 2007b)	wheat	Germany	detritivores, herbivores, predators	organic/ conventional, in-field plant diversity	42 (o), 17 (i-f)	2003
conn01	(Connelly *et al.*, 2015)	strawberry	USA	pollinators	organic/ conventional	13	2012
danf01	(Russo *et al.*, 2015)	apple	USA	pollinators	organic/ conventional, in-field plant diversity	10	2009
diek01	(Diekötter *et al.*, 2010)	wheat	Germany	detritivores, herbivores, predators	organic/ conventional	12	2007
drit01	(Dritschilo & Erwin, 1982)	corn	USA	predators	organic/ conventional	8	late 1970s?
eige01	Eigenbrode, Sanford	coffee	Costa Rica	predators	organic/ conventional	6	2001
ekro01	(Ekroos *et al.*, 2010)	various grains (combined)	Finland	predators	organic/ conventional, in-field plant diversity	28 (o), 29 (i-f)	1998
febe01	(Feber *et al.*, 1998)	wheat	England	predators	organic/ conventional	6	1995
frei01	Freitas, Breno	acerola	Brazil	pollinators	in-field plant diversity	4	2010

frei02	Freitas, Breno	cotton	Brazil	pollinators	in-field plant diversity	4	2010
fuku01	(Fukuda *et al.*, 2011)	pasture	New Zealand	detritivores, herbivores, predators	organic/ conventional	20	2009
gain01	Gaines, Hannah; Gratton, Claudio	cranberry	USA	pollinators	organic/ conventional	15	2008
hesl01	(Hesler *et al.*, 1993)	rice	USA	herbivores, predators	organic/ conventional	6	1988
hokk01	(Hokkanen & Holopainen, 1986)	cabbage	Germany	herbivores, predators	organic/ conventional	4	1982
holz01	(Holzschuh *et al.*, 2007)	wheat	Germany	pollinators	organic/ conventional, in-field plant diversity	42	2003
isaa01	(Isaacs & Kirk, 2010)	blueberry	USA	pollinators	in-field plant diversity	12	2008
isai01	(Isaia *et al.*, 2006)	grape	Italy	predators	organic/ conventional	5	2003
jha01	(Jha & Vandermeer, 2010)	coffee	Mexico	pollinators	organic/ conventional	7	2006
jona01	(Jonason *et al.*, 2013)	various grains (combined)	Sweden	herbivores, predators	organic/ conventional	36	2011

jone01	(Jones *et al.*, In press, In pressb; Mills *et al.*, In press)	apple	USA	herbivores, pollinators, predators	organic/ conventional	8	2011
klat01	Klatt, Björn; Tscharntke, Teja	strawberry	Germany	pollinators	in-field plant diversity	8	2010
klei01	Brittain, Claire; Klein, Alexandra	almond	USA	pollinators	organic/ conventional	13	2009
krau01	(Krauss *et al.*, 2011)	triticale	Germany	pollinators	organic/ conventional	24	2008
krem01	(Kremen *et al.*, 2002, 2004)	watermelon	USA	pollinators	organic/ conventional	21	2000
leto01	(Drinkwater *et al.*, 1995; Letourneau & Goldstein, 2001; Letourneau & Bothwell, 2007; Letourneau *et al.*, 2012, 2015)	broccoli, brussel sprouts	USA	predators	organic/ conventional, in-field plant diversity	10	2006
mall01	(Mallinger *et al.*, 2015)	apple	USA	pollinators	organic/ conventional	17	2012
mart01	(Martin *et al.*, 2016)	potato, daikon radish, rice, soybean	South Korea	predators	organic/ conventional	7 (radish), 8 (other crops)	2009

memm01	(Gibson *et al.*, 2007; Macfadyen *et al.*, 2009a, 2009b, 2011a, 2011b)	grains, brassicas, legumes	England	herbivores, predators	organic/ conventional	20 (grains), 5 (brassicas), 10 (legumes)	2005 (grains, legumes), 2006 (brassicas)
mora01	(Morandin & Winston, 2005, 2006)	canola	Canada	pollinators	organic/ conventional	16	2002
neam01	Elle, Elizabeth; Neame, Lisa	winter squash	Canada	pollinators	organic/ conventional	9	2010
ober01	(Öberg, 2007; Öberg *et al.*, 2007)	various grains (combined)	Sweden	predators	organic/ conventional, in-field plant diversity	8	2003 (i-f), 2004 (o)
otie01	(Otieno *et al.*, 2015)	pigeonpea	Kenya	pollinators	organic/ conventional, in-field plant diversity	12	2009
pfif01	(Pfiffner & Luka, 2003)	various grains (combined)	Switzerland	predators	organic/ conventional	12	1996-8
poco01	(Pocock & Jennings, 2008)	various grains (combined)	England	detritivores, herbivores, predators	organic/ conventional	40	2003
ponc01	(Ponce *et al.*, 2011)	wheat, barley	Spain	detritivores, herbivores, predators	organic/ conventional	27 (wheat), 11 (barley)	2008
pott01	(Carré *et al.*, 2009)	field bean	England	pollinators	in-field plant diversity	10	2005

pove01	(Poveda *et al.*, 2012); Martinez, Eliana	potato	Colombia	herbivores, predators	in-field plant diversity	11	2007
rose01	(de Valpine & Rosenheim, 2008)	cotton	USA	herbivores, predators	organic/ conventional	15	1993
rund01	(Bommarco *et al.*, 2012)	red clover	Sweden	pollinators	in-field plant diversity	17	2010
sard01	(Sardiñas & Kremen, 2015)	sunflower	USA	pollinators	in-field plant diversity	10	2011
saun01	(Saunders & Luck, 2013)	almond	Australia	detritivores, herbivores, predators	in-field plant diversity	15	2010
scho01	(Schon *et al.*, 2011)	pasture	New Zealand	detritivores, herbivores, predators	organic/ conventional	10	2007
scil01	Sciligo, Amber	strawberry	USA	pollinators	in-field plant diversity	17	2012
sidh01	(Sidhu, 2013)	squash	USA	pollinators	organic/ conventional	8	2011
snyd01	Crowder, David; Snyder, William	potato	USA	detritivores, herbivores, predators	organic/ conventional	20	2010
vese01	(Veselý & Šarapatka, 2008)	wheat, barley	Czech Republic	predators	organic/ conventional	4 (wheat), 4 (barley)	2001 (wheat), 2005 (barley)

weib01	(Weibull *et al.*, 2000)	cereals, clovers, grasses (combined)	Sweden	pollinators	organic/ conventional	16	1997-8
weis01	(Winqvist *et al.*, 2011)	wheat	Germany	predators	organic/ conventional, in-field plant diversity	30 (o), 31 (i-f)	2007
will01	Williams, Neal	watermelon	USA	pollinators	in-field plant diversity	10	2010
wils01	(Tuell *et al.*, 2009)	blueberry	USA	pollinators	organic/ conventional	15	2005
winf01	(Winfree *et al.*, 2007, 2008; Lonsdorf *et al.*, 2009; Rader *et al.*, 2013)	watermelon	USA	pollinators	organic/ conventional	10	2010
winf02	(Winfree *et al.*, 2008)	pepper, tomato	USA	pollinators	organic/ conventional	22 (pepper), 13 (tomato)	2004 (pepper), 2005 (tomato)

References in Table S1

Armstrong G (1995) Carabid beetle (Coleoptera, Carabidae) diversity and abundance in organic potatoes and conventionally grown seed potatoes in the north of Scotland. *Pedobiologia*, **39**, 231–237.

Batáry P, Holzschuh A, Orci KM, Samu F, Tscharntke T (2012) Responses of plant, insect and spider biodiversity to local and landscape scale management intensity in cereal crops and grasslands. *Agriculture, Ecosystems & Environment*, **146**, 130–136.

Bommarco R, Lundin O, Smith HG, Rundlöf M (2012) Drastic historic shifts in bumble-bee community composition in Sweden. *Proceedings of the Royal Society B: Biological Sciences*, **279**, 309–315.

Cariveau DP, Williams NM, Benjamin FE, Winfree R (2013) Response diversity to land use occurs but does not consistently stabilise ecosystem services provided by native pollinators. *Ecology Letters*, **16**, 903–911.

Carré G, Roche P, Chifflet R et al. (2009) Landscape context and habitat type as drivers of bee diversity in European annual crops. *Agriculture, Ecosystems & Environment*, **133**, 40–47.

Carvalheiro LG, Seymour CL, Veldtman R, Nicolson SW (2010) Pollination services decline with distance from natural habitat even in biodiversity-rich areas. *Journal of Applied Ecology*, **47**, 810–820.

Carvalheiro LG, Seymour CL, Nicolson SW, Veldtman R (2012) Creating patches of native flowers facilitates crop pollination in large agricultural fields: mango as a case study. *Journal of Applied Ecology*, **49**, 1373–1383.

Chaplin-Kramer R, de Valpine P, Mills NJ, Kremen C (2013) Detecting pest control services across spatial and temporal scales. *Agriculture, Ecosystems & Environment*, **181**, 206–212.

Clough Y, Kruess A, Kleijn D, Tscharntke T (2005) Spider diversity in cereal fields: comparing factors at local, landscape and regional scales. *Journal of Biogeography*, **32**, 2007–2014.

Clough Y, Holzschuh A, Gabriel D et al. (2007a) Alpha and beta diversity of arthropods and plants in organically and conventionally managed wheat fields. *Journal of Applied Ecology*, **44**, 804–812.

Clough Y, Kruess A, Tscharntke T (2007b) Organic versus conventional arable farming systems: Functional grouping helps understand staphylinid response. *Agriculture, Ecosystems & Environment*, **118**, 285–290.

Connelly H, Poveda K, Loeb G (2015) Landscape simplification decreases wild bee pollination services to strawberry. *Agriculture, Ecosystems & Environment*, **211**, 51–56.

Diekötter T, Wamser S, Wolters V, Birkhofer K (2010) Landscape and management effects on structure and function of soil arthropod communities in winter wheat. *Agriculture, Ecosystems & Environment*, **137**, 108–112.

Drinkwater LE, Letourneau DK, Workneh F, Bruggen AHC van, Shennan C (1995) Fundamental differences between conventional and organic tomato agroecosystems in California. *Ecological Applications*, **5**, 1098–1112.

Dritschilo W, Erwin TL (1982) Responses in abundance and diversity of cornfield carabid communities to differences in farm practices. *Ecology*, **63**, 900–904.

Ekroos J, Hyvönen T, Tiainen J, Tiira M (2010) Responses in plant and carabid communities to farming practises in boreal landscapes. *Agriculture, Ecosystems & Environment*, **135**, 288–293.

Feber RE, Bell J, Johnson PJ, Firbank LG, MacDonald DW (1998) The effects of organic farming on surface-active spider (Araneae) assemblages in wheat in southern England, UK. *Journal of Arachnology*, **26**, 190–202.

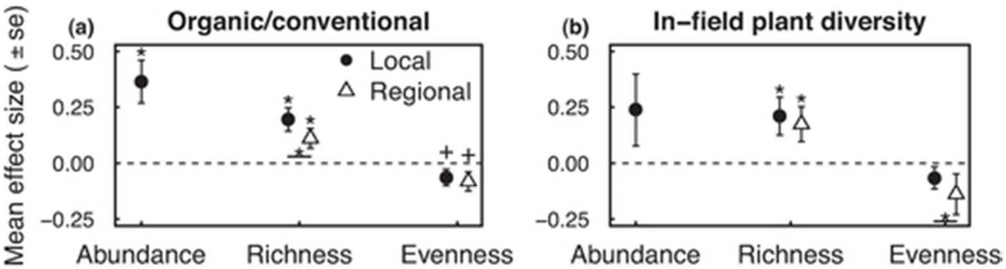
Fukuda Y, Moller H, Burns B (2011) Effects of organic farming, fencing and vegetation origin on spiders and beetles within shelterbelts on dairy farms. *New Zealand Journal of Agricultural Research*, **54**, 155–176.

Gibson RH, Pearce S, Morris RJ, Symondson WOC, Memmott J (2007) Plant diversity and land use under organic and conventional agriculture: a whole-farm approach. *Journal of Applied Ecology*, **44**, 792–803.

Hesler LS, Grigarick AA, Oraze MJ, Palrang AT (1993) Arthropod fauna of conventional and organic rice fields in California. *Journal of Economic Entomology*, **86**, 149–158.
Hokkanen H, Holopainen JK (1986) Carabid species and activity densities in biologically and conventionally managed cabbage fields. *Journal of Applied Entomology*, **102**, 353–363.
Holzschuh A, Steffan-Dewenter I, Kleijn D, Tscharntke T (2007) Diversity of flower-visiting bees in cereal fields: effects of farming system, landscape composition and regional context. *Journal of Applied Ecology*, **44**, 41–49.
Isaacs R, Kirk AK (2010) Pollination services provided to small and large highbush blueberry fields by wild and managed bees. *Journal of Applied Ecology*, **47**, 841–849.
Isaia M, Bona F, Badino G (2006) Influence of landscape diversity and agricultural practices on spider assemblage in Italian vineyards of Langa Astigiana (Northwest Italy). *Environmental Entomology*, **35**, 297–307.
Jha S, Vandermeer JH (2010) Impacts of coffee agroforestry management on tropical bee communities. *Biological Conservation*, **143**, 1423–1431.
Jonason D, Smith HG, Bengtsson J, Birkhofer K (2013) Landscape simplification promotes weed seed predation by carabid beetles (Coleoptera: Carabidae). *Landscape Ecology*, **28**, 487–494.
Jones VP, Horton DR, Mills NJ et al. (In press) Evaluating plant volatiles for monitoring natural enemies in apple, pear and walnut orchards. *Biological Control*.
Jones VP, Horton DR, Mills NJ et al. (In press) Using plant volatile traps to develop phenology models for natural enemies: An example using *Chrysopa nigricornis* (Burmeister) (Neuroptera: Chrysopidae). *Biological Control*.
Krauss J, Gallenberger I, Steffan-Dewenter I (2011) Decreased functional diversity and biological pest control in conventional compared to organic crop fields. *PLoS ONE*, **6**, e19502.
Kremen C, Williams NM, Thorp RW (2002) Crop pollination from native bees at risk from agricultural intensification. *Proceedings of the National Academy of Sciences*, **99**, 16812–16816.
Kremen C, Williams NM, Bugg RL, Fay JP, Thorp RW (2004) The area requirements of an ecosystem service: crop pollination by native bee communities in California. *Ecology Letters*, **7**, 1109–1119.
Letourneau DK, Bothwell SG (2007) Comparison of organic and conventional farms: challenging ecologists to make biodiversity functional. *Frontiers in Ecology and the Environment*, **6**, 430–438.
Letourneau D k., Goldstein B (2001) Pest damage and arthropod community structure in organic vs. conventional tomato production in California. *Journal of Applied Ecology*, **38**, 557–570.
Letourneau DK, Bothwell Allen SG, Stireman JO (2012) Perennial habitat fragments, parasitoid diversity and parasitism in ephemeral crops. *Journal of Applied Ecology*, **49**, 1405–1416.
Letourneau DK, Bothwell Allen SG, Kula RR, Sharkey MJ, Stireman III JO (2015) Habitat eradication and cropland intensification may reduce parasitoid diversity and natural pest control services in annual crop fields. *Elementa: Science of the Anthropocene*, **3**, 69.

Lonsdorf E, Kremen C, Ricketts T, Winfree R, Williams N, Greenleaf S (2009) Modelling pollination services across agricultural landscapes. *Annals of Botany*, **103**, 1589–1600.
Macfadyen S, Gibson R, Polaszek A et al. (2009a) Do differences in food web structure between organic and conventional farms affect the ecosystem service of pest control? *Ecology Letters*, **12**, 229–238.
Macfadyen S, Gibson R, Raso L, Sint D, Traugott M, Memmott J (2009b) Parasitoid control of aphids in organic and conventional farming systems. *Agriculture, Ecosystems & Environment*, **133**, 14–18.
Macfadyen S, Craze PG, Polaszek A, Achterberg K van, Memmott J (2011a) Parasitoid diversity reduces the variability in pest control services across time on farms. *Proceedings of the Royal Society of London B: Biological Sciences*, **278**, 3387–3394.
Macfadyen S, Gibson RH, Symondson WOC, Memmott J (2011b) Landscape structure influences modularity patterns in farm food webs: consequences for pest control. *Ecological Applications*, **21**, 516–524.
Mallinger RE, Werts P, Gratton C (2015) Pesticide use within a pollinator-dependent crop has negative effects on the abundance and species richness of sweat bees, *Lasioglossum* spp., and on bumble bee colony growth. *Journal of Insect Conservation*, **19**, 999–1010.
Martin EA, Seo B, Park C-R, Reineking B, Steffan-Dewenter I (2016) Scale-dependent effects of landscape composition and configuration on natural enemy diversity, crop herbivory, and yields. *Ecological Applications*, **26**, 448–462.
Mills NJ, Jones VP, Baker CC et al. (In press) Using plant volatile traps to estimate the diversity of natural enemy communities in orchard ecosystems. *Biological Control*.
Morandin LA, Winston ML (2005) Wild bee abundance and seed production in conventional, organic, and genetically modified canola. *Ecological Applications*, **15**, 871–881.
Morandin LA, Winston ML (2006) Pollinators provide economic incentive to preserve natural land in agroecosystems. *Agriculture, Ecosystems & Environment*, **116**, 289–292.
Öberg S (2007) Diversity of spiders after spring sowing – influence of farming system and habitat type. *Journal of Applied Entomology*, **131**, 524–531.
Öberg S, Ekbom B, Bommarco R (2007) Influence of habitat type and surrounding landscape on spider diversity in Swedish agroecosystems. *Agriculture, Ecosystems & Environment*, **122**, 211–219.
Otieno M, Sidhu CS, Woodcock BA et al. (2015) Local and landscape effects on bee functional guilds in pigeon pea crops in Kenya. *Journal of Insect Conservation*, **19**, 647–658.
Pfiffner L, Luka H (2003) Effects of low-input farming systems on carabids and epigeal spiders – a paired farm approach. *Basic and Applied Ecology*, **4**, 117–127.
Pocock MJO, Jennings N (2008) Testing biotic indicator taxa: the sensitivity of insectivorous mammals and their prey to the intensification of lowland agriculture. *Journal of Applied Ecology*, **45**, 151–160.
Ponce C, Bravo C, de León DG, Magaña M, Alonso JC (2011) Effects of organic farming on plant and arthropod communities: A case study in Mediterranean dryland cereal. *Agriculture, Ecosystems & Environment*, **141**, 193–201.

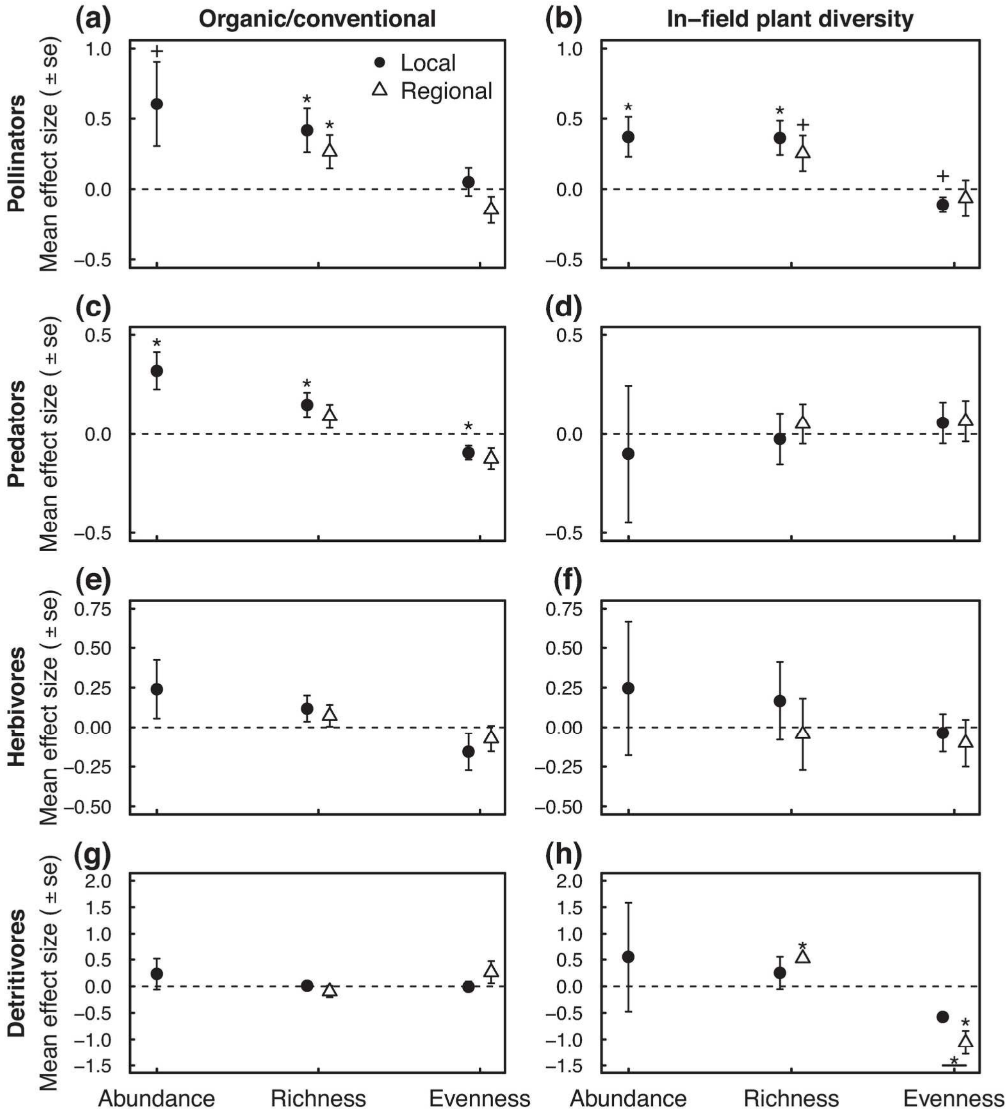
Poveda K, Martínez E, Kersch-Becker MF, Bonilla MA, Tscharntke T (2012) Landscape simplification and altitude affect biodiversity, herbivory and Andean potato yield. *Journal of Applied Ecology*, **49**, 513–522.
Rader R, Reilly J, Bartomeus I, Winfree R (2013) Native bees buffer the negative impact of climate warming on honey bee pollination of watermelon crops. *Global Change Biology*, **19**, 3103–3110.
Russo L, Park M, Gibbs J, Danforth B (2015) The challenge of accurately documenting bee species richness in agroecosystems: bee diversity in eastern apple orchards. *Ecology and Evolution*, **5**, 3531–3540.
Sardiñas HS, Kremen C (2015) Pollination services from field-scale agricultural diversification may be context-dependent. *Agriculture, Ecosystems & Environment*, **207**, 17–25.
Saunders ME, Luck GW (2013) Pan trap catches of pollinator insects vary with habitat. *Australian Journal of Entomology*, **52**, 106–113.
Schon NL, Mackay AD, Minor MA (2011) Soil fauna in sheep-grazed hill pastures under organic and conventional livestock management and in an adjacent ungrazed pasture. *Pedobiologia*, **54**, 161–168.
Sidhu CS (2013) *Farmscape and landscape-level effects on cucurbit pollinators on small farms in a diversified agroecosystem*. PhD dissertation, The Pennsylvania State University, State College, PA, 204 pp.
Tuell JK, Ascher JS, Isaacs R (2009) Wild bees (Hymenoptera: Apoidea: Anthophila) of the Michigan highbush blueberry agroecosystem. *Annals of the Entomological Society of America*, **102**, 275–287.
de Valpine P, Rosenheim JA (2008) Field-scale roles of density, temperature, nitrogen, and predation on aphid population dynamics. *Ecology*, **89**, 532–541.
Veselý M, Šarapatka B (2008) Effects of conversion to organic farming on carabid beetles (Carabidae) in experimental fields in the Czech Republic. *Biological Agriculture & Horticulture*, **25**, 289–309.
Weibull A-C, Bengtsson J, Nohlgren E (2000) Diversity of butterflies in the agricultural landscape: the role of farming system and landscape heterogeneity. *Ecography*, **23**, 743–750.
Winfree R, Williams NM, Dushoff J, Kremen C (2007) Native bees provide insurance against ongoing honey bee losses. *Ecology Letters*, **10**, 1105–1113.
Winfree R, Williams NM, Gaines H, Ascher JS, Kremen C (2008) Wild bee pollinators provide the majority of crop visitation across land-use gradients in New Jersey and Pennsylvania, USA. *Journal of Applied Ecology*, **45**, 793–802.
Winqvist C, Bengtsson J, Aavik T et al. (2011) Mixed effects of organic farming and landscape complexity on farmland biodiversity and biological control potential across Europe. *Journal of Applied Ecology*, **48**, 570–579.



Effects of farm management schemes on arthropod abundance, local diversity, and regional diversity. Values shown are for the entire arthropod community, and represent the mean log-response ratio (± SE) of (a) adopting organic farming and (b) promoting in-field plant diversity on abundance, richness, and evenness. A "*" ($p < 0.05$) or "+" ($0.05 \leq p < 0.1$) above a mean denotes a significant difference from zero (determined via one-sample t-tests; statistical details in Table S8), while one below a pair of means indicates a significant difference between local and regional diversity (determined via linear mixed models; Tables S9-S12).

Fig. 1

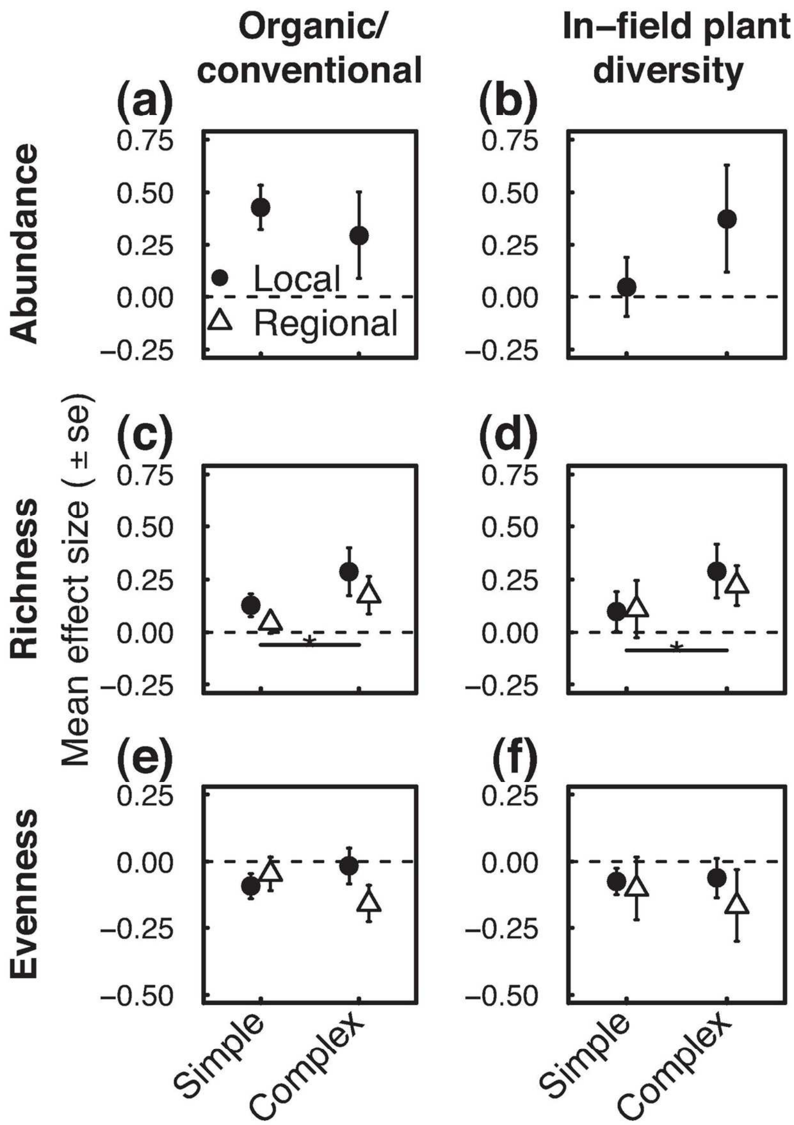
44x12mm (300 x 300 DPI)



Effects of farm management schemes on abundance, local diversity, and regional diversity of arthropod functional groups. Mean log-response ratios (± SE) of (left column) adopting organic farming and (right column) promoting in-field plant diversity for (a-b) pollinators, (c-d) predators, (e-f) herbivores, and (g-h) detritivores. A "*" ($p < 0.05$) or "+" ($0.05 \le p < 0.1$) above a mean denotes a significant difference from zero (determined via one-sample t-tests; Tables S15-S18). Meta-regressions indicated that differences between local and regional values did not vary with functional group (Tables S9-S12).

Fig. 2

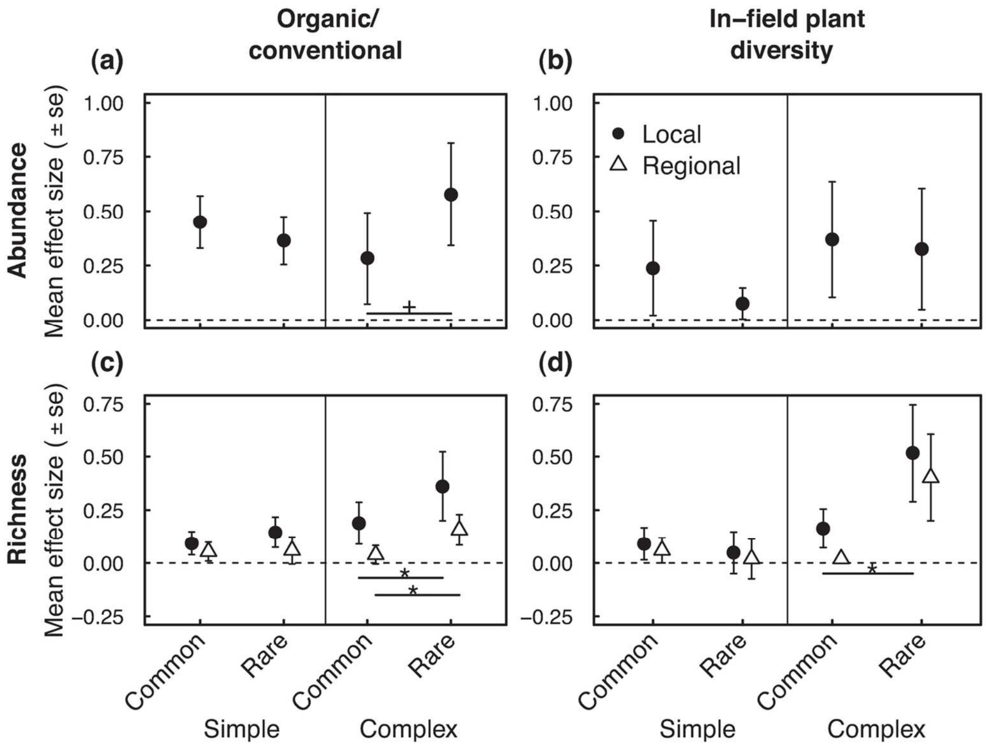
190x218mm (300 x 300 DPI)



Effects of landscape complexity on the entire arthropod community in organic vs. conventional farms (left column) and fields with high vs. low in-field plant diversity (right column). Each graph shows the mean log-response ratio (± SE) for studies in simple (≤ 20% natural habitat) or complex (>20% natural habitat) landscapes for (a,b) abundance, (c,d) richness, and (e,f) evenness. A "*" ($p < 0.05$) or "+" ($0.05 \leq p < 0.1$) below a set of means indicates a significant difference between means at the habitat complexity levels (Tables S9-S12).

Fig. 3

114x174mm (300 x 300 DPI)



Effects of farm management schemes on abundance (a, b) and richness (c, d) of common vs. rare taxa in simple and complex landscapes. Mean log-response ratios (±SE) of (left column) adopting organic farming and (right column) promoting in-field plant diversity. A "*" ($p < 0.05$) or "+" ($0.05 \leq p < 0.1$) below a pair of means indicates a significant difference between rare and common taxa within a landscape complexity category (determined via paired t-tests; Table S19).

Fig. 4

125x93mm (300 x 300 DPI)