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RESEARCH ARTICLE

Towards a process of translational palaeoecology: A practical guide to research co-production

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Abstract

1. Palaeoecology has the potential to support practical conservation, offering a long-term perspective to issues such as biodiversity loss, environmental restoration and peatland carbon storage. However, achieving a widespread and effective application of palaeoecology within conservation practice requires greater and more efficient collaboration between academics, practitioners and policymakers.
2. Translational palaeoecology offers a methodological approach to achieve collaboration between academia and conservation and produce palaeoecological research that can support and inform conservation action.
3. This paper reports the results of a workshop involving academics undertaking palaeoenvironmental research and conservation practitioners concerning the barriers and practical recommendations for effective research-practice collaboration. The experiences of the participants highlight the benefits of a collaborative approach for producing palaeoecological research that is enriched with experiential and contextual knowledge. Key themes emerging from the workshop include the importance of mutual learning and knowledge exchange, and supporting practitioners to be co-researchers.
4. *Practical implication*. The workshop outcomes are presented as a framework of practical guidelines for implementing translational palaeoecology. Key recommendations for academics include engaging with practitioner activities as relationship-building opportunities, utilising field visits for knowledge exchange, adopting a knowledge facilitation role or involving a facilitator to support

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practitioner understanding, using workshops to explore the practical relevance of palaeoecological data and enabling practitioners to communicate palaeo-research findings in their sphere. Key recommendations for practitioners include inviting academics to practitioner meetings, providing tacit and experiential knowledge throughout the process, exploring practitioner- or land-owner-led funding opportunities for translational research and partaking in communication roles for wider dissemination of research.

KEYWORDS
collaborative research, knowledge co-production, palaeoecology, translational palaeoecology

1 | INTRODUCTION

In the face of pressing environmental crises that threaten ecosystem functioning, finding time- and resource-efficient solutions depends on collaboration between scientists, practitioners and policymakers (Cvitanovic et al., 2016). Many studies have explored the barriers to and opportunities for collaboration between academics and practitioners (e.g. Cvitanovic et al., 2016; Laurance et al., 2012; McCabe et al., 2023). Norström et al. (2020) outline good practice for knowledge co-production as a shared process between researchers and research end-users that is interactive, focused on common goals, shaped by local context and inclusive of different perspectives, where the process of research is a shared space between researchers and research end-users. However, academic research processes do not always align with these principles or integrate practitioner perspectives, which can lead to divergence between the science produced and practitioner needs or capacity (Enquist et al., 2017).

The landscape of what is considered 'typical' academic research is changing, with increasing emphasis on social responsibility and research impact. In the United Kingdom, the increased focus on impact in response to the Research Excellence Framework (REF, the UK's assessment system for allocation of public funding to higher education providers) suggests a culture change amongst funding bodies that is more supportive of practice-focused projects (Rose et al., 2019; Whitman et al., 2015). To facilitate impact, scientists are increasingly adopting alternative approaches to expedite context-based research into practical action and decision-making (Sutherland et al., 2019). Translational research is part of a suite of research approaches that aim to enable practical and context-driven solutions to complex problems by engaging researchers, practitioners, decision makers and other stakeholders in an intentional process of knowledge co-production (Meadow et al., 2015). Translational research has roots in biomedical science (Enquist et al., 2017), and its principles have been adopted by a range of disciplines including education (Mitchell, 2016), agriculture (Passioura, 2020) and ecology (Schlesinger, 2010).

Translational ecology embodies intentional efforts by ecologists, stakeholders and decision makers to develop collaborative research to improve environmental decision-making (Enquist et al., 2017). However, the concepts and practices are not yet fully integrated in the allied (or sub-) discipline of palaeoecology. There is a growing recognition that palaeoecology has value for conservation management in many different settings; examples include lowland heathland (Siggery et al., 2025), peatlands (Chambers et al., 2007), island biodiversity (Nogué et al., 2017), forest management (Morales-Molino et al., 2017) and southern African savannas (Gillson & Ekblom, 2020). However, the contribution of palaeoecology to conservation is often not fully realised due to the challenges of integrating palaeoecological research into practice (Froyd & Willis, 2008).

Translational palaeoecology (Flessa, 2017) may help to address these challenges (Manzano et al., 2020; Nogué et al., 2017). We define translational palaeoecology as an intentional process of collaboration between palaeoecologists and end-users (i.e. the individuals who benefit from or who are impacted by research outputs) for the purpose of creating problem-focused and actionable research to support environmental management decisions. Translational palaeoecology is underpinned by the theory of Mode 2 research—that is, research that is transdisciplinary and use-oriented (Bandola-Gill et al., 2023)—and it is conceptually similar to approaches such as co-production (Meadow et al., 2015) and translational ecology (Enquist et al., 2017).

The concepts of translational research are not new to palaeoecology. Palaeoecology has contributed to management decisions on issues such as sulphur deposition (Battarbee, 1990), farmland pond restoration (Walton et al., 2021), water quality (Battarbee, 1990; Bennion & Battarbee, 2007) and coastal habitat monitoring (Dietl et al., 2023). However, a translational approach to palaeoecological research is not yet normalised and examples of palaeoecological translation remain relatively few (Dietl et al., 2023; Groff et al., 2023; Manzano et al., 2020).

The persistence of a palaeoecology research-practice gap, despite urgent advocacy for better collaboration, highlights the need for a deliberate translational approach to action-oriented palaeoecology (Groff et al., 2023; Siggery et al., 2023; Wingard et al., 2024). Formal training in approaches to translational research is non-existent or rare in most university palaeoenvironmental programmes (Kelley & Dietl, 2022) with the result that few academics have had training in working collaboratively with conservation

practitioners and applying palaeoecology to practical conservation problems (Kelley et al., 2018). Better documentation and communication of collaborative experiences and the integration of social science approaches within palaeoecological research are essential for both the development of best-practice collaboration (Davies et al., 2014; Lemos et al., 2018) and developing a scaffold for collaborative efforts (Meadow et al., 2015).

The purpose of this paper is to propose a practical framework for translational palaeoecology for those wishing to undertake collaborative, action-focused research. We incorporate the perspectives and experiences of conservation practitioners and palaeoecology researchers in a framework that recognises the barriers that can cause palaeoecology to become lost in translation (e.g. Davies et al., 2014; Froyd & Willis, 2008) and present a toolkit of evidence-based solutions to support effective translational palaeoecology.

2 | MATERIALS AND METHODS

An online workshop held on 8 February 2024 brought together a group of 30 conservation professionals, practitioners, and palaeoenvironmental researchers to share experiences in collaborative research-practice partnerships and incorporation of palaeo-data into conservation management. The participant base was largely dominated by UK peatland practitioners and palaeoecologists, although a range of wider expertise was represented, including palaeolimnology, palaeoclimatology and forest management (see Table S1). The workshop was guided by a discussion framework structured around phases of the research process, and the discussion below follows this structure: Phase 1. Making connections and building relationships, Phase 2. Designing research: co-producing research aims and questions, Phase 3. Undertaking research: collaboration during data collection and analysis, Phase 4. Translating research: communicating and implementing results and Phase 5. Applying research: post-project engagement and monitoring research impact. Phases 2–5 were part of the predetermined discussion framework, whereas Phase 1 emerged from the workshop discussion.

The workshop was held and recorded on Zoom; it was then transcribed and anonymised. In addition to the verbal discussion, participants were encouraged to contribute ideas via the chat function. Individual or small-group follow-ups were conducted as necessary to clarify or expand on contributions made in the workshop. The discussion transcript and chat were analysed via an inductive thematic analysis approach (e.g. Braun & Clarke, 2006) to elucidate key themes relating to barriers and solutions within each of the discussion sections, implemented in NVivo version 14 (Lumivero, 2023) (see Table S2). We use this dialogue and associated exchanges to develop a framework for academics and practitioners concerning effective collaboration throughout the research process. Participants are hereafter referred to by a pseudonym in the form of A*n* (academics) or P*n* (practitioners).

3 | RESULTS AND DISCUSSION

The thematic analysis (Table 1) highlights key differences between academic and practitioner contributions that inform the discussion that follows. We present the outcomes of the workshop as a framework (Table 2) that can inform a translational approach to future palaeoecological-conservation practice. The solutions presented go beyond the call for greater collaboration (e.g. Rose et al., 2019) to focus on creating an interactive process that supports practitioners to participate as co-researchers from the outset and builds towards actionable research (Reed, 2008). Additionally, we present a case study (Box 1) that embodies the phases and recommendations of translational palaeoecology and demonstrates the effectiveness of research–practice collaboration for facilitating novel conservation solutions informed by palaeoecological research.

3.1 | Phase 1. Making connections and building relationships

Phase 1 prioritises building trust and developing working relationships between palaeoecologists and practitioners. Early and ongoing engagement is a key strategy in co-production literature for aligning motivations, objectives, expectations (of participation requirements and outcomes) and understanding between academics and practitioners (Bojovic et al., 2021; Djenontin & Meadow, 2018; Norström et al., 2020; Reed, 2008). This phase fosters trust and rapport (Chapman et al., 2015; Wingard et al., 2024), which is vital for producing research that is trustworthy, context based and credible (Cash et al., 2002). However, the importance of this phase is easily overlooked (Dillon et al., 2022; Knight et al., 2008). We considered four aspects of relationship building (Table 1): priorities within academic culture, practitioner access to academic literature, attitudes of conservation funders towards the research and outreach.

Academics discussed how the institutional drive for large-scale, higher monetary grants can affect relationship building with practitioners. For example, participant A8 noted that the growing emphasis on impact—for example, through REF activities—is affecting the type of work they do but that the funding support is lacking. It is anticipated that guidance for UK REF 2029 will remove the quality threshold for the research that underpins impact case studies. However, case studies will continue to be evaluated by 'reach' and 'significance', which may mean that individual, and localised, translational research efforts remain undervalued by universities, as they are unlikely to score highly on 'reach'. Although the changes to REF indicate a positive culture change that is more inclusive of small-scale collaborative and practice-focused work, there continues to be a lack of institutional support and funding for the small-scoping projects that are often necessary for establishing research-practice relationships. This discussion echoes existing critiques within co-production literature concerning the 'publish-or-perish' culture within academia and the perceived negative impact

TABLE 1 Results of thematic analysis, detailing the key themes that emerged for each stage and raw counts of academic and practitioner contributions per theme.

Phase	Nature of theme	Theme	Academic contribution	Practitioner contribution
Phase 1. Making connections and building relationships	Barriers	Attitude of conservation funders towards palaeoecology	2	5
		Practitioner access to palaeoecology	4	2
		Trust issues	1	0
		Academic culture	5	0
	Solutions	Align palaeoecology with policy priorities	3	2
		Building relationships through outreach	5	5
		Making palaeo-research accessible	2	1
Phase 2. Designing research	Barriers	Lack of support from conservation funding	2	5
		Priority mismatch	0	2
		Lack of capacity within practitioner teams	0	5
	Solutions	Knowledge exchange	7	3
		Financial solutions	5	5
		Align palaeoecology with practitioner activity	2	0
		Menu of options	5	2
		Value of small projects	4	1
Phase 3. Undertaking research	Barriers	Academic assumptions	6	4
		Lack of capacity within practitioner teams	1	3
	Solutions	Communication facilitators	4	3
		Develop communication skills	2	6
		Practitioners as co-researchers	7	12
		Sense of ownership	0	4
Phase 4. Translating research	Barriers	Academic culture	2	0
		Influence of practitioner context	0	1
		Temporal mismatch	0	1
		Communication challenges	3	6
	Solutions	Appropriate timeframes	0	1
		Communicating results	4	5
		Translating results	4	0
Phase 5. Applying research	Barriers	Financial barriers	0	1
		Conflict with conservation policy	1	2
	Solutions	Defining impact	3	1
		Wider impact of research	5	2

Note: Colour shade corresponds with the number of contributions, with darker shades corresponding with a greater number of contributions and lighter shades corresponding with fewer contributions. See Table S2 for further information on themes including description, flag words and example statements.

of small-scale or local collaborative projects on career progression (Adams et al., 2021; Rose et al., 2019).

Participants commented on the physical (P1: 'most practitioners do not have access to academic journals') and epistemic (A4: 'they don't think about [palaeoecology] from a contemporary perspective') inaccessibility of scientific literature. The inefficiency of scientific literature for communicating research to practitioners is a well-known barrier to knowledge co-production as it affects

TABLE 2 Phases of the 'Translational Palaeoecology' process with an overview of the purpose of each phase and the key action points that emerged from the workshop.

	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Purpose	Engage in outreach and connect with practitioners. Establish research–practice relationships and trust	Define a conservation problem and design research aims and methods. Define roles and responsibilities of actors	Undertake research fieldwork, sample and data collection and data analysis	Communicate research results to practitioners and translate into action and practical implications	Monitor and evaluate impact of research. Determine future research needs and opportunities. Disseminate widely to academia, practice and policymakers
Recommendations	• *Beyond academic literature*: Increase accessibility of palaeoecology through open data repositories and practitioner publications • *Undertake outreach*: Build awareness through practitioner conferences, workshops and approaching site managers • *Context conversations*: Take time to understand the practitioner and academic perspectives and context in which research will be applied	• *Feasibility and relevance*: Use practitioner context to frame research scope • *Boundary object*: Use joint field visits to facilitate knowledge exchange and mutual learning • *Menu of options*: Use a menu approach to support shared decision-making in research design	• *Practitioner-led involvement*: Account for practitioner workload; practitioners determine level of involvement • *Knowledge facilitation*: Maximise this phase as a learning opportunity • *Collaborative research fieldwork*: To increase transparency around the research process and support practitioner understanding of palaeoecology	• *Rapid delivery*: Align delivery with practitioner needs, including frequent status and data updates • *Knowledge scaffolds*: Support practitioner understanding of palaeoecological data and connection with own knowledge through data visualisation and primer documents • *Translation*: Use knowledge scaffolds to support academic–practitioner discussions on research meaning and management	• *Joint approach*: Broaden research platform through academic- and practitioner-led communication • *Target policymakers*: Enhance profile of palaeoecology with decision makers • *Case studies*: Document process of translational palaeoecology and demonstrate applied value of palaeoecology for conservation

practitioner awareness and understanding of relevant research (Adams et al., 2021; Clark et al., 2019; David et al., 2016). This issue is particularly relevant for palaeoecology as limited teaching of the subject outside of select University programmes means that there is a broad spectrum of understanding of palaeoecology within the conservation community and limited overlap in knowledge and methods (Siggery et al., 2023). Lack of awareness of palaeoecology and its relevance for conservation practice hinders relationship building as practitioners and policymakers are less likely to seek out a working relationship with academics.

Practitioners also commented on how perceptions of research held by funders of conservation work can impact practitioner–academic collaborations. Conservation funders often seek 'quantity-over-quality' (in terms of long-term conservation outcomes) productivity metrics as evidence that 'they've done so much work, but they're not actually interested in whether or not that work's been successful' (P6); for example, focusing on the number of peat dams installed as a measure of restoration success as opposed to the long-term impact of peat dams on water table depth. As a consequence, conservation funders may prioritise research that has an immediate, visible payoff perceived as relevant to the immediate issues at the site (such as flood control). This may mean that scoping projects and relationship building with academics remain undervalued and/or underfunded, unless practitioners can 'convince [funders] that it's worth it' (P6).

Better engagement between palaeoecologists and conservation practitioners is needed to raise the profile of palaeoecology in the conservation community and establish a trusting relationship between palaeoecologists and conservation practitioners (Wingard et al., 2024). Recommended outreach methods (Table 2) include attending practitioner conferences, writing for practitioner-focused journals and magazines (e.g. *Conservation Land Management Magazine*), running workshops targeted at different agencies, and having direct conversations with site managers. Such conversations should cover the potential for palaeoecology to contribute to practitioner understanding, strategies and decisions. Conversations should also be an opportunity for academics to learn about practitioner context, including the boundaries and obligations of conservation funding. Conferences such as the United Kingdom and Ireland Lakes Network Annual Conference, the US National Conference on Ecosystem Restoration, and the IUCN UK Peatland Programme Conservation Fora are ideal opportunities for cross-sector conversations, as they attract both academic and practitioner delegates.

3.2 | Phase 2. Designing research: Co-producing research aims and questions

In translational research, research design needs to consider what is feasible and relevant to the practitioner. Feasibility comes from 'an understanding of practitioner timescales tied to funding/access to sites' (P9). The contextual factors explored in Phase 1, such as 'very short funding windows' (P6), may determine what is achievable in terms of undertaking research and implementing recommendations. A key recommendation (Table 2) to achieve relevance and feasibility is to frame the project aims around a jointly defined issue, such as a restoration problem. Actors should then set out how palaeoecology can support resolution of the agreed problem and consider the time- and resource-dependent options available (Lang et al., 2012). This approach means that practitioner capacity in terms of time, skills, and resources is accounted for, meaning that aims and eventual recommendations remain realistic (Cvitanovic et al., 2016; Reed, 2008). A narrower project scope that is aligned with practitioner funding windows may also allow for 'quick wins', in terms of faster research delivery. This outcome can help to establish trust with practitioners and provides evidence to convince funders that palaeoecology is worthwhile (Reed et al., 2014).

Academics might bring their own resources to Phase 2 through funded PhD projects, university 'seedcorn' funding, or research council grants in order to circumvent the funding barriers to practitioner engagement outlined in Phase 1. Although this may pre-empt some limitations of practitioner resources, the need to refine aims and methodologies within the grant application process could preclude essential practitioner input in Phase 2 and may limit practitioners to token participation (Whitman et al., 2015). Other recommendations (Table 2) include using practitioner knowledge of the conservation funding landscape to find opportunities for supporting palaeoecological research from non-academic funding streams. Participants noted the Department for Environment, Food and Rural Affairs (DEFRA) Landscape Recovery scheme and biodiversity credit markets as examples of funding opportunities in the United Kingdom that could embed palaeoecological research in practitioner- or landowner-led projects. Conversations with practitioners prior to sourcing funding can reveal wider financial opportunities that support the research and develop the applied aspect more fully.

Academic and practitioner participants commented on using the environment to facilitate conversation on the research problem through coordinated site visits. Joint field visits may be the part of the research process most suitable for direct collaboration as they are often achievable irrespective of different practitioner capacities. For example, P9 described using site visits to discuss practical issues with academics and stated 'that's a really easy way for us to work with academics, and it kind of suits the way that we work'. A2 discussed using sites as a practical arena to introduce palaeoecology to practitioners. Palaeoecologists and practitioners will likely view the site through different lenses and with different purposes. Field visits offer a concrete setting in which to bridge different perspectives by exploring the more abstract concepts of palaeoecology and sharing the present-day needs of site managers. In this sense, the landscape may be thought of as a boundary object (Star & Griesemer, 1989)—a concept or object that has a distinct identity, but which can be interpreted differently by different actors (Bishop et al., 2018). This interpretative plasticity allows the site to be used as an epistemic bridge between actors, creating a space for relational discourse and mutual learning of different perspectives, understanding, and knowledge (Lundgren, 2021). Such an approach is useful for both

BOX 1 Lowland heathland conservation in Surrey, UK

Across the United Kingdom, managing lowland heathland is challenged by an increasing risk of drought and drought-related wildfire, driven by climate change. As these threats increase, new approaches to conservation are needed. One such effort explored how palaeoecology can inform novel approaches to heathland management by providing a long-term perspective on environmental history and key drivers (Siggery et al., 2025). The project focused on Chobham Common National Nature Reserve, Surrey—a site that has experienced recurring fire events in recent years—and brought together palaeoecology researchers and conservation practitioners, who benefited from an established working relationship. A collaborative research approach was employed in order to increase relevance and usability of the research.

Collaboration between researchers and practitioners focused on research fieldwork, data presentation and translating research into practical messages; as such, the collaborative process followed within this project aligns most strongly with Phases 3 (undertaking research) and 4 (translating research) of the translational palaeoecology framework. Practitioners contributed site knowledge to research fieldwork, advised and assisted in selecting sampling locations and provided transport and equipment. Practitioners reported that being involved in the research fieldwork improved their understanding of the research and made the palaeoecology more tangible. The involvement of practitioners in research fieldwork and the mutual value gained from practitioner involvement highlights the importance of Phase 3 (Figure 1).

Data presentation involved an iterative discussion process where practitioners provided feedback on how graphical outputs could be made more accessible to those less familiar with palaeoecology. This process highlighted some of the challenges of communicating palaeoecological data to non-specialists that may transpire in the communication aspect of Phase 4; for example, diatoms, and the ways in which they translate to pH, were generally unfamiliar to practitioners and time was needed to explain how to read a stratigraphic diagram. Scaling data by age and historic events, rather than depth, and removing minor aspects of data to focus on key messages proved helpful. Feedback resulted in improvement of some figures and creation of others in response to practitioner needs; for example, practitioners wanted to know the spatial coverage of the data and specific area to apply management recommendations. The discussion process also generated conversation concerning data limitations and explanation of methods such as transfer function models and dating techniques. This exemplifies the need for two-way discussion in Phase 4 to ensure that research outcomes are clear.

The understanding that practitioners gained through their involvement in the research process enabled them to collaborate with researchers in developing management recommendations from research, thus reflecting the translation aspect of Phase 4. The long-term perspective provided by the palaeoecological research had several implications for management, including targeted monitoring of key wetland species, opportunity for species reintroduction and the suggestion for less-intensive management of *Molinia caerulea* in light of a higher historic presence than previously understood. This co-creation of recommendations meant that factors such as practitioner time and resources were naturally accounted for and that recommendations, such as the experimental management of *Molinia caerulea*, did not conflict with existing management obligations.

practitioners, who need to communicate management needs, and palaeoecologists, who are engaging in an arena where their work can be misunderstood or undervalued. This supports research design as it may help palaeoecologists and conservation practitioners to achieve a common understanding of the problem, maintaining a focus on creating practical solutions to 'on-the-ground' issues (Fazey et al., 2018). The benefits of joint field visits can transcend the boundaries of the individual phase; for example, A6 commented that 'practitioners usually have more complete knowledge about land-use history that is very relevant for the discussion of our results'.

Practitioners also suggested using a 'menu of options' (Figure 2) as a communication tool to help identify ways in which palaeoecology can inform practitioner interests and concerns and facilitate joint decision making (Table 2). This 'menu' would detail options for palaeoecological analysis, ranging from less detailed, exploratory and/or low-tech approaches to high-resolution, state-of-the-art analyses and outline the differences in costs, level of information gained and implications for the eventual outcomes.

The advantage of a menu approach is that it creates clarity about the costs, benefits and limitations of different proxies and levels of detail and how such data translates to practical implications for conservation management. For example, A3 discussed the value of low-resolution analytical approaches for providing conservation bodies with broad information on the timing, nature, and drivers of change in a 'cheaper and more cheerful' way. The transparent link between research choices and practical outcomes also demonstrates research relevancy, including why more detailed analyses may be needed, and allows for clarity around what can and cannot be achieved with palaeoecology.

A further benefit of the menu approach is that it can create a more even power dynamic, as it puts practitioners in a more informed position. Being more informed enables practitioners to lead

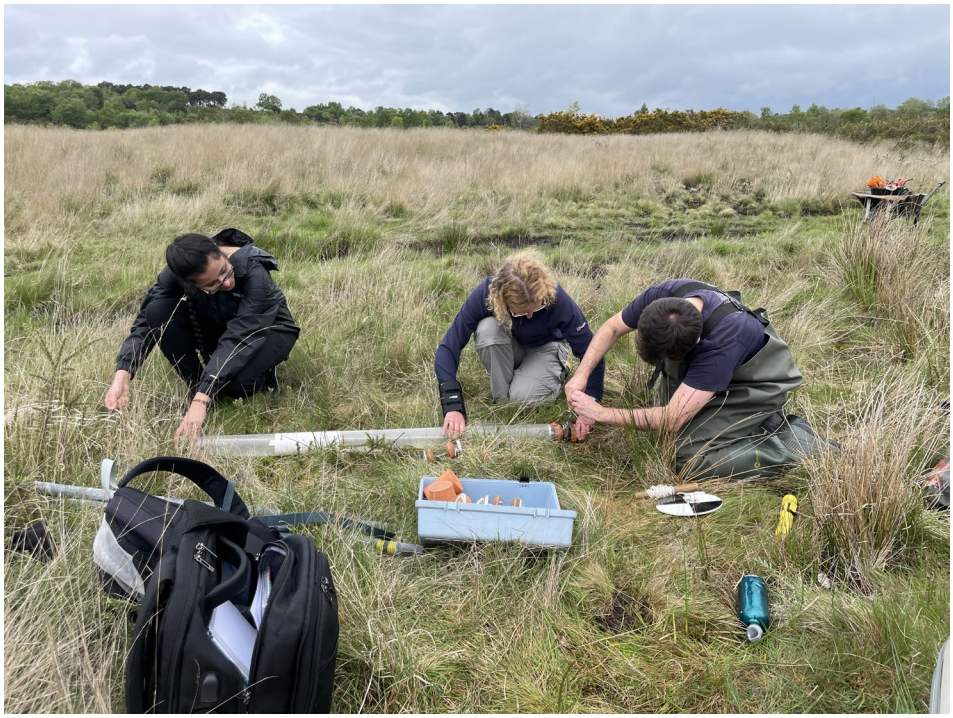

FIGURE 1 Collaborative fieldwork for the Chobham Common project, photo credit Ben Siggery.

a co-designed process and ensure research is tailored to the needs and resources of different sites and conservation contexts, with an understanding of how such decisions will affect outputs (Whitman et al., 2015). Although a collaborative approach to research design requires significant time investment, failure to co-design research can create uneven power dynamics that suppress the active role and voice of the practitioner, leading to a reduced sense of ownership of the research, which may lead to biased and unrepresentative outputs (Cvitanovic et al., 2016; Reed, 2008; Whitman et al., 2015).

3.3 | Phase 3: Undertaking research: Collaboration during data collection and analysis

While Phase 3 is where palaeoecologists contribute specialist skills and knowledge, practitioner input is just as essential as it is to phases of research design (Phase 2) and implementation of results (Phase 4) (Hilger et al., 2021). Translational methods are not conducted in parallel with scientific research but are embedded in the research process, including phases that may be perceived to be rooted in the academic domain (Van der Hel, 2018). Continuing to be mindful of practitioner capacity is necessary, as often practitioners do not 'have the ability, or the capacity, or the time to be involved in generating the research' (P10). However, academics should avoid assumptions and not 'discount the ability of practitioners to do or want to do any of this work in house' (A13). Some participants felt that practitioner input was essential in Phase 3; for example, P5 offered 'if we're talking about fundamentally trying to make this an applied process then […] it should be at least part led […] by the practitioners' and, in general, practitioners were enthusiastic to be involved as co researchers (Table 1). Key to Phase 3 is allowing practitioners the autonomy to decide their place in the translational process. As such, it is recommended to define roles and responsibilities before Phase 3 begins.

Joint field visits continued to be regarded as a key part of collaborative working (Table 1). Practitioners indicated that involvement in fieldwork and sampling in Phase 3 was valuable for building a stronger understanding of palaeoecology. For example, P4 described hands-on research fieldwork—specifically, looking at sediment cores—as a means of translating between the original question and research methods. Furthermore, P3 linked the knowledge gained through involvement in research fieldwork to practitioner ability to later communicate research outcomes more effectively, stating 'we went out and helped with the collection of the data, doing the cores […] doing that makes it so much easier for us to communicate it because we've been part of that process'. Using research fieldwork as experiential learning opportunities increases transparency for the practitioner around the data collection process. This leads to a greater understanding of palaeoecology, enabling practitioners to take on active roles in later phases and develop a shared sense of ownership of the research through their ability to communicate it as research experts within their sphere (McCabe et al., 2023).

The workshop findings highlight that Phase 3 represents more than data collection; it also implies knowledge exchange and learning ahead of result implementation in Phase 4. This does not mean that practitioners need to be trained to be fully-fledged palaeoecological researchers; rather, efforts put into practitioner learning translate into a better understanding of and ability to communicate

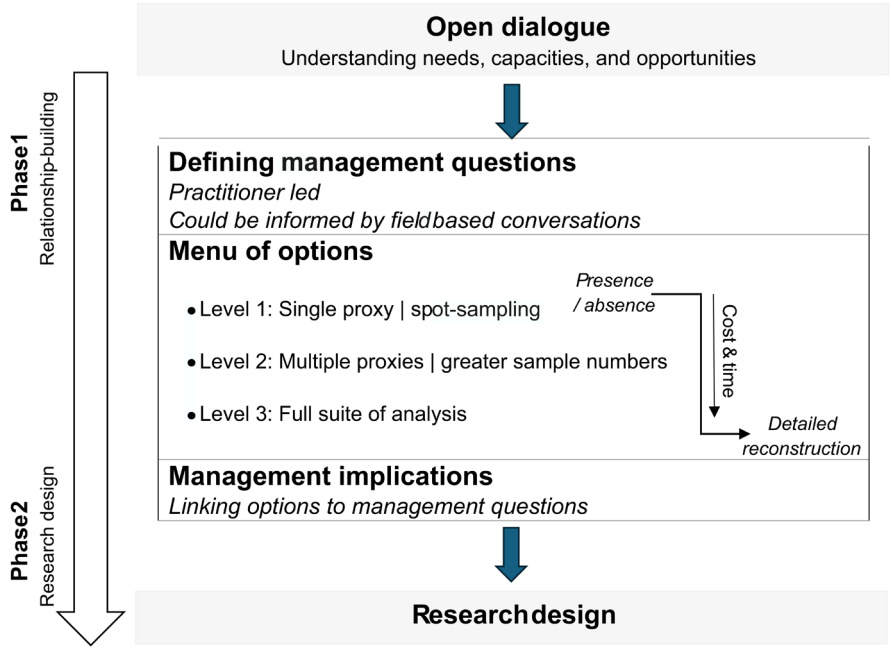

FIGURE 2 A model for developing a 'menu of options' approach to research design. In practice, the 'menu' approach can highlight trade-offs between levels of available analyses, the information gained relative to the management questions and the costs in terms of money, time and resources. This can be informative to both academics and practitioners. For practitioners, it may highlight that a cheaper and quicker Level 1 approach may not yield enough information to answer management questions. Alternatively, the 'menu' can illustrate that a Level 3 approach may suit broader academic interests but might be too detailed for immediate site priorities. The transparency created by the 'menu' can empower practitioners to contribute to decisions that are most appropriate for management needs. As such, the 'menu' can act as a communication tool within research co-design for resolving different priorities by promoting a mutual understanding of critical questions and options for answering questions, including an open appraisal of cost.

about palaeoecology. Our findings reiterate the view that formalising the practitioners' role in the data collection stage is an important way of legitimising the role of the practitioner and their knowledge (McCabe et al., 2023). Being part of the process ensures that practitioners have continued opportunity to integrate their knowledge into the process, ultimately enabling them to communicate the research more widely. While academic expertise will maintain scientific rigour, it is practitioner involvement as co-researchers that supports salience and legitimacy (Dietl et al., 2023).

3.4 | Phase 4. Implementing research: Communicating and translating results

Phase 4 involves communicating the results of the research between the co-production partners as a step towards transforming the palaeoecological research into practical outputs and contextualising that knowledge within the conservation setting. The discussion emphasised that Phase 4 is not solely about communication but also the translation of results. While traditional communication may be unidirectional within a linear model of dissemination from academic to practitioner (Jarvis et al., 2020), translation requires balanced academic and practitioner input to frame the results in the practitioner context. The process of translating results can be seen as having two steps. The first step is to make the palaeoecological data understandable. The second step is to transform the palaeoecological results into applicable knowledge that can inform solutions to the problem(s) defined in Phase 2.

Regarding the first step, both academic and practitioner participants agreed that the traditional graphical outputs and technical language used to communicate palaeoecological data are not intuitive or widely understood within the conservation community. Practitioners expressed the value of accessible visual presentation. Alternative suggestions to traditional data visualisations (such as the 'dreaded pollen diagram'—Birks, 2012) include the use of infographics, block diagrams, synthesis figures, schematic diagrams, illustrated restoration scenarios and spatially mapped outputs. Creating accessible data visualisations can be an iterative and collaborative process where practitioner feedback is used to create more 'practitioner friendly' plots (Box 1). The creativity displayed in the discussion illustrates the progress made in starting to address this issue within the research community but also indicates 'new training needs' (A3) for palaeoecologists.

Despite the key role for visualisation, some academics were concerned about oversimplifying the message. Moreover, further information may be necessary to bridge gaps in practitioner knowledge, even when data visualisation is adjusted to practitioner needs (Box 1). P5's suggestion to provide a 'primer document' (i.e. a plain language summary) can offset this simplification by expanding on information not included in diagrams and

clarifying the assumptions inherent in interpreting palaeoecological data. A primer document should act as a 'knowledge scaffold' (Vygotsky, 1978; Wood et al., 1976), enabling practitioners to understand the palaeoecology and connect key findings to their own ecological and tacit knowledge. There is a need to be critical about what information is relevant; for example, practitioners may not find value in detailed taxonomic lists of testate amoebae or diatoms, but quantitative reconstructions, for example, of water table depth or water quality parameters derived through transfer functions, are more intuitive. Practitioners expressed that sharing foundational knowledge can be useful for their understanding and for supporting two-way communication regarding research implications. Furthermore, A6 suggested that, in the international context, such primer documents should be written in the practitioner's native language, as the tendency for scientific literature to be published in English can reduce accessibility for practitioners for whom English is not a first language.

The concerns raised in the discussion suggest a need for multiple outputs, allowing academics to communicate effectively with practitioners and fulfil performance reviews that value research papers. Academics tend to prioritise time-consuming, but academically valued, publications (Djenontin & Meadow, 2018); however, this 'pressure to publish academically' (A13) does not encourage rapid delivery of easily digestible and practically relevant information. P4 stated that practitioners need quick access to results in order to maintain momentum and interest, indicate whether work has been successful and inform imminent funding bids. The key to timely delivery is to focus on purpose over perfection (Reed et al., 2014).

The second step is to transform the palaeoecological results into applicable knowledge that can inform solutions to the fundamental problem(s) of common interest. Participants noted that practitioners must often follow site-specific directives that may not align with the restoration targets suggested by palaeoecological analyses. Therefore, this step requires practitioner knowledge on management plans and decision-making, as well as site history, condition and dynamics to keep recommendations feasible (Box 1) (O'Connor et al., 2021; Whitman et al., 2015). For A3, bringing project actors together in workshops and symposia has been a valuable way to collectively 'understand what [the results] meant for the management of the catchment'.

We recognise that not all academics have the necessary skillset to communicate with wider audiences, and the demands of Phase 4 need to be addressed through training, collaboration and development opportunities. While interdisciplinary skills are emphasised in university degree programmes (e.g. Dillon et al., 2022), there is a need to develop this training for academics (Kelley et al., 2018). In parallel, there are few existing resources on how to understand and interpret palaeoecology for practitioners, compared to other elements of conservation practice where 'there's lots of really easy to access information out there' (P2). One suggestion to address this lack of resources is to create a 'palaeoecology toolbox', similar to Historic England's technical guidance for environmental archaeology (Campbell et al., 2011). A 'palaeoecology toolbox' could be a collective effort between palaeoenvironmental researchers and guided by practitioners to create a wider resource for 'translating some of that language into practitioner understanding' (P5).

3.5 | Phase 5. Applying research: Post-project engagement and monitoring research impact

Phase 5 covers implementation of recommendations from Phase 4, wider dissemination and ongoing monitoring of research impacts. Monitoring impact should involve consideration of how project success is defined or evaluated, which raised questions among participants of how we define and document research impact. Phase 5 may also include consideration of what the 'next steps' should be, wider communication of the research within academic, practitioner or policy circles, or further research needs or opportunities. The ability of actors to engage beyond the typical limits of a research project 'fundamentally comes down to funding' (P4) and time, echoing the wider barriers identified for Phases 1 and 2. As such, long-term funding is required to support post-project engagement, impact monitoring, further research, access to the study site and capacity of practitioners to take on additional responsibilities.

Active communication across research, practice and policy is needed to develop the impact of research. There is currently little information on how palaeoecology influences practice and the few existing examples serve to highlight the complexities of translating palaeoecology into practice (cf. Sayer et al., 2012). As such, the wider engagement of Phase 5 should include dissemination to other palaeoecologists, practitioners and policymakers. This communication could include policy-focused outputs, such as POSTnote-style communications (short reports that summarise scientific research and policy implications) and accessible practitioner-focused outputs, such as blogs, podcasts or practitioner magazines. The final suggestion from P11 was to produce digestible case studies that showcase the practical value of palaeoecology and collaborative academic–practitioner relationships. As P12 stated 'One of the main goals is to make palaeoecology more visible, and therefore more likely to be funded in the future'. The potential to produce REF impact case studies from translational palaeoecology research should be considered; in addition to evidencing research value beyond academia, impact case studies may be a way of encouraging further academic–practitioner interaction (Jensen et al., 2022). Wider communication in Phase 5 can be a shared responsibility. The benefits of a shared approach to wider dissemination include that it can be more efficient and a broader platform for the research.

Monitoring the impact of the research is a long-term goal, but it is recognised that 'impact' can have different definitions, which has implications for how impact is evaluated. In the United Kingdom, REF has strict definitions and methods of framing impact that will differ from systems elsewhere. Similarly, academic and practitioner participants will have their own perspectives on what can be considered 'impact', in part framed by their institution and their personal research and career interests. For example,

P12 highlighted the importance of impact on local communities in peatland conservation, explaining that part of the practitioner role is to help 'people understand why peatlands are fragile ecosystems that need to be preserved [...] by connecting people to their landscape'. This community impact and connection may be more difficult to achieve with the 'abstract ecological processes and invisible proxies' (A9) of palaeoecology compared to the human stories found within archaeology. Community, sense of place and perhaps biocultural heritage may be useful ways of framing palaeoecological narratives of landscape fragility and change (Davies, 2011; Lindholm & Ekblom, 2019).

The experiences of the workshop participants support that broader, less tangible and longer-term outcomes still constitute valuable impact (Groff et al., 2023; Lawrence et al., 2022). In particular, the discussion around community engagement exemplifies that good examples of translational palaeoecology do not always lead to on the ground change. A1 demonstrated the broader 'ripple effect' of impact (Rossi et al., 2017) by offering 'the impact … that collaboratively we've achieved, is that now [partnership – name redacted] employ three archaeologists. That is a significant impact of the work we've been doing'; this participant also highlighted the need to consider cumulative impact by noting that success should include the 'broader impact of what we, as a palaeoecological community, have been doing with the people we work with'.

4 | CONCLUSIONS

The workshop demonstrated that there is a strong willingness from amongst academics and practitioners to work together within carefully co-designed programmes that seek to address the challenges faced within ecosystem management, on local scales and in recognition of global environmental crises. On the basis of our discussion, we put forward five key recommendations for academics and four for practitioners to facilitate collaborative research.

For academics wishing to engage in the process of translational palaeoecology we recommend: (i) engaging with the practitioner community through practitioner conferences, meetings, outreach activities and practitioner publications to further promote the practical value of palaeoecology; (ii) inviting practitioners to be part of funding bids and project development; (iii) undertaking collaborative site visits as mutual learning experiences; (iv) broadening communication approaches, with key examples being the 'menu of options' approach to research design and creation of knowledge scaffolds and (v) promoting and engaging with community-wide skill-sharing and training in visual presentation methods and communication.

For practitioners, we recommend: (i) inviting academics to practitioner meetings; (ii) engaging with the research process to contribute their contextual and experiential knowledge; (iii) providing feedback on written communication to clarify areas of knowledge mismatch and (iv) working with academics to produce and communicate policy-targeted case studies. Practitioners are often well positioned to influence, or respond to, funding sources that are not typically explored directly by academics. As such, they may have greater opportunities to advocate for the inclusion of translational palaeoecology within larger funding schemes.

The overarching objective is to build academic–practitioner collaboration throughout the research process. As such, the recommendations should not be viewed as isolated action points but as part of a connected process. A key achievement of the workshop discussions was the sharing of knowledge and perspective among participants. Many of the emerging recommendations focus on empowerment, mutual learning, and equal decision-making. Building and maintaining relationships of mutual respect and trust between the various actors involved remains central to success. Greater effort is needed to document and share the collaborative processes via demonstration case studies of effective palaeo-practitioner partnerships to advance translational palaeoecology.

AUTHOR CONTRIBUTIONS

Jessica Gauld conceived the work and designed the methodology under the supervision of William J. Fletcher and Emma L. Shuttleworth. All authors participated in the workshop. Jessica Gauld undertook the analysis of the workshop transcript. Jessica Gauld prepared the manuscript. All authors contributed to the revision and editing of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

PEER REVIEW

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DATA AVAILABILITY STATEMENT

The participants did not give written consent for the data to be shared publicly, so due to the nature of the research, supporting data are not available.

STATEMENT ON INCLUSION

Our study brings together authors from a number of different countries, including both junior and senior scientists, with a balance of genders and academic and non-academic authors.

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SUPPORTING INFORMATION

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

Table S1. Participant characteristics.

Table S2. Codebook for analysis of workshop materials.

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