

1 **Supplementary information**

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3 **Dominance of cropland reduces the pollen deposition from bumble bees**

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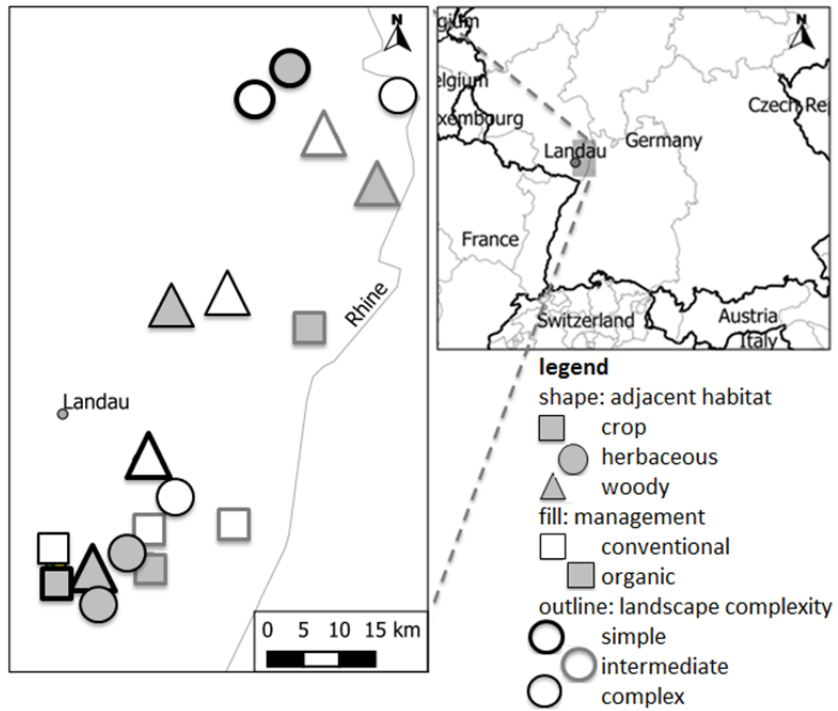
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8 **Supplementary Figure S1, Supplementary Tables S1-S5**

9 **Supplementary Figure 1**



10  
11 **Fig. S1** Geographic location of the 18 studied pumpkin fields in the Upper Rhine valley. Fields differed in  
12 adjacent habitats (crop, herbaceous, woody), management (organic, conventional) and landscape  
13 complexity in 1 km radius (simple < 10% SNH, intermediate 10-30% SNH, complex > 30% SNH in 1 km  
14 radius).

15 **Supplementary Tables**

16 **Table S1** Proportions of the different classified habitat types in 1 km radius around the 18 focal fields (landscapes = LS). In cropland the proportions  
 17 of all annual and perennial crops are summed up. SNH is the sum of all seminatural habitats (ha = herbaceous areal, hl = herbaceous linear, wa =  
 18 woody areal, wl = woody linear). In addition the farming system (organic: yes or no) and adjacent seminatural habitat of the focal field are given.

	LS1	LS2	LS3	LS4	LS5	LS6	LS7	LS8	LS9	LS10	LS11	LS12	LS13	LS14	LS15	LS16	LS17	LS18
adjacent	crop	crop	herb	woody	herb	crop	crop	crop	herb	woody	woody	woody	crop	woody	herb	woody	herb	herb
organic	no	yes	yes	yes	yes	yes	no	no	no	no	yes	no	yes	yes	no	no	yes	no
<b>habitat</b>																		
Apple	2.4	9.8	0.0	0.2	0.2	3.1	3.5	0.1	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Asparagus	3.3	0.0	0.0	0.0	1.5	4.7	1.4	0.0	0.0	0.9	0.7	2.4	0.1	0.0	0.0	0.7	2.2	0.0
Cabbage	0.0	3.2	0.0	0.8	0.0	4.4	0.2	0.6	0.5	0.0	0.0	0.1	2.3	0.0	0.0	0.0	3.1	2.4
Carrot	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.7	2.2	0.7	0.0	0.5	0.2	7.1	0.0	1.3	3.0	4.6
Maize	18.6	20.4	15.3	35.9	13.9	18.2	13.8	24.2	16.2	17.2	7.8	10.8	26.6	12.8	12.4	4.8	0.8	3.9
Oilseed rape	2.1	0.4	0.0	0.8	0.0	0.1	4.2	0.0	0.0	1.2	0.0	0.9	0.0	0.0	0.5	4.5	0.0	0.0
Onion	0.7	3.0	0.0	0.0	0.3	2.7	0.0	0.4	0.0	2.6	0.0	1.3	2.1	0.0	0.0	3.0	4.4	10.7
Potato	0.6	0.9	0.0	0.7	0.0	0.0	1.5	0.8	0.7	7.7	2.2	1.9	1.0	1.4	0.0	10.2	6.8	5.2
Pumpkin	2.1	3.8	0.5	3.8	1.3	5.3	1.0	0.8	2.5	0.7	2.9	3.1	2.7	0.7	0.5	8.2	8.2	4.0
Radish	0.2	2.3	1.4	0.3	0.0	0.8	3.2	1.0	0.0	0.0	1.1	1.4	0.0	0.0	0.0	3.3	4.5	0.7

Rhubarb	0.9	1.2	0.0	0.0	1.9	0.1	0.0	0.7	1.1	0.0	0.9	0.0	0.0	0.0	0.0	0.2	0.0	1.0
Salad	0.1	3.4	0.0	0.6	0.7	1.7	0.0	0.0	0.0	0.0	1.4	3.0	0.6	0.0	0.0	0.0	0.2	2.0
Strawberry	0.0	0.4	0.0	0.0	0.4	2.0	0.0	0.0	4.0	0.0	0.4	1.5	0.0	0.0	0.0	0.0	1.1	0.0
Sugar beet	0.3	5.5	3.6	18.2	0.0	5.9	2.4	7.5	3.1	12.9	4.4	8.6	3.6	3.7	0.3	3.1	1.9	3.3
Vine	12.6	8.7	0.0	6.4	0.0	0.1	0.0	1.0	0.9	2.1	2.2	0.0	1.5	0.0	0.0	0.0	0.0	0.0
Winter cereals	11.3	7.5	13.2	12.9	1.9	10.8	15.9	16.8	3.5	40.7	13.3	7.1	12.3	7.3	16.7	13.4	1.9	1.1
Other crops	5.8	20.0	4.2	9.1	6.0	12.6	14.1	4.3	4.8	3.5	14.0	5.9	8.8	0.8	1.2	14.9	12.2	11.3
<b>Cropland</b>	<b>60.9</b>	<b>90.7</b>	<b>38.1</b>	<b>89.8</b>	<b>28.0</b>	<b>72.6</b>	<b>65.1</b>	<b>62.9</b>	<b>39.3</b>	<b>90.8</b>	<b>51.3</b>	<b>48.5</b>	<b>61.8</b>	<b>33.8</b>	<b>31.6</b>	<b>67.6</b>	<b>50.3</b>	<b>50.1</b>
Ha	22.5	0.6	23.1	3.2	17.8	6.6	11.2	3.3	7.3	1.5	23.1	7.8	7.8	0.5	8.4	6.0	0.4	2.8
hl	2.5	1.6	1.6	2.0	1.8	1.8	2.6	1.2	2.6	2.7	1.7	1.4	2.8	2.5	2.6	3.0	1.5	1.7
wa	3.2	0.0	1.2	0.0	24.2	9.7	9.3	15.4	20.8	0.0	2.8	37.9	7.5	6.7	17.7	3.7	4.1	0.0
wl	3.7	2.8	6.3	2.3	3.9	3.4	4.0	0.5	4.8	2.1	4.3	2.3	1.7	4.9	4.6	5.0	3.5	3.6
<b>SNH</b>	<b>31.9</b>	<b>5.0</b>	<b>32.9</b>	<b>7.4</b>	<b>47.7</b>	<b>21.6</b>	<b>27.1</b>	<b>20.4</b>	<b>35.5</b>	<b>6.3</b>	<b>31.8</b>	<b>49.4</b>	<b>19.8</b>	<b>14.7</b>	<b>33.3</b>	<b>17.7</b>	<b>9.4</b>	<b>8.1</b>
urban	4.9	2.2	25.1	0.7	20.9	2.7	3.4	15.1	23.0	0.0	14.9	0.3	12.0	28.0	25.4	6.5	33.7	37.0
Water bodies	0.3	0.0	0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.3	4.6	21.6	5.9	0.2	0.5	0.4
Other habitats	2.0	2.1	4.9	2.1	3.3	3.1	4.3	1.6	1.9	2.9	1.5	1.6	1.8	1.9	3.8	8.0	6.2	4.4

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21 **Table S2**

22 Average number of insecticide treatments of the 16 dominant crops in our study area (proportion of total  
23 area in the landscapes, LS = number of landscapes, where the crop was present) according to the cited  
24 literature.

<b>crop</b>	<b>% of total area (range)</b>	<b>LS</b>	<b>N insecticide treatments</b>	<b>literature</b>
apple	0 – 10%	9	7.5	Roßberg 2009
asparagus	0 – 5%	10	1.1	Roßberg & Hommes 2014
cabbage	0 – 4%	10	4.9	Roßberg & Hommes 2014
carrot	0 – 7%	11	1.7	Roßberg & Hommes 2014
maize	1 – 36%	18	0.03	Roßberg 2016
oilseed rape	0 – 4%	9	2.7	Roßberg 2016
onion	0 – 11%	11	0.7	Roßberg & Hommes 2014
potato	0 – 10%	14	0.8	Roßberg 2016
pumpkin	1 – 8%	18	0.5	Own data mean of 18 conv. fields
raphanus	0 – 4%	11	2.0	DLR, pers. comm.
rhubarb	0 – 2%	10	0.0	DLR, pers. comm.
salad	0 – 3%	10	2.7	Roßberg & Hommes 2014
strawberry	0 – 4%	7	2.4	Roßberg 2009
sugar beet	0 – 18%	17	0.14	Roßberg <i>et al.</i> 2010
vine	0 – 14%	9	0.4	Roßberg 2010
winter wheat	1 – 41%	18	0.7	Roßberg 2016

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26 **References**

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39 **Table S3** Pearson rank correlation coefficients for all pairs of explanatory variables (lower panel) and  
 40 asymptotic p-values (upper panel). Pearson correlations with  $r \geq 0.40$  ( $p \leq 0.1$ ) are marked in bold.  
 41 Variables with  $r > 0.6$  are not included in the same model. For variables with  $r < 0.4$  covariances were  
 42 fixed in the structure equation model.

	Adjacent SNH	Organic	% Agricultural land	% SNH	Insecticide intensity
Adjacent SNH		1.0	0.08	0.61	0.04
Organic	0		1.0	0.52	0.93
% Cropland	<b>-0.42</b>	0		0.004	0.10
% SNH	0.13	-0.16	<b>-0.65</b>		0.11
Insecticide intensity	<b>-0.48</b>	-0.02	0.40	-0.39	

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44 **Table S4** Direct effects of adjacent habitat (factor: crop or SNH), field management (factor: organic or  
 45 conventional), proportion of seminatural habitats in 1 km radius (% SNH, continuous), and insecticide  
 46 intensity in the landscape (continuous) on visits of honey and bumble bees and direct and indirect effects  
 47 of them on pollen delivery. Indirect effects on pollen delivery are split in effects mediated by bumble bee  
 48 visits or by honey bee visits. Results from the structure equation model (number of observations = 18,  
 49 minimum generalised least-squares chi-square statistic = 12.5, df = 11) are displayed. For all predictors  
 50 estimates, standard errors, z-values and p-values are given. R<sup>2</sup> is given per response.

<b>response</b>	<b>mediated by</b>	<b>predictor</b>	<b>estimate</b>	<b>Std.Err</b>	<b>z-value</b>	<b>p</b>	<b>R<sup>2</sup></b>	
Honey bee visits	~						0.19	
		Adjacent SNH	-1.4	20.2	-0.07	0.95		
		Organic	-18	11	-1.7	0.096		
		% SNH	0.4	0.6	0.7	0.51		
		Insecticide intensity	-1.7	5.2	-0.3	0.75		
Bumble bee visits	~						0.51	
		Adjacent SNH	12	10	1.2	0.24		
		Organic	7.3	5.6	1.3	0.20		
		% SNH	0.6	0.3	1.9	0.050		
		Insecticide intensity	1.8	2.5	0.7	0.48		
Pollen delivery	~						0.82	
		Honey bee visits	6	21	0.3	0.77		
		Bumble bee visits	255	51	5.0	< 0.001		
	Honey bee visits		Adjacent SNH	-8	125	-0.07	0.95	
			Organic	-112	394	-0.3	0.78	
			% SNH	2	9	0.3	0.80	
			Insecticide intensity	-10	46	-0.2	0.82	
	Bumble bee visits		Adjacent SNH	3052	2567	1.2	0.23	
			Organic	1859	1382	1.3	0.18	
			% SNH	152	74	2.1	0.040	
		Insecticide intensity	460	651	0.7	0.48		



52 **Table S5** Number and mode of field operations (number of herb management operations  
53 (mechanical and herbicide applications), number of applications of insecticides and fungicides,  
54 and the amount of nitrogen in kg/ha) are based on farmer's questionnaires. The proportion of weed  
55 cover was measured in four 5m<sup>2</sup>-plots per field at four samplings (28.-30.5., 25.-27.6., 15.-17.7.  
56 and 6.-9.8.2014). The diversity and abundance of flowering weeds was measured in twenty 1m<sup>2</sup>-  
57 plots per field at four samplings (28.-30.5. and parallel to the three pollination samplings on 2-6,  
58 15-17, 23-25 of July 2014). Superscript letters (A, B) mark significant different groups. The test  
59 statistic (F- or  $\chi^2$ -value with degrees of freedom and p-value) are given.

variable	organic		conventional	value	p
	EU-Bio	Bio- association			
N fields	3	6	9		
N herb management	2.3 <sup>A</sup>	2.3 <sup>A</sup>	3.3 <sup>B</sup>	F <sub>1,16</sub> = 7.2	0.016
Mode herb management		mechanical	Herbicides (1.4) + mechanical (1.9)		
% weed cover	2.3 <sup>A</sup>	4.8 <sup>A</sup>	8.5 <sup>B</sup>	$\chi^2_{1,16} = 3.9$	0.049
N flowering weeds (log)	1.8	1.7	2.5	F <sub>1,16</sub> = 2.5	0.13
S flowering weeds	4.3	4.8	6.8	$\chi^2_{1,16} = 1.5$	0.22
N insecticides	3 <sup>A</sup>	0 <sup>B</sup>	0.3 <sup>B</sup>	$\chi^2_{2,14} = 19$	< 0.001
N fungicides	2.3 <sup>A</sup>	0 <sup>B</sup>	2 <sup>A</sup>	$\chi^2_{2,14} = 32$	< 0.001
Nitrogen [kg/ha]	142 <sup>A</sup>	76 <sup>B</sup>	103 <sup>AB</sup>	F <sub>2,14</sub> = 3.6	0.054
Fertilizer mode		organic	synthetic		