Biological Recording Company

sapperton wilder

Baseline Earthworm Survey Report

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Version 3

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1 Contents

2 Acknowledgements

Earthworm Surveys

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3 Project aims

The Sapperton Wilder project takes an evidence-based approach to land use in an area of poor, over-worked soils, to understand how we can maximise returns for nature, the local community, and grow food profitably.

Sapperton Wilder is exploring methods of land restoration while measuring biodiversity and social benefits. Over the next 30 years, the project will monitor key ecological indicators and socioeconomic returns by transforming 380 acres of 'marginal' Cotswold arable land to nature-based farming and creating a wildlife haven that aims to inspire nature recovery across the country. We use the term 'marginal' in reference to the geological nature of Cotswold soils, naturally thin and stony, requiring high levels of input for economic return.

The site is divided into 3 blocks, which are further divided into a total of 19 fields (Figure **1**). A further 3 fields are used as control sites at other farms within Gloucestershire.

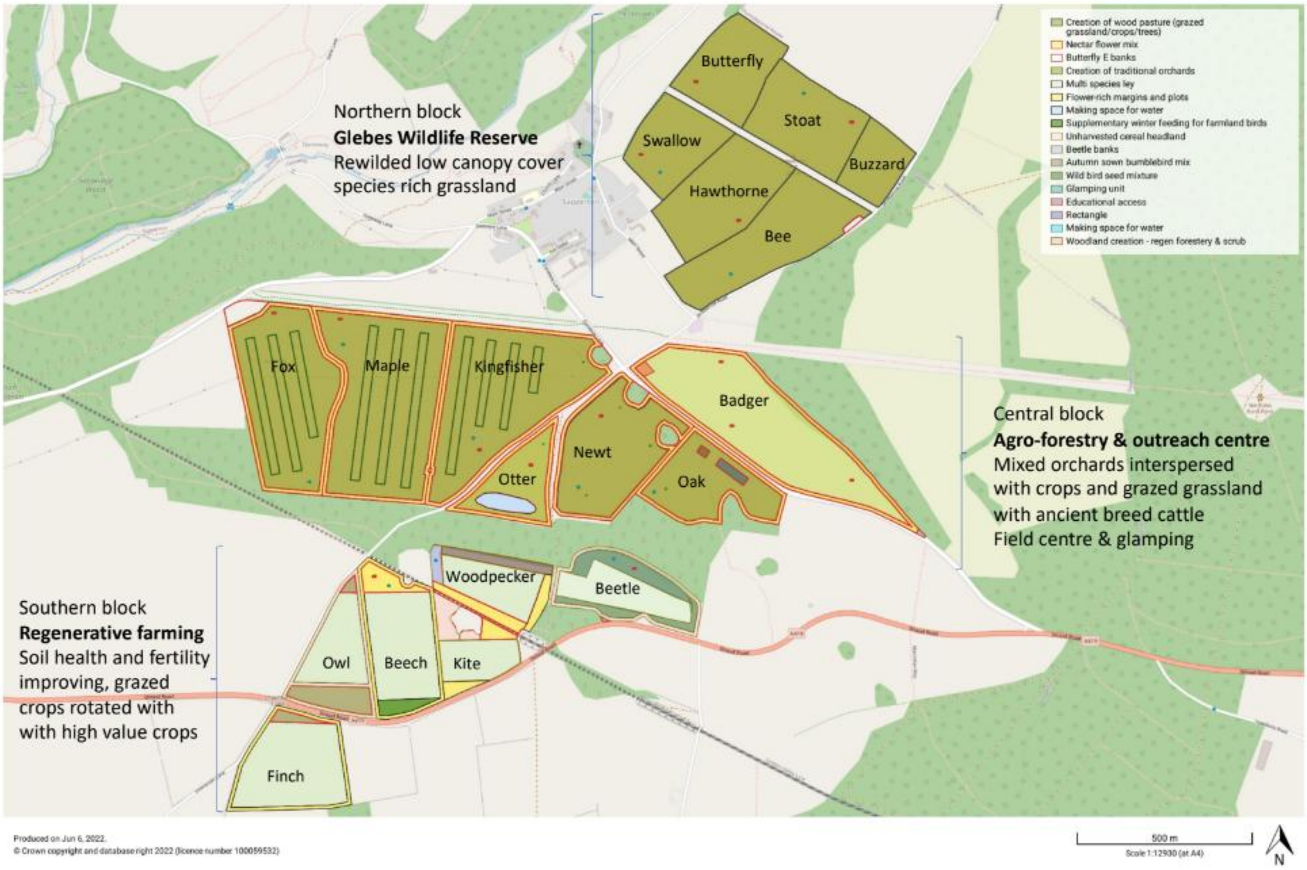


Figure 1: Land use map illustrating the location of the 3 blocks and 19 fields contained within the Sapperton Wilder experiment.

The Biological Recording Company was commissioned in April 2023 to assist in undertaking a baseline survey of the sites involved in the Sapperton Wilder experiment in Gloucestershire prior to the beginning of experimental treatments across the study site. A baseline earthworm survey was undertaken at Sapperton Wilder in May 2023. The baseline survey was repeated in April 2024 and March/April 2025 to account for annual variation in earthworm populations due to weather.

The baseline survey consisted of a single component:

1. **Soil pit survey transects**

This report presents the methodology, limitations and results of this survey, alongside any conclusions that can be drawn from the findings.

4 UK earthworms

The UK and Ireland are home to 33 species of earthworm, which can be broken down into groups based on their morphology, ecology and behaviour. Traditionally, the separation of species into groups has been into ecological categories based on their morphology, using three poles on a triangular scale:

- **Anecic earthworms** make permanent vertical burrows in soil. They feed on leaves on the soil surface that they drag into their burrows. They also cast on the surface, and these casts can quite often be seen in grasslands. Some anecic earthworm species also make middens (piles of casts) around the entrance to their burrows. Anecic species are the largest species of earthworms in the UK. They are darkly coloured at the head end (red or brown) and have paler tails.
- **Endogeic earthworms** live in and feed on the soil. They make horizontal burrows through the soil to move around and to feed and they will reuse these burrows to a certain extent. Endogeic earthworms are often pale colours, grey, pale pink, green or blue. Some can burrow very deeply in the soil.
- **Epigeic earthworms** live on the surface of the soil in leaf litter, deadwood, dung and compost. These species tend not to make burrows. Epigeic earthworms are also often bright red or red-brown, and sometimes even stripy.

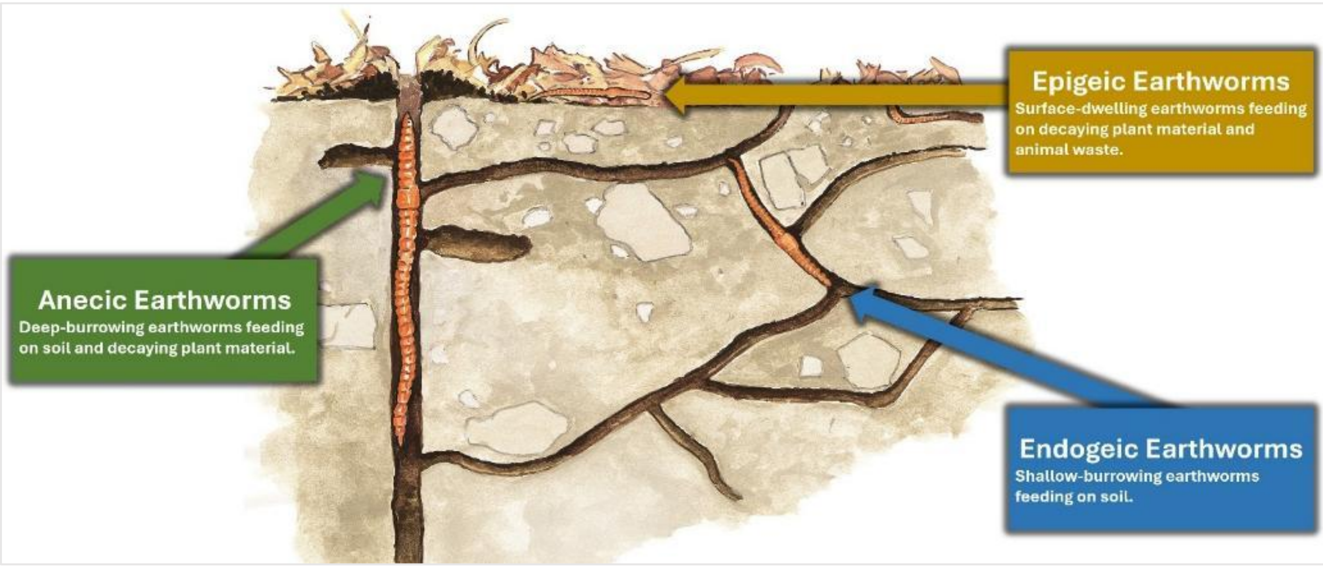


Figure 2: Earthworm ecological categories. Illustration (c) Rick Kollath https://kollathdesign.com/

Earthworms were selected as an indicator of general soil biodiversity health as they are widely regarded to be of great ecological importance, with different ecological categories of earthworm contributing to soil processes and resulting in a number of ecosystem services (**Figure 3**) (Keith & Robinson, 2012).

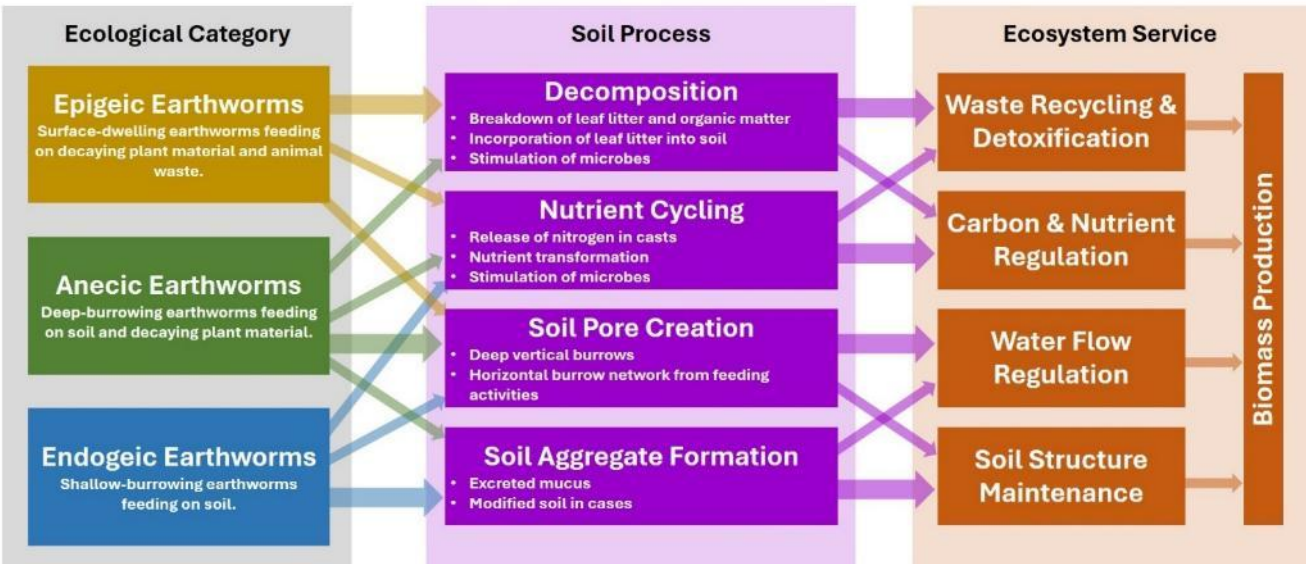


Figure 3: Earthworm ecosystem services adapted from Keith & Robinson 2012.

More recently, earthworms have been categorised into one of 6 functional groups based on their bioturbation behaviour as illustrated in **Figure 4** (and including an additional intermediate grouping) (Capowiez, Marchán, Decaëns, Hedde, & Bottinelli, 2024):

- **Litter dwellers** were described as small pigmented earthworms with very high surface activity and which make a few shallow galleries in the soil. A link can be made with the epigeic ecological category.
- **Burrowers** were described as large pigmented earthworms which feed and cast on the surface. They make a limited number of true burrows and have higher activity close to the surface. A link can be made with the epi-anecic ecological category.
- **Intense tunnelers** were described as very large pigmented earthworms that also feed and cast on the surface. However, they make extensive burrow systems. A link can be made with the anecic ecological category.
- **Shallow bioturbators** were described as small non-pigmented earthworms that have very low surface activity and make refilled and shallow galleries in the soil. A link can be made with epi-endogeics.
- **Deep bioturbators** were described as non-pigmented average to large earthworms that also have low surface activity. They make refilled galleries which can be found deeper in the soil profile. These may also be referred to as hypo-endogeics.
- A sixth category was classified as the **Intermediate** group. This included species without marked characteristics and included both pigmented and non-pigmented species.

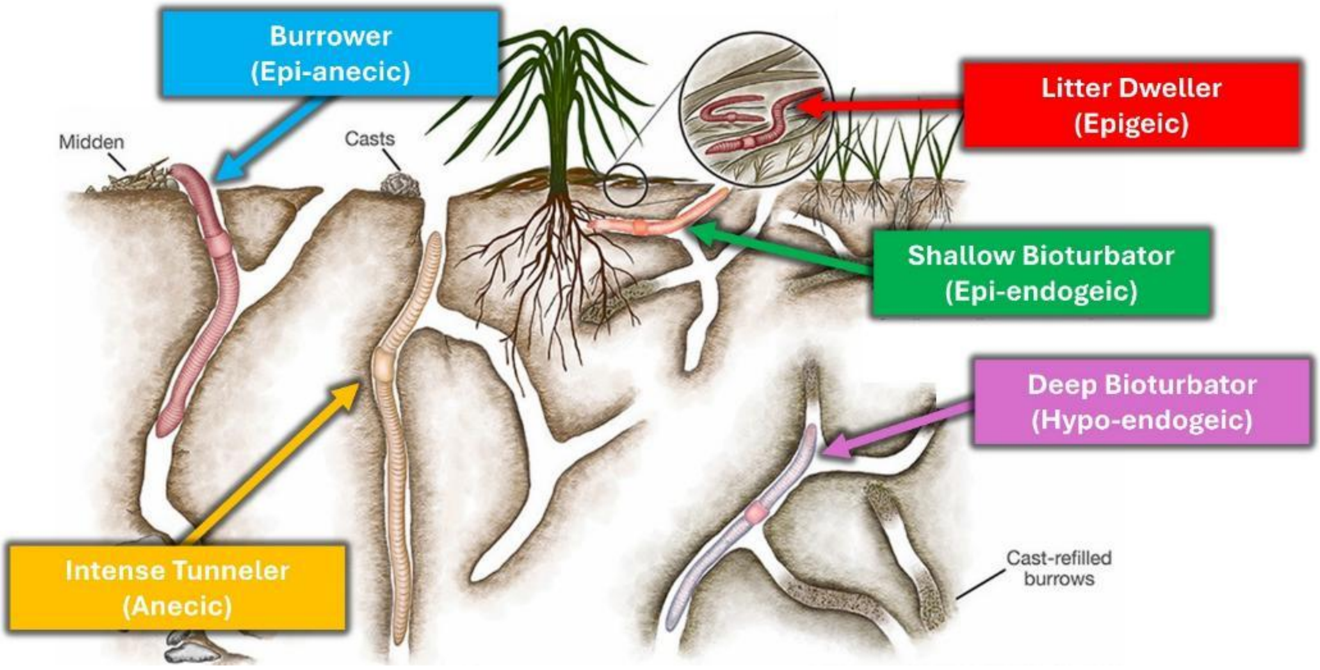


Figure 4: Earthworm Functional Groups adapted from Capowiez et al (2024).

5 Soil pit survey transects

This survey involved undertaking soil pit survey transects to investigate the communities of soil-dwelling earthworm species.

5.1 Methodology

One soil pit survey transect was undertaken within each of the 19 arable fields on the Sapperton Wilder site to establish baseline data with regards to earthworm abundance, species richness and species assemblage across the site.

In addition, 3 control arable sites were surveyed:

- Lower Hampen Farm: Regenerative Agriculture Control 1
- CP Farm: Conventional Control 1
- Bathurst Farm: Conventional Control 2

Details of the survey dates and locations for each sample site can be found in **Table 1** below.

Table 1: Details of soil pit transect sites surveyed for earthworms in this study.

Block	Field	2023		2024		2025	
		Sampling Date	Grid Reference	Sampling Date	Grid Reference	Sampling Date	Grid Reference
Northern Block	Butterfly	23/05/2023	SO951036	11/04/2024	SO952034	31/03/2025	SO952034
	Stoat	23/05/2023	SO953034	09/04/2024	SO954032	31/03/2025	SO954032
	Buzzard	17/05/2023	SO955032	09/04/2024	SO955032	02/04/2025	SO955032
	Swallow	23/05/2023	SO949034	11/04/2024	SO951034	31/03/2025	SO950034
	Hawthorne	23/05/2023	SO951033	10/04/2024	SO953033	02/04/2025	SO953033
	Bee	24/05/2023	SO953031	10/04/2024	SO955032	02/04/2025	SO953032
Central Block	Fox	17/05/2023	SO938028	12/04/2024	SO938028	03/04/2025	SO938025
	Maple	17/05/2023	SO941027	12/04/2024	SO940029	04/04/2025	SO940029
	Kingfisher	17/05/2023	SO944025	12/04/2024	SO943027	04/04/2025	SO943027
	Otter	22/05/2023	SO946023	18/04/2024	SO946025	04/04/2025	SO946025
	Newt	20/05/2023	SO947023	17/04/2024	SO947025	07/04/2025	SO947025
	Oak	20/05/2023	SO950024	16/04/2024	SO950025	07/04/2025	SO950025
	Badger	17/05/2023	SO949027	16/04/2024	SO949027	02/04/2025	SO949027
Southern Block	Finch	30/05/2023	SO937015	22/04/2024	SO938016	11/04/2025	SO938016
	Owl	24/05/2023	SO941018	22/04/2024	SO940021	08/04/2025	SO940021
	Beech	20/05/2023	SO942018	17/04/2024	SO941021	08/04/2025	SO941021
	Kite	20/05/2023	SO943019	23/04/2024	SO945019	11/04/2025	SO945019
	Woodpecker	20/05/2023	SO943021	17/04/2024	SO946021	10/04/2025	SO944021
	Beetle	20/05/2023	SO947021	17/04/2024	SO946021	07/04/2025	SO946021
Regen Ag Control 1		27/05/2023	SP062195	13/04/2024	SP062195	09/04/2025	SP062195
Conventional Control 1		29/05/2023	SO036014	22/04/2024	SO935014	11/04/2025	SO935014
Conventional Control 2		27/05/2023	SO987034	13/04/2024	SO987034	09/04/2025	SO987034

Each transect consisted of 5 soil pits, selected at random points across the sample site. The National Earthworm Recording Scheme guidance on soil pit sampling (Brown, Earthworm Recorders Handbook [Version 8], 2019) was followed as outlined below.

5.1.1 For each soil pit

1. A soil pit measuring approximately 25cm by 25cm was excavated to a depth of around 10cm. Excavated pits were also checked to ensure no earthworms were in the bottom or sides.

2. The soil excavated from the pit was placed on a sorting tray and the pit was checked for any earthworms.

3. Any adult earthworms that were found in the soil were removed and collected into a labelled sample tube.

4. Any juvenile earthworms that were found were returned to the soil pit, and the total number of earthworms returned to the soil was recorded.

5. The soil was returned to the pit once the contents had been sorted and compacted down to avoid leaving a hole or uneven surface that people could trip over.

Figure 5: Hand-sorting of excavated soil for earthworms. Image: Anna Rebmann.

5.1.2 For each transect

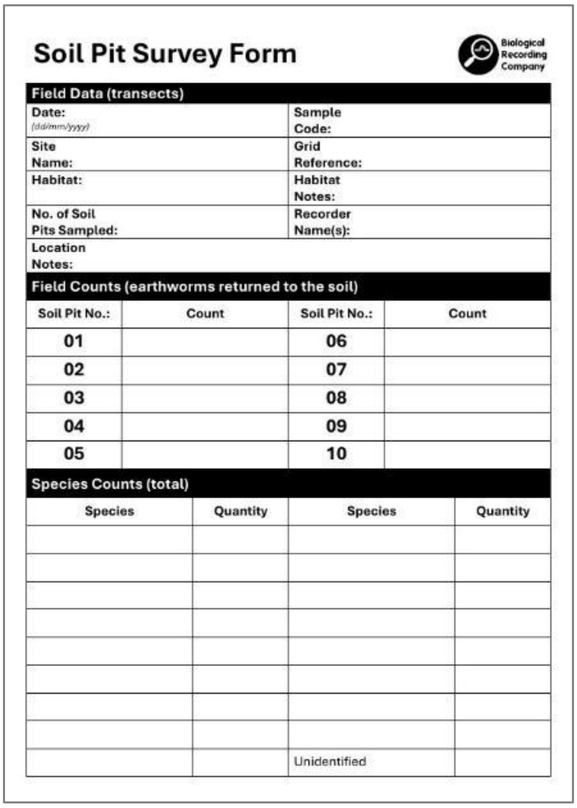
1. 5 replicate soil pit excavations were completed, all within the same 100 m Ordnance Survey grid square.

2. A Soil Pit Survey Form was completed, recording the sampling date, name of the field and location (e.g., Beetle Field, Sapperton Wilder), name of the lead surveyor (recorder name), 6-figure OS grid reference, habitat, number of soil pits sampled and any other notes regarding the sampling site.

3. All earthworm specimens were examined and identified where possible using a microscope and the Key to the Earthworms of the UK & Ireland (2nd Edition) (Sherlock, 2018).

4. The total number of unidentified earthworms was calculated by adding the number of unidentifiable specimens from the sample tubes to the number of specimens returned to the soil in the field.

5. The data for each site were submitted to the National Earthworm Recording Scheme via the Soil Pit Survey form on iRecord. All records have since been accepted into the National Earthworm Recording Scheme and have passed the National Earthworm Recording Scheme verification protocol (Brown, Verification, 2022).



Soil Pit Survey Form

Biological Recording Company

Field Data (transects)	
Date: (dd/mm/yyyy)	Sample Code:
Site Name:	Grid Reference:
Habitat:	Habitat Notes:
No. of Soil Pits Sampled:	Recorder Name(s):
Location Notes:	

Field Counts (earthworms returned to the soil)

Soil Pit No.:	Count	Soil Pit No.:	Count
01		06	
02		07	
03		08	
04		09	
05		10	

Species Counts (total)

Species	Quantity	Species	Quantity
		Unidentified	

Figure 6: Soil Pit Survey Form used to record sample site details and the number of unidentified earthworms returned to the soil.

5.2 Limitations of the survey methodology

1. **Patchy earthworm distributions**: Soil conditions are known to have a significant influence on earthworm populations. Conditions can, however, vary greatly within a single site or over time. Ideally, it is recommended that more than 5 sample points per site be surveyed to gather robust data to inform any conclusions regarding earthworm abundance and species richness at any given location. The budget and capacity for this baseline survey were limited, so it was decided to opt for a lower number of replicates per field to gather data on each of the 19 Sapperton Wilder fields and 3 control fields.

2. **Soil moisture**: Weather can be another important factor as it has a direct impact on soil conditions, particularly soil moisture. Survey results may need to be taken in context with seasonal and annual weather cycles. The initial surveys were undertaken after an unusually dry spring, and the soil was noticeably dry. The survey was repeated for the following two years to establish an average and account for annual variation in weather patterns and soil moisture.

3. **Sampling biases**: Soil pit surveying is effective for extracting soil-dwelling species from the top layers of soil and can easily be standardised and used to gain good qualitative data for research. However, as a sampling method, it is biased towards soil-dwelling species (particularly shallow and deep bioturbator species) and less effective than mustard sampling for extracting burrower and intense tunneller species. No sampling methods designed to target surface-dwelling earthworms were undertaken, and as a result, species categorised within the litter dweller functional groups are likely to be missed or under-represented.

5.3 Results

Across all sampled fields and control plots, 4868 earthworms were recorded, with an overall mean abundance of approximately 76 earthworms per transect across all years. The lowest earthworm abundance was recorded at Conventional Control 2 in 2023 (8 earthworms, 1 species). The second-lowest abundance was recorded at Stoat field (Northern Block) in 2023 (15 earthworms, 3 species), representing the lowest value observed within the sampled fields. The highest earthworm abundance was recorded at Swallow field (Northern Block) in 2024 (226 earthworms, 6 species).

Mean species richness was approximately 3 species per transect. The lowest species richness recorded across the dataset was 1 species, which occurred in several fields and conventional control plots across multiple years. The highest species richness recorded was 6 species, observed in multiple locations in 2024 and 2025, including both sampled fields and the regenerative agriculture control.

A summary of the soil pit survey results by transect can be found in Table 2.

- The **Northern Block** contained both the highest abundances recorded and some of the lowest inter-annual values, indicating high variability.
- The **Central Block** generally supported moderate to high abundance and relatively high species richness.
- The **Southern Block** tended to support lower abundance and species richness.
- The **conventional controls** consistently recorded the lowest earthworm abundance and species richness across all three survey years. These results provide a robust reference for earthworm communities under continued intensive arable management and illustrate the lower bound of earthworm abundance and species richness within the local landscape.
- In contrast, the **regenerative agriculture control** consistently recorded higher abundance and species richness than the conventional controls, and values comparable to or exceeding those recorded in many sampled fields. This suggests that regenerative management practices are associated with more favourable soil conditions for earthworm populations, even within the early years of implementation.

Table 2: Total earthworm counts and species richness by transect

Block	Field	2023		2024		2025		Mean	
		Total Earthworms	Species Richness	Total Earthworms	Species Richness	Total Earthworms	Species Richness	Total Earthworms	Species Richness
Northern Block	Butterfly	24	2	134	6	96	2	84.67	3.3
	Stoat	15	3	111	3	28	4	51.33	3.3
	Buzzard	27	2	76	2	90	3	64.33	2.3
	Swallow	38	2	226	6	209	3	157.67	3.7
	Hawthorne	35	1	181	4	30	2	82.00	2.3
	Bee	31	1	118	3	28	2	59.00	2.0
Central Block	Fox	49	4	149	6	61	3	86.33	4.3
	Maple	36	1	108	3	59	4	67.67	2.7
	Kingfisher	46	4	92	6	57	2	65.00	4.0
	Otter	31	3	82	1	96	2	69.67	2.0
	Newt	76	5	123	3	61	4	86.67	4.0
	Oak	52	2	143	4	78	3	91.00	3.0
	Badger	26	3	95	4	49	4	56.67	3.7
Southern Block	Finch	42	2	143	2	65	2	83.33	2.0
	Owl	54	1	95	5	31	1	60.00	2.3
	Beech	39	1	55	5	56	4	50.00	3.3
	Kite	55	2	59	2	29	3	47.67	2.3
	Woodpecker	42	1	57	2	60	4	53.00	2.3
	Beetle	26	2	100	1	57	5	61.00	2.7
Regen Ag Control 1		98	5	168	3	134	6	133.33	4.7
Conventional Control 1		37	1	107	2	84	2	76.00	1.7
Conventional Control 2		8	1	69	3	32	3	36.33	2.3

5.3.1 Earthworm abundance

Earthworm abundance differed significantly between survey years across the 19 sampled fields. Mean abundance per transect was lowest in 2023, highest in 2024, and intermediate in 2025, with notable variation between fields in 2025.

Inter-annual differences in abundance were assessed using a Friedman test to account for the repeated sampling of the same fields and the non-normal distribution of count data. The analysis identified a statistically significant effect of year on earthworm abundance ($p < 0.001$) (see Box 1 and Figure 7).

Post-hoc pairwise comparisons using Wilcoxon signed-rank tests with Holm correction indicated that abundance was significantly higher in 2024 compared with 2023 ($p < 0.001$) and 2025 ($p = 0.004$). Abundance in 2025 was also significantly higher than in 2023 ($p = 0.007$). These results confirm that earthworm abundance varied significantly between all three survey years.

Statistical analysis: Earthworm abundance by year
Sample size: 19 fields surveyed across three years
Data did not meet the assumptions of normality and were therefore analysed using non-parametric repeated-measures statistical tests.

Friedman test (non-parametric repeated measures) results:

- $\chi^2 = 39.65$
- df = 2
- $p < 0.001$

This indicates a highly significant difference in earthworm abundance between years.

Post-hoc Wilcoxon signed-rank tests (Holm adjusted):

- 2023 vs 2024: $p < 0.001$ (very strong level of statistical significance)
- 2023 vs 2025: $p = 0.007$ (strong level of statistical significance)
- 2024 vs 2025: $p = 0.004$ (strong level of statistical significance)

All pairwise comparisons were statistically significant.

Box 1: Statistical analysis summary for earthworm abundance data.

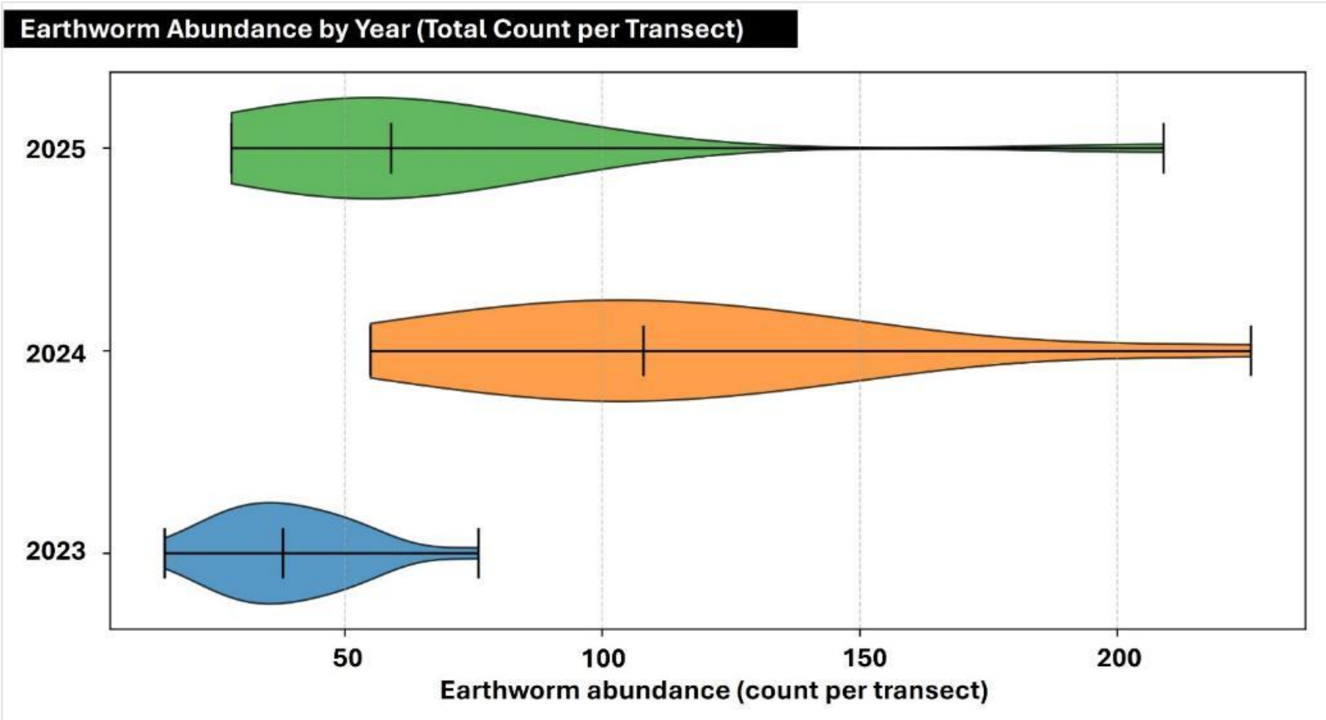


Figure 7: Horizontal violin plot showing the distribution of total earthworm abundance per transect across survey years (2023–2025). The width of each violin represents the density of observations across the 19 sampled fields. Median values are indicated by black horizontal lines. Earthworm abundance was significantly higher in 2024 than in 2023 and 2025, with statistically significant differences detected between all years (Friedman test, $\chi^2 = 39.65$, df = 2, $p < 0.001$).

5.3.2 Species richness

Earthworm species richness showed significant variation between survey years. Species richness per transect was generally low in 2023, with most transects supporting one to three species. Species richness was higher in 2024, with several transects recording four to six species, and was intermediate in 2025.

Differences in species richness between years were assessed using a Friedman test, which identified a statistically significant effect of year on species richness ($p < 0.001$) (see Box 2 and Figure 8).

Post-hoc Wilcoxon signed-rank tests (Holm adjusted) indicated that species richness was significantly higher in 2024 compared with 2023 ($p < 0.001$) and 2025 ($p = 0.011$). Species richness in 2025 was also significantly higher than in 2023 ($p = 0.042$). These results demonstrate consistent inter-annual differences in earthworm species richness across the site.

Statistical analysis: Species richness by year
Sample size: 19 fields surveyed across three years
Data did not meet the assumptions of normality and were therefore analysed using non-parametric repeated-measures statistical tests.

Friedman test (non-parametric repeated measures) results:
- $\chi^2 = 19.12$
- df = 2
- $p < 0.001$

This indicates a highly significant difference in species richness between years.

Post-hoc Wilcoxon signed-rank tests (Holm adjusted):
- 2023 vs 2024: $p < 0.001$ (very strong level of statistical significance)
- 2023 vs 2025: $p = 0.042$ (strong level of statistical significance)
- 2024 vs 2025: $p = 0.011$ (statistically significant difference)

Species richness differed significantly between all three years, with 2024 supporting the highest species richness.

Box 2: Statistical analysis summary for earthworm species richness data.

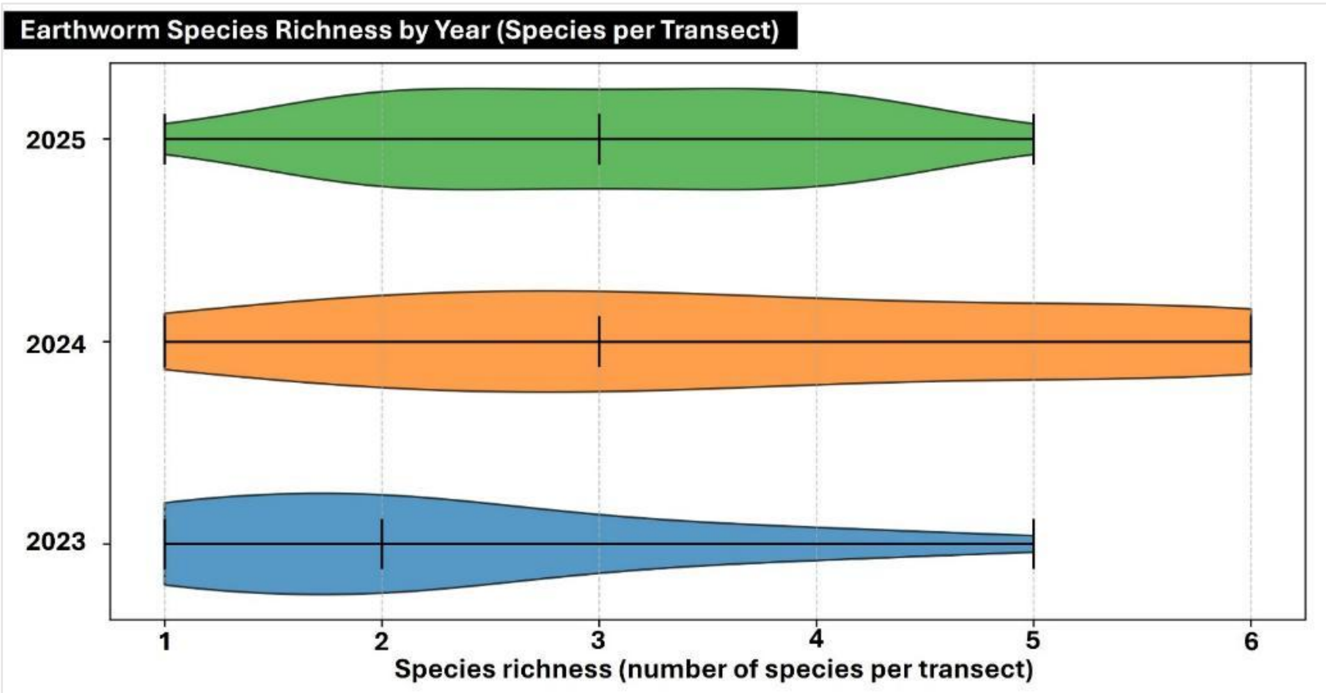


Figure 8: Horizontal violin plot showing the distribution of earthworm species richness (number of species per transect) across survey years (2023–2025). The width of each violin represents the density of observations across the 19 sampled fields. Median values are indicated by black horizontal lines. Species richness differed significantly between years, with the highest values recorded in 2024 (Friedman test, $\chi^2 = 19.12$, df = 2, $p < 0.001$).

5.3.3 Species composition

A summary of the species recorded within this project is provided below (Table 3), including notes on functional group, rarity and habitat specificity (Ashwood, et al., 2024) (Bottinelli, Hedde, Jouquet, & Capowiez, 2020) (Hoeffner, et al., 2022) (Brown, UK Earthworm Provisional Conservation Status Assessment Report, in prep).

A total of 9 different earthworm species were recorded across the sites out of a total of 33 species known to occur in the UK and Ireland. 8 of the 9 species recorded are classed as very common or common, one species is regarded as uncommon, and one species is regarded as rare.

All the recorded species have low habitat specificity and widespread UK distributions.

All of the species detected at the control sites were also detected at multiple sites within the experiment.

Table 3: Summary of earthworm species recorded within this survey.

Species	Functional group (ecological category)	Distribution	Habitat specificity	Rarity
Allolobophora chlorotica	Shallow bioturbator (Epi-endogeic) [3]	Widespread	Low	Very common
Aporrectodea caliginosa	Shallow bioturbator (Epi-endogeic) [1 4]	Widespread	Low	Very common
Aporrectodea longa	Intense tunneler (Anecic) [2]	Widespread	Low	Common
Aporrectodea rosea	Shallow bioturbator (Epi-endogeic) [1 4]	Widespread	Low	Common
Lumbricus castaneus	Litter dweller (Epigeic) [1 3]	Widespread	Low	Common
Lumbricus rubellus	Litter dweller (Epigeic) [1 3]	Widespread	Low	Common
Lumbricus terrestris	Burrower (Epi-anecic) [1 2 3]	Widespread	Moderate	Common
Murchieona muldali	Shallow bioturbator (Epi-endogeic) [1]	Moderately widespread	Moderate	Rare
Satchellius mammalis	Litter dweller (Epigeic) [3]	Moderately widespread	Low	Uncommon

[1] Ecological category is based ecological category model presented in Bottinelli et al 2020.
[2] Functional group is based on categories provided in Hoeffner et al 2022.
[3] Functional group is based categories provided in Capowiez et al 2024.
[4] Functional group estimated based on the author's experience.

Table 4, Table 5 and Table 6 on the following pages present the earthworm species data by site for 2023, 2024 and 2025 respectively.

Allolobophora chlorotica (Figure 9) was by far the most recorded species across both the experiment and control sites (over 70% in both 2023 and 2024, though this fell to 56.6% in 2025). This shallow bioturbator species (shallow-burrowing and feeding on soil) is likely the most common species of earthworm within the UK and accounts for 11.4% of all earthworm records submitted to the National Earthworm Recording Scheme (see References for list of occurrence datasets). It is known to be disturbance-tolerant and commonly recorded in large numbers in agricultural soils.

Figure 9: *Allolobophora chlorotica* (c) Frank Ashwood. https://www.frankashwood.com/

Table 4: Number of earthworms sampled at each site by species during the 2023 sampling period.

2023 Survey		Species									
Block	**Field**	*Allolobophora chlorotica*	*Aporrectodea caliginosa*	*Aporrectodea longa*	*Aporrectodea rosea*	*Lumbricus castaneus*	*Lumbricus rubellus*	*Lumbricus terrestris*	*Murchieona muldali*	*Satchellius mammalis*	Unidentified
Northern Block	Butterfly	2			1						21
	Stoat	2	1		1						11
	Buzzard	12			1						14
	Swallow	8								1	29
	Hawthorne	6									29
	Bee	14									17
Central Block	Fox	9			5	1				3	31
	Maple	7									29
	Kingfisher	4	2	1	1						38
	Otter	7	4	1							19
	Newt	19	1	2		1				1	52
	Oak	6			2						44
	Badger	7			1					1	17
Southern Block	Finch	10	1								31
	Owl	2									52
	Beech	5									34
	Kite	3	1								51
	Woodpecker	1									41
	Beetle	5	2								19
Regen Ag Control 1		24	7	1	6					2	58
Conventional Control 1		11									26
Conventional Control 2		3									5
TOTAL		**167**	**19**	**5**	**18**	**2**	**0**	**0**	**0**	**8**	**668**

Table 5: Number of earthworms sampled at each site by species during the 2024 sampling period.

2024 Survey		Species									
Block	**Field**	*Allolobophora chlorotica*	*Aporrectodea caliginosa*	*Aporrectodea longa*	*Aporrectodea rosea*	*Lumbricus castaneus*	*Lumbricus rubellus*	*Lumbricus terrestris*	*Murchieona muldali*	*Satchellius mammalis*	Unidentified
Northern Block	Butterfly	24			5		1	1	2	1	100
	Stoat	21			2				8		80
	Buzzard	1							14		61
	Swallow	29	1		5	1			2	3	185
	Hawthorne	20			4			1	21		135
	Bee	16			1				4		97
Central Block	Fox	33		2	4	2			1	1	106
	Maple	26			1				1		80
	Kingfisher	20		2	3			1	2	2	62
	Otter	18									64
	Newt	22			2			1			98
	Oak	31			4	5				1	102
	Badger	17			4				5	1	68
Southern Block	Finch	24							4		115
	Owl	8	2		1	1		2			81
	Beech	6	1		2			1	2		43
	Kite	14	1								44
	Woodpecker	9			3						45
	Beetle	19									81
Regen Ag Control 1		17			1				13		137
Conventional Control 1		24	6								77
Conventional Control 2		3			6				4		56
TOTAL		**402**	**11**	**4**	**48**	**9**	**1**	**7**	**83**	**9**	**1917**

Table 6: Number of earthworms sampled at each site by species during the 2025 sampling period.

2025 Survey		Species									
Block	**Field**	*Allolobophora chlorotica*	*Aporrectodea caliginosa*	*Aporrectodea longa*	*Aporrectodea rosea*	*Lumbricus castaneus*	*Lumbricus rubellus*	*Lumbricus terrestris*	*Murchieona muldali*	*Satchellius mammalis*	Unidentified
Northern Block	Butterfly	12			3						81
	Stoat	3			1	1				1	22
	Buzzard	24			6				1		59
	Swallow	10			4	4					191
	Hawthorne	5			3						22
	Bee	1						1			26
Central Block	Fox	2			1	4					54
	Maple	5	2		2				1		49
	Kingfisher	4			1						52
	Otter	7							3		86
	Newt	11	1		1				1		47
	Oak	7			9				1		61
	Badger	2	1		2				1		43
Southern Block	Finch		1					2			62
	Owl	1									30
	Beech	8			2	1			1		44
	Kite	7				2			1		19
	Woodpecker	17		1		3				2	37
	Beetle	7			1	1		1		1	46
Regen Ag Control 1		11	6	1	1				5	2	108
Conventional Control 1			16	1							67
Conventional Control 2		2	1	3							26
TOTAL		**146**	**28**	**6**	**37**	**16**	**0**	**4**	**15**	**6**	**1232**

Aporrectodea caliginosa (Figure 10) is also a shallow bioturbator and was the second-most recorded species in 2023 (accounting for 8.7% of adults and recorded across 8 sites) and 2025 (accounting for 10.9% of adults and recorded across 7 sites). However, it was much less abundant in 2024 and accounted for just 1.9% of identifiable adults (11 individuals across 5 of the 22 sites). Like *A. chlorotica*, it is often abundant at sites where it occurs and is classed as very common. It is also known to be disturbance-tolerant and often recorded in large numbers from agricultural soils.

Aporrectodea longa (Figure 10) is an intense tunneler species (deep-burrowing and feeding on soil and above-ground decaying plant material), meaning that it is important for soil pore creation and therefore soil aeration and drainage. This species was detected in small numbers at relatively few sites (5 Sapperton Wilder sites and all 3 control sites). It is regarded as a common species and found in a wide range of habitats (including agricultural soils).

Figure 10: Images of earthworm species.
Left: *Aporrectodea caliginosa* (c) Keiron Derek Brown.
Right: *Aporrectodea longa* (c) Keiron Derek Brown.

Aporrectodea rosea is another shallow bioturbator species and is considered common. It consisted of around 8% of total adult earthworms during 2023 and 2024, and was the second-most abundant species in 2025 (accounting for 14.7% of adults). It is also considered disturbance-tolerant and found in a wide range of habitats, including agricultural soils.

Lumbricus castaneus (Figure 11) is commonly found in both the soil and above-ground microhabitats, and is categorised as a litter dweller species. It is regarded as a common species and found in a wide range of habitats (including agricultural soils). It was recorded in small but increasing numbers over the 3-year sampling period.

Lumbricus rubellus (Figure 11) is also is commonly found in both the soil and above-ground microhabitats, and is categorised as a litter dweller species. It is regarded as a common species and is thought to have the lowest habitat of all UK earthworm species. Only a single individual was detected throughout the 3-year sampling period (recorded during 2024 from Butterfly Field, Northern Block).

Figure 11: Images of earthworm species.
Left: *Lumbricus castaneus* © Keiron Derek Brown.
Right: *Lumbricus rubellus* © Keiron Derek Brown.

Lumbricus terrestris (Figure 12) is the largest species of earthworm occurring in the UK and was detected for the first time in 2024, with 1-2 individuals recorded across 8 sites during 2024 and 2025. It is a burrower species that creates middens at the entrances to its deep burrows going down to depths of up to 2.5 metres. It is known to feed on soil throughout the soil profile as well as surface material (such as leaf litter). It is a common species and often found in agricultural soils, though it can be particularly susceptible to tilling.

Murchieona muldali is considered a rare species of earthworm and appears to have a preference for farmland habitats, particularly field margins. It is a very small shallow bioturbator species that lives within the soil and feeds on soil. It can be easy to overlook due to its small size and pale/indistinct appearance, and may therefore be more common than it is known to be. It was absent in 2023, but recorded across a range of sites in 2024 and 2025 (both in Sapperton Wilder and at 2 of the 3 control sites). In 2024, it was the second-most abundant species and accounted for 14.6% of total adult earthworms.

Satchellius mammalis (Figure 12) is another species that is found in both the soil and above-ground microhabitats, and is classified as a litter dweller species in terms of functional group. It is regarded as uncommon due to the known distribution being more patchy than that of common species. It was recorded in small numbers at 4-6 sites each year of the baseline survey.

Figure 12: Images of earthworm species.
Left: *Lumbricus terrestris* © Keiron Derek Brown.
Right: *Satchellius mammalis* © Bob Kemp.

5.3.4 Functional group composition

A breakdown of the percentage of earthworms by functional group for the Sapperton Wilder site is provided in **Figure 13** below. Four of the five functional groups were represented within the data collected from this survey, indicating that there may be a gap in the provision of ecosystem services delivered by earthworms on this site.

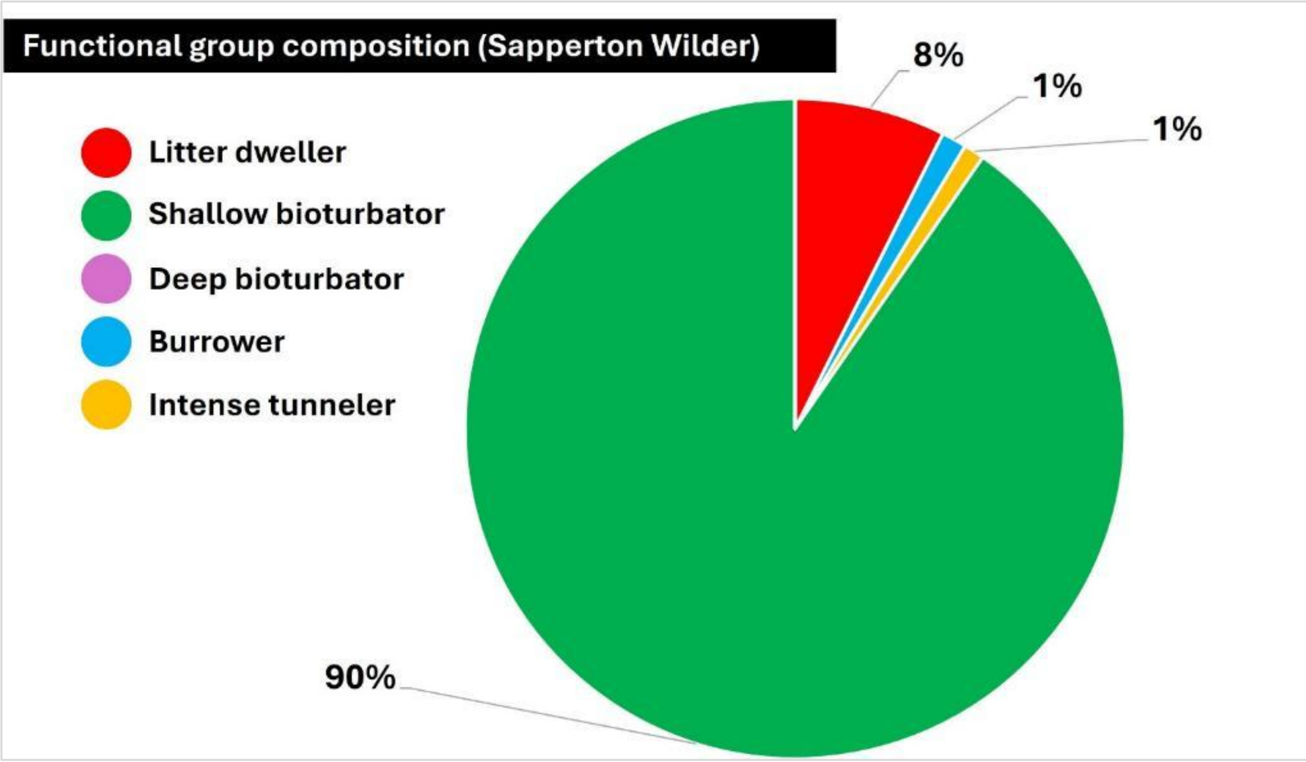


Figure 13: Pie chart displaying the composition of earthworms detected by functional group across all surveys. Pie chart slice colours indicate the functional group of the represented species. (*n* = 874)

Shallow bioturbators comprised the majority of the adult earthworms collected (90%). Soil pit sampling transects can cause biases towards the detection of these species, but the extent to which this group is over-represented is greater than would be expected. The 3 common species of bioturbator that were detected are all known to be disturbance-tolerant and are often found in intensively farmed landscapes, sometimes even in relatively high numbers in the absence of other species.

Although only 8% of the adult earthworms detected were **litter dwellers**, the survey methods used were not optimal for detecting high numbers. Just 3 of the 14 species of litter dweller known to occur in the UK and Ireland were detected at Sapperton Wilder.

Deep bioturbators were not detected during this survey, suggesting that the soil processes provided by these earthworms may be absent from the underground ecosystem. However, due to the stony nature of the site, soil pit sampling was limited to a depth of 10 cm, so it is possible that these species are present but difficult to detect due to their presence deeper in the soil profile.

Both **burrowers** and **intense tunnelers** were both represented by single species and were overall underrepresented in the data collected (just 1% for each group). Again, the sampling method is known to be less effective for these groups, but the extent to which these groups are under-represented is greater than would be expected.

6 Conclusions

This three-year dataset provides a robust baseline range for earthworm abundance and species richness under post-arable conditions, capturing both low and high activity years.

The species richness across the whole site was relatively low as just 9 species were recorded. All of the species that were recorded are known to have a low habitat specificity and 7 of the species are regarded as widespread and either very common or common (with just a single species regarded as rare, with a known to have a preference for agricultural environments).

Furthermore, the functional group composition appeared to be greatly skewed towards shallow bioturbator species, with other functional groups under-represented or absent. Therefore, earthworm activity to undertake soil processes such as decomposition, nutrient cycling and soil pore creation may be limited and have a knock-on effect on the provision of ecosystem services such as waste recycling & detoxification, carbon & nutrient cycling and water flow regulation.

Both earthworm abundance and species richness exhibited statistically significant inter-annual variation. The highest values for both metrics were consistently recorded in 2024, with lower values in 2023 and a partial decline in 2025.

Such pronounced year-to-year variation is typical of earthworm communities and reflects the sensitivity of earthworms to environmental conditions, particularly soil moisture and temperature during the spring sampling period.

Differences in spring weather conditions provide a strong explanatory framework for the observed patterns:

- **Spring 2023** was broadly near average in terms of temperature and rainfall. These conditions are likely to have supported moderate earthworm activity but may have limited surface movement during sampling, resulting in relatively low recorded abundance and species richness (Met Office, 2023).
- **Spring 2024** followed an exceptionally wet winter and was both warmer and wetter than average. Soils are likely to have remained moist throughout the sampling period, creating highly favourable conditions for earthworm activity, feeding and surface movement. This provides a robust explanation for the markedly higher abundance and species richness recorded across the site in 2024 (Met Office, 2024).
- **Spring 2025** was characterised by warmer, drier and sunnier conditions, leading to reduced soil moisture during sampling. Under such conditions, earthworms typically retreat deeper into the soil profile, reducing detectability in shallow soil pits. This is consistent with the observed decline in abundance and species richness relative to 2024, despite ongoing land-use change (Met Office, 2025).

Overall, the results suggest that weather-driven detectability and activity effects are likely to have played a major role in shaping the observed inter-annual differences. Future monitoring should therefore focus on multi-year trends, rather than single-year comparisons, when assessing the impacts of regenerative agriculture, agroforestry and grassland restoration.

Multi-year trends can be monitored in either of the following ways:

1. By assessing a post-intervention period of 3-years following completion of an intervention and comparing the results to the baseline survey metrics (see Table 7 on the following page).
2. By assessing a site annually before, during and following an intervention. At least 3 years of annual sampling should be undertaken following an intervention to reduce the impact of inter-annual variation.

Table 7: List of baseline values based on this study for various earthworm metrics.

Earthworm metric for comparison	Baseline value
Earthworm Abundance Sapperton Wilder	27.47
Earthworm Abundance Northern Block	83.17
Earthworm Abundance Central Block	74.71
Earthworm Abundance Southern Block	59.17
Earthworm Abundance Conventional Control	56.17
Earthworm Abundance Regen Ag Control	133.33
Earthworm Richness Sapperton Wilder	2.9
Earthworm Richness Northern Block	2.8
Earthworm Richness Central Block	3.4
Earthworm Richness Southern Block	2.5
Earthworm Richness Conventional Control	2.0
Earthworm Richness Regen Ag Control	4.7

This report provides baseline values for a number of earthworm metrics that can be used to assess the site over time and measure the success (or failure) of interventions. The following three earthworm metrics could be used to monitor the impact of future interventions by repeating the soil pit survey transects:

1. **Earthworm abundance**: Counting earthworms provides earthworm abundance values that can be used as a proxy for earthworm activity. The impact of interventions on earthworm activity can be established by comparing post-intervention earthworm abundance to the baseline values provided in Table 7.
2. **Earthworm richness**: Recording the number of species present provides a species richness value that can be used to measure if soil ecosystems are increasing or decreasing in bioRichness. The impact of interventions on earthworm species richness can be established by comparing post-intervention earthworm species richness to the baseline values provided in Table 7.
3. **Functional group composition**: Optimal soil ecosystems have representation from all five earthworm functional groups, indicating that a wide range of soil processes and resulting ecosystem services are being provided by earthworm assemblages inhabiting the soil. Interventions that result in an increase in the representation of the litter dweller, deep bioturbator, burrower and/or intense tunneler groups could be considered successful with regard to improving soil processes on site.

Aside from measuring the impact of interventions, other potential activities that could improve our understanding of earthworm populations at Sapperton Wilder include:

- **Undertaking vermifuge sampling**: Soil pit sampling is known to under-represent species belonging to the burrower and intense tunneler functional groups. The addition of vermifuge sampling within soil pits may yield higher numbers of individuals from these groups and help to establish if currently undetected species from these groups are present on the site.
- **Undertaking microhabitat surveys**: Soil pit sampling is known to under-represent species belonging to the litter dweller functional group. The addition of a site-wide microhabitat survey would enable a more comprehensive earthworm species list to be generated for the site.
- **Surveying the site in autumn/winter**: Repeating the survey method in autumn/winter (ideally in November) would provide information regarding earthworm abundance, species richness and functional group composition at an alternative time of the year. This may result in the detection of new species for the site and establish if the representation of functional groups varies throughout the year.

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