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Shapes Successful Habitat
Monitoring

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for Biodiversity Monitoring
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A Decade of Monitoring
Slow Worm Populations
in Bedfordshire

The Enduring Legacy
of Mathew Frith

Habitat Monitoring

A Decade of Monitoring Translocated Slow Worm Populations in South Bedfordshire



Slow worm (*Anguis fragilis*).



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Bedfordshire,
Cambridgeshire and
Northamptonshire

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“ Slow worms are generalists that often utilise gardens and brownfield sites, making them vulnerable to development. ”

When reptiles are translocated away from a development site there are seldom resources available to monitor what becomes of them in the long term. We were given a rare opportunity to study the populations of slow worms translocated away from a new guided busway route in south Bedfordshire over 10 years to ensure they were thriving in their new surroundings.

Introduction

Slow worms (*Anguis fragilis*) are generalist in their habitat requirements, often utilising gardens and brownfield sites (Edgar *et al.* 2010, Inns 2009), making them particularly vulnerable to development. All six native British reptiles are protected from intentionally being killed or injured under the Wildlife and Countryside Act 1981, so when there are no suitable on-site solutions mitigation involves translocating them to suitable habitats close by. In this case study, 1524 slow worms were translocated away from a disused

railway line that was to become the route for the Luton and Dunstable Guided Busway and taken to three new sites. All translocations were carried out by ecological consultants working for the busway project. The mitigation included a 10-year monitoring plan, which the Wildlife Trust for Bedfordshire, Cambridgeshire and Northamptonshire (BCN) was paid to implement in exchange for using their reserve.

Translocation sites

The initial receptor site chosen was Totternhoe Nature Reserve,

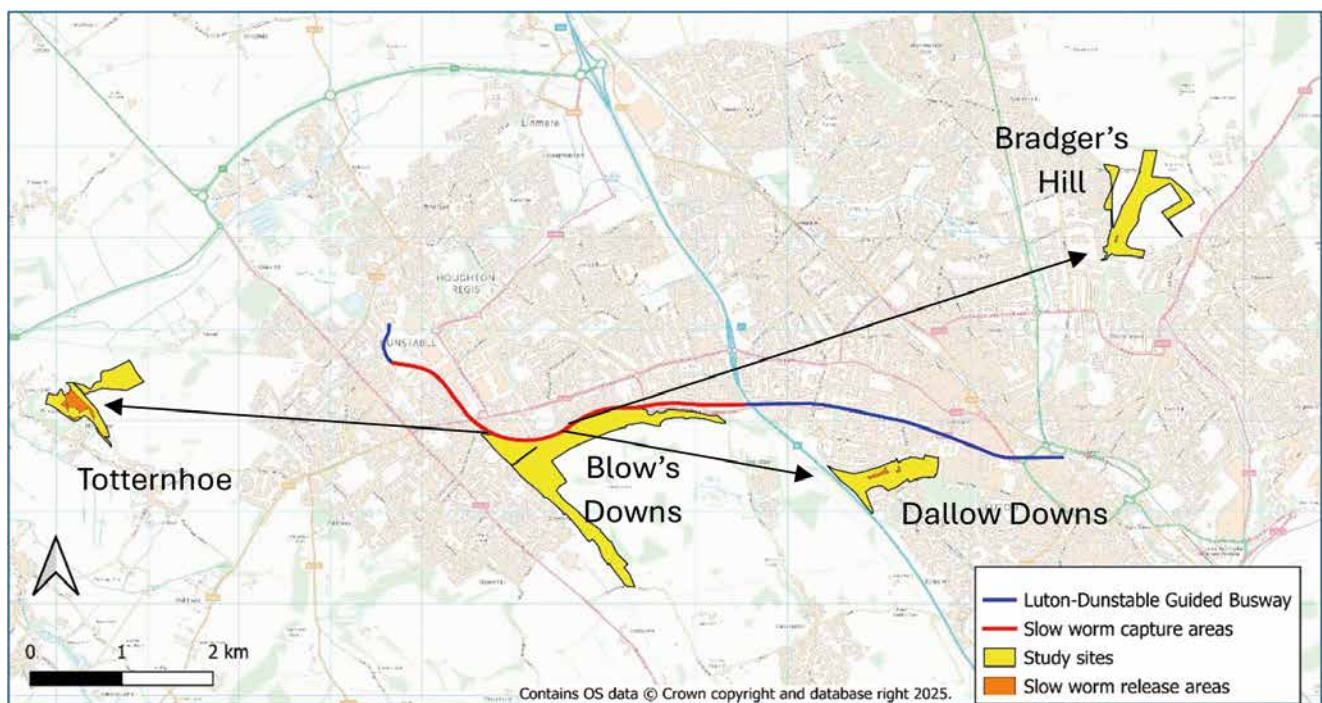


Figure 1. Map of the busway and the study sites.

approximately 5.5 km from the busway route (Figure 1). Owned and managed by the Wildlife Trust BCN, this reserve contains a mosaic, partially a Site of Special Scientific Interest (SSSI), of chalk grassland, scrub and bare chalk slopes. An area of rough grassland which had previously been quarried and then partially restored was chosen as the release area. This flat field of long grass is surrounded by chalk cliffs and rubble piles at various stages of succession. In total, 902 slow worms were translocated to the site in 2009. No reptiles had previously been recorded at the site, likely due to large-scale quarrying.

Due to an unexpectedly high number of slow worms captured, and being unable to accurately calculate the carrying capacity for Totternhoe, two wildlife sites in Luton were chosen as additional receptor sites: Dallow Downs and Bradger's Hill. Both are chalk grassland and scrub mosaics, managed by Luton Borough Council, on steep west- and north-west-facing slopes. A small population of slow worms had been recorded at the east end of Dallow Downs, whereas the western release area had been recently cleared of scrub and was previously deemed unsuitable habitat. Similarly, a small population was known at Bradger's Hill, but scrub work opened up new habitat for them. Between 2009 and 2011,

397 slow worms were moved 3 km to Dallow Downs, and 187 to Bradger's Hill (5.5 km) during 2010 and 2011.

In 2011 an additional 38 slow worms were moved to Blow's Downs, a Wildlife Trust BCN reserve adjacent to the busway containing slow worms from the same population. This area consists of SSSI chalk grassland and scrub on a steep north-facing slope, with an additional area of grassland between the SSSI and busway added to the reserve as part of the mitigation plan.

Survey methods and aims

A successful translocation is defined as the production of a viable, self-sustaining population, which has been studied for a sufficient length of time to give confidence that adequate recruitment is occurring (Germano and Bishop 2009). To assess this, we had three main objectives:

1. to confirm the continued presence of slow worms at the receptor sites, and in surrounding habitat
2. to assess the condition of the slow worms to detect problems in populations
3. to confirm that breeding was occurring at receptor sites and was sufficient to maintain the slow worm population.

Slow worms are rarely seen basking, making the use of artificial cover objects (ACOs) necessary for accurate surveying (Reading 1997, HGBI 1998). Slow worms and reptiles in general readily use cover to thermoregulate, greatly increasing the likelihood of them being found by surveyors if ACOs are employed. Recommendations for the number of ACOs varied considerably from 5 to 100 per hectare (HGBI 1998, Froglife 1999, Platenberg and Griffiths 1999). We used 22 ACOs per hectare and biased their placement towards optimal slow worm habitat including long grass at habitat edges and rubble piles.

As ACOs we used 50×50 cm squares of roofing felt rather than heavier, corrugated iron 'tins' due to access issues, and slow worms preferring them (Riddell 1996). ACOs were placed at least 10 days before the first survey, then monitored weekly for at least 8 weeks in spring (April/May) and 8 weeks in autumn (August–October) with a minimum of 6 days between visits (Reading 1997, Gent and Gibson 1998, Froglife 1999). To standardise monitoring, surveys were carried out under the following optimal conditions where possible: temperature 10–20°C, calm or light wind, no rain.

For every slow worm encountered the location, age and sex were recorded. When individuals could be safely

captured, snout–vent length (SVL) and weight were measured, and their head patterns photographed to identify individuals (Figure 2). We used weight adjusted by SVL as a proxy for slow worm condition, which we monitored over time and between sites. Data were analysed using analysis of covariance (ANCOVA). Translocated populations were monitored during the first 2 years post-translocation, then again at 5 and 11 years (the pandemic prevented surveying in 2020, the 10th year). Additional surveys were conducted on the source population at Blow’s Downs, and in intervening years at Totternhoe. Due to the staggered release over 3 years and constraints on staff time, these surveys were conducted in different years at different sites.

Results

Objective 1: confirm continued presence of slow worms at the receptor sites

Totternhoe

At Totternhoe we recorded 906 slow worm sightings between 2010 and 2021. The number of slow worms seen at Totternhoe dropped drastically after the first 2 years then appeared to stabilise from 2015, although with an increase in 2021 (Figure 3). The initial drop may have been due to high initial mortality at a new site, high levels of dispersal (especially if more were released than the area could hold), more microhabitats used as they became familiar with the new site, any combination of these or other reasons.

After 11 years, slow worms continue to be found across the release areas and into adjacent areas. There are several south-facing locations which they favour, with slight differences observed between spring and autumn, and between years.

Luton sites

At Dallow Downs we had 266 slow worm sightings between 2010 and 2022. During the surveys in 2010 and 2011 more slow worms were released on this site so the surveys were paused to prevent counting those just released; counting from 2012 onwards we had 222 records. This site suffered from many ACOs being moved by the public in spring 2012, so the surveys were



Figure 2. Left: adult female slow worm. Right: the dark head markings allow us to identify individuals. Photo credits: Gwen Hitchcock.

paused to reduce disturbance to the slow worms. Thankfully, later surveys were carried out with minimal ACO disturbance. Counts given in Figure 3 for 2011 and 2012 are from these partial surveys; full counts would have been higher, likely showing a similar trend to those from Totternhoe. Given this, a similar drop was seen at the 5-year survey in 2016. The subsequent increase in 2022 suggested that the population is stable but fluctuates.

At Bradger’s Hill no slow worms were found in 2011, but the high levels of disturbance – including the destruction of a purpose-built hibernaculum – meant surveys were halted early. In subsequent surveys there was a total of 96 slow worm records. Although there

are data from only 2 years, the numbers indicate a stable population.

At Dallow Downs and Bradger’s Hill certain areas are hotspots, with other areas getting variable use. On both sites slow worms favour the south- (Dallow Downs) or east- (Bradger’s Hill) facing scrub edges downhill, which are more sheltered and catch the morning sun.

Objective 2: assess the condition of slow worms across populations

At Totternhoe 624 slow worm captures were weighed and measured over 11 years to assess body condition. The rest either escaped or were left for welfare reasons, such as being heavily pregnant. At Dallow Downs 157 were weighed along with 64 at Bradger’s Hill. From the

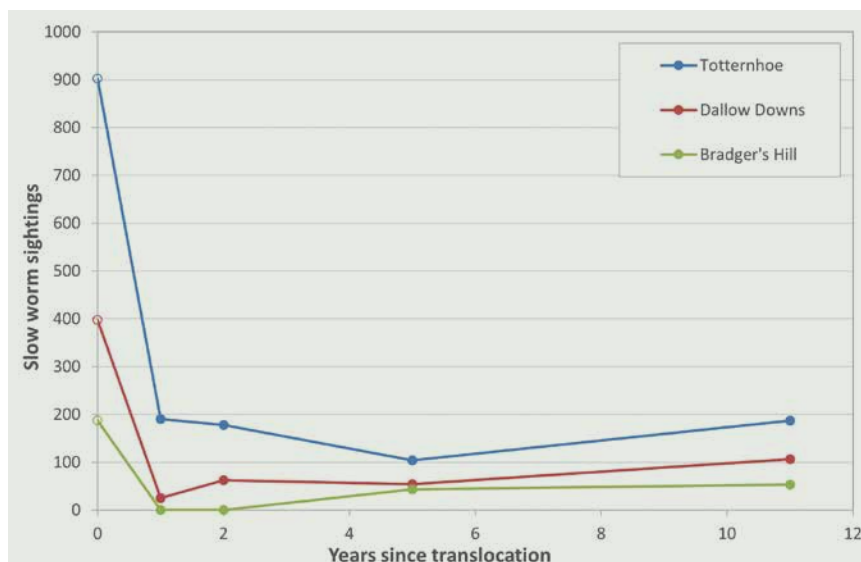


Figure 3. Slow worm numbers at receptor sites. Open circles at year 0 are translocated individuals.

source population at Blow's Downs 161 were weighed between 2010 and 2023.

During the first and fifth years there was no significant difference in body condition between the translocation sites and source population (Y1: ANCOVA $F_{(2,120)}=0.96, p=0.386$; Y5: $F_{(3,202)}=2.20, p=0.089$). During the final surveys at 11 years the slow worms at Blow's Downs were significantly heavier than their counterparts at the three translocation sites ($F(3,314)=7.13, p<0.001$; *post-hoc* Tukey test $p<0.001$). The slow worms at Blow's Downs in this year (2023) were also heavier than in previous years at Blow's Downs ($F_{(4,156)}=300.35, p<0.001$; *post-hoc* Tukey test $p<0.05$). More studies are needed at Blow's Downs to determine if condition here is improving, or if 2023 was an exceptionally good year for them.

Slow worm condition varied across the years at both Totternhoe (Figure 4; $F_{(6, 623)}=2.36, p<0.05$) and Dallow Downs ($F_{(4,156)}=300.35, p<0.001$). In both cases there was a single year when longer slow worms were comparatively lighter compared to shorter ones (*post-hoc* Tukey tests $p<0.05$). At Totternhoe this was 2015, with latter years returning to previous conditions, implying this was a natural fluctuation and that body condition remained stable. At Dallow Downs it was 2022 when none of the larger cohorts of slow worms were found, which appears to have skewed the results since the other data collected falls within the range of previous years. Follow-up surveys are required to

Table 1. Proportion of pregnant females and juvenile slow worms at Totternhoe.

	2010	2011	2015	2016	2018	2019	2021
Pregnant females (autumn only)	55.1%	3.7%	48.5%	45.5%	0%	33.3%	40.6%
First-year juveniles	28.7%	12.1%	9.5%	3.4%	0%	0%	1.6%
All juveniles	57.8%	51.3%	46.4%	40.3%	40.6%	40.5%	43.5%

determine if this was a normal fluctuation or long-term trend. At Bradger's Hill we only found slow worms in 2016 and 2022 and there was no difference in condition between the two ($F_{(1,63)}=0.52, p=0.473$). There is no published guidance on what a healthy body weight/SVL ratio should be, but ours falls within the range of other studies (Platenberg and Griffiths 1999, Giner *et al.* 2024).

Objective 3: confirm that breeding was occurring at the receptor sites sufficient to maintain the slow worm population

Breeding has been recorded at all sites with both pregnant females and juveniles being recorded regularly. Since the number of slow worms found varied, the proportions of juveniles found and females pregnant were used for analysis rather than raw counts. Slow worms take a few years to reach maturity, so the proportions of both first-year (<70 mm) and all (<130 mm) juveniles were considered, the latter smoothing out some of the inter-year variation in birth rate and survey success.

The proportion of pregnant females seen at Totternhoe has been around 40–55% in most years (Table 1). Slow worms in England are thought to breed biennially (Patterson 1983), with similar proportions of pregnant females observed in the UK and Netherlands (Patterson 1983, Stumpel 1985, Smith 1990). The first year after translocation (2010) was a particularly good year for both pregnant females and first-year juveniles with some ACOs being used by several females before and after birth. We have not observed this phenomenon in any other years or at other sites and suspect it to be an anomaly, possibly due to being in an unfamiliar environment. Although the number of pregnant females and first-year juveniles found fluctuates between years the proportion of all juveniles appears relatively stable, excluding the anomalous first year. Given the low evidence of breeding in recent years the site will continue to be monitored to ensure the population remains stable. Although numbers of pregnant females and first-year juveniles were low in 2018 and 2019, the presence of a good number of older juveniles in 2021 indicates that breeding has been taking place on site and slow worms were likely just not using ACOs during the surveys.

At Dallow Downs no pregnant females have been observed to date, but first- or second-year juveniles have been observed in 2 years (9.3% in 2012 and 9.1% in 2022). The proportion of all juveniles found (35–56%) across 5 years is in a similar range to Totternhoe, although with wider fluctuations. Pregnant females (22–50%) and first-year young (5–42%) were observed at Bradger's Hill; although observed signs of breeding were low in 2016, they were higher in 2022, and the proportion of the population which were juveniles (35–39%) is comparable to the lower

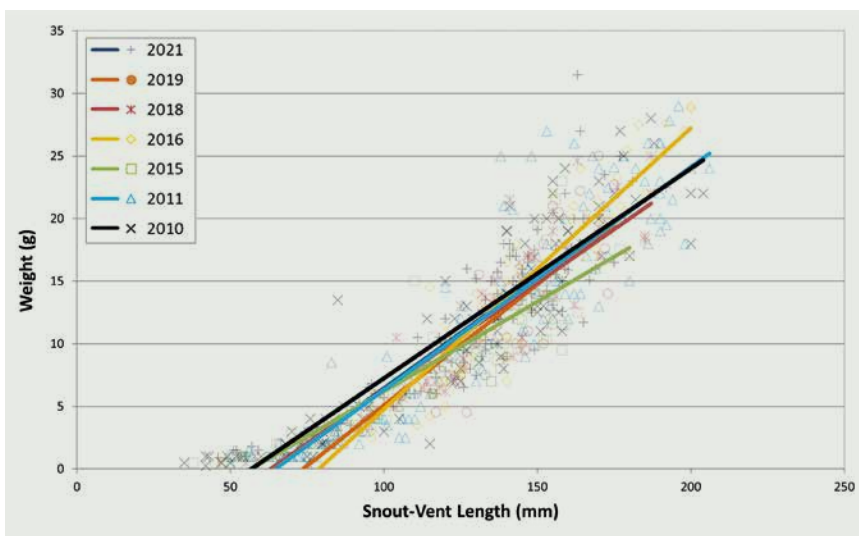


Figure 4. Condition of slow worms across the years at Totternhoe showing that body condition remains stable, with yearly fluctuations.

range found at Dallow Downs. At Blow's Downs the proportion of all juveniles was within a similar range (38–49%) while the proportion of pregnant females remained low (7–18%).

The high fluctuations recorded may be natural variation between sites and years; since no significant downwards trend was noted, the populations appear to be stable. Previous studies (Platenberg and Griffiths 1999, Hubble and Hurst 2006) have found similar proportions of juveniles and with similarly high fluctuations between years.

Limitations

A major limitation was the lack of time to carry out a full survey at the receptor sites prior to translocation. However all the sites are well visited by naturalists, and the local environmental records centre was consulted. This, coupled with major quarrying until 1962, made it unlikely that any slow worms were present at Totternhoe. In contrast the Luton sites were both known to host small populations and recent scrub clearance greatly increased the areas available to them. At Dallow Downs the distance and habitats between the existing population and release area make it likely that most slow worms found were from the translocated population. Slow worms are sedentary creatures and tend not to move long distances (Stumpel 1985, Smith 1990); of our repeat sightings 68% were under the same ACO, and of those that had moved the median distance was only 21 m. At Bradger's Hill it is likely the translocated and resident populations mixed, making these results less conclusive.

We attempted to use the population of slow worms at the far end of Dallow Downs as a control population, but numbers found were too low for meaningful comparisons. The decision was made to focus on changes within the translocated populations, and the source population.

A general limitation of slow worm studies is that only a small proportion of the population is found each year; their fossorial lifestyle means they are not reliably seen even when sufficient refuges are used on a site (Baker *et al.* 2004). Our studies also show that not all classes of a population are found

every year, this coupled with yearly variations in weather make long-term studies particularly important.

Conclusions

Slow worm populations are still present at all three receptor sites 11 years later, and average body condition has remained stable. Yearly fluctuations in numbers and condition occur, but this is perhaps not unexpected for a reclusive ectotherm. Evidence of reproduction also varies greatly between years, yet the number of slow worms found and proportion of juveniles within the population shows no sign of declining, implying breeding is occurring at a level sufficient to maintain the populations. The persistence of these populations is due to the sensitive ongoing management to ensure suitable habitats. Other monitoring work indicates slow worms are expanding beyond the release areas in the new sites. These results show that the translocations were successful, not just in the short term but for the long-term establishment of new slow worm populations. It may be extrapolated that where suitable habitat and management occur that other translocated populations would also thrive, although it would be beneficial for more long-term studies to be carried out to confirm this.

Further investigations

The movement of individual slow worms has been explored using repeat sightings, and we are working with a student on further analysis of existing data. Future monitoring of these populations will be carried out to ensure their ongoing survival. We hope this study will promote others to conduct long-term studies of translocated populations, which could feed into a larger analysis over conditions where they succeed or fail.

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References

- Baker, J., Suckling, J. and Carey, R. (2004). Status of the adder *Vipera berus* and slow-worm *Anguis fragilis* in England. English Nature Research Report ENRR546. Available at: <https://publications.naturalengland.org.uk/publication/142003?category=47017>. Accessed 14 January 2026.
- Edgar, P., Foster, J. and Baker, J. (2010). *Reptile Habitat Management Handbook*. Amphibian and Reptile Conservation, Bournemouth.
- Froglife (1999). *Reptile Survey: An Introduction to Planning, Conducting and Interpreting Surveys for Snake and Lizard Conservation*. Froglife Advice Sheet 10. Froglife, Halesworth.
- Gent, T. and Gibson, S. (1998) *Herpetofauna Workers' Manual*. Joint Nature Conservation Committee, Peterborough.
- Germano, J.M. and Bishop, P.J. (2009). Suitability of amphibians and reptiles for translocation. *Conservation Biology*, **23**: 7–15.
- Giner, G., Montori, A. and Franch, M. (2024). Phenological, ecological, and demographic data of the slow worm (*Anguis fragilis*) population from southern Catalonia (Spain). *Herpetozoa*, **37**: 269–280.
- HGBI (Herpetofauna Groups of Britain and Ireland) (1998). *Evaluating Local Mitigation/Translocation Programmes: Maintaining Best Practice and Lawful Standards*. HGBI Advisory Note for Amphibian and Reptile Groups (ARGs). Herpetofauna Groups of Britain and Ireland.
- Hubble, D.S. and Hurst, D.T. (2006). Population structure and translocation of the slow-worm, *Anguis fragilis* L. *Herpetological Bulletin*, **97**: 8–13.
- Inns, H. (2009). *Britain's Reptiles and Amphibians*. WILDGuides Ltd, Old Basing.
- Patterson, J.W. (1983). Frequency of reproduction, clutch size and reproductive effort in the lizard *Anguis fragilis*. *Amphibia-Reptilia*, **4**: 195–203.
- Platenberg, R.J. and Griffiths, R.A. (1999). Translocation of slow-worms (*Anguis fragilis*) as a mitigation strategy: a case study from south-east England. *Biological Conservation*, **90**: 125–132.
- Reading, C.J. (1997). A proposed standard method for surveying reptiles on dry lowland heath. *Journal of Applied Ecology*, **34**: 1057–1069.
- Riddell, A. (1995). Monitoring slow worms and common lizards, with special reference to refugia materials, refugia occupancy and individual identification. In: Foster, J. and Gent, T. (eds), *Reptile Survey Methods*. English Nature Science Series no. 27. English Nature, Peterborough, pp. 46–60.
- Smith, N. (1990). The ecology of the slow-worm (*Anguis fragilis* L.) in southern England. PhD thesis. University of Southampton, Southampton.
- Stumpel, A.H.P. (1985). Biometrical and ecological data from a Netherlands population of *Anguis fragilis* (Reptilia, Sauria, Anguillidae). *Amphibia-Reptilia*, **6**: 181–194.

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