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Harnessing practitioner knowledge to inform the conservation of a protected species, the hazel dormouse *Muscardinus avellanarius*

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Abstract

1. Conservation decisions are typically constrained by the availability of published evidence. Practitioners and non-academic experts often possess additional knowledge, including about the practical plausibility of conservation actions, which may lead to more effective planning and outcomes. However, practitioner knowledge is rarely considered during formal evidence syntheses.

2. Alongside a formal literature review, we conducted 26 interviews involving 38 conservation professionals to elicit their knowledge of the conservation of a protected and declining species in England, the hazel dormouse *Muscardinus avellanarius*.

3. Practitioners and non-academic experts provided additional insights about dormouse ecology and conservation, beyond those synthesized from the published literature, though we found few contradictions between these different information sources. Instead, practitioner knowledge helped to verify, clarify and expand upon evidence from empirical studies. In general, practitioners emphasized that dormice are far more adaptable than traditionally perceived, with thriving populations found in hedgerows, scrub, road verges and railway verges, rather than solely within broadleaf woodlands.

4. Proposed opportunities for restoring dormouse populations included improving hedgerow management, creating new woodlands, bringing existing woodlands back into management, setting aside unproductive land and improving habitat connectivity. However, participants emphasized the need for landscape-scale approaches, accounting for the impacts of climate change, and better surveying and monitoring. Key practical considerations included overcoming time and financial constraints, providing better advice, knowledge and training, changing attitudes of land owners and managers and balancing other demands such as agricultural productivity and the requirements of other species.

5. Despite the insights they provided, participants highlighted many remaining knowledge gaps. These included uncertainties arising from the published literature, as

well as scarcely studied topics that are of major practical importance, namely the effectiveness of dormouse mitigation measures in planning and development, and the impacts of anthropogenic disturbance and pollution on dormice.

6. Our findings improve the evidence base for restoring hazel dormouse populations and for further empirical evidence gathering. More generally, the study highlights how practitioner knowledge can help both to supplement traditional published evidence and to better frame conservation programmes, which may lead to more successful outcomes.

1 | INTRODUCTION

Conservation decisions should be based on evidence, ideally from formal and robust syntheses. Unfortunately, however, published literature is almost always limited in extent, scope, quality and/or relevance (Christie et al., 2020, 2021). Sometimes this reflects a genuine lack of knowledge. However, there is often a wealth of additional information held by non-academic experts and practitioners. We refer to this as 'practitioner knowledge'. Practitioner knowledge is typically neglected from evidence syntheses, in part because it is more difficult to access than carrying out simple database searches, but also because it is not clear how such knowledge should be verified and integrated alongside more formally established scientific evidence.

Practitioners possess a variety of knowledges beyond those recorded in published sources. Explicit knowledge might include internal reports that are not publicly available. Implicit knowledge includes insights from practical experience, which are not formally documented. Tacit knowledge is similar but consists of more intuitive and harder-to-define 'know-how' (Hulme, 2014). The level of agreement between practitioner knowledge and data from traditional scientific methods can be favourable (Cook et al., 2014), though has rarely been assessed, and is not always comparable. There is growing recognition of the value of practitioner knowledge, as well as local knowledges (Hernández-Morcillo et al., 2014; Joa et al., 2018), and of the need to incorporate these into evidence-based decision-making (Christie et al., 2022; Persson et al., 2018). Doing so may result in more successful conservation outcomes, especially because practitioner knowledge can account for practical considerations, including feasibility, acceptability, costs, values and local context, which are generally not well documented within the conservation evidence literature (Christie et al., 2020, 2022).

In this study, we use research interviews to gather and evaluate practitioner knowledge for supplementing scientific evidence from a formal literature review. We focus on the conservation of a protected species in England, the hazel dormouse *Muscardinus avellanarius*. The hazel dormouse is a mainly nocturnal, arboreal small rodent that occurs across much of Central and Western Europe. It is generally associated with heterogeneous mid-successional stages of broadleaved woodland (Goodwin, Hodgson, et al., 2018; Goodwin, Suggitt, et al., 2018; Sozio et al., 2016), and uses a variety of food sources, including flowers, buds, seeds, fruits and invertebrates, which provide continuity throughout the year (Goodwin et al., 2020; Juškaitis, 2007a). Dormice build summer nests in existing cavities such as tree hollows and nest boxes, though will also weave their own nests, including within hedgerows and scrub (Bright et al., 2006; Wolton, 2009). In winter, dormice hibernate at ground level within a specially woven nest (Gubert et al., 2022). There is high mortality during this period, often with more than half of individuals perishing (Csorba, 2003; Juškaitis, 1999, 2003).

Dormouse populations are experiencing chronic, ongoing declines in England. Nestbox monitoring data indicate a 72% decline (95% confidence interval: 62%–79%) in dormouse counts over the 22 years from 1993 to 2014 (Goodwin et al., 2017). Potential causes include habitat loss, reductions in traditional woodland management practices such as coppicing, habitat fragmentation (including due to the historic and ongoing loss and degradation of hedgerows) and impacts of climate change (Goodwin, Suggitt, et al., 2018). These declines have occurred despite a suite of species protection measures. The hazel dormouse is a European Protected Species and is listed under Annex IV of the European Commission Habitats Directive (1992). At a national scale, hazel dormice are also protected under U.K. law by the Conservation of Habitats and Species Regulations (2017), which make it an offence to deliberately disturb, capture, injure or kill them, and by the Wildlife and Countryside Act (1981). In practice, these regulations require that protected species are considered during planning, development and other land management. Nonetheless, legal measures have been unsuccessful in reversing, or even halting, dormouse population declines.

The Environment Act 2021 provides a mechanism for developing 'Species Conservation Strategies'. These seek to identify what needs to be done, at a landscape scale, to restore populations, and are driven by a statutory obligation to maintain a 'Favourable Conservation Status' for the species (Mousley & van Vliet, 2021). For dormice, Favourable

Conservation Status in England is currently defined in terms of natural range and distribution, population of the species and the extent and quality of habitat necessary for the long-term maintenance of populations (Morris, 2021). These Species Conservation Strategies could be used, for example, to allow mitigation and compensatory measures to focus on what is best in the wider landscape, rather than necessarily providing localized protection.

As part of a project to build an evidence base for a Species Conservation Strategy that could underpin a programme to restore the hazel dormouse to Favourable Conservation Status in England, we initially conducted a formal review of the international scientific and 'grey' literature. This identified and critically appraised evidence for the effectiveness of different management actions for benefiting hazel dormouse populations (Bell et al., in prep). Our review identified numerous published works relating to woodland and forest management (demonstrating various benefits of maintaining early-mid successional habitat stages, e.g. Bright & Morris, 1990; Capizzi et al., 2002; Goodwin, Suggitt, et al., 2018; Juškaitis, 2020; Sozio et al., 2016), and the provision of nest boxes (demonstrating associated increases in dormouse density, e.g. Juškaitis, 2005, 2006; Morris et al., 1990), and some investigations into the use and management of hedgerows (suggesting that dormice are more likely to be found in wider, denser, less intensively managed hedgerows, e.g. Bright & MacPherson, 2002; Ehlers, 2012). The literature was otherwise limited. Research into most other topics was scarce, limited in scope or provided only weak evidence. Much of the reviewed research was from Central and Eastern Europe, so may also have less relevance to England, where the species is at the edge of its range. Given these limitations, there was a need to seek out additional evidence, as well as to understand the practical opportunities and constraints for implementing management interventions for dormice.

We gathered and analysed practitioner knowledge, with a view to informing the conservation of a protected species in England, the hazel dormouse. This served to provide a broad initial overview of the problems facing dormouse conservation, and potential solutions, upon which to guide future efforts and research investments. The aims of this study were (1) to build upon the scientific evidence regarding dormouse ecology and conservation, (2) to identify practical opportunities and constraints for restoring dormouse populations and (3) to identify remaining knowledge gaps. We adopted a qualitative approach and conducted semi-structured interviews with non-academic experts and practitioners. We had an a priori expectation that these stakeholder groups held considerable additional knowledge, beyond that which is available within the published literature, due to the amount of survey and conservation effort to which dormice are subject, resulting from their legal protections. We describe the findings within the context of the scientific literature, highlighting the additional insights provided by practitioner knowledge.

Although we focus on a single species, the approach and many of the findings have broad applicability to the conservation of protected species. The study also provides general insights into nature conservation approaches in the United Kingdom, with perspectives on the management of key habitats such as woodlands, hedgerows and scrub, and on underpinning mechanisms, namely planning and development, agri-environment and climate change mitigation schemes.

2 | MATERIALS AND METHODS

We conducted semi-structured interviews (Young et al., 2018) with practitioners and non-academic experts to elicit their views of dormouse ecology and conservation, and to identify associated practical opportunities and constraints. We considered semi-structured interviews to be the most appropriate method due to the broad scope of the topics that we aimed to cover, and their possibility of raising new insights from more open questioning. Although we considered using formal consensus methods (e.g. the IDEA protocol), which are well established in conservation (Hemming et al., 2018), such methods favour questions with answers that are readily summarized, such as quantitative values, rather than the more open aspect of our study. Ethical approval for the study was provided by the University of Exeter's College of Life and Environmental Sciences Cornwall Ethics Committee on 5 November 2021.

Interviews focused on two counties in South West England—Devon and Dorset—which were the focus of the Species Conservation Strategy project. These regions are considered to be strongholds for dormice in Great Britain (Bright et al., 2006). We identified stakeholder groups with direct and indirect interests in hazel dormouse conservation. These were local authorities, government bodies, conservation organizations, ecological consultants, infrastructure organizations and private landowners. From these, we identified key informants, who were specific individuals and organizations within each stakeholder group. Participants were recruited by email via existing contacts. In a few cases, we contacted generic email addresses.

We successfully recruited 38 participants (Table 1). In all but one case, participants were conservation professionals. The exception was an amateur naturalist and active member of a local mammal group. Participants were classified as dormouse experts and/or practitioners. We made this distinction to ensure that participants were asked questions that were appropriate to their experience. Dormouse experts were those who were knowledgeable about dormice. For simplicity, we use the term 'expert', though some participants did not identify themselves as such. Many of these were ecologists or ecological consultants with a lot of experience of surveying for dormice, that is dormouse surveys and ecology formed a major component of their work. 'Practitioners' were land managers and associated advisers, including ecological consultants. Most dormouse experts were also practitioners (14 of 18), but only around half of practitioners were classed as dormouse experts (14 of 34). At least six dormouse experts had published peer-reviewed papers on dormice.

We developed an interview schedule consisting of three sections: (1) Dormouse conservation status and targets for recovery; (2) Effective management for restoring dormouse populations and (3) Practical opportunities and constraints for restoring dormouse populations. Sections 1 and 2 were targeted at dormouse experts. Section 3 was targeted at practitioners. Interviews were semi-structured and were

TABLE 1 Details of the 38 stakeholders that were involved in the 26 interviews (18 individual and eight group interviews) about dormouse conservation

Stakeholder type	Number of participants	Of which were interviewed as…	
		Dormouse experts	Practitioners
Local authorities	4	0	4
Government bodies	9	4	8
Conservation organizations	7	4	4
Ecological consultants	9	9	9
Infrastructure organizations	5	1	5
Other land owners/ managers	4	0	4
Total	38	18	34

Note: Dormouse experts were typically ecologists or ecological consultants with dormice forming a major component of their work. 'Practitioners' were land managers and associated advisers, including ecological consultants. Most dormouse experts were also practitioners, but only around half of practitioners were classed as dormouse experts.

adapted to focus on the remit, experience and interests of the participant. Questions were qualitative, except for Section 2 Q2.3 (see Appendix S1). This asked dormouse experts to score (from 1 = *very low* to 5 = *very high*) how effective they perceived each of 20 different conservation measures to be for restoring hazel dormouse populations, and their associated confidence in each case. We carried out two pilot interviews to test the interview schedule, then made minor changes to improve the flow and comprehension of the questions, and to reduce the overall length. The final interview schedule is provided in Appendix S1.

A total of 26 interviews (18 individual and eight group interviews, involving a total of 38 participants) were undertaken by a single interviewer (BP) between 19 November 2021 and 17 January 2022. All participants provided informed consent. Interviews were carried out over online video calls and typically lasted for around 1 h. Interviews were recorded, transcribed verbatim, then qualitatively analysed in NVivo (Release 1.2) by a single coder, who was also the interviewer (BP). Responses were coded through an inductive process of close reading, labelling responses in relation to thematic categories, and then refining the groupings. Initial codes were based around the broad topics covered by the interview questions. These included dormouse ecology, dormouse population status and trends, restoring dormouse populations (with subcodes for topics relating to hedgerows, woodlands, scrub and connectivity), knowledge gaps and various practical opportunities, constraints and considerations. Emergent ideas and themes within each topic were then coded in greater detail. The findings are reported using a narrative summary, and are set within the context of the scientific literature to highlight the additional insights that were provided by practitioner knowledge.

3 | RESULTS AND DISCUSSION

We summarize practitioner perspectives around the following topics, which broadly reflect the interview structure: (1) Dormouse ecology; (2) Conservation measures for restoring dormouse populations; (3) Practical opportunities, constraints and considerations and (4) Remaining knowledge gaps.

3.1 | Hazel dormouse ecology

Dormice have primarily been characterized as a conservative woodland species (Bright et al., 2006). However, there is a growing body of published evidence suggesting that scrub habitats are also important (e.g. Berg & Berg, 1998, 1999; Dondina et al., 2016; Ehlers, 2012; Goodwin, Hodgson, et al., 2018; Wolton, 2009). Many participants echoed this change from what they described as a traditional view, or received wisdom, and instead argued that dormice are more accurately described as a woodland edge or scrub species:

> '*I do think we see them as a forest species but actually they're much more of an edge habitat species. So we detect them in a forest, but actually where they thrive is on the ride edges and the edges where you get light getting into the canopy and that's why they thrive in scrub and to some extent in hedgerows as well, where they're not massively managed*'. Dormouse Expert at a conservation charity

Some practitioners also emphasized that dormice are more adaptable than widely perceived, in terms of the habitats, nest sites and food and nesting resources they will use:

> '*They're extremely adaptable. They will eat different things. They will nest in different places, so they are adapting. They will make use of whatever they can before they get into trouble. So I think they're quite resourceful, and in that respect I think they've been able to maximize their opportunities in these counties… People are finding them nesting in really strange garden plants and kind of exotic species*'. Ecologist and Dormouse Expert

Participants described finding dormice in heathland, culm grassland, gardens, central reservations of highways, coastal areas, including those prone to flooding, and in nest tubes attached only to wire fencing. Dormice were also reported to have been found in closely flailed hedgerows, in apparently poor-quality woodlands and road verges, and in small, isolated pockets of high-quality habitats:

> '*I think… the traditional perceived wisdom is changing. So we do quite a lot of work in South Wales and there was a perceived wisdom ten years ago or so that you didn't really get dormice on the levels… We're finding them everywhere, all over the Gwent levels… The perceived wisdom was that*

they weren't necessarily in those habitats and… road verges with bits of rough scrub and really flailed hedgerows that ten years ago, you might have thought no, there's not going to be dormice in those, they're turning up in those places. I'm not suggesting they've just colonized them. It's probably a case that we didn't know they were there'. Ecological Consultant

As a result, one dormouse expert emphasized the importance of not automatically discounting any site from having dormice. Some similar examples are provided in the scientific literature (e.g. Büchner, 2008; Chanin & Gubert, 2012; Juškaitis, 2007b) and grey literature reports (Chanin & Woods, 2003), though, in general, this flexibility in habitat use remains poorly acknowledged. However, the fact that participants raised these examples as noteworthy suggests that they are probably not typical of dormouse habitat preferences. Participants were generally unclear about if and when such non-classical habitats were able to support viable long-term populations, rather than dormice temporarily moving into or through them from elsewhere.

Three characteristics of favourable habitats were repeatedly highlighted as being important, and are well supported by the scientific literature (Capizzi et al., 2002; Dondina et al., 2016; Goodwin, Suggitt, et al., 2018; Sozio et al., 2016). These were (i) a dense three-dimensional habitat structure to facilitate movement, and to provide food, nest sites and protection from predators, (ii) a diversity of plant species and habitats to provide nesting materials and continuity of food resources throughout the year and (iii) connectivity both within and between habitats.

3.2 | Movement and dispersal

Much of the scientific literature claims that dormice are almost entirely arboreal and averse to crossing open ground. This assertion is largely based on early radio tracking studies (e.g. Bright, 1998; Bright & Morris, 1991, 1992). For example, one study found that dormice never crossed a 6-m hedgerow gap (Bright, 1998). One participant questioned whether this is realistic because the study used translocated individuals which are likely to have been *'frightened'*. More generally, many participants highlighted their experience that the movement and dispersal capabilities of dormice are probably much greater than widely perceived. It was reported that dormice are frequently found in isolated habitat patches, and will cross woodland rides, gaps in hedgerows (e.g. gateways) and roads, which has also been reported in the scientific literature (Chanin & Gubert, 2012; Kelm et al., 2015).

Nonetheless, connectivity was universally mentioned as being critical for dormice. Open areas were considered to at least discourage movement, and perhaps to be absolute barriers in some cases. For example, regarding dual carriageway roads without a central reservation, one dormouse expert said *'I think the jury is out. I don't believe dormice are isolated by them, but they probably don't move as freely across them'.* Another participant highlighted that we probably still underestimate dormouse dispersal ability:

> *'I'm always concerned whenever the habitat preferences of settled individuals, who have an established home range, get extrapolated to the habitat preferences of dispersing individuals… dispersed individuals have much lower habitat specificity and they're much more likely to go through habitat that might not feed them for the day, or whatever. They're driven by this urge to go and find a new home'.* Conservation professional at a charity

This is supported by evidence finding juvenile dormice dispersing up to 1200 m (Juškaitis, 1997), and crossing distances of 500 m across open ground to reach nearby woodlands (Büchner, 1997, 2008). Such events may be ecologically significant, but difficult to capture using short-lived and intensive field studies due to their rarity. Ecological consultants on the other hand, who collectively survey dormice far more extensively than is carried out for most published scientific studies, may have greater awareness of such rare events.

3.3 | Nesting and hibernation

Dormice are known to create summer nests in a variety of locations, including in natural cavities, and woven nests in hedgerows and scrub (Bright et al., 2006; Juškaitis & Remeisis, 2007; Wolton, 2009). However, one participant suggested that dormice tend to be outcompeted for natural cavities in mature trees by nesting birds. This was also found in a non-peer-reviewed study from southern England (Grogan, 2004). In terms of hibernation, it was stated that dormice choose to nest on the floor in the open, and may even move outside of a woodland or hedgerow to do so. This was suggested as being far more typical than in log piles, or in the roots of old coppice stools, or at the base of hedgerows, as has been claimed in some conservation documents (e.g. Bright et al., 2006):

> *'I haven't heard it for a while, but… at least two ecological consultants who have been looking for hibernation nests at the base of a hedgerow… recorded dormice that were five, ten feet out into the field'.* Dormouse Expert at a conservation charity

Participants mentioned the importance of plant diversity for providing suitable nest materials. Research in southern England, however, found that dormice typically use an average of just two materials to create a hibernation nest (Gubert et al., 2022), and three to four materials to create a summer nest (Bracewell & Downs, 2017). These materials were predominantly hazel leaves and honeysuckle bark for summer nests, and bracken, other ferns, grasses and leaves of oak and hazel for hibernation nests.

3.4 | Conservation measures for restoring dormouse populations

When participants were asked what they thought needed to be done to restore dormouse populations, the most frequently mentioned
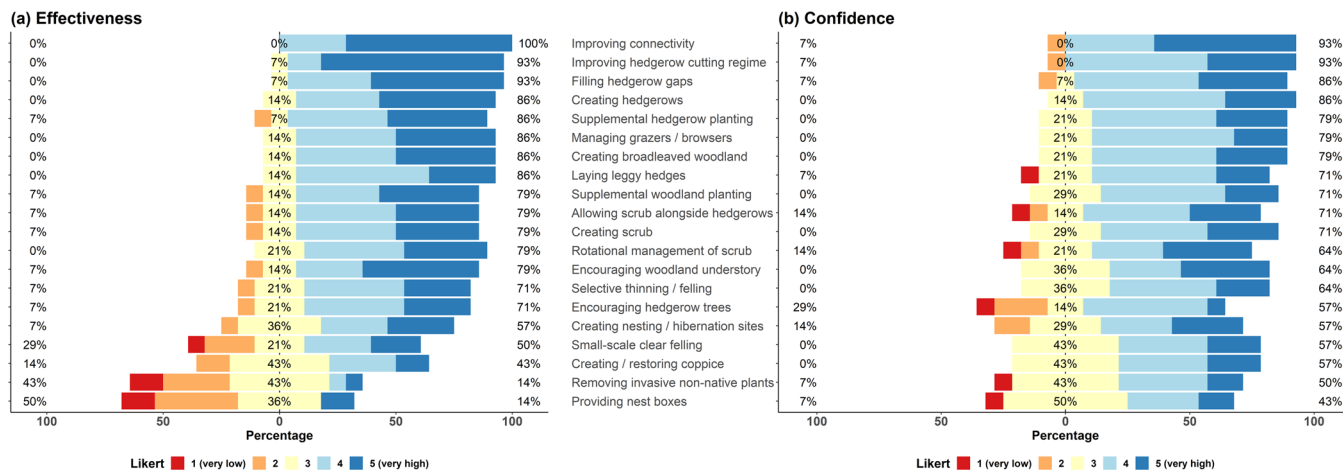
FIGURE 1 Summary results of a survey of practitioner knowledge, asking non-academic dormouse experts (*n* = 14) about (a) how effective they perceived different management actions to be for restoring hazel dormouse populations, and (b) how confident they were about that assertion in each case. Management actions are paraphrased for clarity (see Appendix S1 for full descriptions).

opportunities were (i) improving hedgerow management, (ii) creating new woodlands, (iii) bringing existing woodlands back into management, (iv) setting aside unproductive land, and (v) improving habitat connectivity. These interventions were perceived as being effective, if conducted at sufficient scale, and plausible, if sufficient mechanisms were put in place.

After initial discussion of their ideas, we presented a list of management actions to dormouse experts (Appendix S1). This was an abridged version of interventions that had been synthesized from our review of the published literature. Experts were asked to score management actions in terms of their effectiveness for restoring dormouse populations, and their associated confidence in each assertion. Many participants understandably described the exercise as being too simplistic because the answers are context dependent. Nonetheless, most management actions were perceived as being at least somewhat effective for restoring dormouse populations (Figure 1a), with 15 of the 20 actions perceived as being highly effective by at least 70% of respondents. Respondents were generally confident in these assertions, though were less confident about management actions that they perceived to be less beneficial (Figure 1b). These are described under the corresponding sections below.

3.4.1 | Woodland creation

Woodland creation was frequently mentioned with regard to national tree planting ambitions. These aim to increase woodland cover in England from 10% to 12% by 2060, which involves planting trees on 180,000 ha by 2042 (Defra, 2018). Some participants highlighted similar ambitions within their organizations. For example, the National Trust has a target of establishing 20 million trees by 2030, which will create 18,000 ha of new woodland (National Trust, 2020). Most woodland creation in England is currently focusing on broadleaves (~90%) rather than coniferous or commercial forestry, and this has mostly

occurred on private land (>95%) (Forest Research, 2022). However, an advisor from a large private estate reported that their woodland creation is focused on conifers, with perhaps 25% broadleaf cover, due to the risks of high losses of broadleaf plantings resulting from ring barking and bark stripping by non-native invasive grey squirrels *Sciurus carolinensis*.

While we found no published evidence explicitly assessing the colonization and use of newly created woodlands by dormice, participants suggested that woodland creation will inevitably be beneficial, particularly whilst these woodlands have a young age structure. However, it was emphasized that woodland creation needs to be about '*the right tree in the right place for the right reason*'. For example, the quality of these woodlands for dormice will depend to a large degree on the approaches used to create them, including the species mix, as well as if, and how, they are ultimately managed. Although regrowing forest has been shown to be a preferred habitat for dormice (e.g. Sozio et al., 2016), woodland creation in England is often carried out in non-wooded areas (e.g. pastoral fields). It is unclear to what extent these new woodlands will become naturally colonized by dormice, or the plant species on which they rely, compared to within (or next to) established woodlands.

Natural regeneration of scrub, and subsequently woodland, was described as producing good-quality dormouse habitat in the early stages of succession, and as much easier and cost-effective than tree planting. However, it was acknowledged that '*if you're wanting a relatively quick result, for whatever reason, it's not going to be the way to go*'. Despite tree-planting ambitions providing a major lever for habitat creation, participants recognized obstacles to achieving these targets. Finding locations to plant trees was highlighted as a prominent challenge, as well as the time and costs involved in acquiring and planting trees:

> '*We just want to get trees in the ground, and it's so difficult. Whether they are trees or shrubs, or whatever—good for dormice—the whole system has just gone to sleep over*

the last 30 or 40 years. It's difficult now to wake it up, get the trees and shrubs from nurseries into the ground with some grant aid, despite all the targets and issues that we're aware of about biodiversity and climate change—it's just very, very time consuming and expensive to do that'. Environmental Adviser for a large private landowner

3.4.2 | Woodland management

Participants stressed that most woodlands are not currently managed due to insufficient incentives. Many of these are small, privately owned fragments of woodland located on slopes or in other inaccessible or unproductive areas. Woodland management was therefore highlighted as posing a significant opportunity to benefit dormice, if adequate funding and incentives were put in place. Respondents agreed that the main aim of woodland management should be to create and maintain diversity, '*getting more woodland in at the younger stages, more understory, opening up woodlands, and in that way diversifying structure'.* This was suggested to be important for providing dormice with opportunities for feeding and nesting, and, as described previously, is strongly supported by scientific studies. Suggested methods for encouraging diversity were based around maintaining an open canopy, for example maintaining rides and glades, coppicing and selective thinning, as well as managing in rotation and controlling the impacts of deer.

Perhaps surprisingly, there were more mixed perceptions of both coppicing and small-scale clear felling, which are some of the few management interventions that were reasonably well supported in our review of the scientific literature. Coppicing was frequently mentioned as being beneficial for dormice, though was perceived less favourably than most of the other proposed woodland management actions (Figure 1). Some participants highlighted possible short-term negative impacts of both coppicing and small-scale clear felling on dormice (Figure 1). Scientific studies suggest that both are indeed detrimental in years immediately following implementation, but are subsequently beneficial, before eventually becoming less suitable when they reach old-stage coppice or high forest (Bright & Morris, 1990; Capizzi et al., 2002; Goodwin, Hodgson, et al., 2018; Juškaitis, 2020; Sozio et al., 2016).

Two practitioners separately highlighted, one from personal experience, that coppicing can be detrimental when deer pressure is high because regrowth is browsed. Impacts of deer on dormice were regularly mentioned by participants, not just in relation to coppicing. We found no published empirical studies on this topic, though studies have found fewer dormice in woodlands that are grazed by cattle (Capizzi et al., 2002), or which contain feral boar (Rozycka et al., 2015). Many participants described challenges due to deer browsing the understory layer and planted saplings. However, it was also recognized that deer pressure is highly variable across the United Kingdom, and one ecologist suggested that low densities of deer might be more beneficial to the woodland understory than their total absence.

Removing non-native invasive plants was perceived as being relatively less beneficial because some are known to be used by dormice.

This insight is not well covered in the scientific literature. For example, multiple participants reported that *Rhododendron ponticum* is used as a food source, and provides an understory layer, so can be beneficial at low densities, particularly because it is shade tolerant:

'*So of course Rhododendron itself has big juicy flowers, there are nectar and insects and so on, so you can understand why the dormice would like it. It also provides quite good cover and I think it probably provides opportunities for nesting. However, of course, what we then wanted to do was to improve the habitat for dormice, so we got rid of the rhododendrons and planted stuff underneath it—hazels for example, shrubby things—and they wouldn't grow because there was too much shade from the canopy. But we couldn't cut down the trees because the estate wanted them to grow up, so they could harvest them'.* Dormouse Expert

Finally, despite a consensus that many woodlands would benefit from more management, one dormouse expert suggested that this is not always the case:

'*I think sometimes we over-manage things, so we just need to kind of step back once we are happy with what's happening to a site. If you go to a site, you go into woods and you see fantastic bryophytes, woodland floors, their diverse, structured canopy. There is nothing to do. Walk away because I think one of the issues is we've been over-managing these sites. And where we are at the moment is the lowest point in biodiversity in history. So whatever we do, we need to be considerate of that. Maybe it's time to stop doing what we're doing and just kind of think and just be specific about management and when it's needed and with what intensity'.* Ecologist and Dormouse Expert

3.4.3 | Commercial forestry

Dormice are often found living in and around coniferous plantations. For example, 36% of known dormouse sites in Wales were in the deciduous margins of conifer plantations (Bright, 1995). Several participants similarly emphasized that coniferous woodlands can provide suitable habitat for dormice, particularly during the early stages of growth if scrub is allowed to persist. One dormouse expert suggested that '*undoubtedly dormice do use conifers but the densities, we're fairly confident, are pretty low'.*

There is little published empirical evidence about the impacts of different commercial forestry practices on dormice. Nonetheless, participants, including those involved in forestry, held much knowledge about perceived best practices, which are also documented in various guidance (e.g. see Bright et al., 2006). Participants from government forestry organizations explained that they follow best practice guidance, the U.K. Forestry Standard, and have a biodiversity plan, all of which act as levers for managing public forests in ways that are

likely to benefit dormice. Proposed approaches for improving commercial plantations for dormice included incorporating permanent broadleaf cover, for example a border around the edge of each plantation block, harvesting in winter ahead of hibernation, using a mix of commercial species and having areas of continuous cover forestry. Multiple participants also mentioned the benefits for dormice of removing conifers over time from plantation sites that were historically ancient woodlands. This is supported by empirical studies in England (Trout et al., 2012, 2018).

3.4.4 | Hedgerows and scrub

The importance of hedgerows and scrub for dormice was a common theme among participants. Many scientific studies have found dormice and their nests in these habitats (Berg & Berg, 1998, 1999; Bright & MacPherson, 2002; Dondina et al., 2016; Ehlers, 2012; Ramakers et al., 2014; Wolton, 2009). Participants talked about hedgerows and scrub as both corridors for movement and dispersal, and as habitats in their own right, providing structure, food sources and nest sites. Few scientific studies have examined the potential of hedgerows and scrub as habitats per se because most consider these as extensions of woodlands, often in highly wooded landscapes (e.g. Berg & Berg, 1998, 1999; Ramakers et al., 2014). There is, however, some evidence for long-term persistence of dormice in these habitats (Bright & MacPherson, 2002; Schulz & Büchner, 2018). Of the subset of experts that were asked explicitly about this, some were confident that hedgerows and scrub often sustain viable populations of dormice, particularly when they are large, species rich and form part of a well-connected network of habitat. Published studies agree that these characteristics are associated with greater likelihood or densities of dormice (e.g. Berg & Berg, 1998; Bright & MacPherson, 2002; Dondina et al., 2016; Ehlers, 2012). However, most hedgerows in England are not like this:

> '*Good hedges can have healthy dormouse populations. Paul Bright showed that, didn't he, that dormouse populations can be just as high in hedgerow networks as in the best of woodlands… And what makes a good hedge for dormice? Well, thick, bushy, species-rich. Those are the things, I think. So your typical Midlands hedge, which is single-species hawthorn, very narrow, wind whistling through the base, that's not much good for dormice. But here in Devon and Dorset of course we've got all these magnificent species-rich hedges and, if managed appropriately, most of them would make good dormouse habitat*'. Dormouse Expert

Participants suggested that scrub has traditionally been neglected by policy, especially compared to hedgerows. It was described as having been '*an unloved habitat for many years*', and as often seen by land managers as a '*waste of space*'. Scrub was often proposed as a relatively cheap and easy win for dormice because it can be created with minimal effort via natural regeneration, for example by allowing scrubby outgrowths to generate along hedgerows, on the edges of woodlands, in field corners and in unproductive areas of farmland:

> '*I mean, the big wins are for those people who can lose a part of their land and not really worry about it, in those marginal edge habitats… You're not doing anything, if you're allowing that scrubbiness to develop, if you're allowing that hedgerow to grow because you're not tinkering with it any longer*'. Conservation Professional for a government body

One participant described this as allowing habitats and landscapes to have more '*scruffiness*' and '*blurred edges*'.

We found no experimental evidence of the impacts of hedgerow management on dormice. However, surveys of hedgerows across England found that intensively managed, low diversity hedgerows lacked dormice (Bright & MacPherson, 2002). Many participants were frustrated with current hedgerow management practices. For example, one ecological consultant said, '*I drive around pulling my hair out regularly at this time of year, looking about how many hedges have been completely flat-topped and just flailed to within an inch of their life*'. Another said that '*it just seems the 1st of September comes, and you can just literally see farmers itching to get out there and just flail the hedgerows*'. Participants suggested that this annual, close-cropped cutting of hedgerows is bad for dormice because it limits habitat structure, reduces the availability of food sources and may directly destroy late-season dormouse nests. It was therefore frequently suggested that there is a major opportunity to benefit dormice by improving hedgerow management: encouraging bigger, thicker hedgerows by not cutting annually, and by cutting less tightly. Management diversity was also suggested to be very beneficial, for example not cutting all hedges or both sides of the same hedge in a single year, and varying the cutting height. Participants again emphasized the importance of hedgerow species diversity, and the potential of supplementary planting to increase this. Whilst participants were less certain about the importance of hedgerow trees (Figure 1), others suggested that they are beneficial, and can help to bridge hedgerow gaps, gateways and roads.

Although hedgerow cutting regimes were mentioned frequently, one participant who was a recognized hedgerow expert suggested that '*there's far too much focus at the moment just on trimming frequency and not nearly enough thinking around whole management cycle of hedges*'. Several participants also referred to the need to think about hedgerow management in terms of a long-term management cycle, whereby a hedgerow inevitably becomes 'gappy' as it develops into a line of mature trees and shrubs, and subsequently needs rejuvenating via either laying or coppicing. It was suggested that both gappy and recently laid hedgerows are less suitable for dormice, though we found little published evidence for this. Nonetheless, it underlines the need to manage hedgerows at a landscape scale to ensure that there are a variety of hedges at different stages in their management cycles nearby.

Hedgerow creation was much less frequently mentioned than hedgerow management, and we also found no empirical studies of its

impacts on dormice. Some participants highlighted challenges associated with hedgerow creation, for example the costs, skills required and difficulties in finding locations for doing so. One participant highlighted the Net Zero incentives for creating more hedgerows:

> 'The Climate Change Committee recommended that we increase the extent of hedge by forty percent as part of our drive to reach net zero by 2050. By extent, people think that means planting new hedges but equally well it can mean letting hedges get wider. And… if you just let them get naturally wider, they develop these soft edges, which I like. So I think that's a real opportunity at the moment for dormice'. Hedgerow Expert

They also pointed to Natural England's Favourable Conservation Status definition for hedgerows, which recommends an average density of 10 km/km^2 (Staley et al., 2020). Nationally, this would require an additional 335,000 km of rural hedgerow, equivalent to a 61% increase in length. Many parts of Devon and Dorset are considered not to meet this target, despite having relatively high densities of hedgerows in comparison to other parts of England.

3.4.5 | Road and railway verges

Road and railway verges form well-connected linear networks of woodland, hedgerows and scrub. We found several studies of dormice in road verges (Chanin & Gubert, 2012; Garland, 2005; Kelm et al., 2015; Schulz et al., 2012), which included dormice being found within as little as 1 ha or less of fragmented roadside habitat (Chanin & Gubert, 2012; Garland, 2005). We found no studies of dormice in railway verges. Ecologists and ecological consultants who had experience of working on road and railway verges emphasized their value for dormice:

> 'I think if you start with the basics, dormice need food resource like any species, and shelter, and to be able to disperse. And our soft estate in many cases provides that with long, long belts of habitat so the dormice can move. There's quite often a variety of species like hazel, and obviously there'll always be bramble, blackthorn, hawthorn and other species so I think there's a good variety of feeding resources. And because there's no disturbance there's lots of leaf litter on the ground, lots of moss, lots of fern so there's lots of habitat for them to hibernate in, as well as in the trees themselves and the woody shrubs. So we seem to tick the box; everything dormice need, we have in our soft estate in many areas. And if you drive along the A30 you can just see, it's just swathes of really nice habitat. And in many cases they're linked to hedgerows off-site, so it's that connectivity as well'. Ecologist working on behalf of a highways operator

Several participants explained that verges can contain very high densities of dormice, and that 'the highest numbers of dormouse in a given site have been found in road verges'. Participants also repeated that dormouse populations have been found in central reservations and traffic islands, as has been recorded in published studies (Chanin & Gubert, 2012; Kelm et al., 2015; Schulz et al., 2012). The relative lack of disturbance by people and the reduced risk of predation were suggested as possible reasons contributing to verges being particularly good for dormice, but this has not been tested empirically.

Ecologists representing road and rail organizations explained that verges are mainly managed in a reactive manner. This is primarily for safety purposes, for example to reduce the risks of falling trees. The removal and selective thinning of trees for safety reasons is likely to contribute to improving verges for dormice by enhancing diversity and age structure. Furthermore, specific habitat enhancements are sometimes being carried out in verges along railways and trunk roads at the same time as safety works. Such enhancements include many of the suggested management actions (Figure 1). Verges along non-trunk roads (i.e. those managed by local authorities) are generally only managed to a minimum level outside of urban areas, for example cutting grass, hedges and trees to maintain visibility splays. In all cases, practitioners explained that proactive management is limited due to the significant costs and logistical challenges associated with accessing road and railway verges. Overall, it was suggested that there might be relatively little opportunity to further enhance road and railway verges for dormice due to both the described constraints, and because they are often already of good quality.

3.4.6 | Habitat connectivity

The importance of habitat connectivity featured heavily in most interviews. There is a surprising lack of research looking at the impacts of large, landscape-scale approaches to dormouse conservation, though several published studies provide evidence for the importance of habitat connectivity, particularly via hedgerows (Capizzi et al., 2002; Dondina et al., 2018; Keckel et al., 2012; Mortelliti et al., 2011). Comments about connectivity similarly often mentioned hedgerows—the need for more hedgerows, for filling gaps in hedgerows, and otherwise improving the quality of existing hedgerows. Participants also talked about improving connectivity across potential barriers such as roads and tracks, for example by encouraging and maintaining aerial tree connections wherever possible. The potential for incorporating or retrofitting crossing structures (e.g. green bridges, dormouse bridges and underpasses) was also mentioned several times. The effectiveness of some of these measures was questioned, however, and highlighted as a knowledge gap. There is some published evidence demonstrating the use of a dormouse bridge over a railway line (White & Hughes, 2019), though one ecological consultant argued that this is not generalizable, and unlikely to work across busy roads.

Another conservation professional, with a research background in habitat connectivity, took a slightly different view to enhancing connectivity. They stressed that 'there's often too much emphasis put on structural connectivity', and that 'if we can increase populations, then there'd be more dispersers sent out into the matrix anyway and that's

probably more worthwhile than a couple of hedges here or there'. As described previously, the participant reasoned that the habitat specificity of dispersing individuals is typically far lower than that of settled individuals.

3.4.7 | Provision of nest sites

Of those who mentioned it, participants were unsure whether nesting and hibernation opportunities were an important factor limiting the carrying capacity of dormouse populations. This may explain why experts were much less certain about the effectiveness of the associated management actions, and why these were perceived as being less effective, compared to most other interventions (Figure 1). In contrast, several studies in the scientific literature do suggest that the provision of nest boxes increases dormouse densities (Juškaitis, 2005, 2006; Morris et al., 1990). Participants may have considered nest box provision to be a less effective strategy because it would be very difficult to implement at scale.

3.4.8 | Reintroductions and translocations

Reintroductions and translocations were rarely mentioned, perhaps because these are less relevant in Devon and Dorset, which were the focus of the study and where the species is widely distributed. However, it was suggested that reintroductions might have an important role to play in areas where dormice have been lost and are not likely to recolonize naturally soon, particularly in more northern areas of England. However, one participant emphasized that reintroductions should be *'an absolute last resort if there's nothing else, and where we're absolutely convinced it's the right thing to do, and it's likely to have a really good chance of working'*.

3.4.9 | Mitigation measures

We found no studies testing the effectiveness of mitigation measures, for example interventions that are routinely carried out as part of planning and development. This was highlighted as a crucial knowledge gap by participants. In terms of on-site mitigation, ecologists and ecological consultants expressed concerns about the quality of habitats that are created or maintained on-site, for example on large-scale residential developments, which are subsequently exposed to novel disturbance, and are often mismanaged:

> *'I've seen that before on large-scale residential sites where the internal hedgerows have been retained as part of the design plan but they've been also accounted for in terms of the meterage of compensation habitat retained or created. And I don't think that's appropriate because every single hedgerow I've seen internally within a residential development is disturbed, mismanaged, kids play through*

it. They're not suitable anymore for dormice'. Ecological Consultant

Given these concerns, off-site compensation measures were perceived as being often more beneficial for dormice. However, it was highlighted that finding sites where private landowners are willing to *'tie up the land for 30 years'* is a major challenge. Examples of land that had been used for biodiversity offsetting included that which is owned by local authorities (including county farms) and conservation organizations. One participant explained that they *'could foresee maybe a huge building up of money and then never being able to spend it on achieving the offsite stuff on the ground'*. Planning and development relating to dormouse conservation are discussed in much greater detail in Appendix S2.

3.5 | Practical opportunities, constraints, and considerations

Participants discussed various mechanisms for restoring dormouse populations, namely dormouse legal status, planning and development (including off-site compensation), agri-environment schemes and national programmes for tree planting (often carried out for the purpose of climate change mitigation). However, various issues were raised about each mechanism. For example, mitigation measures during planning and development were often considered to be inappropriate, not delivered effectively and not enforced. Recent research suggests that mitigation measures in the United Kingdom, including for dormice, are generally poorly based on empirical evidence (Hunter et al., 2021). The effectiveness of current agri-environment schemes was also questioned, largely due to the scale, longevity and lack of flexibility of interventions. The lack of policy support for scrub habitats was highlighted as a major limitation for dormice. There was a mixture of optimism and scepticism about if and how these challenges might be overcome in the future, for example via the upcoming Biodiversity Net Gain and Environmental Land Management schemes in England. These sentiments are echoed in the scientific literature (Hurley et al., 2022; zu Ermgassen et al., 2021). Practitioner perspectives on these mechanisms are discussed in further detail in Appendix S2.

Participants also raised various practical considerations relating to dormouse conservation, including general issues such as accounting for future climate change, as well as challenges and opportunities relating to landowners, land managers and on-the-ground implementation. These are summarized in Tables 2 and 3.

3.6 | Remaining knowledge gaps

The most frequently mentioned knowledge gaps highlighted by practitioners related to dormouse distribution, monitoring and population trends, the use of non-classical habitats, the impacts of anthropogenic disturbance and pollution, dormouse movement and dispersal

TABLE 2 Summary of the practical considerations mentioned by interviewed practitioners (n = 38) relating to restoring hazel dormouse populations

	Consideration	Details
Major themes	Landscape-scale approaches	The need for more coherent, larger scale, strategic approaches, longer term thinking and partnership working (including across sectors). • The importance of the Lawton principles ('more, bigger, better and joined'). • Including in planning and development (e.g. off-site compensation), agri-environment schemes (e.g. farm clusters) and deer management. • Managing habitat features collectively rather than individually (e.g. staggering hedgerow management). • The potential of rewilding was mentioned to a lesser extent.
	Climate change	Accounting for future climate change. • Areas that are currently suitable for dormice may not be in the future, and vice versa. • Climate change may also increase the risks of pests and diseases, affecting habitat suitability and resilience for dormice, particularly in woodlands. • If milder winters result in dormice being more active, it may be beneficial to encourage plant species that provide food during this period.
	Surveying and monitoring	The need for more and better dormouse survey data. • Often one of the first practical opportunities mentioned for benefiting dormice, though may reflect that many participants' primary experience of dormice is through surveying. • Some practitioners had insufficient information to determine where to best focus efforts, and reported barriers to accessing and sharing dormouse records.
Minor themes	Engaging the public, communities and volunteers	• Promoting public interest in and awareness of dormice, leveraging perceptions of them as a charismatic species. • Harnessing local community groups and volunteers to help with surveying and habitat management.
	Time delay for achieving outcomes	• Interventions for dormice will often take years, if not decades, to achieve the desired outcomes (e.g. natural regeneration of scrub; hedgerow and woodland creation). • Interventions may be detrimental in the first instance (e.g. coppicing, small-scale clear felling and hedge laying). • Further hampered by the dormouse's slow rate of reproduction.

Note: A version of this table with example quotations is provided in Appendix S2.

behaviour, the effectiveness of mitigation measures and the impacts of climate change (Table 4).

4 | CONCLUSIONS

Practitioners and non-academic experts provided a wide range of additional insights about dormouse ecology and conservation beyond those that were synthesized from the published literature. Encouragingly, we found few explicit contradictions between these different information sources. Instead, practitioner knowledge helped to verify, clarify and expand upon evidence from empirical studies. The main additional insights that were shared by participants during the interviews were as follows:

1. Dormouse ecology: Practitioners emphasized that dormice are far more adaptable than traditionally perceived. Hedgerows, scrub, road verges and railway verges were all suggested to be capable of supporting thriving populations. Practitioners also provided examples of dormice being found in a wide range of other habitats, so argued that they should not immediately be discounted from any site. Practitioner knowledge was particularly valuable in this regard because surveys carried out by ecological consultants often focus on non-classical habitats, for which empirical studies are scarce.

2. Conservation measures: Practitioners highlighted opportunities for restoring dormouse populations. The most frequently mentioned were (i) improving hedgerow management, (ii) creating new woodlands, (iii) bringing existing woodlands back into management, (iv) setting aside unproductive land and (v) improving habitat connectivity. These interventions were perceived as being effective, if conducted at sufficient scale, and plausible, if sufficient mechanisms were put in place. The proposals go significantly beyond any recommendations that can be made from empirical research because studies of dormouse habitat management are limited almost exclusively to woodlands and forests. The main mechanisms that were proposed for implementing these management interventions were through planning and development (particularly off-site compensation), agri-environment schemes, and national programmes for tree planting. Many issues were raised relating to these mechanisms, and there was a mixture of both optimism and scepticism about if and how these challenges might be overcome in the future.

3. Practical considerations: Practitioners provided detailed insights into a wide range of practical considerations, including opportunities and constraints for restoring dormouse populations. The

TABLE 3 Summary of the most prominent practical considerations for landowners/land managers that were mentioned by interviewed practitioners (*n* = 38) relating to restoring hazel dormouse populations

		Consideration	Details
Major themes		Time, money and incentives	A lack of time, money and other incentives are key management constraints. Existing and proposed mechanisms for overcoming these issues are discussed in Appendix S2.
		Advice, knowledge and training	Engaging with landowners and land managers, providing training and support. • Helping to find ways of benefitting dormice within working constraints. • Impartial advisors who can provide on-site expertise during forestry, road, rail and other works, and who can help farmers with understanding, applying to and implementing agri-environment schemes.
		Changing attitudes and mindsets	Changing attitudes and mindsets of landowners and land managers. • Considering and incorporating nature conservation within other works, rather than as a separate, conflicting demand. • Changing perceptions around tidiness, especially relating to management of hedgerows and scrub.
		Balancing other needs, species, trade-offs	• Balancing other demands, such as loss of cropping area and agricultural productivity due to habitat creation. • Balancing the needs of other species, which may have conflicting habitat requirements and recommended management. • Considering the broader environmental benefits, and the benefits for other species, provides a stronger justification for interventions that benefit dormice.
Minor themes		Safety & access	Safety is a major constraint in managing verges along railways and trunk roads for dormice. • Surveys and habitat enhancements mostly carried out reactively alongside essential works such as tree and vegetation management for safety reasons. • Even greater constraints on vegetation and its management within the railway lineside. • Preferred tree species for planting in railway verges are those that have less leaf fall. • Access is a major challenge, especially for railway verges where there are sections lacking entry points for several kilometres. • Works may need to be carried out at night, or train schedules adjusted, resulting in significant additional costs.
		Ash dieback	Various potential impacts of ash dieback on dormice. • Mentioned as having a largely negative impact on woodland ecosystems. • However, suggested that dormice may benefit dormice somewhat due to more open woodland canopies. • Also provides a need for management arising from safety concerns along road and railway verges, and in publicly accessible areas: an opportunity for simultaneous habitat enhancements, which may otherwise not have taken place.
		Lack of space	Challenges around finding opportunities to create or enhance habitat, for example to meet tree planting ambitions.
		Timing of management	Various constraints on when habitat management can be carried out. • Legal restrictions, including due to breeding birds and the presence of dormice. • Working around other seasonal demands and challenges, for example use of heavy machinery on wet ground in winter. • Balancing optimum management timing for dormice with that of other species.
		Tenants and tenancy agreements	Tenancy agreements may lock in constraints that limit the environmental ambitions of landowners. • Described as a major challenge by all interviewed large private landowners.

Note: A version of this table with example quotations is provided in Appendix S2.

main practical considerations included the need for landscape-scale approaches, the need to account for the impacts of climate change, and the need for better surveying and monitoring. The main considerations for landowners and land managers included the need to overcome time and financial constraints, for example by providing sufficient incentives, the need for better advice, knowledge and training, the need to change attitudes, for example perceptions around tidiness of habitats and landscapes, and the need to balance other demands such as agricultural productivity and the requirements of other species.

4. Knowledge gaps: Participants highlighted knowledge gaps including uncertainties arising from the published literature (such as details about dormouse movement and dispersal behaviour), and the use of non-classical habitats. Participants mentioned additional topics that are of major practical importance, but which are scarcely covered in the scientific literature, namely the effectiveness of dormouse mitigation measures in planning and development, and the impacts of anthropogenic disturbance and pollution on dormice. Practitioners also revealed various shortcomings of empirical studies and available data. For example, some dormouse experts emphasized the limitations of available survey and monitoring data. They also questioned the relevance of findings from some studies, such as those based on the movement patterns of dormice that have been translocated.

TABLE 4 The main remaining knowledge gaps that were most prominently mentioned by interviewed practitioners (*n* = 38) about hazel dormouse ecology and conservation

	Knowledge gap	Details
Major themes	Monitoring and population trends	What are the current and historic distributions, locations and population sizes of dormice, and how have these changed/are these changing? • Major uncertainty around available survey data due to limitations of existing methods, for example: • Surveys by consultants typically only indicate presence or absence. • The National Dormouse Monitoring Programme focuses on woodlands, so trends may not reflect those in other habitats. • Uncertainty around when, why and how much dormouse use nest boxes, tubes and tunnels. These are typically no more than 2 m from the ground, whereas dormice may be active much higher in the canopy. Their use is likely confounded by other factors such as the availability of natural nest sites. • Potential of new technologies for monitoring, for example bioacoustics and eDNA (Priestley et al., 2021).
	Use of non-classical habitats	When and why do dormice use different non-classical habitat types, including hedgerows and scrub? • Some evidence from empirical studies with further insights from practitioners. However, clarification is needed about the relative roles of non-classical habitats compared to woodlands, and long-term persistence within these.
	Anthropogenic disturbance and pollution	What are the impacts of anthropogenic disturbance and pollution on dormouse populations? • Both in and around new and existing developments, and in rural areas such as woodlands, for example direct and indirect impacts of dogs, cats, human disturbance, light pollution, noise pollution and pesticides. • Practitioners highlighted these as major concerns, but empirical studies are lacking.
	Movement and dispersal	How, when and why do dormice move and disperse? • How do dormice use the canopy? When, why and how far will dormice move across the ground? How does this differ between settled versus dispersing individuals? What constitutes a barrier to movement or dispersal? When and why do dormice use crossing structures? • Although empirical studies provide various insights, further clarification is needed. • Insights from tracking studies that use translocated individuals were questioned.
	Effectiveness of mitigation measures	How effective are mitigation measures during planning and development? • Empirical studies are very limited. • Post-mitigation monitoring and reporting is needed to address this.
	Climate change	What are the current and future impacts of climate change on dormouse populations? • What are the direct impacts on dormice, for example on hibernation and overwinter survival? What are the indirect impacts, for example via the availability of food sources, or on the prevalence of tree diseases? To what extent does climate change affect the viability of current populations and currently suitable habitats? • Studies in England suggest that dormice benefit from warmer, drier, sunnier springs, summers and autumns and colder winters (Bright et al., 1996; Goodwin, Suggitt, et al., 2018). However, potential impacts of climate on dormice are diverse (reviewed in Bright & Morris, 1996). • Much more clarification is needed, including population-level impacts under different future climate scenarios.
Minor themes	Grazers, browsers and pheasants	What are the impacts of grazers and browsers on dormouse populations? • Direct impacts may include disturbance and trampling during hibernation; indirect impacts include changes in vegetation. • How do impacts vary with grazer/browser density? What are the impacts of pheasants on dormice? • Published studies are very limited.
	Hibernation	What factors determine overwinter survival? • What makes a good hibernation site? What makes a good hibernaculum? Why and how often do dormice wake up? • Despite some recent research (Gubert et al., 2022), published studies remain very limited.
	Timing of management	What is the impact of management timing on dormouse populations, for example in woodlands and hedgerows? • To what extent are dormice displaced or killed? How quickly do dormice recolonize? • Despite some evidence, practitioners emphasized that more research is needed because this is such a major constraint on woodland management.

Note: A version of this table with example quotations is provided in Appendix S2.

Despite the valuable insights provided by practitioners and non-academic experts, there are limitations to our approach. First, it is important to acknowledge that there are various biases associated with expert judgement (Hemming et al., 2018). These include psychological biases—heuristics such as anchoring, groupthink and overconfidence, as well as more experience-based biases such as the availability heuristic (Hemming et al., 2018). For example, many ecological consultants primarily survey for dormice in hedgerows and scrub (because these are often located on sites of potential development), so they may perceive these habitats as being disproportionately important. Second, it was not always clear when practitioner knowledge was based on personal experience, published empirical studies or second-hand information. For example, many participants explained that dormice inhabit some highway central reservations. The frequency with which this was mentioned may have suggested that this is a widespread phenomenon. However, it seemed to instead be repetition of a few interesting and well-known, but potentially atypical, examples (Chanin & Gubert, 2012). Our approach could be improved in future studies by asking participants explicitly about the basis for their statements, distinguishing between personal experience, the experience of colleagues and published sources. This would have clarified the central reservation example. In many cases, however, practitioner knowledge is based on a mixture of sources, including experience-based intuition (Hulme, 2014), which are not always easy to pin down.

Nevertheless, our findings have contributed to the evidence base towards developing strategies for restoring dormouse populations. Our approach was successful in providing an initial overview of the problems facing dormouse conservation, and in broadly characterizing potential solutions, including management actions that are supported by practitioners. This provides the foundation for possible further work using more formal, structured expert elicitation techniques (e.g. the IDEA protocol; Hemming et al., 2018). The study has also highlighted how practitioner knowledge can be used to supplement formally published evidence. This approach is particularly useful when, as in our situation, decisions are time constrained but evidence from available empirical studies is inadequate. Furthermore, we have shown that practitioner knowledge can help to better account for practical considerations, including feasibility and local context. Combining practitioner and scientific knowledge is likely to help better frame conservation programmes, leading to more successful outcomes.

AUTHOR CONTRIBUTIONS

Robbie McDonald and Sarah Crowley conceived the ideas that formed the basis of the study. Benjamin Phillips developed the methods, collected and analysed the data and led the writing of the manuscript. All authors contributed to the ideas, methods and manuscript drafts and gave final approval for publication.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Interview transcripts will not be made available to conform with participant consent.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Appendix S1. Interview schedule

Appendix S2. Supplementary results

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