Appendix S1. References of published studies included in our synthesis.

Arthur, A.D., Li, J., Henry, S. & Cunningham, S.A. (2010). Influence of woody vegetation on pollinator densities in oilseed Brassica fields in an Australian temperate landscape. *Basic and Applied Ecology*, 11, 406-414.

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

Bommarco, R., Marini, L. & Vaissière, B.E. (2012). Insect pollination enhances seed yield, quality and market value in oilseed rape. Oecologia, 169, 1025-1032.

Blanche, K.R., Ludwig, J.A. & Cunningham, S.A. (2006). Proximity to rainforest enhances pollination and fruit set in orchards. *Journal of Applied Ecology*, 43, 1182-1187.

Carré, G., Roche, P., Chifflet, R., Morison, N., Bommarco, R., Harrison-Crips, J., Krewenka, K., Potts, S.G., Roberts, S.P.M., Rodet, G., Settele, J., Steffan-Dewenter, I., Szentgyörgyi, H., Tscheulin, T., Westphal, C., Woyciechowski, M. & Vaissière, B.E. (2009). Landscape context and habitat type as drivers of bee diversity in European annual crops *Agriculture, Ecosystems and Environment*, 133, 40-47.

Carvalheiro, L.G., Seymour, C.L., Veldtman, R. & Nicolson, S.W. (2010). Pollination services decline with distance from natural habitat even in biodiversity-rich areas. *Journal of Applied Ecology*, 47, 810-820.

Carvalheiro, L.G., Veldtman, R., Shenkute, A.G., Tesfay, G.B., Pirk, C.W.W., Donaldson, J.S. & Nicolson, S.W. (2011). Natural and within-farmland biodiversity enhances crop productivity. *Ecology Letters*, 14, 251-259.

Chacoff, N.P., Aizen, M.A. & Aschero, V. (2008). Proximity to forest edge does not affect crop production despite pollen limitation. *Proceedings of the Royal Society B-Biological Sciences*, 275, 907-913.

Chacoff, N.P. & Aizen, M.A. (2006). Edge effects on flower-visiting insects in grapefruit plantations bordering premontane subtropical forest. *Journal of Applied Ecology*, 43, 18-27.

Greenleaf, S.S. & Kremen, C. (2006a). Wild bee species increase tomato production and respond differently to surrounding land use in Northern California. *Biological Conservation*, 133, 81-87.

Greenleaf, S.S. & Kremen, C. (2006b). Wild bees enhance honey bees' pollination of hybrid sunflower. *Proceedings of the National Academy of Sciences - USA*, 103, 13890-13895.

Holzschuh, A., Dudenhöffer, J.-H., Tscharntke, T. (2012). Landscapes with wild bee habitats enhance pollination, fruit set and yield of sweet cherry. *Biological Conservation*, 153, 101-107

Isaacs, R. & Kirk, A.K. (2010). Pollination services provided to small and large highbush blueberry fields by wild and managed bees. *Journal of Applied Ecology*, 47, 841-849.

Jha, S. & Vandermeer, J.H. (2010). Impacts of coffee agroforestry management on tropical bee communities. *Biological Conservation*, 143, 1423-1431.

Klein, A.-M., Brittain, C., Hendrix, S.D., Thorp, R., Williams, N., & Kremen, C. (2012). Wild pollination services to California almond rely on semi-natural habitat. *Journal of Applied Ecology*, 49, 723-732.

Kremen, C., Williams, N.M. & Thorp, R.W. (2002). Crop pollination from native bees at risk from agricultural intensification. *Proceedings of the National Academy of Sciences*, 99, 16812-16816.

Kremen, C., Williams, N.M., Bugg, R.L., Fay, J.P. & Thorp, R.W. (2004). The area requirements of an ecosystem service: crop pollination by native bee communities in California. *Ecology Letters*, 7, 1109-1119.

Morandin, L.A. & Winston, M.L. (2005). Wild bee abundance and seed production in conventional, organic, and genetically modified canola. *Ecological Applications*, 15, 871-881.

Morandin, L.A. & Winston, M.L. (2006). Pollinators provide economic incentive to preserve natural land in agroecosystems. *Agriculture, Ecosystems & Environment*, 116, 289-292.

Ricketts, T.H. (2004). Tropical forest fragments enhance pollinator activity in nearby coffee crops. *Conservation Biology*, 18, 1262-1271.

Ricketts, T.H., Daily, G.C., Ehrlich, P.R. & Michener, C.D. (2004). Economic value of tropical forest to coffee production. *Procedings of the National Academy of Sciences - USA*, 101, 12579-12582.

Sáez, A., Sabatino, M., Aizen, M.A. (2012) Interactive Effects of Large- and Small-Scale Sources of Feral Honey-Bees for Sunflower in the Argentine Pampas. *PLoS ONE,* 7, e30968.

Taki, H., Okabe, K., Makino, S., Yamaura, Y. & Sueyoshi, M. (2009). Contribution of small insects to pollination of common buckwheat, a distylous crop. *Annals of Applied Biology*, 155, 121-129.

Taki, H., Okabe, K., Yamaura, Y., Matsuura, T., Sueyoshi, M., Makino, S.i. & Maeto, K. (2010). Effects of landscape metrics on Apis and non-Apis pollinators and seed set in common buckwheat. *Basic and Applied Ecology*, 11, 594-602.

Tuell, J.K., Ascher, J.S. & Isaacs, R. (2009). Wild bees (Hymenoptera: Apoidea: Anthophila) of the Michigan highbush blueberry agroecosystem. *Annals of the Entomological Society of America*, 102, 275-287.

Winfree, R., Williams, N.M., Dushoff, J. & Kremen, C. (2007). Wild bees provide insurance against ongoing honey bee losses. *Ecology Letters*, 10, 1105-1113.

Winfree, R., Williams, N.M., Gaines, H., Ascher, J.S. & 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.

Appendix S2. Methodology of unpublished studies included in our synthesis.

Methodology for the 16 studies included in our synthesis with unpublished data is described below (see also Table 1).

For **Cariveau (unpublished data)**, the pollination of the Stevens cultivar of *Vaccinium macrocarpon* Aiton (cranberry) was conducted at 16 farms in June 2009 in Burlington County of New Jersey, USA. Farms varied in the amount of surrounding land cover comprised of agriculture. GIS data were compiled by the New Jersey Department of Environmental Protection. Land-cover polygons were delineated with hand-digitization using 2002 digital color infrared orthophotography at a scale of 1:2400 at a 0.31 m pixel resolution.

At each farm, sixty-meter transects were placed parallel with the edge of natural habitat. Along each transect, the author recorded pollen deposition, visitation frequency, flower visitor abundance. To collect pollen depositions, receptive stigmas were collected from open cranberry flowers and placed in 70% EtOH. Pollen tetrads were stained using aniline blue and counted under a compound florescent scope. To assess visitation frequency and flower visitor abundance, each transect was sampled once in the morning and once in the afternoon during two different weeks. Data collection took place between 9:00 and 18:00 during non-inclement weather (temperature > 15°C, wind speed <3.5m s-1). To record visitation frequency, every two meters, a 1x1 meter quadrat of flowers was observed for 45 seconds for a total of 1.55 hours of observation for each farm. Following each observation, flower visitors were collected using a hand-net. Each collection period lasted for 30 minutes and the timer was stopped while handling insects. The resulted in 2 hours of collection for each farm. Managed honey bees (*Apis mellifera*) were the dominant flower visitor (76%); the dominant native flower visitors were *Bombus* species (17%). While honey bees were recorded during flower observations, they were not collected with the hand net. Feral honey bees are not known to occur in this study system.

For **Gaines (unpublished data)**, the abundance and diversity of bees was investigated in commercial cranberry bogs (*Vaccinium macrocarpon)* in Jackson, Juneau, Monroe, and Wood Counties in central Wisconsin (USA) between May and July 2008. Bees were pan trapped four times during the growing season – once before, twice during, and once after cranberry bloom - using blue, yellow and white traps. Traps were left out for 6 hour intervals between 0830 and 1700 under consistent weather conditions (wind < 2.5m/s, sunny to bright overcast, temp > 14^{o}C). Thirty-traps were deployed per site per sampling round and all traps were within 50 meters of a non-agricultural farm edge. This was done at 15 commercial cranberry bogs located at least 2km from each other. Sites were selected such that the landscape within one kilometer covered a gradient ranging from 15-82% woodland and 10-76% agriculture. Agriculture in this area is comprised mainly of cranberry, corn, soybean, alfalfa, and pasture. Landscape information was extracted using a geographic information system (ArcMap) from the United States Department of Agriculture National Agricultural Statistics Services Cropland Data Layer (USDA NASS CDL 2008) with a resolution of 56 meters. Agricultural land-cover categories was based on 2008 satellite imagery (collected between April 1 – Sept 30, 2008) and non-agricultural land-cover categories were based on 2001 satellite imagery (USDA National Land Cover Dataset). *Agapostemon texanus* was the most common species collected out of 1282 total specimens representing 108 species of native bees.

In **Javorek (unpublished data)** study, bee abundance and diversity on lowbush blueberry (*Vaccinium angustifolium* Ait.) was investigated in Prince Edward Island, Canada during 2005, 2007 and 2009 to correspond to the biennial cropping pattern of the fields. Lowbush blueberry fields were established by clear cutting woodland and allowing the

Vaccinium angustifolium (that existed as an under story component) to spread forming a dense mosaic of low-growing “clones” (genotypes). Blueberry is grown in a heterogeneous landscape that includes forests, bogs, wetlands, meadows, abandoned farm fields, mixed agriculture, hayfields and pasture.

At each study site (N =16) , bees were sampled using a combination of aerial netting and pantraps on three days roughly corresponding with early, middle and late lowbush blueberry flowering (June). For aerial netting, the observer moved throughout the blueberry field for one hour capturing each bee encountered. Thirty pantraps were deployed at each study site alternating blue, white and yellow at three meter intervals. Bees collected during this study were identified (S.K. Javorek and J.S. Ascher) and are housed at Agriculture and Agri-Food Canada Research Centre, Kentville Nova Scotia, Canada with select vouchers retained at the American Museum of Natural History, New York, NY, USA. All collections were done between 10:00 and 3:00 on sunny/light overcast days with temperatures >16ºC.

During this study 53 bee species were collected visiting lowbush blueberry. The main wild pollinating species were *Bombus* (*Pyrobombus*) *impatiens* (Cresson), *B.* (*Pyrobombus*) *ternarius* Say, *B.* (*Pyrobombus*) *vagans* Smith, *Andrena* (*Melandrena*) *carlini* Cockerell, *A.* (*Melandrena*) *vicina* Smith, *A.* (*Andrena*) *rufosignata* Cockerell, *A.* (*Andrena*) *carolina* Viereck, *Lasioglossum* (*Dialictus*) spp. and *Lasioglossum (Evylaeus*) spp. Managed honey bees (*Apis mellifera* Linnaeus) or alfalfa leafcutting bees (*Megachile* (*Eutricharaea*) *rotundata* (Fabricius)) where introduced at most sites to bolster pollination.

Botanical surveys were conducted to determine the abundance, diversity and phenologies of flowering plants in cover types within a 2.5 km radius blueberry fields. From this a foraging resource value (0-10) was assigned to each cover type for April/May, June (blueberry bloom), July and August/September. Land-cover data were based visual interpretation and digitization of colour infrared aerial photography flown at 1: 7,500 (flown July –September 2000) (at 1-5 m resolution) and updated to reflect 2005 land cover (PEI Department of Environment 2000).

For **Klein, Brittain and Kremen (unpublished data)**, bee abundance and species richness in almond orchards (*Prunus dulcis* L.) were investigated in Yolo and Colusa counties in northern California, USA, during 2008. Bee species richness and abundance were sampled using pantraps, before, during and after the bloom. This was done in eight organic and fifteen conventional almond orchards with different levels of isolation from semi-natural or natural habitats (chaparral shrub, oak savannah, riparian, and oak woodland). Insects in the 23 orchards were sampled by placing a cluster of three pantraps (yellow, white and blue) at five points 0 meters from the orchard edge and at five points 50/100 meters from the orchard edge. The pans were left out for one day and this was done three times (3 sampling rounds) during 2008: once shortly before almond bloom, once during bloom and once shortly after bloom. This meant that at each orchard there were 30 pans for one sampling round, totalling 90 pantraps per orchard over the season. Only bees were considered in the current analysis and the bees caught in pantraps were identified by Robbin Thorp (UC Davis) and Alexandra-Maria Klein. For information on the sampling of flower visitation and fruit set, see Klein et al. (2012).

Land cover was based on aerial imagery at 1 meter resolution from the National Agriculture Imagery Program (NAIP) from 2009. The land cover surrounding the orchards within 1 km buffers was hand digitized using ArcGIS and assigned to 12 habitat categories.

Kremen (unpublished data) investigated bee visitation to almond (*Prunus dulcis*) in Yolo County, California in 2004. The almond varieties studied were hermaphroditic but self-incompatible and were visited by a variety of wild bees (*Andrena* sp., *Bombus vosenesnskii*, *Halictus tripartitus*, *Halictus farinosus*, *Lasioglossum* (*Evylaeus*) sp., *Lasioglossum* (*Dialictus*) sp., *Lasioglossum* sp. and other unidentified native bee species). Managed honey bees had been placed by farmers at most sites and were abundant at all sites. Pollinator visitation rates and species richness data were obtained in 16 sites that varied in distance from 14 to 989 m from natural habitat including riparian, oak-woodland and chaparral shrub vegetation. In each site, the number and richness of social and solitary bees visiting almond flowers were estimated from 10 whole tree scans per site (circa. 1 min of observation per tree) on a single day between 10:00 and 15:00 during standardized weather conditions (sunny to light overcast skies with temperatures $\geq$14.8°C and wind velocity $\leq$2.7 m s^{-1}). Landcover data are described in Kremen et al. (2004) and are based on a supervised classification of Landsat TM imagery from year 2000.

In the studies coded as **Mandelik (unpublished data) (a,b,c)**, flower-visitors to *Prunus dulcis* (almond), *Helianthus annuus* (sunflower) , and *Citrullus lanatus* Thunb. (watermelon), respectively, were investigated along a gradient of decreasing proportion of open land (not developed or cultivated) in 1500-5000 m radii around sampling points within crop fields. The open land included mainly native dwarf shrubland and chaparral and planted forests (pine and broadleaf). Satellite images and land-cover data were obtained from the GIS unit of the Hebrew University of Jerusalem, updated to 2002 at a 1.3 m resolution. Land-cover types were re-classified into 10 categories: annual rotational crop fields including vegetables, cereals, legume& orchards, built-up area, roads, the area within military bases that is NOT defined as "open area" and includes mainly areas that are either paved or occupied by Acacia, barren land - area that was prepared for development and all natural vegetation removed and ground flattened, planted braodleaf forests, planted pine forests, planted eucalyptus forests, artificial reservoirs, natural habitat. This re-classification best describe differences in availability of foraging resources and nesting substrates along the landscape. Site tours were conducted to verify land-cover data at questionable locations (where a mis-match between different data layers was apparent). All three studies were conducted in the Judean Foothills, a Mediterranean ecosystem in central Israel during crop bloom in February-March 2009 for the almond, and in May-June 2009 for the sunflower and the watermelon. The almond study was conducted in 7 orchard margins, the sunflower study was conducted in 13 field margins, and the watermelon study was conducted in 19 field margins. Study plots (25 × 25 m) were separated by at least 1.2 km from each other. In all three studies field work was conducted under standardized weather conditions (sunny to light overcast skies, temperatures >18 ºC and mean wind velocity <3.5 m s^{-1}, excluding three occasions). Each plot was sampled between one to three times (mostly twice), each time occurring on a separate day. In each sampling day two sampling sessions, 2-3 hours apart, were conducted. Each sampling session included 10-20 min of observations of *Apis mellifera* visits to crop flowers followed by 10 min of bee netting (the stopwatches were stopped when handling bees that were caught). Bee sampling was conducted between 8:00 and 15:00 in the almond study, between 8:00 and 16:00 in the sunflower study, and between 7:00 and 11:00 in the watermelon study. In addition, we used coloured pantraps (ca. 300 ml white, blue and yellow bowls filled with soapy water) to sample bees active in the fields and orchards. In the almond orchard we used 16 pantraps opened for 6 hours, in the sunflower we used 12 pantraps opened for 7 hours, and in the watermelon study we used 12 pantraps opened for 3.5 hours. In all three studies the main flower-visiting species was the managed honey bee *Apis mellifera* (accounting for 99%, 95% and 88% of recorded bee visits in the almond, sunflower, and watermelon studies respectively). All honey bees in the region are managed; there are no feral colonies in the region due to the *Varoa* mites. Dominant wild bee visitors in all three studies were small to medium sized bees of the genus *Lasioglossum* spp.

For **Mayfield (unpublished data)**, the pollination of *Macadamia integrifolia* (Macadamia nut trees) was investigated in the Northern Rivers region of New South Wales, Australia (near the towns of Byron Bay and Lismore), during August and September of 2008. For this study, insects visiting Macadamia flowers were observed on 5 farms and in 10 sampling areas (very large farms - multiple km in diameter - had one to four sampling regions within their boundaries). Farms varied in management approach but pesticides were not sprayed on any farm during our observation period. Observations in each sampling area were made on two or three non-consecutive days across the blooming season. All observations were made on sunny cool days between 0900 and 1730 corresponding to the warmest part of each day. The mean temperature at 0900 in this region was 15 ˚C in August 2008 and 20 ˚C in September 2008 with daily averages ranging from 20˚C in August to 23˚C in September. Macadamia flowers are clustered on pendent inflorescences and thus observations were made on multiple clearly visible inflorescences for each observation period. Each observation period was 5 minutes in length. Concurrent observations were made by 2 – 4 people across three non-consecutive parallel transects running from 5 – 500m from field borders abutting forest vegetation. Observers alternated which end of transects they started at to ensure that near and far trees were observed at multiple times of day within a sampling area. During each observation period the identity of each flower visitor was noted as was the number of flowers it visited. Forest vegetation next to all farms was classified broadly as rehabilitated or remnant patches of subtropical rainforest. *Apis mellifera* were abundant on all farms, even those without kept hives. The largest farm (4 separate sampling regions) had feral and kept *A. mellifera* hives. This farm also had kept native *Trigona* *sp.* bees in hives positioned among the Macadamia trees in several sampling areas. The most abundant flower visitors in this system by far was *A. mellifera*, with beetles, flies, Lepidoptera and native *Trigona* bees representing a very small proportion of flower visits.

The GIS map used in this analysis was created using 2.5 m color imagery acquired by the SPOT 5 satellite (SPOT Imaging Services) in October 2007. Land-cover data was sourced from the NSW Department of Environment, Climate Change and Water for the upper northern extent of New South Wales at 1:25000 resolution based on polygons developed using conventional interpretation of homogenous overstorey patterns discernible from 1997 aerial photography and created in 2001 (Upper North East CRAFTI Floristic Layer).

In the **Neame and Elle (unpublished data)** study, we assessed the contribution of wild bees and honeybees to squash pollination at nine farms in the Okanagan-Similkameen Regional District, located in south-central British Columbia, Canada. All sampling took place in August, 2010. Natural habitat in this region is sage-scrub dominated in the valley bottoms and is the northernmost extension of the Great Basin Desert, with ponderosa pine forest at higher elevations. Conversion of land for agriculture, especially orchards and vineyards, is increasing in the region. Farms were both conventional and organic, but for this crop in this area, farming practices on conventional farms differed very little from the organic farms. All farms grew multiple squash varieties (4 to 15) and usually other ground crops on the same property. Squash varieties assessed were one of three species: *Curcurbita pepo* (summer squash and acorn squash varieties), *C. moschata* (butternut squash), or *C. maxima* (buttercup squash and pumpkin varieties). We assessed wild bee and honeybee visits to multiple varieties, as at any given farm there was substantial variation in the number of plants of each variety. Our observations focused on acorn and butternut squash varieties, but also included buttercup squash and summer squash at sites where those two varieties were not abundant. All honeybees in this area are managed; approximately half of the farms had hives located next to the squash field, but local honeybee keepers have hives located throughout the area so honeybees occur in all sites.

To assess the abundance and visit rate of bees to squash flowers, we conducted visit observation surveys and netting surveys. On each of two survey dates per field we conducted one 15-minute netting and two pollinator visit observation transect surveys. Two sites had fewer visit observation transects (sites CAL and KBF had only two and three visit observation transects respectively, rather than the usual 4) due to weather conditions that inhibited bee activity (especially high winds in these valleys). Both surveys on a sampling date started from the same end of the squash field; on the next survey date we started on the opposite end of the field, in a different row.

Visit observation-transect surveys: We conducted ten visit observations per transect, at 5 m intervals from the edge of the field. For each observation period we chose several flowers that could be observed simultaneously and observed them for two minutes. The number of flowers observed during observation periods was typically 3 to 4 flowers, but ranged from 2 to 7. We recorded the number of pollinator visits, whether the flower visited was male or female, and the morphospecies identity of the visitor (typically to generic level).

Netting surveys: Each netting survey consisted of catching all bees observed visiting squash flowers for 15 minutes. The survey effort was focused on the main varieties in which we conducted visit observations. We pinned and identified all specimens to species, with assistance with *Melissodes* species ID from Terry Griswold (USDA-ARS Bee Biology and Systematics Lab, Logan, Utah). Specimens are stored in the Simon Fraser University collection.

GIS land cover: To obtain land use cover for the area we hand-digitized orthophoto imagery in Google Earth (GE version 6) within a three kilometer radius of each site. Orthophoto imagery in GE6 I this region is sourced from the Province of British Columbia (imagery date August 15, 2010), with images to 1m resolution. We categorized land use into eleven categories that included agricultural (e.g. orchards, ground crops, pasture), developed (residential and commercial), and natural/semi-natural (e.g. sage-scrub, road embankments, riverside) land use types. Categorization of digitized polygons was also informed by personal knowledge of land use surrounding the sample sites. We typically did not differentiate land use at a spatial scale smaller than 5m.

For **Otieno (unpublished data)**, bee diversity, functional traits and visitation to pigeonpea crop were investigated in Kibwezi District in Eastern Kenya. Six simple versus complex site pairs were chosen across a gradient of landscape contexts, each site buffered by a 1 km spatial landscape comprising of semi-native habitats and rain-fed agricultural fields. One site of each pair was locally complex (dominated by semi-native habitat patches) positioned within at most 200 m of these patches. The other site was locally simple (dominated by rain-fed arable fields) positioned within at least 500 m from semi-native patches maintaining a minimum distance of 2km between the site pairs as determined using digital elevation and land use maps in ArcGIS 9.3. The Shuttle Radar Topography Mission (SRTM) data for elevation and a land-use/land-cover map derived from a Landsat 7 Enhanced Thematic Mapper image (2003) were also used to in selecting sites and ground-truthed in April 2009. In all cases, semi-native habitats were considered to be patches of vegetation that comprised predominantly of native plants and animals.

Local management of each site was also assessed to determine whether it was conventional or organic through face to face interviews with farmers. Variations in levels of fertilizer application and pesticide usage were found to be the main management practices used in the study area. Key among these practices was insecticide usage, which emerged as the most consistent practice either used or not used by farmers. Insecticide treated fields were classified as conventional while insecticide free fields were categorized as organic.

To measure the abundance of bees visiting flowers, 100 m long transects were laid in a North to South orientation, each separated by a minimum of 10 m from each other at each site. Five of these transects were within the crop field, five in the semi-natural patches immediately next to the crop and one transect at the interface between the crop field and the semi-natural habitat measuring about 2 m wide. This habitat was consistent in all our study sites and was either a planted hedge or fence with wild plants to mark the boundary of crop fields. Each transect was walked for 10 minutes, twice a day (between 09h00 and 16h00) recording insect flower visitors, 2 m either side once weekly from April to 13th June 2009.

Park & Danforth (unpublished data) surveyed diversity and abundance of bees visiting apple, *Malus domestica*, in Tompkins, Wayne, and Schuyler counties in Western New York, USA. The study landscape was heterogeneous, marked by fragmented deciduous woodlands and mixed agriculture. Apple was a dominant crop species in Wayne County. A total of 14 orchards (10 in 2009, 6 in 2010), varying in size and amount of surrounding natural habitat, were surveyed once in May 2009 and 2010 during the apple bloom on days with temperature > 60°F between 10am and 3:30pm. Distance between sites was at least 1.9km. At each site, multiple trials of 15-minute timed, aerial netting were conducted along tree rows; only bees visiting apple blossoms or hovering around apple trees were collected. The number of timed net collections per site varied according to farm size. Given unequal sample size among orchards, an average estimate of timed netting trials was provided per site. Renting managed honey bees, *Apis mellifera*, for pollination is common practice among growers in this region; the presence of honey bee hives was recorded at each site. Landscape composition within a 3km radius of study orchards was characterized, using a geographic information system (ArcMap 9.3.1), from the United States Department of Agriculture National Agricultural Statistics Service Cropland Data Layer (USDA NASS CDL 2010; 30-m resolution), merged with a hand-digitized orchard layer. The orchard layer was created from USDA Agriculture Service Center county-level, digital orthophotos (USDA ASC 2009; 1-m resolution). Land cover was consolidated into 18 classes. Aside from *Apis mellifera*, the most abundant bees in this study included medium and large *Andrena*, notably *A.* (*Melandrena*) *vicina, A.* (*Melandrena*) *regularis, A.* (*Melandrena*) *crataegi, and A.* (*Simandrena*) *nasonii*.

For **Prache, MacFadyen, & Cunningham (unpublished data)**, the study was conducted in a landscape in southern New South Wales, Australia, defined by a circle of 5-km radius centered on S 34^{o}42’50”, E 147^{o}43’20”. Land use was mainly agricultural, with fields of canola (*Brassica napus* and *juncea*), cereals (wheat, barley), pasture, and remnant patches of native vegetation (*Eucalyptus* woodland).

To construct a land-cover map for this circular landscape we used a SPOT (Système Probatoire d'Observation de la Terre) satellite image acquired in 2005 (2.5 m resolution). Fields (crops and pasture) and patches of remnant vegetation were outlined by hand and then ground survey was used to assign current field type during the study period in 2009.

We sampled bee abundance using blue van traps (Stephen and Rao 2005), hung at 1.2 m above the ground. Trapping locations were at field edges or up to 50 m into the field. Traps were checked weekly over a 5 week period (22 Sept to 27 October 2009) but data were pooled over time. In total 11,674 bees were trapped.

Data were analyzed for 10 locations in the landscape: 4 of the locations represent single trapping points, whereas the other 6 combine two trapping points that were pooled for this study because they were separated by less than 500 m (in which case abundance was halved to make sampling intensity comparable). Although we trapped 29 different species, 16 of these were represented by 5 or fewer individuals so they were excluded from further analysis. The second most abundant species was *Apis mellifera*, which is common as a feral in this landscape, but was also present in managed hives during this study and therefore were also excluded from analysis. This left 12 species, here listed from most to least abundant: *Leioproctus maculatu*s, *Lasioglossum hemichaleum*, *Lasioglossum cambagei*, *Lasioglossum clelandi*, *Lasioglossum vetripene*, *Lasioglossum lanarium*, *Lipotriches* sp., *Lasioglossum litteri*, *Lasioglossum cognatum*, *Lasioglossum soroculum*, *Amegilla chlorocyanea*, *Leioproctus* sp.

In **Rundlöf & Bommarco (unpublished data)**, pollination in arable fields of flowering red clover (*Trifolium pratense* L.) intended for seed production was investigated in Scania, the southernmost part of Sweden, in 2008 (14 sites) and 2010 (17 sites) (Bommarco et al. 2012). The focal red clover seed fields ranged in size from 4-16 hectares in 2008 and from 5-18 hectares in 2010. The region and landscapes surrounding the clover fields are dominated by agriculture, but fields were selected to cover a range of landscapes (radius 1 km) differing in complexity and proportion of semi-natural habitats.

The land-use data in the study is based on the national version of the CORINE land cover, GSD Land Cover Data, which is based on computer classification of satellite imagery from the year 2000 and on a variety of national maps, provided by the Swedish mapping, cadastral and land registration authority (Lantmäteriet 2010). Land cover is divided into 58 classes, data resolution is 25 m, data accuracy is 75 % and the projection is SWEREF 99 TM (SWEdish REference Frame 1999, Transverse Mercator) (Lantmäteriet 2010).

All insects visiting the red clover were recorded along 1 m wide and 50 m long transects in the red clover seed fields; four transects located 4 and 12 m from the field edge in 2008, and two transects located 8 and 100 m (or for smaller fields in the field centre) from the field edge in 2010 (Bommarco et al. 2012). Each site was in 2008 visited twice and in 2010 three to five times (mean 4.0 visits per site), to cover the main flowering period of the red clover fields. Sampling was done between June 25th and July 29th 2008, and July 5th and August 10th 2010, on days with warm, sunny and calm weather. The visitors of the red clover were predominantly bumble bees and honeybees, with a few visits from day-flying butterflies. Bees were either determined to species in the field (honeybees and bumble bee queens) or collected (bumble bee workers and males) and put in individual tubes filled with 70% ethanol and brought to the lab for species determination. The density of bumble bees in the fields were more than three times as high in 2008 (29.3 ± 3.0 (mean± SE) bees per transect) compared to in 2010 (7.8 ± 0.8 bees per transect), while the densities of honeybees were more equal between years (8.1 ± 3.1 and 7.6 ± 1.4 bees per transect, respectively).

For **Steffan-Dewenter, Krewenka, Vaissière & Westphal (unpublished data)**, the study region was located in the vicinity of Göttingen (51.63°n. latitude, 9.86° e. longitude, altitude: 171m above NN), southern Lower Saxony and Northern Hesse, Germany. Ten strawberry fields with a minimum distance between fields of 3.8 km were selected along a gradient of increasing land use intensity. For each field a circular landscape sector with radius of 1000m was mapped in July 2005. A mapping scale of 5m (Deutsche Grundkarte 1:5000, UTM

ETR S89 32N, WGS 84) was used and percentages of land use types were calculated using the program ArcView 3.2 (ESRI Geoinformatik GmbH, Hannover, Germany). The landscape gradient was measured as amount of arable land (annual crops) in the landscape, which ranged from 13.6% (structurally complex) to 82.9% (structurally poor), (50.10 ± 6.77, Mean ± SEM). Calcareous grasslands, hedges, old fallows, orchard meadows, embankments and bushes or small woods were mapped as semi-natural habitats, since they are assumed as sources of bee populations in the agricultural landscape (Garibaldi et al. 2011). Other mapped habitat types were flowering crops like oilseed rape, potato, field beans and peas, clover, phacelia, wild mustard and sunflowers and other land use types including intensively managed grasslands, intensively managed orchards and strawberry fields, forests, gardens, settlements, limestone quarries, roads and water bodies. Additionally, less detailed GIS data were extracted for a radius of 3km from CORINE land-cover maps (Carré et al. 2009).

The size of the studied strawberry fields was at least 80 x 55m and data were collected in an area of 50 x 25m in the centre of the fields in a homogeneous and representative zone, with a distance of at least 15 m to the field boundaries.

Pollinator surveys: During the flowering period from the 27th of April until the 16th of June 2005 pollinator sampling was conducted under good weather conditions, with at least 15°C, no precipitation and dry vegetation and a wind speed below 40 km^{h-1}. Pollinator observations were done in a transect with a length of 150m, which was divided into six subunits of 25m each. The subunits were walked in a slow speed taking five minutes for 25 m, and flower visiting bees were caught with an aerial net in a width of two meters to each side of the transect.

The study **Viana & Silva (unpublished data)** was carried out during 2005 in the ‘irrigated perimeter of Maniçoba’, in São Francisco Valley region, at the municipality of

Juazeiro, State of Bahia (40^{o}16”W e 9^{o}17”S), in Northeast Brazil. The landscape in this area is locally complex composed by several private properties with conventional farm management, used for crop production of various plant species as mango, guava, coconut, passion fruit, sugar cane, among others, interspersed with areas covered by natural white dry forest called “Caatinga”, deforested areas and areas in several stages of ecological succession. Despite the predominance of small farmers in that region (media of farm’s size = 25ha), most of them with polycultures, the land use is very intensive. We represented land cover in this region based on a Supervised Classification (using Maxlike algorithm) of processed and georeferenced satellite imagery acquired from CBERS (China-Brazil Earth Resources Satellite) (www.inpe.br) with 15m spatial resolution (acquired on 17/11/2004).

In order to representatively sample the study area, we generated a random list of geographic coordinates for the landscape and selected the first 16 that felt inside blocks of yellow passion fruit, *Passiflora edulis*. This procedure was aided by the use of ArcView software (version 3.3, ESRI, Redlands, California) and global positioning systems (GPS) (Garmin International, Olathe, Kansas). We used as criterion for including a block in the sample a minimum distance of 1 km to blocks already chosen. We did so in order to ensure the spatial independence of samples. The landcover polygons were handling delineated using 2006 satellite imagery at a 0.30 m pixel resolution.

The relative abundance of bees was determined by measuring the number of bees visiting passion flowers in a transect of 50m long, laid within the crop field, with mean of 90 flowers observed for 15 minutes during three times on three different days. In total was summed twelve hours of observation. The main flower-visiting species was the feral honey bee *Apis mellifera* Linnaeus 1758, wild social bee species *Trigona spinipes* Fabricius 1793 and wild solitary bees species, *Xylocopa (Megaxylocopa) frontalis* Olivier, 1789 and *Xylocopa (Neoxylocopa) grisescens* Lepeletier, 1841. The last two species mentioned above are the main pollinators of passion fruit in the study region. These bees have wide geographic distribution (Hurd & Moure 1963) and build their nests in dry or dead plant material. In general, they construct linear nests, either using pre-existing cavities or digging into dry dead trunks and branches. In the study area, these bees are strongly dependent on the presence of *Commiphora leptophloeos* (Mart.) J. B. Gillett (Burseraceae), a plant species that is endemic of the Caatinga vegetation.

The nest abundance were indirectly evaluated, quantify the number of cavities used by *Xylocopa* sp for nesting in the environment around the plantation sites. The surrounding area of 16 sites cultivated with *Passiflora edulis* were inventoried following the distance method described by Greig-Smith (1983) with modifications. Each sampling area comprised 1km radius measured from the center of *P. edulis* cultivar. Four sampling bases were marked at the edges of the cultivar. Three quadrats were delineated at each sampling base considering the imaginary line traced at 90º, totaling 12 quadrats/site. Thus, the nested *Xylocopa* substrates were located by walking along twelve directions, following quadrats. To estimate the abundance of nested substrates two samples were taken at each quadrat. The abundance of nests per site was determined by the sum of nests in each substrate.

Sources cited:

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

Carré, G., Roche, P. Chifflet, R., Morison, N., Bommarco, R., Harrison-Cripps, J., Krewenka, K., Potts, S.G., Roberts, S.P.M., Rodet, G., Settele, J., Steffan-Dewenter, I., Szentgyörgi, H., Tscheulin, T., Westphal, C., Woyciechowski, M. & Vassière, B.E. (2009). Landscape context and habitat type as drivers of bee biodiversity in European annual crops. *Agriculture, Ecosystems & Environment*, 133, 40–47.

Garibaldi, L.A., Steffan-Dewenter, I., Kremen, C., Morales, J.M., Bommarco, R., Cunningham, S.A., Carvalheiro, L.G., Chacoff, N.P., Dudenhöffer, J.H., Greenleaf, S.S., Holzschuh, A., Isaacs, R., Krewenka, K.M., Mandelik, Y, Mayfield, M.M., Morandin, L.A., Potts, S.G., Ricketts, T.H., Szentgyörgyi, H., Westphal, C., Winfree, R., & Klein, A.M. (2011). Stability of pollination services decreases with isolation from natural areas despite honey bee visits. *Ecology Letters*, 14, 1062–1072

Klein, A.-M., Brittain, C., Hendrix, S.D., Thorp, R., Williams, N.M., & Kremen, C. (2012). Wild pollination services to California almond rely on semi-natural habitat. *Journal of Applied Ecology,* 49, 723-732.

Kremen, C., Williams, N. M., Bugg, R. L., Fay, J. P. & Thorp, R.W. (2004). The area requirements of an ecosystem service: crop pollination by native bee communities in California. *Ecology Letters*, 7, 1109-1119.

Lantmäteriet. (2010). Produktbeskrivning: GSD-Marktäckedata. [Product description: GSD Land Cover Data (in Swedish)]. Updated: March 26, 2010. Downloaded: October 2010. URL: www.lantmateriet.se/upload/filer/kartor/kartor_och_geografisk_info/GSD-Produktbeskrivningar/md_prod.pdf.

PEI Department of Environment. (2000). Energy & Forestry, Resource Inventory, Corporate Land Use Inventory 2000. URL: www.gov.pe.ca/gis/.

Stephen, W. P. and Rao, S. (2005). Unscented Traps for Non-*Apis* Bees (Hymenoptera: Apoidea). *Journal of the Kansas Entomological Society*, 78, 373-380.

Appendix S3. Inter-site distances of farms included in our synthesis.

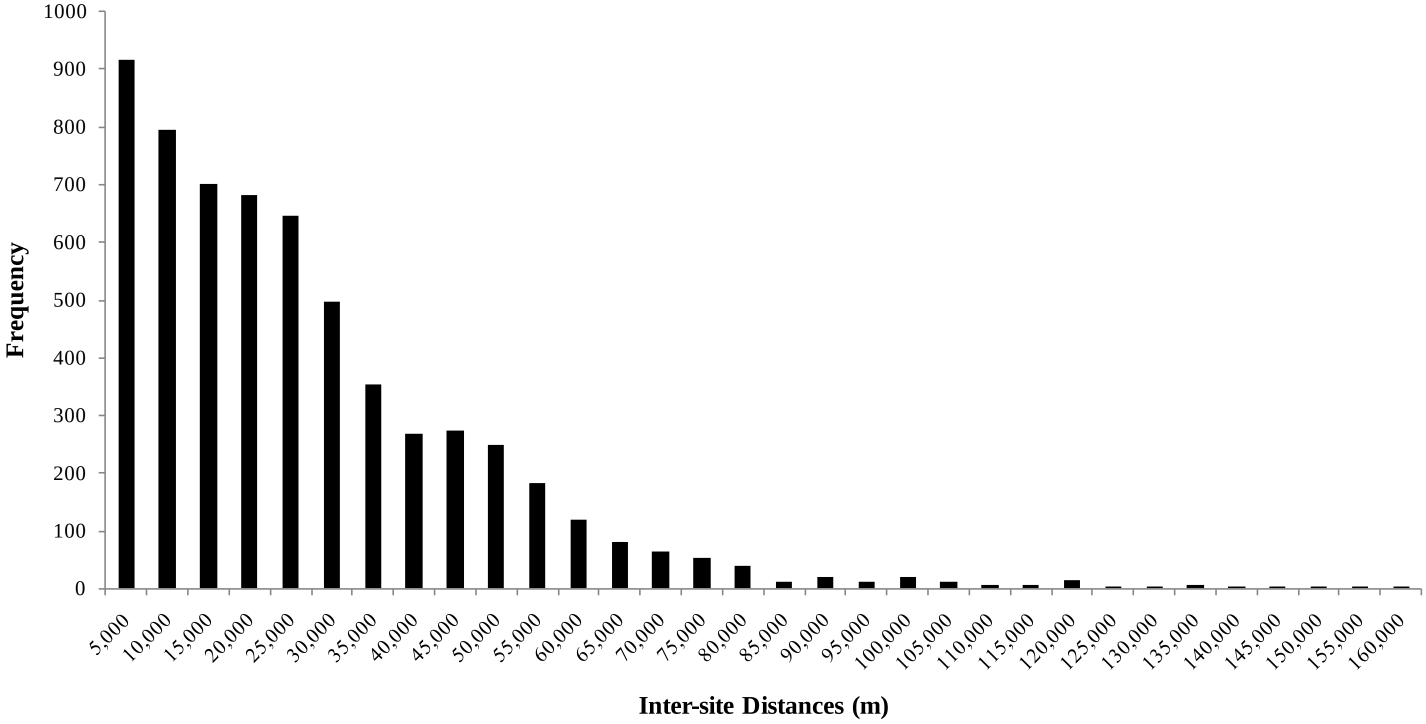
In our synthesis, all field sites sampled within studies were separated by distances of >350–160,000 m (mean ± SD: 25,000 ± 22,000 m), with only 0.02% site pairs located <1 km apart (Figure S3_1). For multi-year studies, inter-site distances include fields sampled within the same year as well as across years. Samples among sites within a similar study region were also commonly separated temporally by different years and/or different crop cycles within years (Table 1). This level of spatial and temporal separation should be sufficient to ensure independent sampling of pollinator communities among sites given known nesting and foraging distances for the majority of bee species (Gathmann & Tscharntke 2002; Greenleaf *et al.* 2007). As further confirmation of independence, we found no evidence of spatial correlation based on visual inspection of semi-variograms for residuals of global models (i.e., models of all studies with all local and landscape variables and their interactions) by inter-site distance ranges (i.e., variance of the difference in residuals did not increase with increasing distance).

Sources cited:

Gathmann, A. & Tscharntke, T. (2002). Foraging ranges of solitary bees. *Journal of Animal Ecology*, 71, 757-764.

Greenleaf, S., Williams, N., Winfree, R. & Kremen, C. (2007). Bee foraging ranges and their relationships to body size. *Oecologia*, 153, 589-596.

Figure S3_1. Distribution of inter-site field distances. 6073 inter-site distances were assessed based on site pairs within each study, including farms sampled with the same year as well as across years for multi-year studies. 10% of site pairs were separated by 5000 m or less, 50% by 20,000 m or less, and 90% by 52,000 m or less.



Appendix S4. Determining landscape composition based on Lonsdorf *et al.* (2009) model

The Lonsdorf *et al.* (2009) model codes multi-class landscapes in terms of their contributions to bee floral and nesting resources, by assigning each land-cover type an estimated suitability of its resources to specific bee guilds. Thus, model scores reflect landscape composition – the proportional areas of different habitat types within a landscape – within bee foraging range(s). To do so, for each study, data holders generated a nesting suitability layer as a direct translation of the land-cover map for each study region. They first assigned each bee taxa to a nesting guild and in turn assigned nesting suitability values for each taxa to each land-cover type in their multi-class land-cover map based on expert opinion (as informed by quantitative field estimates when available) (Lonsdorf *et al* 2009). Suitability was scaled from 0 to 1 (with 0 indicating land cover that provided no nesting resources and 1 indicating land cover that provided 100% suitable nesting habitat), which could differ by bee taxa found within each study system.

The amount of suitable foraging habitat available to pollinators at a nest location was then calculated as the distance-weighted sum of relativized suitability values for each location in the landscape (Lonsdorf *et al.* 2009). Distance decay functions in the model were determined by size-specific foraging capability of each bee species or taxa (Greenleaf *et al.* 2007), using measurements of inter-tegular span, body size or pre-existing databases (Discover Life, Potts *unpublished data*, Williams *et al.* 2010). Like for nesting values, floral values were assigned by data holders. We allowed for floral resource production to vary among seasons. Expert opinion of authors (as informed by survey data when available) was used to assess flight periods for each bee taxa, thus accounting for variation among bee species in their flight seasons (e.g. some are present in summer only, while others are present in multiple seasons). The overall floral resources available were calculated as a weighted sum across seasons. To standardize across studies, we applied the Lonsdorf *et al.* (2009) model at a 30-m resolution; for land-cover maps with <30m resolution, we accounted for proportions of each land-cover class within a 30-m parcel (or cell) (see details on land-cover map resolutions in Appendix S5).

Expert-derived estimation of habitat suitability for land cover types

To characterize how data providers estimated habitat suitability across study regions, we classified empirical land cover classes into standardized cover types (Table S4_1) that were modified based on the National Land Cover Database (NLCD) (Vogelmann *et al.* 1998) and CORINE Land Cover nomenclature (European Environment Agency 2000), because the majority of land cover datasets followed these systems. (We note that this standardization was not applied in the pollinator model runs, as described above, and did not influence the Lonsdorf landscape index for field sites; rather this characterization was done post-hoc to describe trends in how data providers valued land cover types for bees). After standardizing land cover types, we then quantified average floral and nesting values attributed by data providers to these generalized cover classes. To facilitate comparison among studies and cover types, we totaled nesting and floral values across different bee taxa and multiple seasons, respectively (when relevant) and then rescaled resource values from 0 to 1 within each study, such that a cover type with the highest overall nesting or floral resource value was assigned a value of 1 and the lowest a value of 0. Across all 39 studies, highest overall habitat suitabilities (aggregated across nesting and floral resources) were assigned to natural and semi-natural habitat types, in particular shrubland, forest (broadleaved forest and to a lesser extent mixed forest), natural grassland, and woody wetlands, which were estimated to have almost two times more resources than other cover types (Table S4_2). Of secondary importance were certain types of cropland (in particular orchards and vineyards, pasture and fallow fields, and to lesser extent perennial row crops) and low density development and open spaces. Cover classes estimated to provide the most nesting areas were shrubland, broadleaved and mixed forest, woody wetlands, and natural grassland, whereas shrubland, orchards and vineyards, and natural grassland were estimated to provide the greatest floral resources. Least suitable cover types were considered to be open water and barren areas, followed by cropland composed of annual row crops, high intensity developed areas, and herbaceous wetlands.

Sources cited:

European Environment Agency (2000). CORINE land cover technical guide - Addendum 2000. Commission of the European Communities, Coppenhagen, 105 pp.

Greenleaf, S., Williams, N., Winfree, R. & Kremen, C. (2007). Bee foraging ranges and their relationships to body size. *Oecologia*, 153, 589-596.

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.

Vogelmann, J.E., Sohl, T.L., Campbell, P.V. & Shaw, D.M. (1998). Regional land cover characterization using Landsat thematic mapper data and ancillary data sources. *Environmental Monitoring and Assessment*, 51, 415-428.

Williams, N.M., Crone, E.E., Roulston, T.H., Minckley, R.L., Packer, L. & Potts, S.G. (2010). Ecological and life-history traits predict bee species responses to environmental disturbances. *Biological Conservation*, 143, 2280-2291.

Table S4_1. Standardized cover types used to reclassify land cover maps for the 39 studies.

Class (Level I)	**Class (Level II)**	**Class (Level III)**	**Description**
Natural & Semi-Natural	Grassland	Grassland/Herbaceous	Areas dominated by natural gramanoid or herbaceous vegetation that are not subject to intensive management such as tilling.
Natural & Semi-Natural	Forest	Broadleaved Forest	Areas dominated by trees (generally >5 m tall) where broad-leaved species predominate. Includes eucalyptus and deciduous tree plantations, oak woodlands, woodland/riparian areas.
Natural & Semi-Natural	Forest	Coniferous Forest	Areas dominated by trees (generally >5 m tall) where coniferous species predominate. Includes pine plantations, non-evergreen coniferous woodlands (e.g., Larix), and Christmas tree plantations.
Natural & Semi-Natural	Forest	Mixed Forest	Areas dominated by trees (generally >5 m tall) where neither broad-leaved nor coniferous species predominate. Includes mixed-forest woodlands.
Natural & Semi-Natural	Shrubland	Shrubland	Areas dominated by natural or semi-natural herbaceous and scattered woody vegetation (generally <6 m tall, not touching to interlocking). Both evergreen and deciduous trees or shrubs that are small or stunted because of environmental conditions are included. May occur naturally or be a result of human activity; includes chaparral, woodland, savanna, and transitional woodland-shrub.
Natural & Semi-Natural	Wetlands	Herbaceous wetlands	Areas dominated by perennial herbaceous vegetation and where the soil or substrate is periodically saturated with or covered with water.
Natural & Semi-Natural	Wetlands	Woody Wetlands	Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
Natural & Semi-Natural	Cultivated/Ruderal Vegetation	Cultivated/Ruderal Vegetation	Areas consisting of ruderal vegetation or non-agricultural plantings, including hedgerows, field margins (vegetated shrubs/flowers at edges of fields), and vegetation along roadways/ditches.
Cultivated	Cropland	Orchards/Vineyards	Permanent crops such as vineyards, fruit and nut orchards, olive groves, coffee farms, and agro-forestry.
Cultivated	Cropland	Perennial row crops	Areas in production with perennial row crops, including perrennial herbs (e.g., alfalfa), fruits (e.g., berry plantations), and vegatables.
Cultivated	Cropland	Annual row crops	Areas in production with annual row crops, such as cereals, legumes, roots, and vegetables.
Cultivated	Grassland	Pasture/Fallow Fields	Areas of grasses planted or is intensively managed for livestock grazing or the production of seed or hay crops. Also, includes sugarcane, rice fields, fallow fields and set-asides.
Developed	Developed	Developed-Low intensity to open spaces	Areas with a mixture of constructed materials and vegetation, where impervious surfaces account for <50% percent of total cover. These areas include discontinuous urban fabric, low density housing, urban greenery, lawns, gardens, parks, golf courses, agricultural farms, military bases, and recreation areas.
Developed	Developed	Developed-Medium to high intensity	Areas with a mixture of constructed materials and vegetation, where impervious surfaces account for >50% of total cover. These areas include highly developed areas such as urban centres, commercial/industrial areas, cemeteries, transportation networks/roads, mines, dumps, and construction sites.
Unsuitable	Barren	Barren or sparsely vegetated	Open spaces with little or no vegetation, including bare rock, gravel pits, sand dune,, silt, clay, beaches, dunes, and burnt areas.
Unsuitable	Open water	Open water	Areas of open water or permanent ice/snow cover, including both inland and marine waters.

Table S4_2. Average (± SD) nesting suitability and floral resource values for standardized land cover types across the 39 studies as determined by data providers. Prior to determining mean values, nesting and floral values were totaled across different bee taxa and multiple seasons, respectively, and then rescaled from 0 to 1 within each study.

		Total Nesting + Floral		**Nesting Suitability**		**Floral Resource**	
Land cover type	Count	Mean	SD	Mean	SD	Mean	SD
Natural & Semi-Natural	**145**	**0.60**	**0.33**	**0.62**	**0.33**	**0.47**	**0.34**
Grassland/Herbaceous	**18**	**0.64**	**0.27**	**0.64**	**0.28**	**0.64**	**0.28**
Forest	**62**	**0.60**	**0.35**	**0.67**	**0.33**	**0.37**	**0.36**
Broadleaved forest	38	0.71	0.31	0.76	0.30	0.53	0.35
Coniferous forest	15	0.35	0.25	0.46	0.30	0.06	0.08
Mixed forest	9	0.53	0.38	0.64	0.37	0.25	0.26
Shrubland	**34**	**0.80**	**0.24**	**0.77**	**0.24**	**0.69**	**0.27**
Wetlands	**25**	**0.38**	**0.30**	**0.33**	**0.30**	**0.36**	**0.28**
Herbaceous wetlands	18	0.29	0.28	0.20	0.23	0.38	0.31
Woody wetlands	7	0.61	0.20	0.65	0.19	0.32	0.19
Cultivated/Ruderal vegetation	**6**	**0.38**	**0.20**	**0.46**	**0.24**	**0.23**	**0.07**
Cultivated	**120**	**0.36**	**0.29**	**0.25**	**0.27**	**0.48**	**0.34**
Cropland	**84**	**0.33**	**0.26**	**0.20**	**0.22**	**0.50**	**0.35**
Orchards/Vineyards	25	0.46	0.25	0.28	0.17	0.67	0.31
Perennial row crops	17	0.37	0.27	0.28	0.31	0.50	0.33
Annual row crops	42	0.24	0.23	0.12	0.18	0.40	0.33
Grassland	**36**	**0.42**	**0.33**	**0.36**	**0.32**	**0.42**	**0.32**
Pasture/Fallow fields	36	0.42	0.33	0.36	0.32	0.42	0.32
Developed	**63**	**0.33**	**0.30**	**0.34**	**0.32**	**0.23**	**0.25**
Developed-Low intensity to open spaces	29	0.42	0.31	0.41	0.31	0.31	0.29
Developed-Medium to high intensity	34	0.25	0.26	0.28	0.32	0.15	0.18
Unsuitable	**43**	**0.09**	**0.18**	**0.10**	**0.22**	**0.05**	**0.14**
Barren or sparsely vegetated	**18**	**0.21**	**0.23**	**0.25**	**0.28**	**0.12**	**0.20**
Open water	**25**	**0.00**	**0.01**	**0.00**	**0.01**	**0.00**	**0.01**

Appendix S5. Using neutral modeling to select landscape-level metrics.

In addition to characterizing landscape composition across study regions, we also quantified landscape configuration. To do so, we used neutral landscapes, which are grid representations of maps in which ‘habitat’ distributions are generated by random or fractal algorithms in a way that explicitly controls two fundamental aspects of landscape pattern: composition and configuration (Gardner & Urban 2007). Neutral landscapes are effective tools in ecology and help to identify species’ perceptions to landscape structure (With & King 1997). We applied neutral modeling to select three of the 36 landscape metrics offered by FRAGSTATS to incorporate into a full, mixed-model analysis that includes the Lonsdorf *et al.* (2009) landscape index (LLI). We wanted each chosen metric to be uncorrelated with the LLI, as well as uncorrelated with each other. To identify landscape metrics that captured aspects of landscape structure that were not accounted for by the Lonsdorf *et al.* (2009) model, we generated neutral landscapes that differed regularly along two gradients: proportion of each habitat type ($\%_x$) and aggregation of habitat types over the landscape (p, the degree of spatial autocorrelation among adjacent cells) using modified version of SIMMAP 2.0 software (Saura & Martínez-Millán 2000). Each landscape included three habitat types (classes) that were separately assigned different suitability (x) for bee nesting (N_{sx}) and foraging (F_{sm}) as x=0 for the poor habitat class, x=0.5 or 0.25 for the intermediate habitat class and x=1 for the good habitat class. Suitabilities were assigned under different assumptions of correlation between nesting and foraging habitat quality (as described below). Rather than exploring landscapes along the entire gradients of % and p (cf. Neel *et al.* 2004), we limited the area of good quality habitat in our landscapes to the range that had potential to be fragmented; i.e., $\%_1 \leq 0.5$. Above this amount of habitat in a landscape there is little room for variation in configuration, whereas below it, a small enough proportion of the total landscape is occupied that spatial configuration of habitat patches can vary (Gustafson & Parker 1992). We investigated the 26 combinations of habitat amount in which the condition for $\%_1$ was met and in which $\%_0$ and $\%_{0.5,\, 0.25}$ take all possible values > 0 at 0.1 increments (Figure S5_1a). Each of the 26 combinations was created using five values of p at equal increments from 10 to 50. We chose these values of p because they produced neutral landscapes similar in pattern to empirical landscapes, and p must be less than p_c, the percolation threshold ($p_c \approx 0.5928$) to obtain the full range of landscape patterns possible (Saura 2003). Each *% by p* combination was replicated 100 times yielding 13,000 neutral landscapes. Each landscape comprised 210 x 210 pixels to which we ascribed a pixel size of 30 m to simulate a 6 km x 6 km landscape that was similar to the scale of the empirical landscapes in this study (Figure S5_1b). Patches were defined using an eight neighbor rule for both SIMMAP and FRAGSTATS outputs.

For each of the 13,000 landscapes, we modeled total pollinator (bee) abundance ($Abund_{\mathrm{os}}$) measured at the landscape centroid (i.e., field site) for four bee species with typical foraging distances of 180 m, 360 m, 750 m, and 1500 m and then calculated an average pollinator (bee) abundance score from each of the four species' scores. $Abund_{\mathrm{os}}$ depends on the amount and quality of nesting habitat within an estimated maximum foraging distance of 3 km from the centroid (Figure S5_1b, circle within dark grey "core" area). These pollinators in turn depend on the floral resources 3 km of their nesting site. Thus, $Abund_{\mathrm{os}}$ measured at the centroid potentially depends on the amount and quality of nesting and floral resources within 3 − 6 km of the landscape centroid (Figure S5_1b, light grey circle). To test the effect of variation in habitat suitability among bees we simulated five different nesting and floral suitability patterns with respect to the three different land-cover types from perfectly correlated to perfectly uncorrelated (Table S5_3). Because our goal was to select landscape configuration metrics that were as robust to differences due to variation in suitability estimates as possible, the suitability patterns were designed to maximize differences among degree of correlations. In this way we could evaluate the sensitivity of the relationships between metrics and model scores of abundance to these correlations.

We then calculated landscape-level metrics (Table S5_4) for each of 13,000 neutral landscapes as well as for empirical landscapes. By using landscape-level metrics, we accounted for configuration of all identified habitat cover types in each study region and measured the aggregate properties of landscape heterogeneity rather than focusing on the individual contributions of each habitat type (McGarigal *et al.* 2002). Metrics were calculated for landscapes extending 3 km around each field site where possible, which coincided with the spatial extent calculated by the LLI and typical foraging ranges of bees (Gathmann & Tscharntke 2002; Greenleaf *et al.* 2007). In four studies land-cover data were restricted to 1-km or 1.5-km radii around fields. To capture biologically relevant habitat configuration, land-cover maps were first, reclassified into “habitat suitability” cover types that reflected nesting or foraging suitability (see Appendix S4). As such, different land-cover types designated within a map, such as different forms of development (e.g., urban areas, industrial areas, impervious surfaces) were classified as a single suitability type when they were attributed identical floral and nesting values by expert opinion. The number of habitat suitability cover classes varied from 3 to 27 among the different studies (mean ± 1 SD = 10.74 ± 5.08). It should be noted that landscape configuration metrics were derived from land-cover classifications that reflected unique “habitat suitability” cover types (i.e., classes differed in floral and nesting resources) as determined by expert opinion. If expert-opinion regarding differential resource availability in the initial cover types within a region was faulty, then our ability to detect meaningful relationships would be limited. However, the fact that we did see significant effects of landscape composition alone based on this classification (see Results section) suggests that expert-derived cover types were meaningful in predicting bee responses.

In addition to the number and type(s) of habitat suitability classes, the resolution of land-cover data could have varied by study. About half of the land-cover datasets had ≤10 m pixel sizes (22 of 46 maps). Most fine-scale maps were digitized by data providers from satellite imagery or aerial photography. The remaining studies relied on 25−30 m resolution (N = 18) or 56−100 m maps (N = 6). For the seven studies in which multiple land-cover maps were available, we relied on the map deemed most reliable by each author in terms of its spatial resolution, accuracy, and appropriateness of land-cover classes delineated in relation to the bee community. To allow for comparison across study regions, we standardized maps with resolutions <30 m by resampling and assigning the "majority" land-cover class within a 30-m squared area prior to calculating metrics.

For each of 13,000 neutral landscapes we determined the Pearson's product-moment correlation coefficients (*r*) between each of the landscape metrics and the average LLI model abundance score of the four simulated bee species under the five habitat suitability scenarios. We averaged the model scores from the four bee species and determined the absolute value of the correlation for each of the five habitat suitability scenarios to the 36 landscape metrics. Thus each of the 36 metrics had five correlation values (Table S5_3).

Because the correlations varied across scenarios, we examined the results from the five scenarios in several ways to select final metrics. We computed the average, minimum and maximum correlation value for each metric. We ranked the metrics, as well as ranked the average, minimum and maximum r values. We then averaged the ranks. Each of these analyses yielded slightly different results for the three metrics that showed the minimum correlation or rank. For simplicity we provide only the five correlations. Ultimately, we selected one metric that predominately characterized patch shape, another metric that characterized patch isolation, and finally one that characterized patch contagion or interspersion to capture different elements of landscape structure.

Landscape metrics found to be among the least correlated with model scores, and thus the most likely to explain deviations from model predictions and empirical observations in study landscapes were: (1) perimeter-area ratio distribution (PARA_MN), which measures mean shape and edge density of patches in a landscape ($\bar{r}$ ± 1 SD = 0.02 ± 0.02); 2) Euclidean nearest neighbor distance distribution (ENN_CV) ($\bar{r}$ ± 1 SD = 0.06 ± 0.04), which measures variation in inter-patch connectivity in a landscape; and (3) interspersion & juxtaposition index (IJI) ($\bar{r}$ ± 1 SD = 0.04 ± 0.02), which measures patch aggregation or the extent to which habitat patches are clumped together versus interspersed among different habitat patches (Table S5_5). These metrics were also uncorrelated with model abundance scores based on our empirical modeling of bee assemblages and landscape metrics for the 39 studies (PARA_MN: $r = 0.12$; ENN_CV: $r = -0.09$; IJI: $r = 0.03$) (Table S5_5). In addition to being selected because they were weakly correlated with pollinator (bee) model scores based on both neutral and empirical landscapes, these metrics were also not strongly correlated with one another, thus, captured independent aspects of landscape configuration (i.e., habitat shape, connectivity, and aggregation) ($r < |0.60|$ based on neutral landscapes and $r < |0.12|$ based on empirical landscapes) (McGarigal *et al.* 2000).

In addition to having desired statistical independence, selected configuration metrics have been widely applied and found important in relevant ecological contexts. Euclidean nearest neighbor measures (e.g., ENN_CV) are the most common metrics applied in ecology for structural connectivity (Calabrese & Fagan 2004), and have been found important for pollinators (Ricketts *et al.* 2008). Characterizing patch shape and edges with metrics like PARA_MN is supported by findings that edge (or length of boundaries) of fields or semi-natural areas can strongly impact species richness in agricultural systems (Carré *et al.* 2009; Concepción *et al.* 2012). For example, boundaries with semi-natural vegetation can act as corridors for movement or provide additional food resources in agricultural landscapes, or can be detrimental if they fragment habitats or act as barriers or sinks (Gabriel *et al.* 2010; Concepción *et al.* 2012). Lastly, wild bees have been found to significantly respond to landscape heterogeneity, which has been measured by IJI (Carré *et al.* 2009). An intermixing of habitat types may contain diverse foraging and nesting resources that help support more diverse and abundant bee species (Winfree *et al.* 2007); this landscape aspect was previously predicted by co-authors to be a potential important driver of pollinator communities across diverse agricultural systems (Lonsdorf *et al.* 2009).

Sources cited:

Calabrese, J.M. & Fagan, W.F. (2004). A comparison-shopper's guide to connectivity metrics. *Frontiers in Ecology and the Environment*, 2, 529-536.

Carré, G., Roche, P., Chifflet, R., Morison, N., Bommarco, R., Harrison-Crips, J., et al. (2009). Landscape context and habitat type as drivers of bee diversity in European annual crops *Agriculture, Ecosystems and Environment*, 133, 40-47.

Concepción, E.D., Diaz, M., Kleijn, D., Báldi, A., Batáry, P., Clough, Y., et al. (2012). Interactive effects of landscape context constrain the effectiveness of local agri-environmental management. *Journal of Applied Ecology*, 49, 695-705.

Gabriel, D., Sait, S.M., Hodgson, J.A., Schmutz, U., Kunin, W.E. & Benton, T.G. (2010). Scale matters: the impact of organic farming on biodiversity at different spatial scales. *Ecology Letters*, 13, 858–869.

Gardner, R.H. & Urban, D.L. (2007). Neutral models for testing landscape hypotheses. *Landscape Ecology*, 22, 15–29.

Gathmann, A. & Tscharntke, T. (2002). Foraging ranges of solitary bees. *Journal of Animal Ecology*, 71, 757-764.

Greenleaf, S., Williams, N., Winfree, R. & Kremen, C. (2007). Bee foraging ranges and their relationships to body size. *Oecologia*, 153, 589-596.

Gustafson, E.J. & Parker, G.R. (1992). Relationships between Landcover Proportion and Indexes of Landscape Spatial Pattern. *Landscape Ecology*, 7, 101-110.

Lonsdorf, E., Kremen, C., Ricketts, T., Winfree, R., Williams, N. & Greenleaf, S. (2009). Modelling pollination services across agricultural landscapes. *Ann Bot*, 103, 1589-1600.

McGarigal, K., Cushman, S. & Stafford, S. (2000). *Multivariate Statistics for Wildlife and Ecology Research*. Springer-Verlag New York, Inc., New York, NY.

McGarigal, K., Cushman, S.A., Neel, M.C. & Ene, E. (2002). FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. In. University of Massachusetts Amherst, MA.

Neel, M.C., McGarigal, K. & Cushman, S.A. (2004). Behavior of class-level landscape metrics across gradients of class aggregation and area. *Landscape Ecology*, 19, 435-455.

Ricketts, T.H., Regetz, J., Steffan-Dewenter, I., Cunningham, S.A., Kremen, C., Bogdanski, A., et al. (2008). Landscape effects on crop pollination services: Are there general patterns? *Ecology Letters*, 11, 499-515.

Saura, S. (2003). SIMMAP 2.0 Landscape Categorical Spatial Patterns Simulation Software User's Manual. In. Universidad Politécnica de Madrid Madrid, Spain, p. 22.

Saura, S. & Martínez-Millán, J. (2000). Landscape patterns simulation with a modified random clusters method. *Landscape Ecology*, 15, 661-678.

Winfree, R., Griswold, T. & Kremen, C. (2007). Effect of human disturbance on bee communities in a forested ecosystem. *Conservation Biology*, 21, 213-223.

With, K.A. & King, A.W. (1997). The use and misuse of neutral landscape models in ecology. *Oikos*, 79, 219-229.

Table S5_3. Five scenarios modeled in relation to nesting suitability at a location *x* for bee species *s* (N_{sx}) and foraging suitability in location *m* surrounding nesting location *x* for bee species *s* (F_{sm}), based on three habitat types or land-cover classes (1−3). Nesting and floral values suitability values of 0 indicate a poor habitat type, 0.5 or 0.25 indicate intermediate quality habitat types and 1 a good habitat type. We applied different assumptions of correlation between nesting and foraging habitat: perfectly correlated (scenario 1), intermediate correlation (scenarios 2 and 3), and perfectly uncorrelated (scenarios 4 and 5). Each scenario was modeled for four different species (*s*) with foraging distances of 180, 360, 750, and 1500 m.

	Scenario 1		**Scenario 2**		**Scenario 3**		**Scenario 4**		**Scenario 5**	
	N_{sx}	F_{sm}	N_{sx}	F_{sm}	N_{sx}	F_{sm}	N_{sx}	F_{sm}	N_{sx}	F_{sm}
Class 1	1	1	1	0.25	0.25	1	0	1	1	0
Class 2	0.5	0.5	0.25	1	1	0.25	1	0	0	1
Class 3	0	0	0	0	0	0	0	0	0	0

Table S5_4. Landscape-level metrics calculated for both multi-class neutral landscapes and empirical landscapes for the 39 studies. Metrics were computed using FRAGSTATS 3.3 (using 30-m raster cell size, an eight-neighbor rule for patch delineation). Where relevant, we computed (1) mean (MN), (2) area-weighted mean (AM) and (3) coefficient of variation (CV) for each target metric (as described by McGarigal *et al.* 2002).

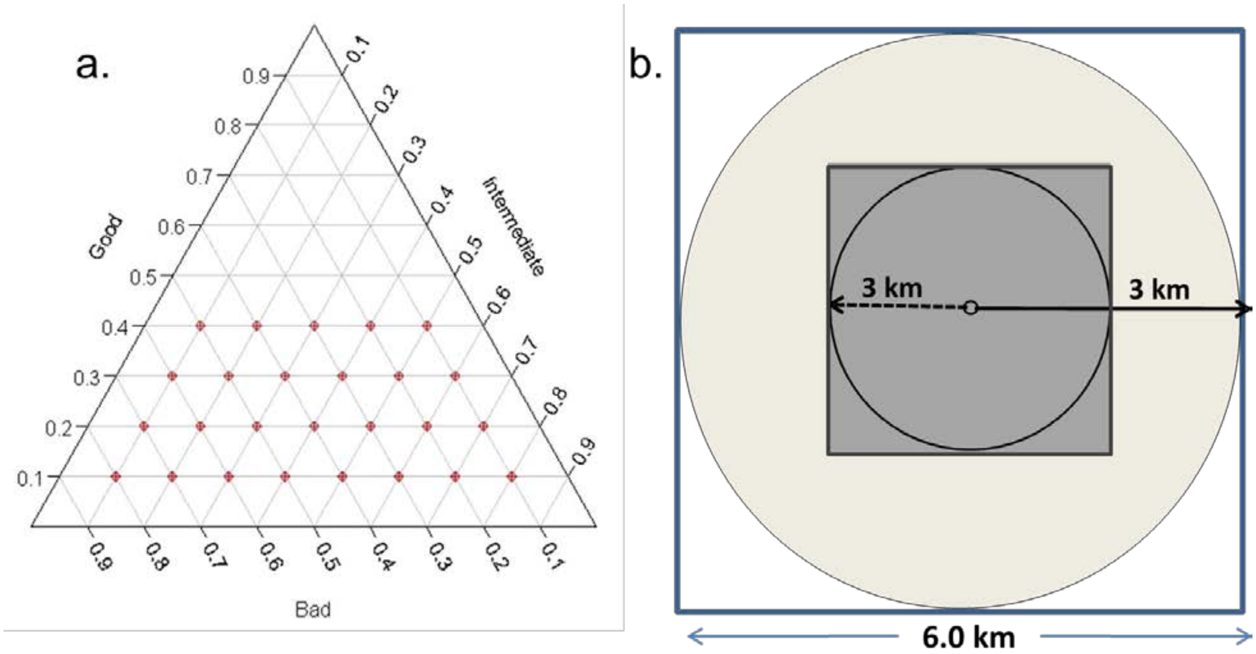
Classification	**Landscape-level metric**	**Code**
Area/Density/Edge metrics	Patch Area Distribution	AREA
	Edge Density	ED
	Radius of Gyration Distribution	GYRATE
	Landscape Shape Index	LSI
	Patch Density	PD
Shape metrics	Fractal Index Distribution	FRAC
	Perimeter-Area Fractal Dimension	PAFRAC
	Perimeter-Area Ratio Distribution	PARA
	Shape Index Distribution	SHAPE
Isolation/proximity metrics	Euclidean Nearest Neighbor Distance Distribution	ENN
Connectivity metrics	Patch Cohesion Index	COHESION
	Connectance Index	CONNECT*
Contagion/Interspersion metrics	Aggregation Index	AI
	Contagion	CONTAG
	Landscape Division Index	DIVISION
	Interspersion & Juxtaposition Index	IJI
	Effective Mesh Size	MESH
	Percentage of Like Adjacencies	PLADJ
Diversity	Modified Simpson’s Diversity Index	MSIDI
	Modified Simpson’s Evenness Index	MSIEI
	Shannon’s Diversity Index	SHDI
	Shannon’s Evenness Index	SHEI
	Simpson’s Diversity Index	SIDI
	Simpson’s Evenness Index	SIEI

* Based on 100 m threshold distance (i.e., search radius)

Table S5_5. Correlations between landscape metrics and Lonsdorf *et al.* (2009) modeled pollinator (bee) abundance scores for 1) empirical study landscapes, and 2) neutral landscapes based on community average score across four simulated species (with typical foraging distances of 180 m, 360 m, 750 m, and 1500 m) and under five different habitat suitability scenarios (as specified in Table S5_3). We report only Pearson's product-moment correlation coefficients (*r*), because they were highly correlated ($r > 0.90$) with the Spearman's rank correlation coefficients (ρ). Landscape metrics selected for analyses appear in bold.

	Empirical		Neutral landscapes				
			Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Metric	***r***	p-value	***r***	***r***	***r***	***r***	***r***
AI	-0.26	0.00	0.04	0.02	0.01	0.16	0.16
AREA_AM	-0.27	0.00	0.32	0.08	0.08	0.26	0.26
AREA_CV	0.03	0.50	0.30	0.09	0.09	0.20	0.20
AREA_MN	-0.13	0.00	0.04	0.01	0.01	0.11	0.11
COHESION	-0.02	0.69	0.19	0.07	0.07	0.21	0.21
CONNECT	-0.18	0.00	0.18	0.04	0.04	0.03	0.03
CONTAG	-0.45	0.00	0.14	0.02	0.02	0.23	0.22
DIVISION	0.3	0.00	0.32	0.08	0.08	0.26	0.26
ED	0.29	0.00	0.04	0.02	0.01	0.16	0.16
ENN_AM	-0.11	0.01	0.00	0.02	0.02	0.12	0.13
ENN_CV	-0.09	0.05	0.04	0.03	0.03	0.10	0.10
ENN_MN	-0.14	0.00	0.02	0.00	0.00	0.16	0.16
FRAC_AM	0.4	0.00	0.21	0.05	0.06	0.12	0.12
FRAC_CV	0.12	0.01	0.19	0.06	0.06	0.24	0.24
FRAC_MN	0.05	0.27	0.14	0.04	0.04	0.21	0.21
GYRATE_AM	-0.18	0.00	0.29	0.08	0.08	0.26	0.26
GYRATE_CV	-0.01	0.75	0.03	0.00	0.00	0.16	0.16
GYRATE_MN	-0.14	0.00	0.20	0.05	0.05	0.10	0.10
IJI	0.03	0.49	0.00	0.06	0.06	0.05	0.05
LSI	0.36	0.00	0.04	0.02	0.01	0.16	0.16
MESH	-0.27	0.00	0.32	0.08	0.08	0.26	0.26
MSIDI	0.19	0.00	0.25	0.04	0.04	0.23	0.23
MSIEI	0.39	0.00	0.25	0.04	0.04	0.23	0.23
PAFRAC	0.22	0.00	0.15	0.05	0.05	0.22	0.22
PARA_AM	0.28	0.00	0.04	0.02	0.01	0.16	0.16
PARA_CV	-0.09	0.05	0.07	0.01	0.01	0.00	0.01
PARA_MN	0.03	0.43	0.05	0.01	0.01	0.02	0.01
PD	0.09	0.04	0.05	0.01	0.01	0.08	0.08
PLADJ	-0.24	0.00	0.04	0.02	0.01	0.16	0.16
SHAPE_AM	0.39	0.00	0.25	0.08	0.08	0.13	0.13
SHAPE_CV	0.39	0.00	0.07	0.02	0.02	0.11	0.11
SHAPE_MN	0.03	0.54	0.23	0.07	0.07	0.26	0.26
SHDI	0.13	0.00	0.21	0.02	0.02	0.21	0.21
SHEI	0.37	0.00	0.21	0.02	0.02	0.21	0.21
SIDI	0.25	0.00	0.24	0.03	0.03	0.23	0.23
SIEI	0.33	0.00	0.24	0.03	0.03	0.23	0.23

Figure S5_1. a. Dots represent combinations of $\%_0$ (bad), $\%_{0.5}$ (intermediate) and $\%_1$ (good) habitat of neutral landscapes that were generated. b. 6 km x 6 km landscape corresponding to bees with typical foraging ranges (arrow) of up to 3 km. Bees nesting in the grey (core) region can reach the centroid (field) of this landscape, but their abundances are influenced by availability of foraging resources within light grey (total) region.



Appendix S6. Candidate model set.

We analyzed the influence of landscape and local factors on empirical wild bee abundance and richness based on the general model structure: $E(a, r) = e^{\beta 0} e^{\beta X} \rightarrow \ln[E(a,r) = \beta_0 + \beta_i X_i$, where E(a, r) is the expected wild bee abundance or richness, β_i are the partial regression coefficients, and X_i are the covariates (local and landscape variables) and covariate interactions. We log-transformed both abundance and richness by ln [a + 1, r + 1]. Residuals of fitted models were approximately normally distributed with no strong pattern of overdispersion or heteroscedasticity (based on plotting residuals vs. fitted values and vs. study identity). We applied Gaussian error distribution based on log-transformed response variables, rather than Poisson or negative binomial error distribution based on counts, because of improved model fits (i.e., lower AIC values and deviance scores). Different error distributions yielded similar strength and directional patterns for covariates. We also investigated transforming our observations using z-scores $(\frac{y_{ji} - \overline{y_i}}{SD_i})$, which standardizes contrasting means $(\overline{y}_i)$ and standard deviations (SD_i) among systems, as applied in other meta-analyses (Garibaldi *et al.* 2011; Maestre *et al.* 2012). Again, we found that the most supported covariates and their directional trends were generally consistent between z-score and ln-transformations. Log-linear models, however, were uniformly more strongly supported than those based on z-scores based on lower deviance scores and AIC values (i.e., ΔAIC > 175 for abundance and ΔAIC > 915 for richness) and lower model weights for richness. Given the lack of improvement based on z-score transformations, and reduced fit with our data, we present only log-linear relationships.

We analyzed 135 models (candidate model set). Our global model included all main effects and all two-way interactions between ecologically-scaled landscape composition

(Londsorf Landscape Index, LLI) and local farming variables (field type, FT, organic vs. conventional, and field-scale diversity, FD, locally simple vs. complex crop diversity) and between LLI, FT, or FD with landscape configuration covariates (perimeter-area ratio distribution , PARA_MN; Euclidean nearest neighbor distance distribution, ENN_CV; interspersion & juxtaposition index, IJI). These interactions reflect previous research that suggests that habitat configuration can mediate effects of habitat amount (Andren 1994; Fahrig 2002; Goodsell & Connell 2002) while local farming practices mediate effects of landscape composition (Holzschuh *et al.* 2007; Rundlöf *et al.* 2008; Batary *et al.* 2011; Concepción *et al.* 2012). We did not include interactions between the different landscape configuration covariates because of a lack of biological justification. The model set was balanced, with each of the six covariates (main effects) appearing in 88 different models and each of the two-way interactions appearing in 13 models. We calculated model-averaged estimates of partial slope coefficients based on the 95% confidence set (Burnham & Anderson 2002). Model averaging combines parameter estimates from each model using their associated Akaike weights to account for the fact that each model has some degree of validity and to provide a mean estimate and standard error that incorporates both within- and across-model uncertainty. This approach reduces model bias and allows for more robust inferences than those based on a single selected best model (Burnham & Anderson 2002); and permits nuanced interpretation of the strength of evidence of the importance of each covariate.

Sources cited:

Andren, H. (1994). Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: A review. *Oikos*, 71, 355-366.

Batary, P., Baldi, 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.

Burnham, K.P. & Anderson, D.R. (2002). *Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach*. 2nd edn. Springer Science + Business Media, LLC, Fort Collins, CO.

Concepción, E.D., Diaz, M., Kleijn, D., Báldi, A., Batáry, P., Clough, Y., et al. (2012). Interactive effects of landscape context constrain the effectiveness of local agri-environmental management. *Journal of Applied Ecology*, 49, 695-705.

Fahrig, L. (2002). Effect of habitat fragmentation on the extinction threshold: A synthesis. *Ecological Applications*, 12, 346-353.

Garibaldi, L.A., Steffan-Dewenter, I., Kremen, C., Morales, J.M., Bommarco, R., Cunningham, S.A., et al. (2011). Stability of pollination services decreases with isolation from natural areas despite honey bee visits. *Ecology Letters*, published online, DOI: 10.1111/j.1461-0248.2011.01669.x.

Goodsell, P.J. & Connell, S.D. (2002). Can habitat loss be treated independently of habitat configuration? Implications for rare and common taxa in fragmented landscapes. *Marine Ecology-Progress Series*, 239, 37-44.

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.

Maestre, F.T., Quero, J.L., Gotelli, N.J., Escudero, A., Ochoa, V., Delgado-Baquerizo, M., et al. (2012). Plant Species Richness and Ecosystem Multifunctionality in Global Drylands. *Science*, 335, 214.

Rundlöf, M., Nilsson, H. & Smith, H.G. (2008). Interacting effects of farming practice and landscape context on bumble bees. *Biological Conservation*, 141, 417-426.

Table S6_1. Candidate model structures testing relationships between pollinator measures (wild bee abundance and wild bee richness) and landscape composition (Lonsdorf landscape index, LLI), local farm management (organic vs. conventional farming and field-scale diversity), and landscape configuration (PARA_MN, ENN_CV, IJI). Models #1-134 were special cases of global model #135. Lonsdorf landscape index (LLI) is the pollinator abundance score derived by the spatially-explicit Lonsdorf *et al.* (2009) model. Field type (FT) is whether fields were conventional or organic and Field diversity (FD) is whether fields were locally simple (large monocultural fields) or locally diverse (small fields with inter-mixed crops and/or non-crop plantings). PARA_MN is the perimeter-area ratio distribution, which measures patch shape complexity in a landscape. ENN_CV is the Euclidean nearest neighbor distance distribution, which measures the variation in inter-patch connectivity in a landscape. IJI is the interspersion & juxtaposition index, which measures habitat aggregation in a landscape. : denotes an interaction effect was modeled.

	Lonsdorf landscape index (LLI)	Farm type (FT)	Field diversity (FD)	Shape (PARA_MN)	Connectivity (ENN_CV)	Aggregation (IJI)	LLI:FT	LLI:FD	FT:FD	LLI:PARA_MN	FT:PARA_MN	FD:PARA_MN	LLI:ENN_CV	FT:ENN_CV	FD:ENN_CV	LLI:IJI	FT:IJI	FD:IJI
1	X																	
2		X																
3			X															
4	X	X																
5	X		X															
6		X	X															
7	X	X	X															
8				X														
9					X													
10						X												
11				X	X													
12				X		X												
13					X	X												
14				X	X	X												
15	X			X														
16	X				X													
17	X					X												
18	X			X	X													
19	X			X		X												
20	X				X	X												
21	X			X	X	X												
22		X		X														
23		X			X													
24		X				X												
25		X		X	X													
26		X		X		X												
27		X			X	X												
28		X		X	X	X												
29			X	X														
30			X		X													
31			X			X												
32			X	X	X													
33			X	X		X												
34			X		X	X												
35			X	X	X	X												
36		X	X	X														
37		X	X		X													
38		X	X			X												
39		X	X	X	X													
40		X	X	X		X												
41		X	X		X	X												
42		X	X	X	X	X												
43	X	X		X														
44	X	X			X													
45	X	X				X												
46	X	X		X	X													
47	X	X		X		X												
48	X	X			X	X												
49	X	X		X	X	X												

50	X		X	X														
51	X		X		X													
52	X		X			X												
53	X		X	X	X													
54	X		X	X		X												
55	X		X		X	X												
56	X		X	X	X	X												
57	X	X	X	X														
58	X	X	X		X													
59	X	X	X			X												
60	X	X	X	X	X													
61	X	X	X	X		X												
62	X	X	X		X	X												
63	X	X	X	X	X	X												
64	X	X					X											
65	X		X					X										
66		X	X						X									
67	X			X						X								
68		X		X							X							
69			X	X								X						
70	X				X								X					
71		X			X									X				
72			X		X										X			
73	X					X										X		
74		X				X											X	
75			X			X												X
76	X	X	X				X											
77	X	X	X					X										
78	X	X	X						X									
79	X	X	X				X	X										
80	X	X	X				X		X									
81	X	X	X					X	X									
82	X	X	X				X	X	X									
83	X			X	X	X				X								
84		X		X	X	X					X							
85			X	X	X	X						X						
86	X	X		X	X	X				X	X							
87	X		X	X	X	X				X		X						
88		X	X	X	X	X					X	X						
89	X			X	X	X							X					
90		X		X	X	X								X				
91			X	X	X	X									X			
92	X	X		X	X	X							X	X				
93	X		X	X	X	X							X		X			
94		X	X	X	X	X								X	X			
95	X			X	X	X										X		
96		X		X	X	X											X	
97			X	X	X	X												X
98	X	X		X	X	X										X	X	
99	X		X	X	X	X										X		X
100		X	X	X	X	X											X	X

101	X	X	X	X	X	X	X											
102	X	X	X	X	X	X		X										
103	X	X	X	X	X	X			X									
104	X	X	X	X	X	X	X	X										
105	X	X	X	X	X	X	X		X									
106	X	X	X	X	X	X		X	X									
107	X	X	X	X	X	X	X	X	X									
108	X	X	X	X	X	X				X								
109	X	X	X	X	X	X					X							
110	X	X	X	X	X	X						X						
111	X	X	X	X	X	X				X	X							
112	X	X	X	X	X	X				X		X						
113	X	X	X	X	X	X					X	X						
114	X	X	X	X	X	X				X	X	X						
115	X	X	X	X	X	X							X					
116	X	X	X	X	X	X								X				
117	X	X	X	X	X	X									X			
118	X	X	X	X	X	X							X	X				
119	X	X	X	X	X	X							X		X			
120	X	X	X	X	X	X								X	X			
121	X	X	X	X	X	X							X	X	X			
122	X	X	X	X	X	X										X		
123	X	X	X	X	X	X											X	
124	X	X	X	X	X	X												X
125	X	X	X	X	X	X										X	X	
126	X	X	X	X	X	X										X		X
127	X	X	X	X	X	X											X	X
128	X	X	X	X	X	X										X	X	X
129	X	X	X	X	X	X	X			X			X			X		
130	X	X	X	X	X	X		X				X			X			X
131	X	X	X	X	X	X			X		X	X		X	X		X	X
132	X	X	X	X	X	X	X	X		X	X		X	X		X	X	
133	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
134	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
135	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Appendix S7. Summary statistics for variables and model selection statistics

Table S7_1. Summary statistics for study variables based on total or mean (± 1SD) values per study (N = 39).

	# Studies	# Sites		Wild Abundance*		Wild Richness*		Honey bees*		# Sites per FT		# Sites per FD		LLI		PARA_MN		ENN_CV		IJI	
Biome†	Total	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Conv	Organic	Simple	Diverse	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Tropical/Subtropical	10	11.80	6.85	72.13	120.72	5.00	6.53	57.13	73.41	108	10	88	30	0.12	0.16	554.42	275.42	105.71	44.98	63.33	10.19
Mediterranean	8	16.88	8.08	27.44	23.91	4.71	2.94	77.63	101.62	96	39	109	26	0.04	0.01	913.62	77.56	150.17	10.70	60.00	6.94
Temperate	21	16.76	9.55	58.26	128.41	9.43	6.56	57.68	63.95	310	42	235	117	0.11	0.10	666.33	279.91	110.23	34.31	64.85	9.72
All Biomes	39	15.51	8.90	55.49	113.88	7.27	6.39	61.21	75.11	514	91	432	173	0.10	0.11	688.36	279.54	117.26	38.20	63.46	9.53

†See Table 1 for biome definitions.

*Based on mean estimates per site (see Table 1 for total bee taxa per crop system).

Table S7_2. Summary of model selection statistics for wild bee abundance and richness as a function of local and landscape variables. K is the number of parameters included in the model (including fixed and random effects); Deviance is -2 times the logarithm of the probability of the data given the estimated model parameters and is a statistical summary of model fit; AIC is Akaike's Information Criterion and AICc is AIC adjusted for finite sample size, which judge a model by how close its fitted values are to true values and can be interpreted as the weight of evidence in favor of model *i* being the best model for the data with respect to the entire model set; ΔAICc is the difference in AICc value for model *i* when compared with the top ranked model; w_i is the Akaike weight of model *i*, which is interpreted as the probability that model *i* is the best model of those considered in the entire model set. The sum of the Akaike weights for all models in the model set = 1. All models that had any weight within the candidate model set are displayed, but models denoted by ⊗ fell outside of the 95% confidence set ($\Sigma w \geq 0.95$). Models in bold are within 2 ΔAIC units of the top model, and considered to have substantial and equal model support ('top models'). The global model was bee abundance or richness = *f* (LLI*FT + LLI*FD + FT*FD + LLI*PARA_MN + FT*PARA_MN + FD*PARA_MN + LLI*ENN_CV + FT*ENN_CV + FD*ENN_CV + LLI*IJI + FT*IJI + FD*IJI), with study and site-within-study treated as random effects (1|Study/Site). * indicates main effects plus their interaction. Model # corresponds to the model specified in the candidate model set (Appendix S6). LLI = Lonsdorf landscape index (an ecologically-scaled index of landscape composition); FT = Field type (conventional vs. organic); FD = Field-scale diversity (locally simple vs. locally diverse); PARA_MN = perimeter-area ratio distribution (measure of patch shape); ENN_CV = Euclidean nearest neighbor distance distribution (measure of inter-patch connectivity); and IJI =

interspersion & juxtaposition index (measure of habitat aggregation).

Model #	Model structure	K	Deviance	AIC_c	ΔAIC_c	*w*	
Total bee abundance							
78	**FT*FD+LLI**	**8**	**1771.37**	**1787.57**	**0.00**	**0.12**	
58	**LLI+FT+FD+ENN_CV**	**8**	**1771.89**	**1788.09**	**0.52**	**0.09**	
7	**LLI+FT+FD**	**7**	**1774.21**	**1788.37**	**0.79**	**0.08**	
81	**LLI*FD+FT*FD**	**9**	**1770.20**	**1788.45**	**0.88**	**0.08**	
77	**LLI*FD+FT**	**8**	**1772.80**	**1789.00**	**1.43**	**0.06**	
76	**LLI*FT+FD**	**8**	**1772.90**	**1789.10**	**1.52**	**0.06**	
80	**LLI*FT+FT*FD**	**9**	**1771.26**	**1789.51**	**1.94**	**0.05**	
62	**LLI+FT+FD+ENN_CV+IJI**	**9**	**1771.32**	**1789.57**	**2.00**	**0.05**	
59	LLI+FT+FD+IJI	8	1773.40	1789.60	2.03	0.04	
79	LLI*FT+LLI*FD	9	1771.84	1790.09	2.52	0.03	
60	LLI+FT+FD+PARA_MN+ENN_CV	9	1771.85	1790.10	2.53	0.03	
57	LLI+FT+FD+PARA_MN	8	1774.14	1790.34	2.76	0.03	
82	LLI*FT+LLI*FD+FT*FD	10	1770.17	1790.48	2.90	0.03	
103	FT*FD+LLI+PARA_MN+ENN_CV+IJI	11	1768.14	1790.51	2.94	0.03	
106	LLI*FD+FT*FD+PARA_MN+ENN_CV+IJI	12	1767.08	1791.52	3.94	0.02	
61	LLI+FT+FD+PARA_MN+IJI	9	1773.30	1791.55	3.98	0.02	
63	LLI+FT+FD+PARA_MN+ENN_CV+IJI	10	1771.26	1791.57	4.00	0.02	
101	LLI*FT+FD+PARA_MN+ENN_CV+IJI	11	1769.25	1791.62	4.05	0.02	
105	LLI*FT+FT*FD+PARA_MN+ENN_CV+IJI	12	1767.78	1792.22	4.65	0.01	
102	LLI*FD+FT+PARA_MN+ENN_CV+IJI	11	1769.96	1792.33	4.76	0.01	
104	LLI*FT+LLI*FD+PARA_MN+ENN_CV+IJI	12	1768.38	1792.82	5.25	0.01	
110	FD*PARA_MN+LLI+FT+ENN_CV+IJI	11	1770.45	1792.82	5.25	0.01	
115	LLI*ENN_CV+FT+FD+PARA_MN+IJI	11	1770.49	1792.86	5.29	0.01	
109	FT*PARA_MN +LLI+FD+ENN_CV+IJI	11	1770.66	1793.03	5.46	0.01	
108	LLI*PARA_MN+FT+FD+ENN_CV+IJI	11	1770.69	1793.07	5.49	0.01	
117	FD*ENN_CV+LLI+FT+PARA_MN+IJI	11	1770.77	1793.14	5.56	0.01	
116	FT*ENN_CV+LLI+FD+PARA_MN+IJI	11	1771.01	1793.38	5.80	0.01	
107	LLI*FT+LLI*FD+FT*FD+PARA_MN+ENN_CV+IJI	13	1766.87	1793.38	5.81	0.01	⊗
123	FT*IJI +LLI+FD+PARA_MN+ENN_CV	11	1771.07	1793.44	5.86	0.01	⊗
124	FD*IJI+LLI+FT+PARA_MN+ENN_CV	11	1771.12	1793.50	5.92	0.01	⊗
122	LLI*IJI+FT+FD+PARA_MN+ENN_CV	11	1771.24	1793.61	6.04	0.01	⊗
Social bee abundance							
58	**LLI+FT+FD+ENN_CV**	**8**	**1847.00**	**1863.21**	**0.00**	**0.17**	
62	**LLI+FT+FD+ENN_CV+IJI**	**9**	**1845.75**	**1864.00**	**0.80**	**0.12**	
60	LLI+FT+FD+PARA_MN+ENN_CV	9	1847.00	1865.25	2.05	0.06	
115	LLI*ENN_CV+FT+FD+PARA_MN+IJI	11	1843.54	1865.92	2.71	0.04	
109	FT*PARA_MN+LLI+FD+ENN_CV+IJI	11	1843.59	1865.97	2.76	0.04	
63	LLI+FT+FD+PARA_MN+ENN_CV+IJI	10	1845.73	1866.04	2.84	0.04	
118	LLI*ENN_CV+FT*ENN_CV+FD+PARA_MN+IJI	12	1841.71	1866.15	2.95	0.04	
123	FT*IJI +LLI+FD+PARA_MN+ENN_CV	11	1844.11	1866.48	3.28	0.03	
116	FT*ENN_CV +LLI+FD+PARA_MN+IJI	11	1844.35	1866.72	3.52	0.03	
102	LLI*FD+FT+PARA_MN+ENN_CV+IJI	11	1844.40	1866.77	3.56	0.03	
117	FD*ENN_CV+LLI+FT+PARA_MN+IJI	11	1844.59	1866.96	3.76	0.03	

110	FD*PARA_MN+LLI+FT+ENN_CV+IJI	11	1844.86	1867.23	4.02	0.02	
103	FT*FD+LLI+PARA_MN+ENN_CV+IJI	11	1845.14	1867.52	4.31	0.02	
122	LLI*IJI+FT+FD+PARA_MN+ENN_CV	11	1845.16	1867.53	4.33	0.02	
125	LLI*IJI+FT*IJI+FD+PARA_MN+ENN_CV	12	1843.35	1867.79	4.58	0.02	
108	LLI*PARA_MN+FT+FD+ENN_CV+IJI	11	1845.43	1867.80	4.60	0.02	
113	FT*PARA_MN+FD*PARA_MN+LLI+ENN_CV+IJI	12	1843.39	1867.83	4.63	0.02	
119	LLI*ENN_CV+FD*ENN_CV+FT+PARA_MN+IJI	12	1843.42	1867.86	4.65	0.02	
127	FT*IJI+FD*IJI+LLI+PARA_MN+ENN_CV	12	1843.42	1867.86	4.65	0.02	
120	FT*ENN_CV+FD*ENN_CV+LLI+PARA_MN+IJI	12	1843.46	1867.90	4.70	0.02	
111	LLI*PARA_MN+FT*PARA_MN+FD+ENN_CV+IJI	12	1843.53	1867.97	4.77	0.02	
101	LLI*FT+FD+PARA_MN+ENN_CV+IJI	11	1845.66	1868.03	4.83	0.02	
124	FD*IJI+LLI+FT+PARA_MN+ENN_CV	11	1845.73	1868.10	4.90	0.02	
121	LLI*ENN_CV+FT*ENN_CV+FD*ENN_CV+PARA_MN+IJI	13	1841.71	1868.22	5.01	0.01	
106	LLI*FD+FT*FD+PARA_MN+ENN_CV+IJI	12	1843.90	1868.34	5.13	0.01	
128	LLI*IJI+FT*IJI+FD*IJI+PARA_MN+ENN_CV	13	1842.01	1868.53	5.32	0.01	
104	LLI*FT+LLI*FD+PARA_MN+ENN_CV+IJI	12	1844.39	1868.83	5.62	0.01	
112	LLI*PARA_MN+FD*PARA_MN+FT+ENN_CV+IJI	12	1844.69	1869.13	5.92	0.01	
105	LLI*FT+FT*FD+PARA_MN+ENN_CV+IJI	12	1845.12	1869.56	6.36	0.01	
126	LLI*IJI+FD*IJI+FT+PARA_MN+ENN_CV	12	1845.14	1869.58	6.37	0.01	
114	LLI*PARA_MN+FT*PARA_MN+FD*PARA_MN+ENN_CV+IJI	13	1843.35	1869.86	6.66	0.01	
7	LLI+FT+FD	7	1855.78	1869.94	6.73	0.01	⊗
59	LLI+FT+FD+IJI	8	1853.85	1870.05	6.84	0.01	⊗
Solitary bee abundance							
76	**LLI*FT+FD**	**8**	**1758.60**	**1774.80**	**0.00**	**0.27**	
79	**LLI*FT+LLI*FD**	**9**	**1757.98**	**1776.23**	**1.43**	**0.13**	
80	LLI*FT+FT*FD	9	1758.60	1776.85	2.05	0.10	
6	FT+FD	6	1765.47	1777.58	2.78	0.07	
66	FT*FD	7	1763.60	1777.76	2.96	0.06	
82	LLI*FT+LLI*FD+FT*FD	10	1757.97	1778.28	3.48	0.05	
36	FT+FD+PARA_MN	7	1764.71	1778.87	4.06	0.04	
38	FT+FD+IJI	7	1765.25	1779.41	4.60	0.03	
7	LLI+FT+FD	7	1765.36	1779.51	4.71	0.03	
37	FT+FD+ENN_CV	7	1765.43	1779.59	4.78	0.02	
78	FT*FD+LLI	8	1763.45	1779.65	4.85	0.02	
101	LLI*FT+FD+PARA_MN+ENN_CV+IJI	11	1757.53	1779.91	5.10	0.02	
77	LLI*FD+FT	8	1764.00	1780.21	5.40	0.02	
81	LLI*FD+FT*FD	9	1762.27	1780.52	5.71	0.02	
40	FT+FD+PARA_MN+IJI	8	1764.54	1780.74	5.93	0.01	
57	LLI+FT+FD+PARA_MN	8	1764.59	1780.79	5.98	0.01	
39	FT+FD+PARA_MN+ENN_CV	8	1764.65	1780.85	6.05	0.01	
104	LLI*FT+LLI*FD+PARA_MN+ENN_CV+IJI	12	1756.89	1781.33	6.52	0.01	
59	LLI+FT+FD+IJI	8	1765.14	1781.34	6.53	0.01	
41	FT+FD+ENN_CV+IJI	8	1765.23	1781.43	6.63	0.01	
58	LLI+FT+FD+ENN_CV	8	1765.32	1781.52	6.72	0.01	
105	LLI*FT+FT*FD+PARA_MN+ENN_CV+IJI	12	1757.53	1781.97	7.17	0.01	⊗
61	LLI+FT+FD+PARA_MN+IJI	9	1764.41	1782.66	7.86	0.01	⊗
42	FT+FD+PARA_MN+ENN_CV+IJI	9	1764.50	1782.75	7.94	0.01	⊗

Total bee richness							
81	**LLI*FD+FT*FD**	**9**	**969.46**	**987.72**	**0.00**	**0.34**	
82	**LLI*FT+LLI*FD+FT*FD**	**10**	**969.02**	**989.34**	**1.62**	**0.15**	
79	**LLI*FT+LLI*FD**	**9**	**971.11**	**989.37**	**1.65**	**0.15**	
77	LLI*FD+FT	8	973.74	989.95	2.23	0.11	
106	LLI*FD+FT*FD+PARA_MN+ENN_CV+IJI	12	965.85	990.30	2.58	0.09	
104	LLI*FT+LLI*FD+PARA_MN+ENN_CV+IJI	12	966.98	991.43	3.71	0.05	
107	LLI*FT+LLI*FD+FT*FD+PARA_MN+ENN_CV+IJI	13	965.01	991.54	3.82	0.05	
102	LLI*FD+FT+PARA_MN+ENN_CV+IJI	11	970.53	992.91	5.19	0.03	⊗
64	LLI*FT	7	981.56	995.72	8.00	0.01	⊗
Social bee richness							
77	**LLI*FD+FT**	**8**	**845.44**	**861.65**	**0.00**	**0.16**	
81	**LLI*FD+FT*FD**	**9**	**843.97**	**862.23**	**0.58**	**0.12**	
130	**LLI*FD+FD*PARA_MN+FD*ENN_CV+FD*IJI+FT**	**14**	**833.72**	**862.33**	**0.68**	**0.11**	
102	**LLI*FD+FT+PARA_MN+ENN_CV+IJI**	**11**	**840.23**	**862.61**	**0.96**	**0.10**	
106	**LLI*FD+FT*FD+PARA_MN+ENN_CV+IJI**	**12**	**838.53**	**862.98**	**1.33**	**0.08**	
82	**LLI*FT+LLI*FD+FT*FD**	**10**	**843.12**	**863.44**	**1.79**	**0.06**	
79	LLI*FT+LLI*FD	9	845.41	863.67	2.02	0.06	
114	LLI*PARA_MN+FT*PARA_MN+FD*PARA_MN+ENN_CV+IJI	13	837.26	863.79	2.14	0.05	
112	LLI*PARA_MN+FD*PARA_MN+FT+ENN_CV+IJI	12	839.73	864.19	2.54	0.04	
107	LLI*FT+LLI*FD+FT*FD+PARA_MN+ENN_CV+IJI	13	838.11	864.64	2.99	0.04	
104	LLI*FT+LLI*FD+PARA_MN+ENN_CV+IJI	12	840.22	864.67	3.02	0.04	
86	LLI*PARA_MN+FT*PARA_MN+ENN_CV+IJI	11	842.67	865.06	3.41	0.03	
110	FD*PARA_MN+LLI+FT+ENN_CV+IJI	11	844.13	866.52	4.87	0.01	
111	LLI*PARA_MN+FT*PARA_MN+FD+ENN_CV+IJI	12	842.64	867.09	5.44	0.01	
113	FT*PARA_MN+FD*PARA_MN+LLI+ENN_CV+IJI	12	842.71	867.16	5.52	0.01	
44	LLI+FT+ENN_CV	7	853.40	867.56	5.91	0.01	
46	LLI+FT+PARA_MN+ENN_CV	8	851.69	867.90	6.25	0.01	
4	LLI+FT	6	856.64	868.76	7.12	0.01	
Solitary bee richness							
76	**LLI*FT+FD**	**8**	**1058.39**	**1074.60**	**0.00**	**0.24**	
79	**LLI*FT+LLI*FD**	**9**	**1057.10**	**1075.36**	**0.76**	**0.17**	
80	**LLI*FT+FT*FD**	**9**	**1057.57**	**1075.83**	**1.24**	**0.13**	
82	**LLI*FT+LLI*FD+FT*FD**	**10**	**1056.24**	**1076.56**	**1.97**	**0.09**	
101	LLI*FT+FD+PARA_MN+ENN_CV+IJI	11	1055.32	1077.70	3.11	0.05	
66	FT*FD	7	1063.86	1078.02	3.42	0.04	
81	LLI*FD+FT*FD	9	1060.29	1078.55	3.96	0.03	
104	LLI*FT+LLI*FD+PARA_MN+ENN_CV+IJI	12	1054.13	1078.58	3.99	0.03	
78	FT*FD+LLI	8	1062.39	1078.59	4.00	0.03	
129	LLI*FT+LLI*PARA_MN+LLI*ENN_CV+LLI*IJI+FD	14	1050.02	1078.63	4.03	0.03	
105	LLI*FT+FT*FD+PARA_MN+ENN_CV+IJI	12	1054.57	1079.02	4.43	0.03	
64	LLI*FT	7	1065.60	1079.76	5.16	0.02	
107	LLI*FT+LLI*FD+FT*FD+PARA_MN+ENN_CV+IJI	13	1053.34	1079.86	5.27	0.02	
6	FT+FD	6	1069.03	1081.15	6.55	0.01	
77	LLI*FD+FT	8	1065.34	1081.54	6.95	0.01	
37	FT+FD+ENN_CV	7	1067.80	1081.96	7.37	0.01	
7	LLI+FT+FD	7	1067.83	1081.99	7.40	0.01	

Model #	Model structure	K	Deviance	AIC_c	ΔAIC_c	*w*	
Bee abundance - Tropical and subtropical biomes							
73	**LLI*IJI**	**7**	**305.63**	**320.47**	**0.00**	**0.51**	
98	LLI*IJI+FT*IJI+PARA_MN+ENN_CV	11	299.82	323.86	3.39	0.09	
125	LLI*IJI+FT*IJI+FD+PARA_MN+ENN_CV	12	297.58	324.00	3.53	0.09	
122	LLI*IJI+FT+FD+PARA_MN+ENN_CV	11	300.55	324.58	4.11	0.07	
95	LLI*IJI+PARA_MN+ENN_CV	9	305.47	324.84	4.37	0.06	
126	LLI*IJI+FD*IJI+FT+PARA_MN+ENN_CV	12	299.46	325.88	5.41	0.03	
128	LLI*IJI+FT*IJI+FD*IJI+PARA_MN+ENN_CV	13	297.16	326.00	5.53	0.03	
99	LLI*IJI+FD*IJI+PARA_MN+ENN_CV	11	302.61	326.64	6.17	0.02	
129	LLI*FT+LLI*PARA_MN+LLI*ENN_CV+LLI*IJI+FD	14	295.39	326.69	6.22	0.02	
132	LLI*FT+LLI*FD+LLI*PARA_MN+FT*PARA_MN+LLI*ENN_CV +FT*ENN_CV+LLI*IJI+FT*IJI	18	286.12	327.68	7.21	0.01	
7	LLI+FT+FD	7	314.45	329.29	8.82	0.01	
4	LLI+FT	6	316.89	329.51	9.04	0.01	⊗
Bee abundance - Mediterranean biome							
110	**FD*PARA_MN+LLI+FT+ENN_CV+IJI**	**11**	**401.94**	**426.00**	**0.00**	**0.18**	
113	**FT*PARA_MN+FD*PARA_MN+LLI+ENN_CV+IJI**	**12**	**399.85**	**426.31**	**0.31**	**0.15**	
130	**LLI*FD+FD*PARA_MN+FD*ENN_CV+FD*IJI+FT**	**14**	**396.16**	**427.52**	**1.52**	**0.08**	
112	**LLI*PARA_MN+FD*PARA_MN+FT+ENN_CV+IJI**	**12**	**401.34**	**427.79**	**1.79**	**0.07**	
114	LLI*PARA_MN+FT*PARA_MN+FD*PARA_MN+ENN_CV+IJI	13	399.26	428.15	2.15	0.06	
78	FT*FD+LLI	8	411.47	428.57	2.57	0.05	
87	LLI*PARA_MN+FD*PARA_MN+ENN_CV+IJI	11	404.68	428.74	2.74	0.04	
126	LLI*IJI+FD*IJI+FT+PARA_MN+ENN_CV	12	402.99	429.45	3.44	0.03	
109	FT*PARA_MN +LLI+FD+ENN_CV+IJI	11	405.42	429.48	3.48	0.03	
99	LLI*IJI+FD*IJI+PARA_MN+ENN_CV	11	405.96	430.03	4.02	0.02	
131	FT*FD+FT*PARA_MN+FD*PARA_MN+FT*ENN_CV+FD*ENN_CV+ FT*IJI+FD*IJI+LLI	17	391.56	430.58	4.58	0.02	
80	LLI*FT+FT*FD	9	411.26	430.65	4.64	0.02	
81	LLI*FD+FT*FD	9	411.34	430.72	4.72	0.02	
5	LLI+FD	6	418.94	431.57	5.57	0.01	
7	LLI+FT+FD	7	416.73	431.58	5.58	0.01	
128	LLI*IJI+FT*IJI+FD*IJI+PARA_MN+ENN_CV	13	402.84	431.73	5.73	0.01	
111	LLI*PARA_MN+FT*PARA_MN+FD+ENN_CV+IJI	12	405.38	431.83	5.83	0.01	
44	LLI+FT+ENN_CV	7	417.15	432.00	5.99	0.01	
59	LLI+FT+FD+IJI	8	414.93	432.03	6.03	0.01	
45	LLI+FT+IJI	7	417.29	432.14	6.14	0.01	
4	LLI+FT	6	419.52	432.15	6.15	0.01	
52	LLI+FD+IJI	7	417.38	432.23	6.22	0.01	
82	LLI*FT+LLI*FD+FT*FD	10	410.56	432.27	6.27	0.01	
58	LLI+FT+FD+ENN_CV	8	415.24	432.34	6.34	0.01	
103	FT*FD+LLI+PARA_MN+ENN_CV+IJI	11	408.36	432.42	6.42	0.01	
134	LLI*FD+FT*FD+LLI*PARA_MN+FT*PARA_MN+FD*PARA_MN +LLI*ENN_CV+FT*ENN_CV+FD*ENN_CV+LLI*IJI+FT*IJI+FD*IJI	21	382.76	432.59	6.59	0.01	
48	LLI+FT+ENN_CV+IJI	8	415.78	432.88	6.88	0.01	

Bee abundance - Other temperate biomes						
100	**FT*IJI+FD*IJI+PARA_MN+ENN_CV**	**11**	**968.41**	**991.03**	**0.00**	**0.37**
127	**FT*IJI+FD*IJI+LLI+PARA_MN+ENN_CV**	**12**	**967.96**	**992.70**	**1.67**	**0.16**
128	LLI*IJI+FT*IJI+FD*IJI+PARA_MN+ENN_CV	13	967.96	994.81	3.78	0.06
74	FT*IJI	7	981.23	995.49	4.46	0.04
124	FD*IJI+LLI+FT+PARA_MN+ENN_CV	11	973.29	995.91	4.88	0.03
66	FT*FD	7	981.76	996.02	4.99	0.03
64	LLI*FT	7	982.61	996.87	5.84	0.02
78	FT*FD+LLI	8	980.62	996.95	5.92	0.02
131	FT*FD+FT*PARA_MN+FD*PARA_MN+FT*ENN_CV+FD*ENN_CV+ FT*IJI+FD*IJI+LLI	17	962.00	997.45	6.42	0.01
76	LLI*FT+FD	8	981.22	997.55	6.52	0.01
96	FT*IJI +PARA_MN+ENN_CV	9	979.19	997.61	6.58	0.01
126	LLI*IJI+FD*IJI+FT+PARA_MN+ENN_CV	12	973.25	997.98	6.95	0.01
133	LLI*FT+FT*FD+LLI*PARA_MN+FT*PARA_MN+FD*PARA_MN+LLI*ENN_CV+FT*ENN_CV+FD*ENN_CV+LLI*IJI+FT*IJI+FD*IJI	21	953.95	998.16	7.13	0.01
129	LLI*FT+LLI*PARA_MN+LLI*ENN_CV+LLI*IJI+FD	14	969.43	998.42	7.39	0.01
80	LLI*FT+FT*FD	9	980.26	998.68	7.65	0.01
123	FT*IJI +LLI+FD+PARA_MN+ENN_CV	11	976.20	998.82	7.79	0.01
81	LLI*FD+FT*FD	9	980.46	998.88	7.85	0.01
68	FT*PARA_MN	7	984.62	998.88	7.85	0.01
2	FT	5	988.91	999.05	8.02	0.01
22	FT+PARA_MN	6	986.88	999.07	8.04	0.01
98	LLI*IJI+FT*IJI+PARA_MN+ENN_CV	11	976.63	999.25	8.22	0.01
125	LLI*IJI+FT*IJI+FD+PARA_MN+ENN_CV	12	974.67	999.40	8.37	0.01
36	FT+FD+PARA_MN	7	985.20	999.46	8.43	0.01
79	LLI*FT+LLI*FD	9	981.19	999.61	8.58	0.01
6	FT+FD	6	987.45	999.64	8.61	0.01
Bee richness - Tropical and subtropical biomes						
73	**LLI*IJI**	**7**	**136.35**	**151.19**	**0.00**	**0.26**
77	LLI*FD+FT	8	136.27	153.35	2.16	0.09
65	LLI*FD	7	138.84	153.67	2.49	0.08
95	LLI*IJI+PARA_MN+ENN_CV	9	134.93	154.29	3.10	0.06
67	LLI*PARA_MN	7	140.01	154.84	3.66	0.04
79	LLI*FT+LLI*FD	9	135.89	155.25	4.06	0.03
81	LLI*FD+FT*FD	9	136.21	155.57	4.39	0.03
16	LLI+ENN_CV	6	143.08	155.71	4.52	0.03
4	LLI+FT	6	143.32	155.95	4.76	0.02
1	LLI	5	145.53	155.98	4.79	0.02
44	LLI+FT+ENN_CV	7	141.16	156.00	4.81	0.02
112	LLI*PARA_MN+FD*PARA_MN+FT+ENN_CV+IJI	12	130.16	156.58	5.39	0.02
82	LLI*FT+LLI*FD+FT*FD	10	135.19	156.87	5.68	0.02
98	LLI*IJI+FT*IJI+PARA_MN+ENN_CV	11	133.14	157.17	5.99	0.01
5	LLI+FD	6	144.64	157.26	6.07	0.01
7	LLI+FT+FD	7	142.69	157.52	6.34	0.01
51	LLI+FD+ENN_CV	7	142.70	157.54	6.35	0.01
70	LLI*ENN_CV	7	142.90	157.74	6.55	0.01
122	LLI*IJI+FT+FD+PARA_MN+ENN_CV	11	133.75	157.78	6.59	0.01
15	LLI+PARA_MN	6	145.17	157.79	6.61	0.01
18	LLI+PARA_MN+ENN_CV	7	142.96	157.79	6.61	0.01
20	LLI+ENN_CV+IJI	7	143.08	157.91	6.72	0.01

43	LLI+FT+PARA_MN	7	143.10	157.93	6.75	0.01	
58	LLI+FT+FD+ENN_CV	8	140.92	158.00	6.81	0.01	
45	LLI+FT+IJI	7	143.27	158.10	6.92	0.01	
64	LLI*FT	7	143.28	158.12	6.93	0.01	
17	LLI+IJI	6	145.52	158.14	6.96	0.01	
86	LLI*PARA_MN+FT*PARA_MN+ENN_CV+IJI	11	134.14	158.17	6.98	0.01	
46	LLI+FT+PARA_MN+ENN_CV	8	141.10	158.18	7.00	0.01	
48	LLI+FT+ENN_CV+IJI	8	141.12	158.20	7.02	0.01	
83	LLI*PARA_MN+ENN_CV+IJI	9	138.93	158.30	7.11	0.01	
99	LLI*IJI+FD*IJI+PARA_MN+ENN_CV	11	134.49	158.53	7.34	0.01	
108	LLI*PARA_MN+FT+FD+ENN_CV+IJI	11	134.62	158.65	7.46	0.01	
87	LLI*PARA_MN+FD*PARA_MN+ENN_CV+IJI	11	134.73	158.76	7.57	0.01	
114	LLI*PARA_MN+FT*PARA_MN+FD*PARA_MN+ENN_CV+IJI	13	130.01	158.85	7.67	0.01	
102	LLI*FD+FT+PARA_MN+ENN_CV+IJI	11	134.82	158.86	7.67	0.01	
128	LLI*IJI+FT*IJI+FD*IJI+PARA_MN+ENN_CV	13	130.15	159.00	7.81	0.01	⊗

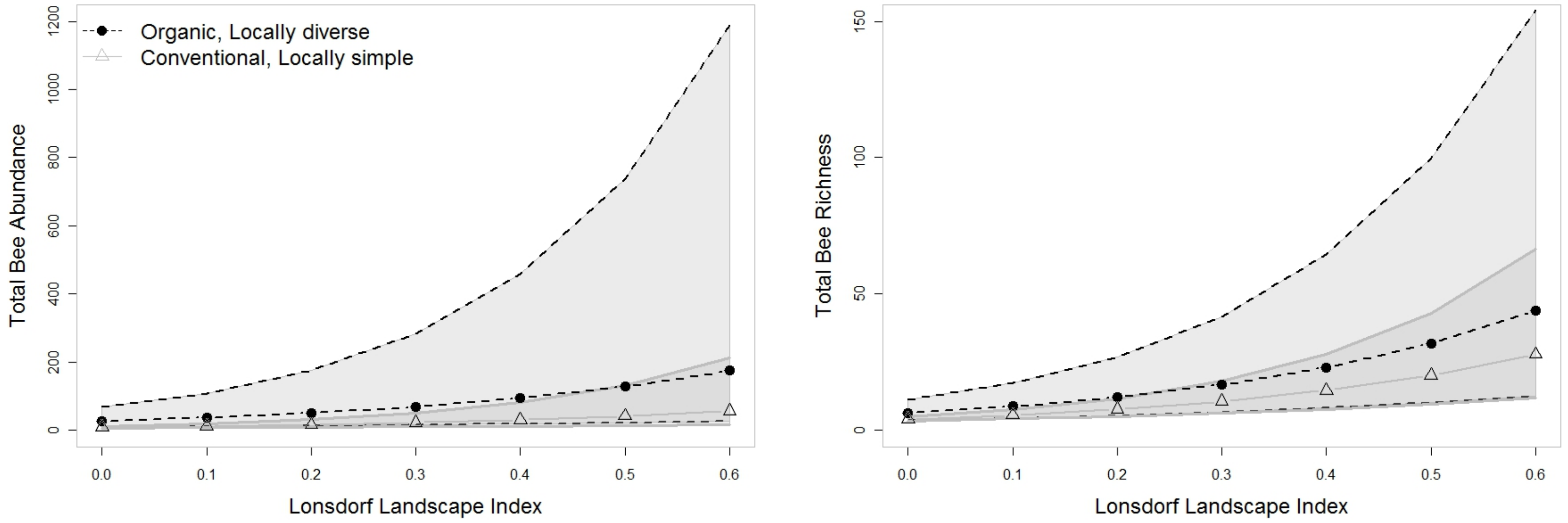
Bee richness - Mediterranean biome

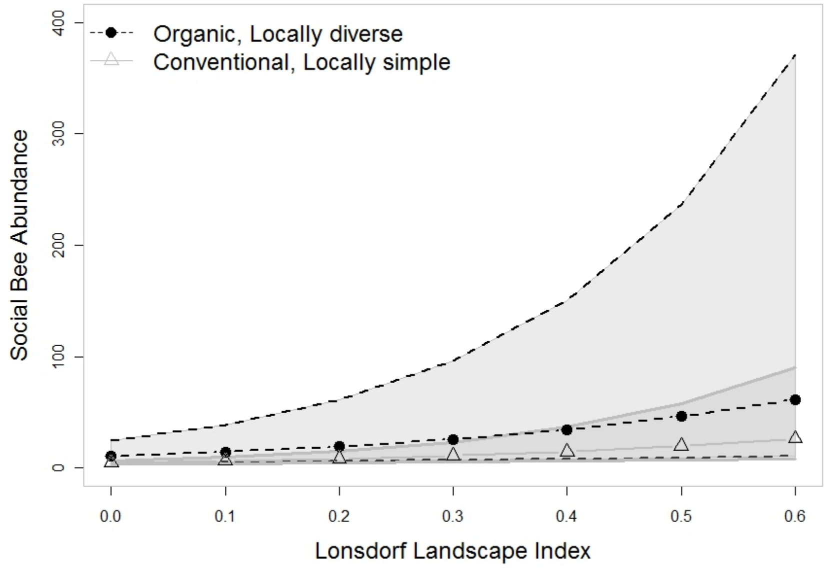
126	**LLI*IJI+FD*IJI+FT+PARA_MN+ENN_CV**	**12**	**151.98**	**178.44**	**0.00**	**0.26**	
130	**LLI*FD+FD*PARA_MN+FD*ENN_CV+FD*IJI+FT**	**14**	**148.34**	**179.70**	**1.26**	**0.14**	
128	LLI*IJI+FT*IJI+FD*IJI+PARA_MN+ENN_CV	13	151.85	180.74	2.31	0.08	
110	FD*PARA_MN+LLI+FT+ENN_CV+IJI	11	156.89	180.96	2.52	0.07	
78	FT*FD+LLI	8	164.70	181.80	3.37	0.05	
112	LLI*PARA_MN+FD*PARA_MN+FT+ENN_CV+IJI	12	156.47	182.92	4.49	0.03	
81	LLI*FD+FT*FD	9	163.69	183.08	4.64	0.03	
99	LLI*IJI+FD*IJI+PARA_MN+ENN_CV	11	159.07	183.13	4.69	0.03	
113	FT*PARA_MN+FD*PARA_MN+LLI+ENN_CV+IJI	12	156.75	183.21	4.77	0.02	
82	LLI*FT+LLI*FD+FT*FD	10	161.54	183.25	4.81	0.02	
131	FT*FD+FT*PARA_MN+FD*PARA_MN+FT*ENN_CV+FD*ENN_CV+ FT*IJI+FD*IJI+LLI	17	144.73	183.74	5.31	0.02	
4	LLI+FT	6	171.15	183.78	5.35	0.02	
80	LLI*FT+FT*FD	9	164.43	183.81	5.37	0.02	
45	LLI+FT+IJI	7	169.04	183.89	5.46	0.02	
98	LLI*IJI+FT*IJI+PARA_MN+ENN_CV	11	159.95	184.02	5.58	0.02	
7	LLI+FT+FD	7	169.84	184.69	6.25	0.01	
124	FD*IJI+LLI+FT+PARA_MN+ENN_CV	11	160.90	184.96	6.52	0.01	
59	LLI+FT+FD+IJI	8	168.07	185.17	6.73	0.01	
114	LLI*PARA_MN+FT*PARA_MN+FD*PARA_MN+ENN_CV+IJI	13	156.32	185.21	6.77	0.01	
43	LLI+FT+PARA_MN	7	170.54	185.39	6.96	0.01	
77	LLI*FD+FT	8	168.64	185.74	7.30	0.01	
125	LLI*IJI+FT*IJI+FD+PARA_MN+ENN_CV	12	159.28	185.74	7.30	0.01	
64	LLI*FT	7	170.97	185.82	7.38	0.01	
134	LLI*FD+FT*FD+LLI*PARA_MN+FT*PARA_MN+FD*PARA_MN+LLI*ENN_CV+FT*ENN_CV+FD*ENN_CV+LLI*IJI+FT*IJI+FD*IJI	21	135.99	185.82	7.38	0.01	
47	LLI+FT+PARA_MN+IJI	8	168.75	185.85	7.42	0.01	
48	LLI+FT+ENN_CV+IJI	8	168.84	185.94	7.51	0.01	
44	LLI+FT+ENN_CV	7	171.14	185.99	7.56	0.01	
103	FT*FD+LLI+PARA_MN+ENN_CV+IJI	11	162.08	186.15	7.71	0.01	⊗
107	LLI*FT+LLI*FD+FT*FD+PARA_MN+ENN_CV+IJI	13	157.41	186.30	7.86	0.01	⊗
79	LLI*FT+LLI*FD	9	166.97	186.35	7.91	0.01	⊗

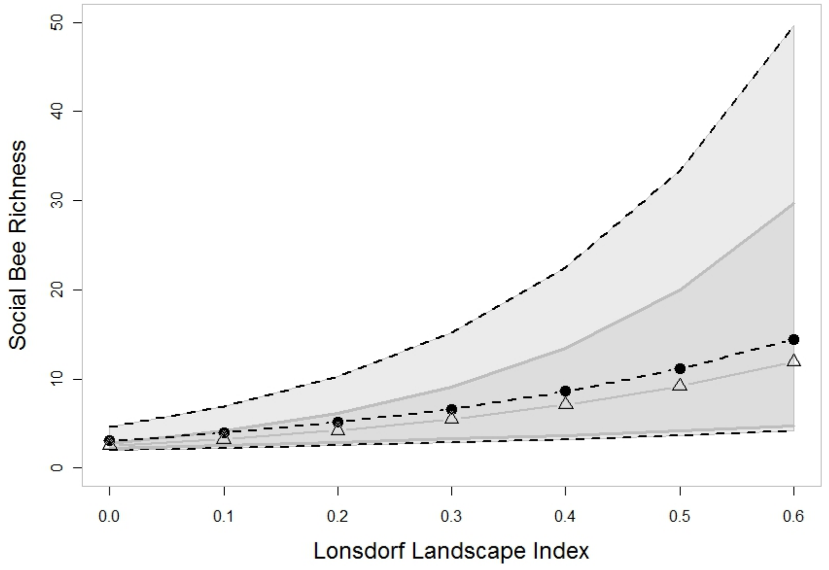
Bee richness - Other temperate biomes

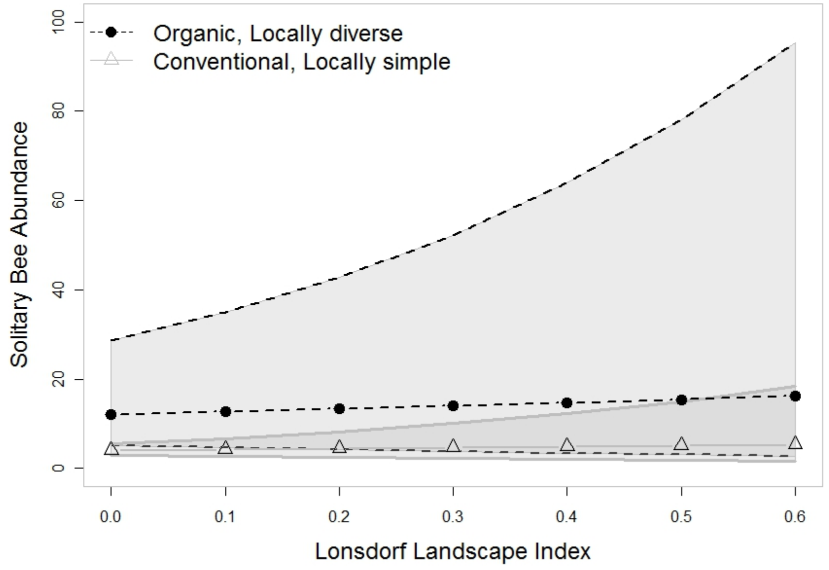
74	**FT*IJI**	**7**	**615.63**	**629.90**	**0.00**	**0.46**	
96	FT*IJI +PARA_MN+ENN_CV	9	614.22	632.66	2.76	0.12	
100	FT*IJI+FD*IJI+PARA_MN+ENN_CV	11	611.10	633.75	3.85	0.07	
66	FT*FD	7	619.85	634.12	4.22	0.06	
127	FT*IJI+FD*IJI+LLI+PARA_MN+ENN_CV	12	610.86	635.63	5.73	0.03	
68	FT*PARA_MN	7	621.43	635.70	5.81	0.03	
78	FT*FD+LLI	8	619.47	635.82	5.93	0.02	
123	FT*IJI +LLI+FD+PARA_MN+ENN_CV	11	613.38	636.02	6.13	0.02	
98	LLI*IJI+FT*IJI+PARA_MN+ENN_CV	11	613.84	636.49	6.59	0.02	
81	LLI*FD+FT*FD	9	618.13	636.57	6.67	0.02	
84	FT*PARA_MN +ENN_CV+IJI	9	618.58	637.02	7.12	0.01	
64	LLI*FT	7	622.78	637.05	7.16	0.01	
128	LLI*IJI+FT*IJI+FD*IJI+PARA_MN+ENN_CV	13	610.68	637.57	7.68	0.01	
80	LLI*FT+FT*FD	9	619.36	637.80	7.91	0.01	
76	LLI*FT+FD	8	621.54	637.89	8.00	0.01	
86	LLI*PARA_MN+FT*PARA_MN+ENN_CV+IJI	11	615.28	637.93	8.03	0.01	
79	LLI*FT+LLI*FD	9	619.56	638.00	8.10	0.01	
125	LLI*IJI+FT*IJI+FD+PARA_MN+ENN_CV	12	613.34	638.10	8.21	0.01	
103	FT*FD+LLI+PARA_MN+ENN_CV+IJI	11	615.71	638.35	8.46	0.01	
82	LLI*FT+LLI*FD+FT*FD	10	617.94	638.48	8.58	0.01	
106	LLI*FD+FT*FD+PARA_MN+ENN_CV+IJI	12	613.96	638.73	8.83	0.01	⊗

Figure S7_1. Response to landscape composition (Lonsdorf landscape index, LLI) of total, social and solitary wild bee abundance and richness on organic, locally diverse fields versus conventional, locally simple fields. Estimates are based on model-averaged partial regression coefficients (and unconditional 95% CIs) for all studies (N = 39) for important main effects (E (abundance, richness) = f (LLI + FT + FD)) (see also Table 2). Organic, locally diverse: black circles and dashed line (CIs outlined by dashed line with light grey shading); Conventional, locally simple: triangles and grey solid line (CIs with dark grey shading). Note that y-axis scales vary by bee response measures; relationships between LLI = 0 up to 0.60 are graphed (even though LLI = 1.0 is the theoretical maximum) because 0.61 was the maximum score derived for empirical study landscapes.




Organic, Locally diverse
Conventional, Locally simple
Social Bee Abundance
0
100
200
300
400
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Lonsdorf Landscape Index


Social Bee Richness
0
10
20
30
40
50
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Lonsdorf Landscape Index


Organic, Locally diverse
Conventional, Locally simple
Solitary Bee Abundance
0
20
40
60
80
100
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Lonsdorf Landscape Index

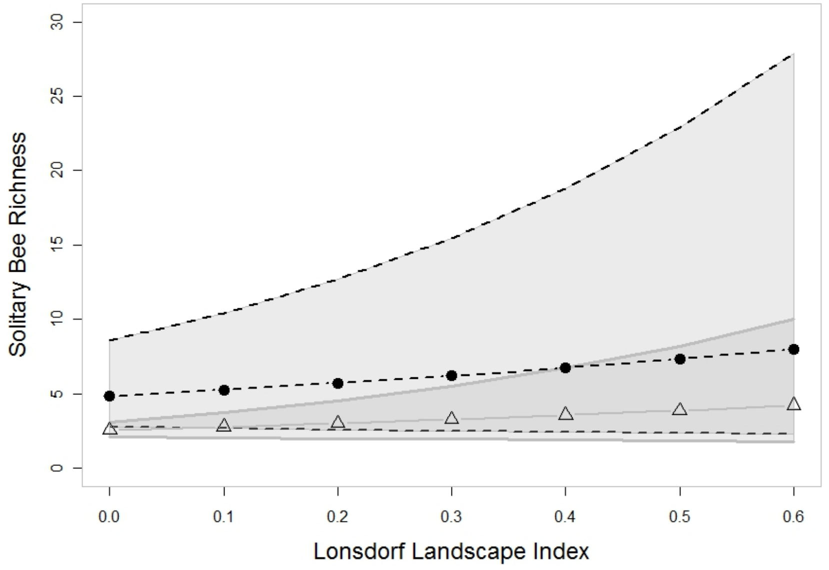
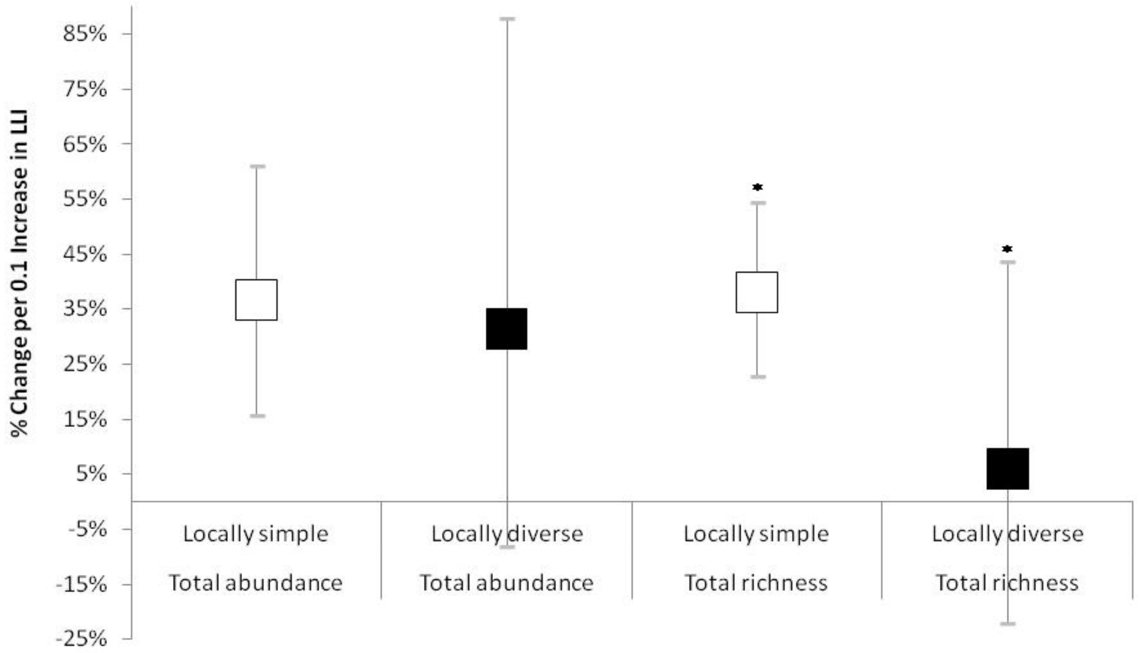
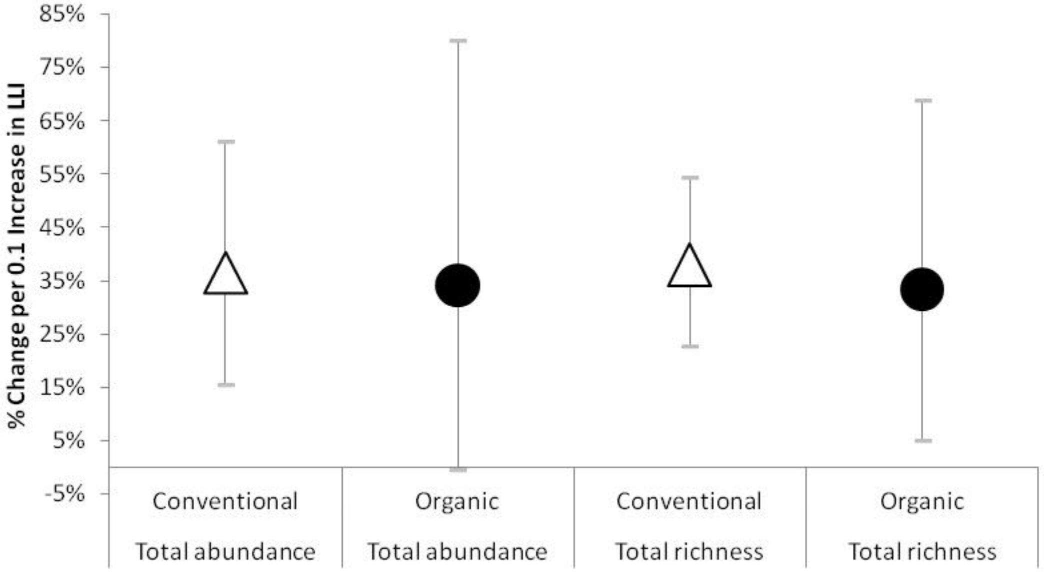

Solitary Bee Richness
0
5
10
15
20
25
30
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Lonsdorf Landscape Index

Figure S7_2. Percent change in wild bee abundance and richness per 0.1 incremental increase in the Lonsdorf landscape index (LLI) in relation to (a) field-scale diversity, FD (locally simple vs. locally diverse) and (b) field type, FT (conventional vs. organic) and (c) percent change in bee abundance and richness on locally simple and diverse fields on organic relative to conventional fields. Estimates based on model-averaged partial regression coefficients (and unconditional 95% CIs) for important main effects plus each individual target interaction (E(abundance, richness) = ƒ (LLI + FT + FD) + (LLI:FD or LLI:FT or FT:FD, respectively); * denotes two-way interaction with unconditional 95% CIs around model-averaged partial slope coefficient that did not include 0 (asymmetric CIs due to exponential relationship) (see Table 2).

(a)



(b)


% Change per 0.1 Increase in LLI
85%
75%
65%
55%
45%
35%
25%
15%
5%
-5%
Conventional
Total abundance
Organic
Total abundance
Conventional
Total richness
Organic
Total richness

(c)

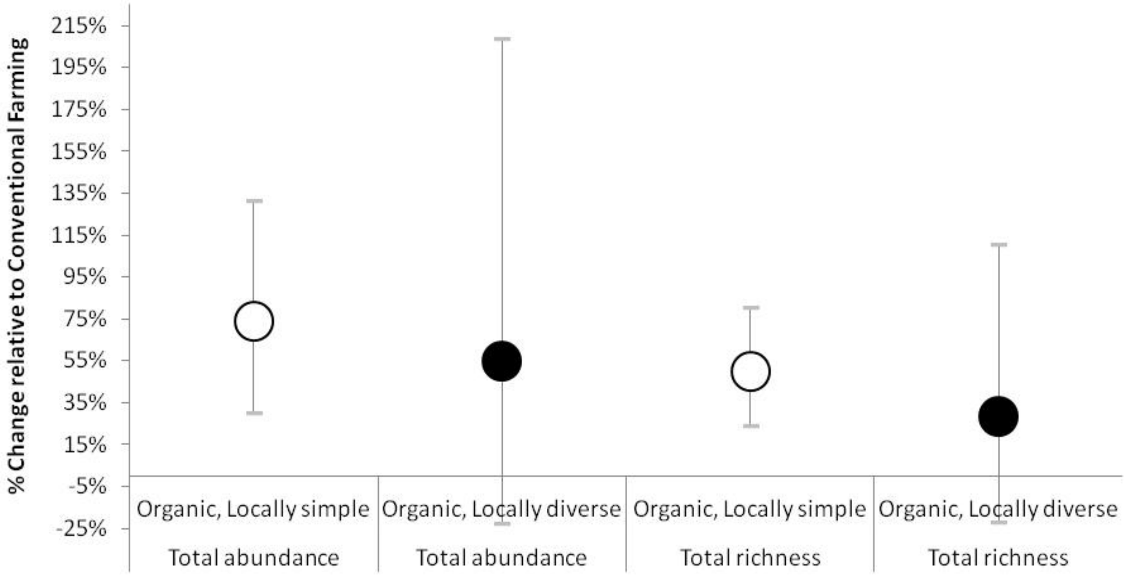

% Change relative to Conventional Farming
215%
195%
175%
155%
135%
115%
95%
75%
55%
35%
15%
-5%
-25%
Organic, Locally simple
Total abundance
Organic, Locally diverse
Total abundance
Organic, Locally simple
Total richness
Organic, Locally diverse
Total richness

Figure S7_3. Percent change in wild bee abundance in tropical and subtropical studies (N = 10) per 0.1 increase in the Lonsdorf landscape index (LLI) in relation to landscape configuration (interspersion & juxtaposition index, IJI). Across studies, IJI ranged from 0 to 95.91 (mean = 63.33) (theoretical IJI range: 0-100) (Table S7_1). Estimates based on model-averaged partial regression coefficients (and unconditional 90% CIs) for important main effects plus target interaction (E(abundance) = f (LLI + IJI+ LLI:IJI). 90% CIs around model-averaged partial slope coefficient did not include 0 (asymmetric CIs due to exponential relationship) (see Table 3). Significant interaction between LLI:IJI indicates that maximum bee abundance is achieved with high LLI and IJI values, and effect of LLI is greater with increasing IJI values.