

Landscape Ecology

Enhanced crop diversity but not smaller field size benefit bats in agricultural landscapes

Thomas Hiller^{a,b*}, Friederike Gall^a, Ingo Grass^{a,b}

^a Ecology of Tropical Agricultural Systems, University of Hohenheim, Stuttgart, Germany

^b Center for Biodiversity and Integrative Taxonomy (KomBioTa), University of Hohenheim,
Germany

* Corresponding author: thomas.hiller@uni-hohenheim.de

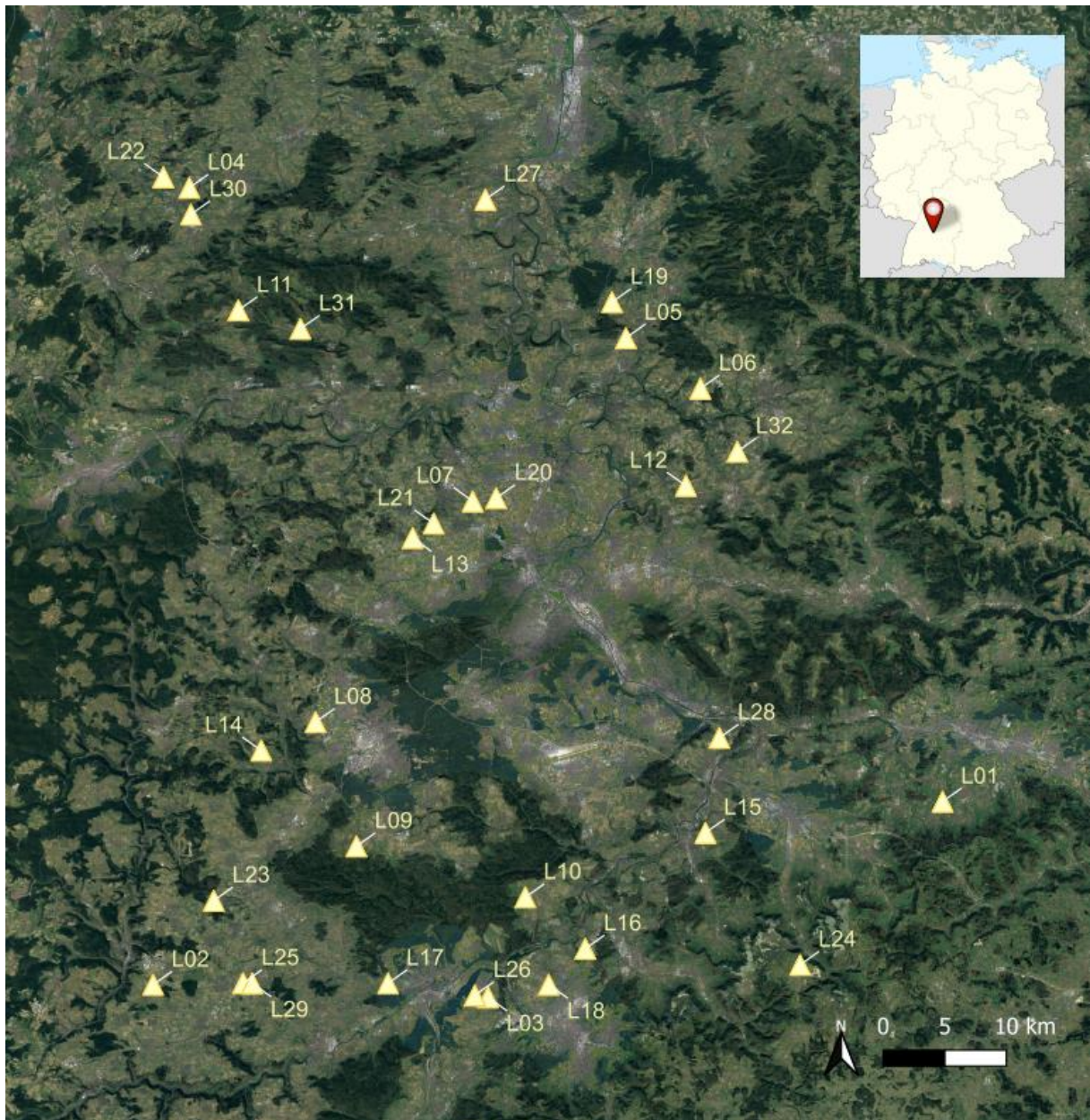


Figure S1. Map of our study region in Southwestern Germany (red pin of inset) showing all 32 study landscapes. Detailed information for each study landscape can be found in Table S2.

Table S1: Classification of crops following the classification scheme of the State Ministry for Agriculture Baden-Württemberg

crops	alfalfa, asparagus, cicerchia (<i>Lathyrus</i> sp.), clover grass, clover mix, edible potatoes, fava bean, field grass, flax, fodder beet, herbs, lupin, miscellaneous clover, mix clover alfalfa, mix legumes and cereals, orchard without meadow use, pome stone fruit, silage maize, soybean, strawberries, sugar beet, summer barley, summer spelt, sunflower, Trichogramma maize, vegetables, winter barley, winter oat, winter rapeseed, winter rye, winter soft wheat, winter triticale
other	arable land out of production, fallow annuals, fallow flowers, field margins, gardens, hedges, landscape maintenance greening measures, manure storage, meadow orchard, mowing pasture, nurseries, other surface, pasture, short-rotation plantations, summer sheep pasture, winter greening, yards

Table S2: Detailed presentation of all landscape characteristics used in this study

landscape	crop edge length [m]	crop eff. shannon	linear structures length [m]	seminatural 500m [m ²]	length linear structure in50m [m]	distance forest [m]	recording round	average field size [ha]
L01	9121.771	3.430	1970	38333	124	951	first	0.590
L02	6856.085	3.559	869	117316	101	284	second	0.715
L03	9763.711	3.092	1327	6481	244	831	first	0.598
L04	7367.203	3.532	1964	0	1035	586	first	1.357
L05	9435.063	3.491	1581	103943	0	505	second	0.818
L06	8495.098	4.495	345	17716	0	519	second	0.980
L07	14413.432	4.789	0	3348	0	2829	first	0.575
L08	13955.894	4.181	369	46871	0	857	second	0.562
L09	10906.599	3.669	343	1498	56	463	second	0.541
L10	12122.010	4.018	1810	42069	291	633	first	0.348
L11	9599.139	7.044	1089	24343	0	551	first	0.538
L12	14971.748	3.698	217	17229	0	1159	second	0.395
L13	10097.918	3.933	805	41275	0	374	first	0.783
L14	9066.527	6.030	376	194516	0	56	second	0.546
L15	12442.933	3.728	442	103908	136	352	first	0.442
L16	9625.659	4.712	1417	52625	0	542	first	0.501
L17	10216.378	5.318	2499	139234	438	239	second	0.399
L18	8679.126	4.499	3446	15245	0	436	first	0.334

L19	11854.729	4.283	1579	68069	0	522	second	0.456
L20	10064.936	4.592	2997	28340	364	2226	first	0.826
L21	4166.764	2.657	860	24440	70	218	first	1.932
L22	9936.663	3.438	2902	8146	0	941	first	1.005
L23	8713.827	3.952	1661	25240	245	115	second	0.822
L24	3444.939	2.102	913	0	30	305	first	3.028
L25	8300.509	4.398	1335	8405	652	880	second	1.242
L26	9739.814	3.762	674	2719	104	250	first	0.694
L27	8885.203	2.741	212	0	0	2093	second	1.343
L28	8188.602	4.207	819	103908	0	562	first	1.166
L29	7703.389	4.785	871	156860	296	495	second	1.059
L30	6712.631	4.551	1629	56230	166	410	first	1.420
L31	4504.912	3.928	3766	68844	239	325	first	1.637
L32	7735.825	4.296	362	94530	43	146	second	0.954

Table S3: Bat activity at each recording site and average bat activity per night divided by feeding guild.

landscape	number of passes						bat passes/night		
	open space		edge space			narrow space			
	N. noctula	nyctaloid	P. nathusii/kuhlii	P. pipistrellus	P. pygmaeus	Myotis spp.	open space	edge space	narrow space
L01	0	1	1	18	0	9	0.1	2.7	1.3
L02	0	23	0	146	0	0	3.3	20.9	0.0
L03	1	2	0	7	0	0	0.4	1.0	0.0
L04	2	8	3	21	0	5	1.4	3.4	0.7
L05	3	11	0	12	0	0	2.0	1.7	0.0
L06	0	0	0	22	0	0	0.0	3.1	0.0
L06	3	12	0	7	0	0	2.1	1.0	0.0
L07	1	11	0	51	0	0	1.7	7.3	0.0
L08	2	8	0	347	0	0	1.4	49.6	0.0
L09	0	4	0	10	0	0	0.6	1.4	0.0
L10	5	6	0	5	0	2	1.6	0.7	0.3
L12	3	11	0	21	0	0	2.0	3.0	0.0
L13	2	6	0	23	0	0	1.1	3.3	0.0
L14	2	31	0	139	0	13	4.7	19.9	1.9
L15	0	16	2	371	3	8	2.3	53.7	1.1
L16	0	2	2	35	0	2	0.3	5.3	0.3
L17	35	71	1	103	0	86	15.1	14.9	12.3
L18	0	4	0	61	0	2	0.6	8.7	0.3
L19	0	7	1	6	0	1	1.0	1.0	0.1
L20	0	13	0	5	0	0	1.9	0.7	0.0

L21	1	3	0	48	0	0	0.6	6.9	0.0
L22	0	4	0	0	0	0	0.6	0.0	0.0
L23	0	8	5	12	0	9	1.1	2.4	1.3
L24	0	0	0	9	0	1	0.0	1.3	0.1
L25	0	189	0	344	0	1	27.0	49.1	0.1
L26	0	4	0	8	0	2	0.6	1.1	0.3
L27	0	22	0	73	0	0	3.1	10.4	0.0
L28	0	4	1	14	0	0	0.6	2.1	0.0
L29	10	96	0	46	0	6	15.1	6.6	0.9
L30	5	10	0	242	0	1	2.1	34.6	0.1
L31	0	6	0	588	0	17	0.9	84.0	2.4
L32	2	47	0	23	0	9	7.0	3.3	1.3

Table S4: Checklist of variables considered during this study following the template of AgroEcoList 1.0 (<https://github.com/AgroecoList/Agroecolist>)

Category	Variable Name	Explanation	Extracted from Study	Additions from memory
Experimental/sampling set-up	Start & end date of study		May - June 2021	
	Start & end dates of any interventions/treatments	Interventions/treatments refers to the comparison you are making. E.g. if you are studying flower strips, it is the date(s) they were put in. Or, e.g. if you are comparing a tree crop across different ages, it is the dates the trees were planted.	no intervention	
	Dates/frequency that measurements were taken	When you took your measurements (e.g. collecting samples)	acoustic recordings 3h after sunset; 30s every 2min for 7 days at each location	simultaneous sampling at 18 and 14 sites, respectively
	Size & shape of experimental units (e.g. subplot/plot/field/farm)	A description of a single experimental unit, which would be at subplot/plot/field/farm level depending on your study.	32 study landscapes of 500x500m, differing in crop configuration (field size) and crop composition (crop diversity); details for calculation in our manuscript	
	Experimental/sampling designs (e.g. blocked/randomised, distance between plots)	How your single experimental units (described above) relate to each other. If this is very complicated, you can refer readers to the study site map.	32 study landscapes of 500x500m, differing in crop configuration (field size) and crop composition (crop diversity); details for calculation in our manuscript	
	Number of replicates	The number of experimental units in ONE treatment. E.g., if you are comparing four forest sites with four agricultural sites, you have four replicates.	seven recording nights for each landscape	
Study Site	Co-ordinates & co-ordinate system (e.g. WGS84)	Please ensure that you are not sharing sensitive information that can identify individuals or organisations without their permission (e.g. use a low resolution). Where information has been deliberately lost/blurred this should be indicated along with the scale of blurring.	See Fig. S1, WGS84	
	Country		Germany	
	Site map	State figure number	Figure S1	
	Elevation	Include units (metres above sea level (masl) is the most common)	Not recorded	
	Slope	Slope is the angle from the ground in degrees (e.g. 12°).	Not recorded	
	Aspect	Aspect is the direction the plot is facing (e.g. North).	Not recorded	

	Weather during study period	Can include temperature, humidity, rainfall, wind, or any other relevant characteristics	Not recorded	
	Extreme/atypical events (e.g. flooding, fire, pest outbreak)	Any information on extreme/atypical events (e.g. El Niño Southern Oscillation or a particularly bad pest outbreak) that you think is relevant to the study, or that may be relevant to people reinterpreting/resuing the data.	Not recorded	
	Farm/crop/livestock certification/scheme (e.g. Organic)		Not recorded	
	Artificial structure (e.g. open vs polytunnel, barn vs field)	If it was an open field (i.e. not under a polytunnel or other artificial structure), then say "open". Otherwise describe the artificial structure.	Open	
	Landscape context (e.g. field-edge management, proximity to forest)	Any information on landscape context (e.g. hedgerow density, proximity to towns/roads/lakes/forests) that you think is relevant to the study, or that may be relevant to people reinterpreting/resuing the data. We recommend authors decide the relevant landscape elements based on their study.	Information about structural landscape elements are visible in Table S2	
	Previous land use type & timing of transition (e.g. if converted from forest)	Any information on previous land use that you think is relevant to the study, or that may be relevant to people reinterpreting/resuing the data. We recommend authors decide the relevant timescales and information based on their study.	Not recorded	
Soil	Soil type & soil system (e.g. USDA)	Soil type, e.g. https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/class/ . Please provide depth of sampling if possible.	Not recorded	
	Soil texture (silt, sand, clay)	Soil texture: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_054167 . Please provide depth of sampling if possible.	Not recorded	
	Soil pH	Please provide depth of sampling if possible.	Not recorded	
	Soil organic matter	Please provide depth of sampling if possible.	Not recorded	
Livestock management	Livestock species & breed (including managed pollinators)	The species and breed of livestock. This includes managed pollinators (e.g. honeybees).	Not recorded	
	Livestock grazing management (including density, timing, rotations)	Number of livestock per area (e.g. ha). When the livestock were released into an area and when they were next moved. Only applies if you have livestock; if not, you can put "N/A". If there are multiple species, please give densities for each.	N/A	
	Livestock feeding regime (e.g. free grazing/supplemental)	How the livestock are fed (e.g. are they fed by grazing or do you supplement their diet, e.g. with pellets). If relevant, please give type, rate, and timing. Only applies if you have livestock; if not, you can put "N/A"	N/A	

	Livestock agrochemicals type, rate & timing (list all) (including medicines)	Any agrochemicals given to the livestock. List all of them. If some are known and others are not, state this (e.g. X dose of X chemical on X date. Other agrochemicals were not reported). Only applies if you have livestock; if not, you can put "N/A"	N/A	
	Livestock demography (e.g. lifestage/sex)	The age and sex of the livestock. Only applies if you have livestock; if not, you can put "N/A"	N/A	
Crop & grassland management	Crop species & variety (including main crops, secondary crops & non-cash-crops)	List all crops and non-cash-crops in the rotation during the study. You can also list some prior to the study if you think it is relevant (depending on the context, it may be more relevant in "Previous land use type")	List with all recorded crop species is provided in Table S1; however, for detailed information on plot level contact authors.	
	Crop planting density & arrangement (e.g. broadcast/inter-row)	Planting density and arrangement of each crop or non-cash-crop (e.g. 156 palms/ha, offset at 8m intervals)	Not recorded	
	Crop planting/harvesting timing (including rotations)	Include dates for all crops listed in "Crop species & variety"	Not recorded	
	Cultivation method, depth, & timing	Cultivation refers to any disturbance to the soil (e.g. ploughing). If possible, please include the type of cultivator (e.g. disc cultivator)	Not recorded	
	Mowing/topping method, height & timing	Any mowing/topping. For non-mowing/topping physical removal of weeds, see "Weeding method"	Not recorded	
	Weeding method & timing	Physical removal of weeds (e.g. hand weeding). For mowing see "Mowing/topping". For herbicides see "Crop protection chemicals".	Not recorded	
	Physical control of animal pests (e.g. trapping) method & timing	Physical control of animal pests (e.g. using rat traps). For biological control see "Biological control". For chemical control see "Crop protection chemicals".	Not recorded	
	Biological control agent species, release rate & timing	Includes things like beneficial plants (e.g. to attract parasitic wasps and increase pest predation) or vertebrate predators released to control rats.	Not recorded	
	Irrigation method, rate & timing		Not recorded	
	Fertiliser type, rate & timing (list all)	List all organic & inorganic fertilisers. If some (e.g. organic) are known and others are not (e.g. inorganic) state this as "Organic: X applied at X g/ha on X date. Inorganic: not recorded."	Not recorded	
	Crop protection chemicals type, rate & timing (list all)	List all insecticides, herbicides, fungicides, nematicides etc. If some (e.g. insecticides) are known and others are not (e.g. fungicides) state this as "Insecticides: X applied at X g/ha on X date. Fungicides: not recorded."	Not recorded	
Other chemicals type, rate & timing	Any relevant chemicals not already described in previous categories: "Livestock agrochemicals", "Fertiliser type", "Crop protection chemicals"	Not recorded		

Outputs	Yield	This can include non-cash-crops (e.g. biomass of cover crops if relevant)	Not recorded	
	Quality and/or Commercial grade	Quality can include things like protein or N content. The relevant measure will depend on the crop or non-cash-crop.	Not recorded	
Finances	Any available costs/profits (e.g. interventions, management)	Please include any available information on costs/profitability as management decisions in agricultural landscapes are influenced by finances. Please ensure that you are not sharing confidential information.	Not recorded	