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Arable fields as potential reservoirs of biodiversity: earthworm populations increase in new leys

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Supplementary Information

Table S1. Cropping history of study fields at Leeds University Farm, Tadcaster, UK.

Field crop codes: B = beans, BEET = sugar beet, L = Ley, MZ = maize, OSR = oilseed rape, P = pasture, POT = potatoes, SB = spring barley, VPEA = vining peas, WB = winter beans, WW = winter wheat. Ley strips were established within arable fields during spring 2015.

Field	Field code	Area (Ha)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Valley	P1	6.09	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Sub pad	P2	5.01	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Warren pad	P3	3.36	WW	WW	L	L	MZ	WW	WW	POT	WW	WW	OSR	WW	WW	OSR	P	P	P	P	P
Copse	A1	9.99	WW	WW	WW	WW	POT	WW	WW	VPEA	WW	OSR	WW	POT	WW	OSR	WW	VPEA	WW	WW	SB
Hillside	A2	5.46	P	P	P	P	P	P	P	P	P	P	P	WW	OSR	WW	WW	WB	OSR	WW	WW
BSSE, BSSW	A3, A4	11.1	WW	WW	WW	WW	POT	WW	OSR	WW	BEET	WW	WW	POT	WW	OSR	WW	VPEA	WW	WW	SB

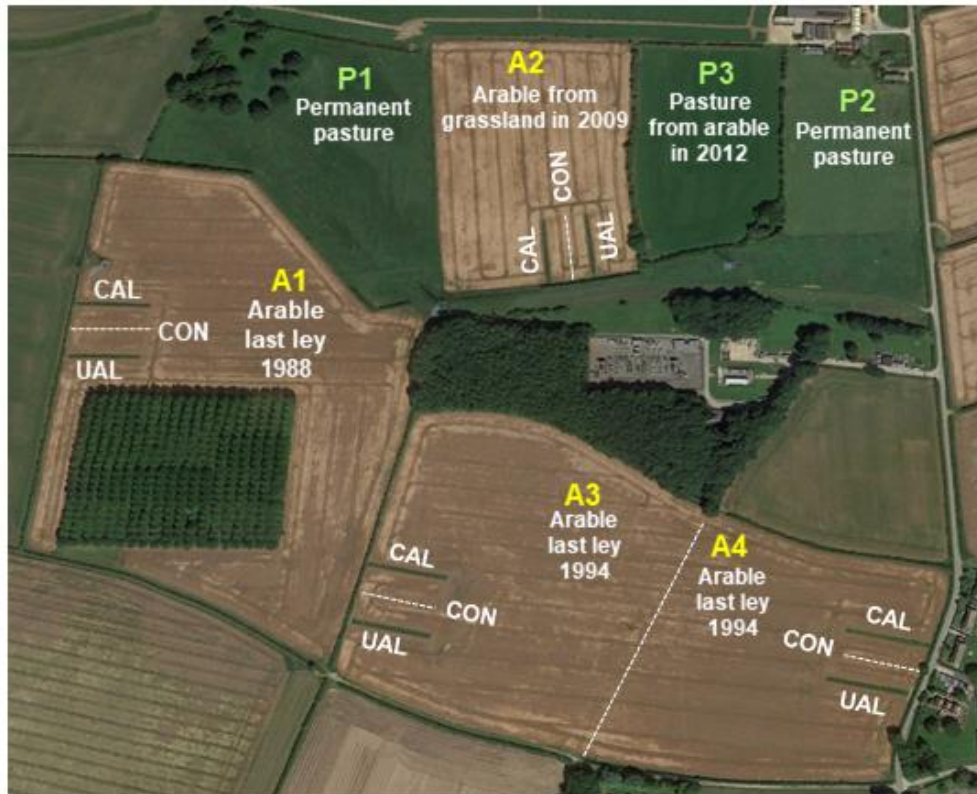


Fig. S1. Location of study fields at Leeds University Farm, Tadcaster, UK. Field management: A1-A4 = arable, P1-P3 = pasture. Treatment codes: CAL = connected ley strip, UAL = unconnected ley strip, CON = arable control (within arable fields). Connected and unconnected ley strips are 70 m long. Source of photo: Google Earth Pro 7.3.2 image© 2019 Google Earth. <http://earth.google.com>.

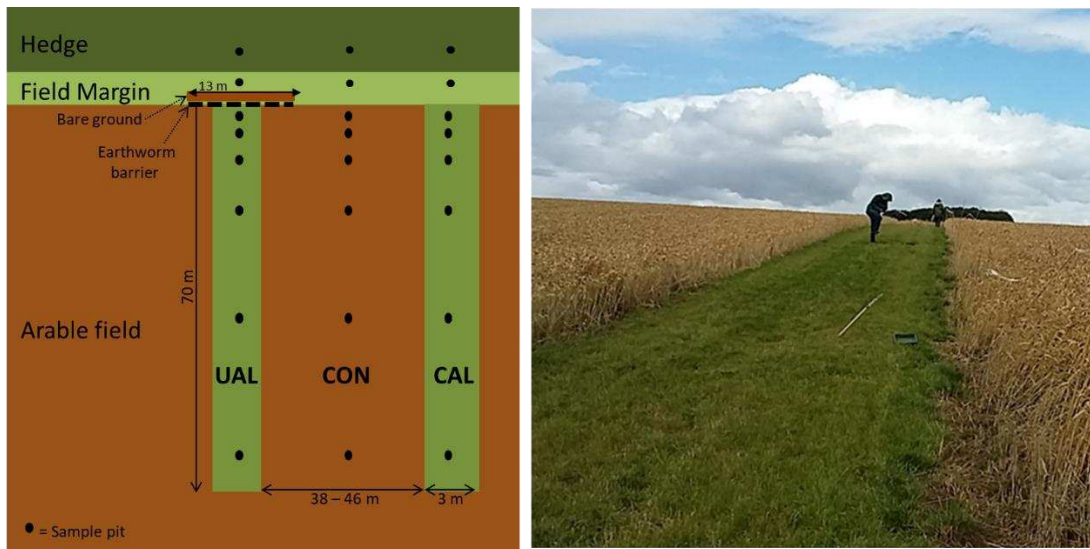


Fig. S2. Schematic of the paired ley strips in an arable field. Ley strips were either unconnected (UAL) by an earthworm barrier or connected (CAL) to the field margin and hedgerow. The area of arable field between the ley strips was the arable control (CON). Sample pits were under hedgerow, within grassy margin and 2, 4, 8, 16, 32 and 64 m from the margin. Not drawn to scale.

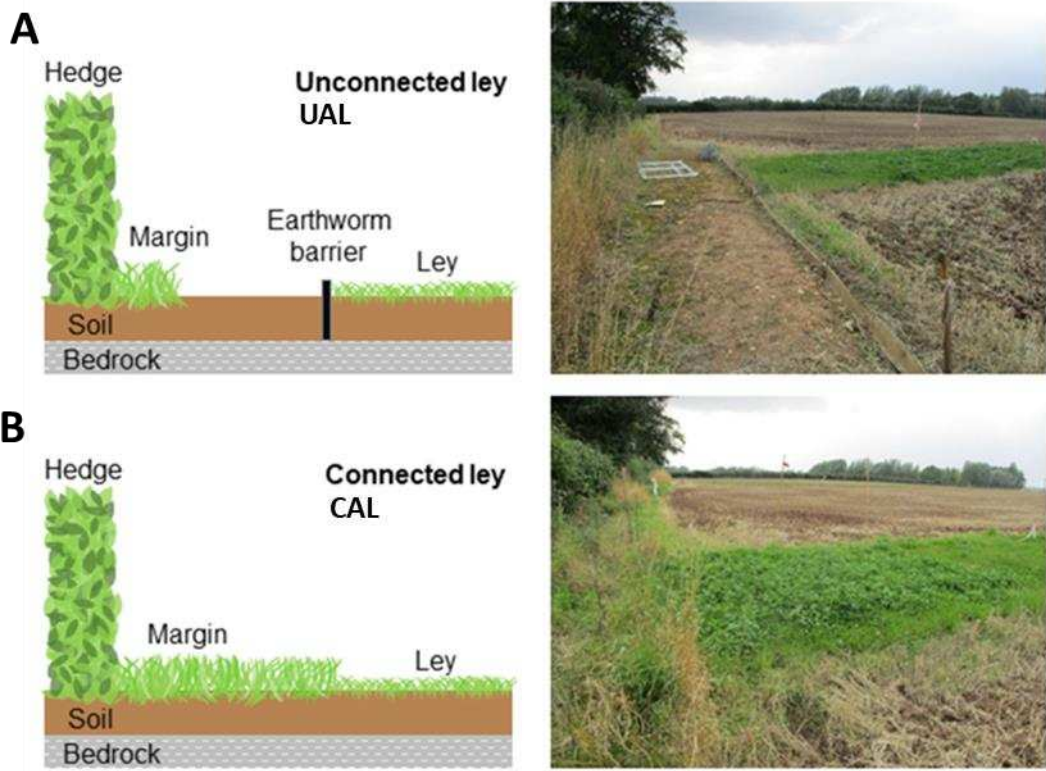


Fig. S3. Schematic of (A) earthworm exclusion barrier within an unconnected ley (UAL) (left) and photo of unconnected ley at field location (right); (B) schematic of connected ley strip (left) and photo of connected ley at field location (right).

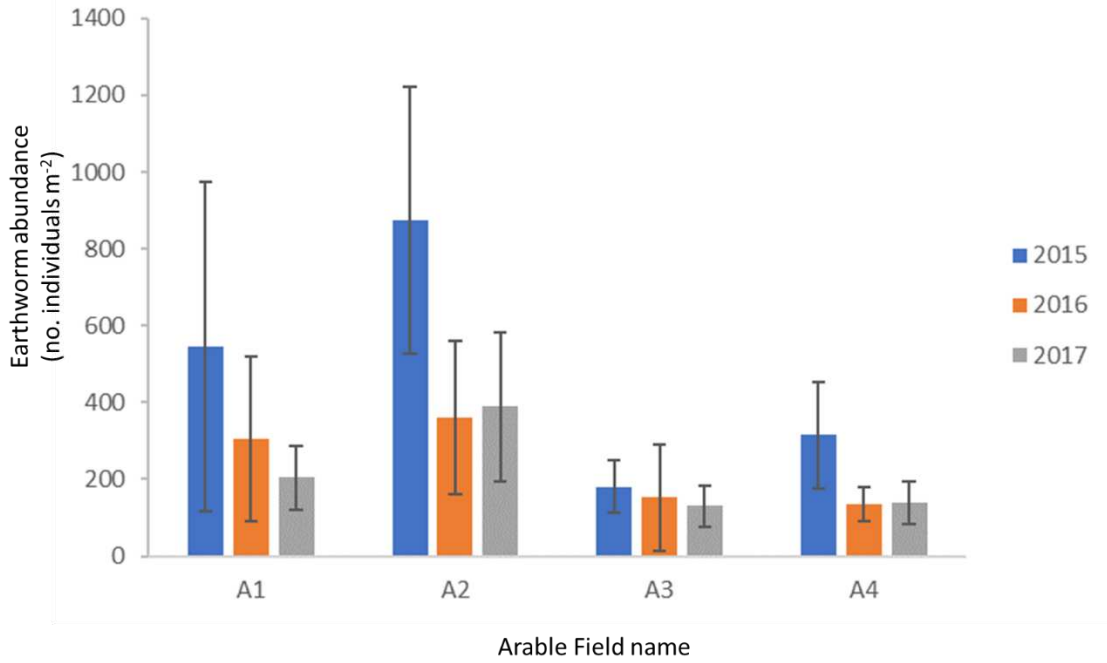


Fig. S4. Earthworm abundance in each arable field (CON strip only) over the sampling period of the study (2015-2017). For Field history and location refer to Table S1 and Fig. S1 respectively. Error bars show ± 1 standard deviation, $n = 6$.

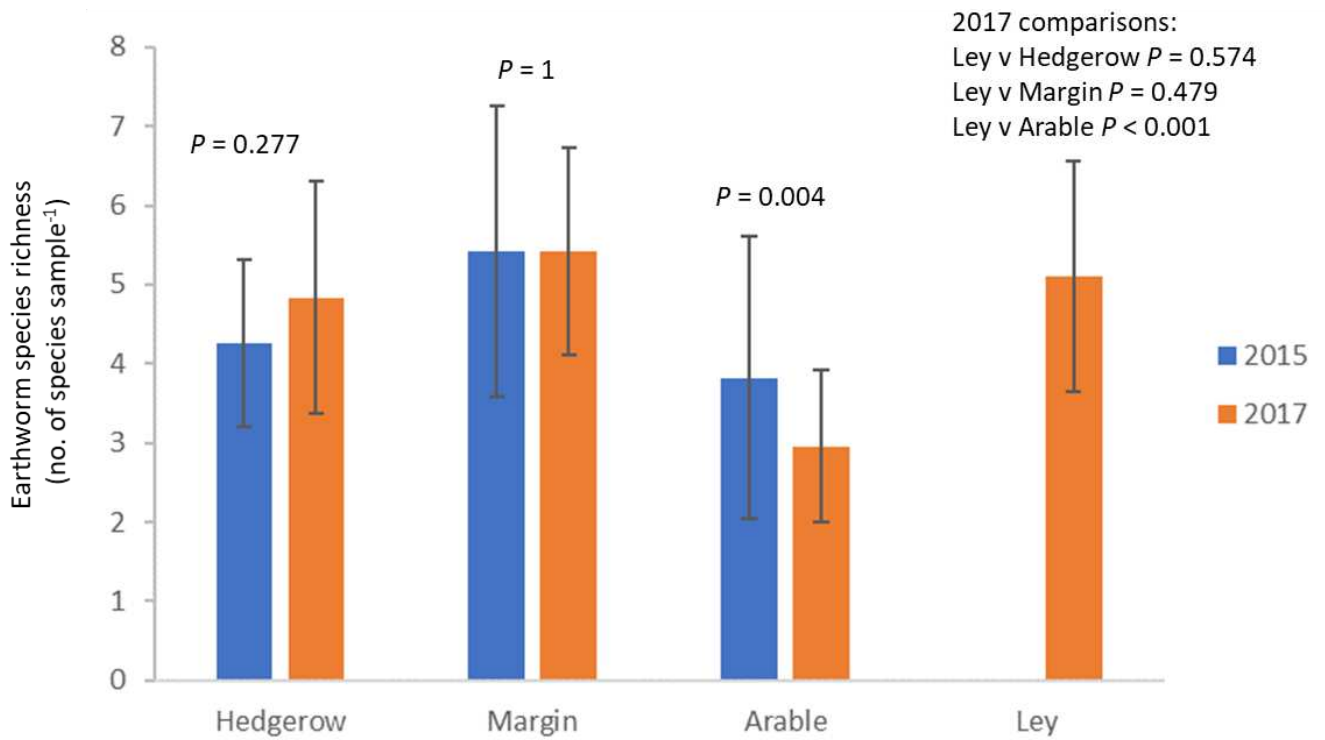


Fig. S5. Earthworm species richness in April 2015 (baseline) and April 2017 (2 yrs after arable-to-ley conversion) in hedgerow, field margin, arable and new ley soils. P values show results from t-test comparisons. Error bars show ± 1 standard deviation.

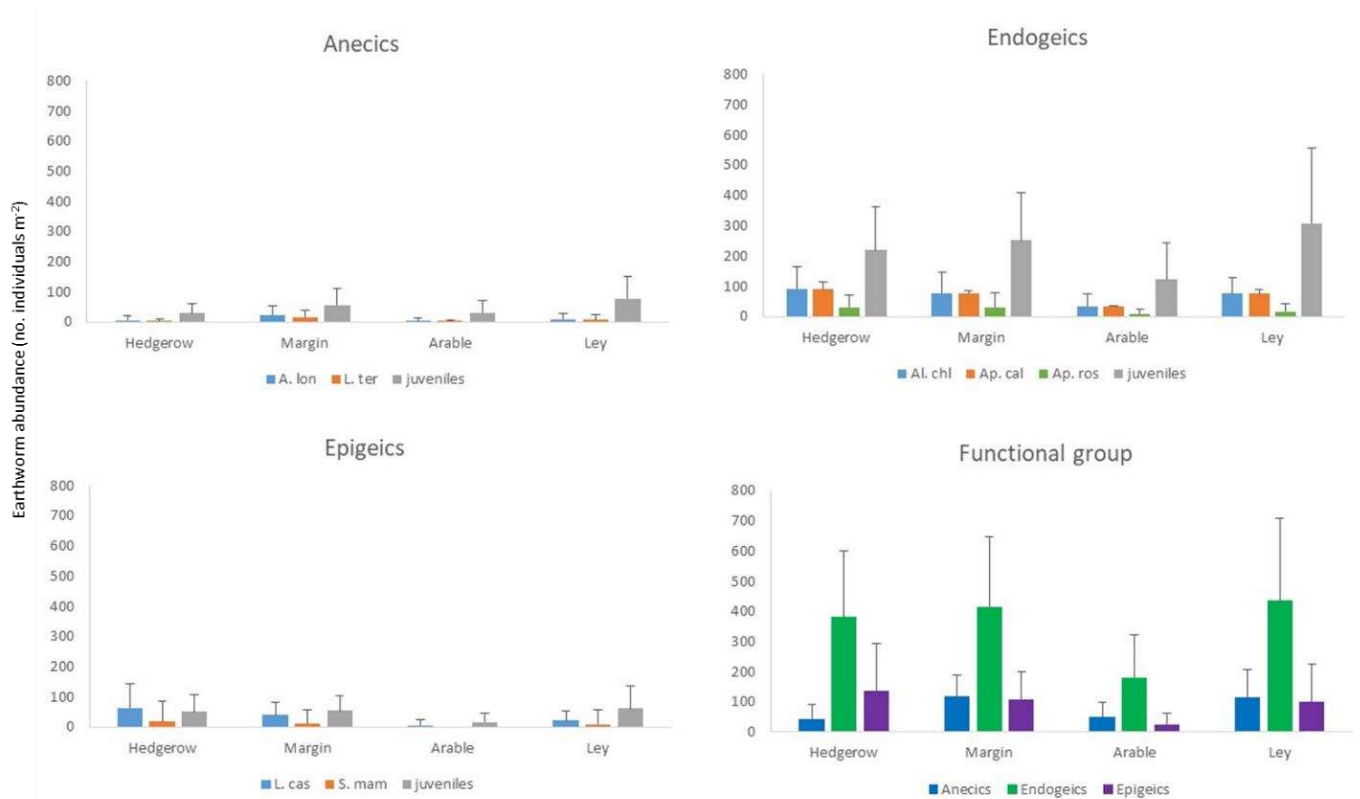


Fig. S6. Earthworm species and functional group mean abundance in each land use. Data show average abundance for annual surveys in April 2016 and 2017. Error bars show +1 standard deviation, where hedgerow, margin n = 12; arable n = 24; ley n = 48 in each year. *A. longa* (Ap.lon); *L. terrestris* (L.ter); *A. chlorotica* (Al.chl); *A. caliginosa* (Ap.Cal); *A. rosea* (Ap.Ros); *L. castaneus* (L.cas); *S. mammalis* (S.mam).

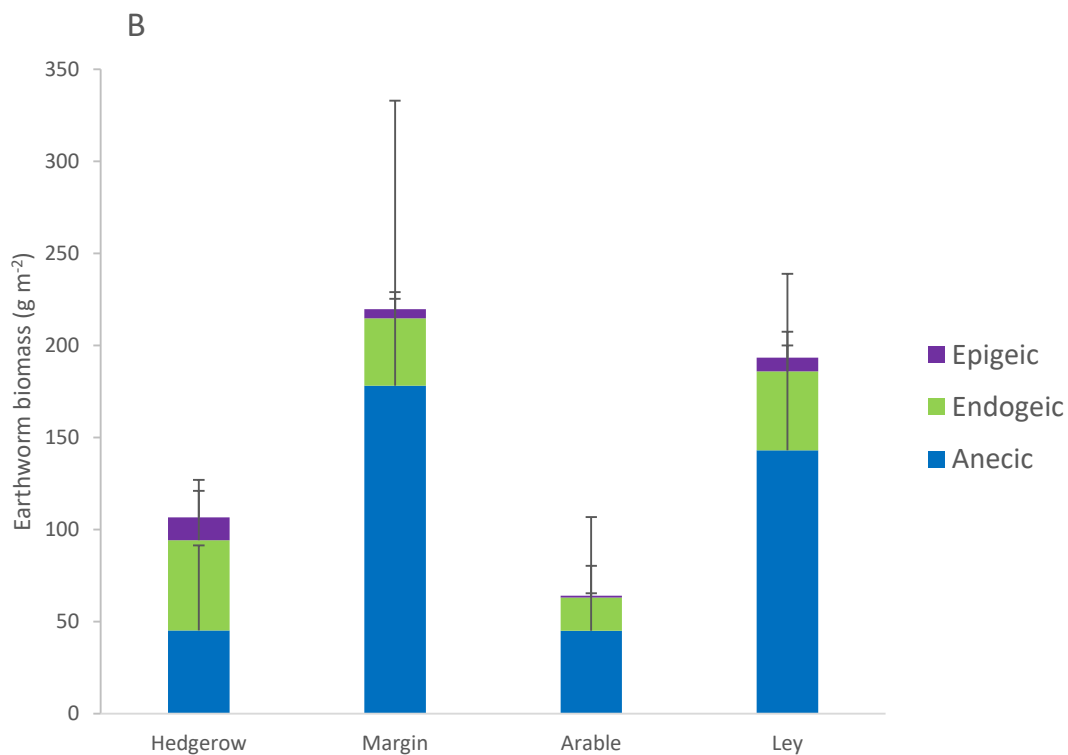
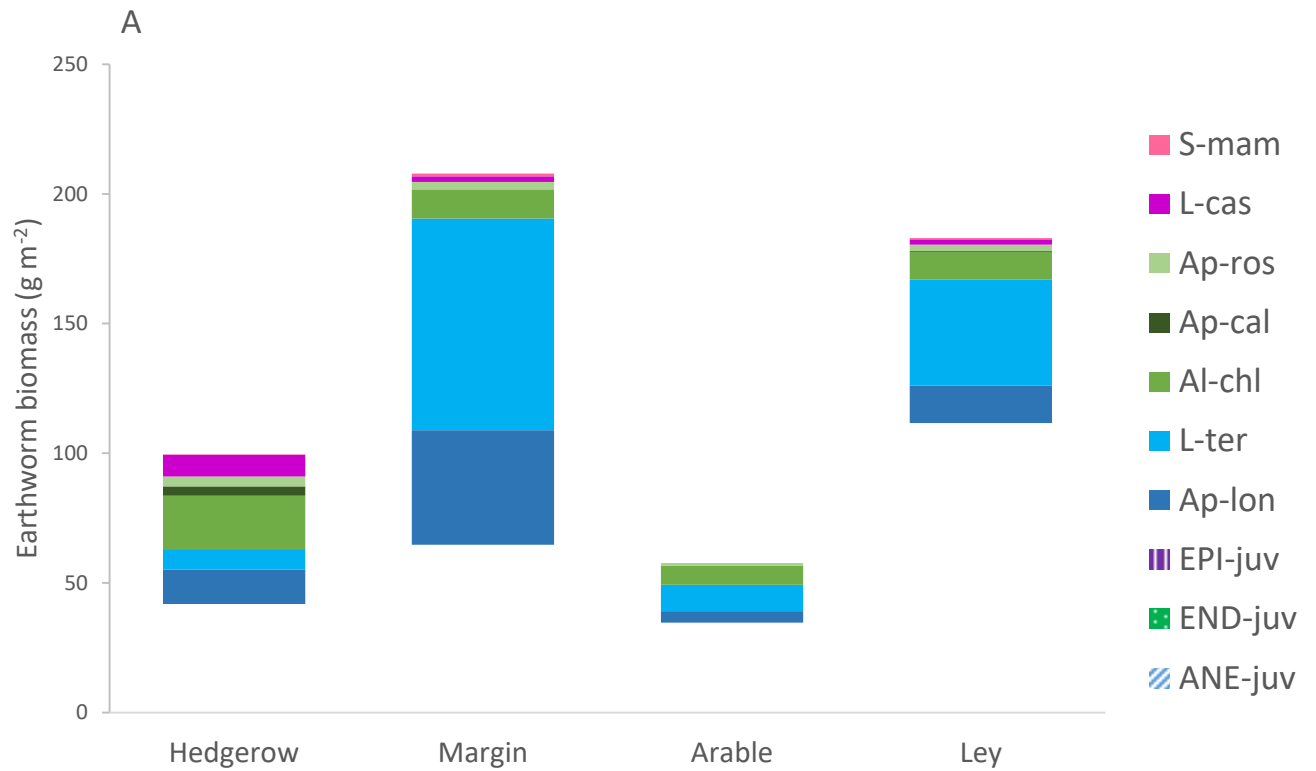


Fig S7. Mean earthworm biomass by species (A) and functional group (B) from hedgerow, margin, arable and ley soils sampled in April 2017. Anecic juveniles (ANE-juv; shaded blue); endogeic juveniles (END-juv; shaded green); epigeic juveniles (EPI-juv; shaded purple); *A. longa* (Ap-lon; dark blue); *L. terrestris* (L-ter; light blue); *A. chlorotica* (Al-chl; light green); *A. caliginosa* (Ap-cal; dark green); *A.*

rosea (Ap-ros; pale green); *L. castaneus* (L-cas; dark pink); *S. mammalis* (S-mam; pink). Error bars show standard deviation.

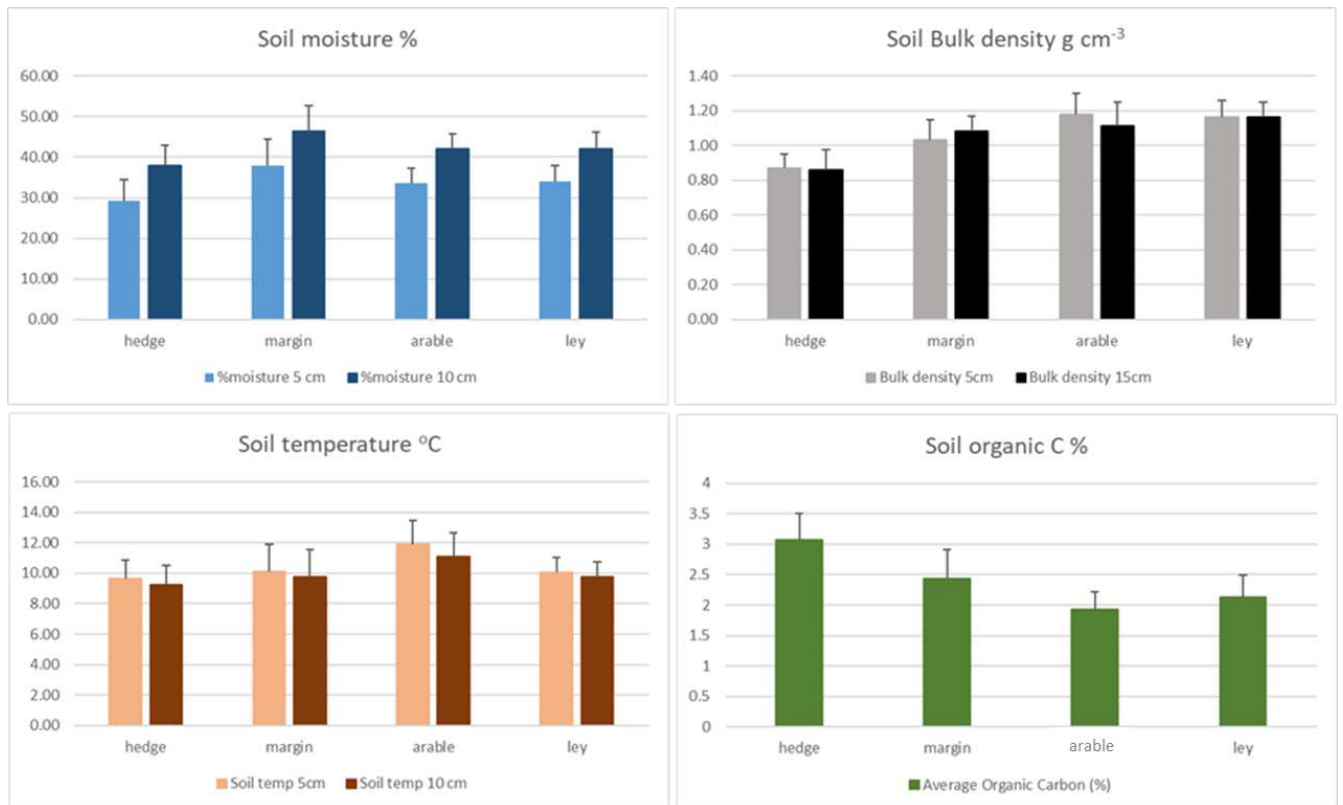


Fig. S8. Mean soil moisture, bulk density, temperature and organic C sampled under hedgerow, field margin, arable and new leys. Samples were collected in April 2017 (for moisture, density, temperature) and April 2018 (for SOC). $n = 12, 12, 24$ and 48 in hedgerow, margin, arable and ley soils. Soil moisture, bulk density and temperature were taken from samples collected at 5 and 10 (or 15 cm) depths, while SOC represents samples taken at 2-7 cm depth.

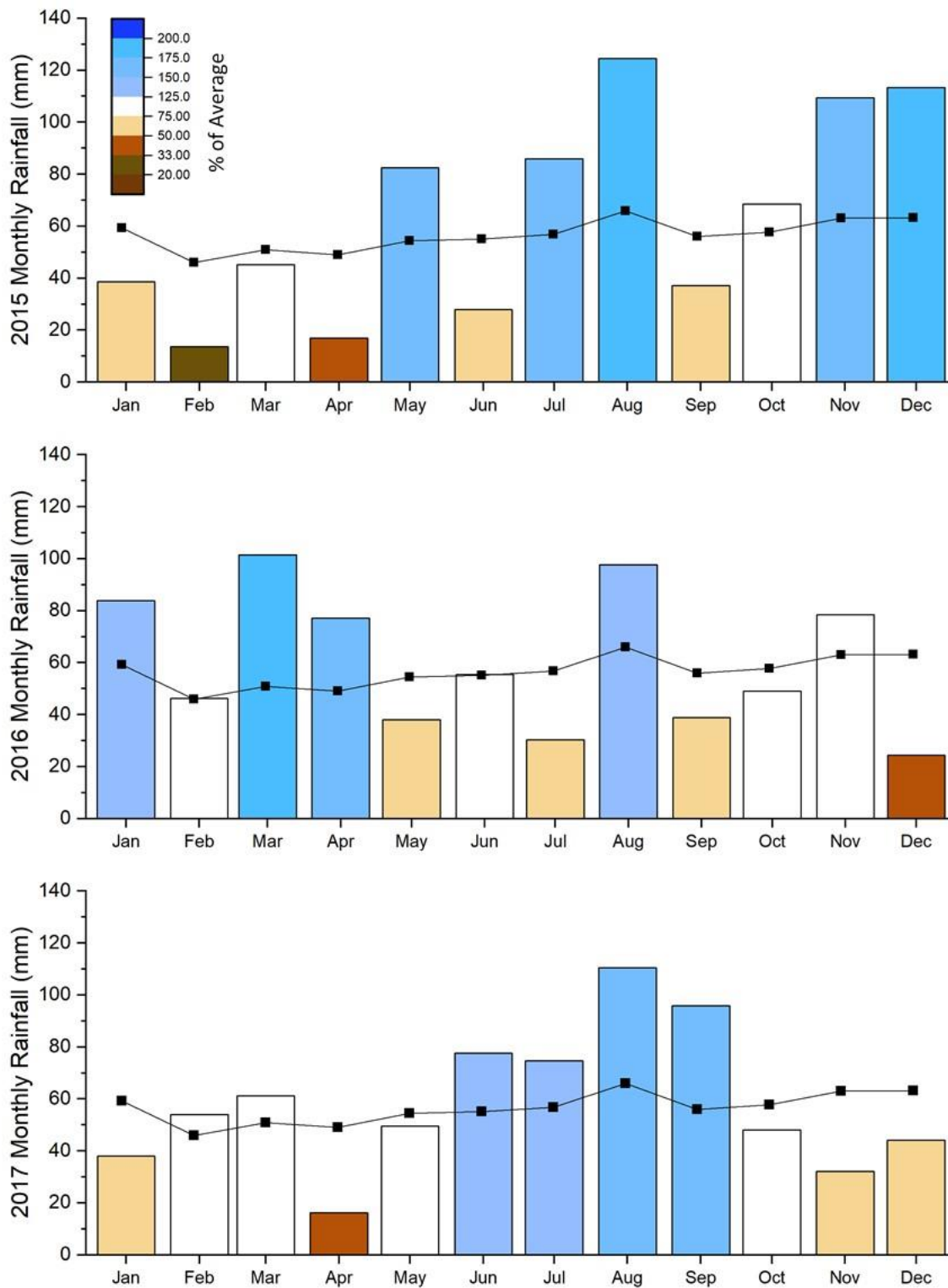


Fig. S9. Monthly rainfall measured at the Leeds Farm site over the study period (2015-2017). The black line indicates the long-term monthly average from 2001-2018 with the shading showing the monthly total as a percentage of the long-term average (blues >115%, white 75-125%, browns <75%). The annual precipitation was 764 mm, 720 mm and 701 mm in 2015, 2016 and 2017 respectively. Data are sourced from the Bramham UK Met Office climate station.



Fig. S10: Mean seasonal abundance of earthworm species and functional groups at one arable field (A4). The annual surveys are on the left panels, with additional seasonal surveys on the right. Hatched colours show juveniles for each functional group. ANECICS: Anecic juveniles (ANE-juv); *A. longa* (Ap-lon); *L. terrestris* (L-ter); ENDOGEICS: endogeic juveniles (END-juv); *A. chlorotica* (Al-chl); *A. caliginosa* (Ap-Cal); *A. rosea* (Ap-ros); *M. muldali* (M-mul); EPIGEICS: epigeic juveniles (EPI-juv); *L. castaneus* (L-cas); *S. mammalis* (S-mam); *D. rubidus* (Ds-rub).