Received: 2 April 2025 | Accepted: 9 April 2025

DOI: 10.1002/2688-8319.70031

Ecological Solutions and Evidence

EDITORIAL

Grey matters: Ensuring management information is a part of the permanent evidence base by creating open grey literature principles

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Handling Editor: Lydia Groves

Keywords: applied intervention, evidence, grey literature, publishing

Ecological research has transformed over the past 20 years, striving to be more equitable and adhering to the principles of open and transparent science (Hampton et al., 2015). This transformation has substantially changed how academic ecologists carry out and communicate research. However, ecological practitioners have not been fully included in these priority shifts (Hampton et al., 2013). There are a multitude of reasons for this, including that practitioners are generally less involved in the open dissemination of their science and practice, systemic barriers exist that limit the ability of practitioners to participate in or get credit for their contributions to research and information generation (Cole, 2020), limited access to research publication funds, limited time, restrictions on accessing published literature, language barriers, necessarily prioritising local deliverables, and fewer incentives to embrace the open data and communication revolutions. Further, articles and data are professional currency for academic researchers, whereas practitioners more often prioritise effective solutions. These limitations are further exacerbated in lower-GDP countries where researchers might struggle to pay for access to journals with paywalls or cover publication costs in open access journals (Nabyonga-Orem et al., 2020; Receveur et al., 2024) and face discrimination against languages other than English (Nuñez et al., 2019).

In academic research, the expectation and requirement from funders and journals that data be made widely available has now become accepted across multiple disciplines. GenBank is now the universally accepted repository for genetic sequence data (Leray et al., 2019), with tens of thousands of new submissions and citations annually (Costa et al., 2016). Species occurrence data and museum digitisation have supplied millions of species records for wider use in ecological and other studies (Nelson & Ellis, 2019). The availability of such data has fundamentally transformed research in terms of the scope and scale of analyses, while the trend towards increased accessibility of scientific information has been mirrored by the need to ensure that computer code, created to analyse or generate data, is also permanently and openly available. Researchers routinely upload

their code to the GitHub repository (Dabbish et al., 2012) including for ongoing projects or for maintaining cohesive versions of record. However, because individual authors can alter or delete GitHub files and accounts, other resources that allow for permanent archiving of code, such as the Zenodo code repository (Sicilia et al., 2017), are favoured by journals and publishers.

We have entered an era where all data types are expected to be permanently available in a third-party archive (Dryad, 2024; Mayo et al., 2016). However, while fundamental data access and transparency are deemed crucial for research progress, the conservation biology and ecology open science movement appears to have overlooked the need to share data and protocols from practical management interventions. This gap is unfortunate as these different forms of information are essential for research transparency and reproducibility, and they provide an evidentiary basis for subsequent analyses and assessing new questions. Open access to data from these projects would enable broader scientific evaluation, potentially yielding improved applied conservation and management efforts.

There are mounting calls for applied interventions to be more empirical and research-orientated (Sutherland, 2022), both in terms of building on past research (Segan et al., 2011; Sutherland et al., 2020) and generating evidence that can both guide future management actions and improve our general understanding of the natural world (Ockendon et al., 2020). One effective approach to simultaneously maximising scientific rigour and actionable science is to prioritise coproduction where researchers work closely with managers/practitioners from the inception of a project to the final deliverables (Enquist et al., 2017; Kurle et al., 2022; Meadow et al., 2015). Another approach to ensuring evidence is incorporated into practice is through concise and thorough evidence summaries. Conservation Evidence (www.conservationevidence.com) is an invaluable resource that compiles evidence for the efficacy of applied management actions and interventions based on systematic searches and synthesis of the published literature (Sutherland et al., 2019) and thus provides valuable information to inform the sound design of future management actions.

Despite these approaches to ensuring effective empiricism in practice, given the sheer number of organisations and interventions, codesigned research can never fully replace practitioner interventions. Further, despite the widespread availability of a resource like Conservation Evidence to collate and synthesise peer-reviewed scientific literature, the data and knowledge generated by management activities are not commonly fed into the open information pipeline. Management interventions produce a diversity of information types that include data, photographs, project descriptions, project reports, case studies, best management practices, policy briefs, executive summaries, workshop and training materials, white papers, planning documents and so on. These can be collectively referred to as 'grey literature'. Grey literature is a catch-all term for information residing outside of peer-reviewed publications and does not by default benefit from standard distribution pipelines, such as journals, preprint servers, data repositories or books and edited volumes (Monash University Library, 2020), although grey literature can go through informal or organisational review processes. Peer-reviewed publications have accepted methods of storage to ensure long-term access (permanent), appear with common search tools (discoverable), and have standardised attribution (citable). We believe that grey literature can similarly be permanent, discoverable and citable, while also conforming to the accepted norms of open research.

1 | WHY MANAGEMENT INFORMATION IS NEEDED

Practitioners conducting on-the-ground interventions and management actions designed to maximise their impacts should have collected information on pre-intervention conditions, along with baseline or benchmark data to assess outcomes, measure the efficacy of management interventions, monitor key variables and more. Further, these projects often result in reports that summarise and synthesise the outcomes or provide management or policy guidance. This information has immense value beyond the actual project. Data collection that comprises robust, high-quality observations can contribute to the knowledge of ecological phenomena, such as species occurrences and abundances (with exemptions for sensitive species), population trajectories, ecosystem properties and phenological events, all of which can be used for testing future ecological hypotheses. The assessments of the management outcomes can help guide similar interventions planned by other agencies and practitioners, saving them from wasting resources by applying ineffective methods. Management policy implications discovered on one project can be used to inform planning elsewhere, providing legitimacy for advocates of new management strategies in similar systems.

Knowledge synthesis is best supported by studies from a diversity of information sources (Bayliss & Beyer, 2015), especially for developing practice or policy insights. Not only are the data and observations themselves of value for more widespread scientific investigations, but the insights, experience and judgement of practitioners can inform management practice elsewhere, and this collective experience is currently not effectively shared. Any attempts at generating broadly applicable management tools (e.g. Extinctions Solutions Index; Martin et al., 2024) require a large number of management evaluations. As a result, there are increasing calls for systematic reviews to move beyond peer-reviewed articles and to include grey literature (Adams & Kanaroglou, 2016). However, if there is variation in how grey literature is made available, including the extent to which it is made easily discoverable, such as through storage in repositories, then the inclusion of grey literature into systematic reviews could potentially be biased by the idiosyncratic nature of how the literature is found. Further, format and presentation can be quite variable for grey literature.

Subject-wide evidence synthesis entails compiling the literature of large subject areas and can include both peer-reviewed and grey literature, though decisions about inclusion criteria need to be made and communicated by the project team. For example, a team might

wish to consider a specific geographical area, a subset of organisms or specific actions or outcomes (Sutherland, 2022). This approach absolutely respects that better quality studies are stronger evidence but posits that it is worth considering the totality of evidence, including that contained within grey literature, then assessing the quality, relevance and bias of all available data in order to arrive at the most robust and inclusive conclusion (Christie et al., 2023).

Additionally, due to limitations of time and other resources inherent to working in management and conservation agencies, practitioners are likely to prioritise cost- and time-effective monitoring of natural resources and concise communication of management actions, so grey literature is more likely to report surrogate and cumulative indices that aim to capture ecological composition, structure and function in ways that not only better align with policy and practice (Wurtzebach & Schultz, 2016), but are also economical. Ecological and environmental integrity metrics are prevalent in regulatory policy and legislative documents (Kuehne et al., 2017), so it is imperative that these types of grey literature also be contextualised and evaluated through incorporation into systematic reviews and meta-analyses. This would allow for a better assessment of their robustness (Doncaster & Spake, 2018) and improve the evidence-based decision-making of policymakers (Yoshida et al., 2024).

2 | A CALL FOR OPEN GREY LITERATURE

Given the importance of grey literature for increasing the strength and value of knowledge syntheses, designing applied interventions and developing best management practices, we are issuing a call for a change in philosophy. Open grey literature (OGL), much like open science, requires a commitment to core principles that ensure that information arising from applied interventions is made useful to others.

We present four key principles that should be adhered to in the publication of OGL:

1. Upload grey literature to a third-party repository with a long-term sustainability plan to ensure permanence and discoverability.
2. Ensure that the material produced by practitioners contributing to grey literature is factually correct, without omissions and created with an attempt to be error-free. Limitations, such as the inability to make observations due to weather, unexpected changes in methodology or shifts in priorities part way through implementation, need to be described. Grey literature is not peer-reviewed; however, providing details on its review by colleagues or other professionals would provide greater credibility.
3. Clearly describe the context and evidence used to support conclusions or recommendations. This would include the methods by which information was collected, details on the analyses and metrics used, the reference or baseline conditions and descriptions of any limitations identified in #2 that might impact the strength of the conclusions.
4. Identify potential conflicts of interest, funding sources and all participants such as the organisation(s) employing the authors and all contributors to the project and resulting document. This allows for appropriate attribution, provides contact information for the corresponding author and/or organisation, and increases trust in the integrity of the data.

Transitioning to this way of working will depend on the support of multiple stakeholders. Government agencies, large NGOs, funders, journals and professional societies can help drive a commitment to and adoption of OGL and the core principles by adding information management and communication to the core competencies of practitioners (e.g. CIEEM: Chartered Institute of Ecology and Environmental Management, 2024). Much like the adoption of open access publishing or GenBank and other repositories, such stakeholders can adopt policies requiring that grey literature conform to OGL principles. Funders that support applied projects have an important role to play as they can require communication plans that adhere to OGL principles and provide a percentage of the funding to ensure that reports and other materials are adequately archived. Journals also have a critical role to play. Articles that rely on or reference grey literature should ensure that these materials are available in an archive; if not, journals should require that the authors or authoring organisation deposit this material in a repository or request permission to upload the materials themselves.

Government agencies and NGOs have the largest supply of grey literature, and yet little of their output is discoverable and permanently archived. We have heard numerous anecdotes about workers in large NGOs or government agencies not being able to find reports or data from within their own organisation several years after publication. Agencies do often have bespoke repositories used to fulfil legislated storage requirements (e.g. https://ecos.fws.gov/ecp/), but these are fragmented, not easily discoverable and subject to agency or policy changes that can threaten access to stored material. Although many organisations host grey literature on their own servers, often highlighted on organisational webpages, we argue that grey literature materials should be stored in an independent repository with a clear plan for permanence. Organisations might dissolve, be reorganised, change focus or undergo other changes that could easily result in the loss of grey literature. For example, the closing of the Natural Resources Wales physical library threatens the permanence and discoverability of valuable information (Newman, 2024). Further, the Centers for Disease Control and Prevention in the USA had websites hosting data and reports removed when that country transitioned to President Trump's administration (Wu, 2025). Such losses of information reduce the long-term value of the work for the organisations that contribute resources to the projects and reports, but also cost the larger communities of practitioners, policymakers and academics because valuable knowledge and insight have disappeared. Organisations bear responsibility to their funders, stakeholders and the public to ensure that information is permanently available. Professional societies have a role to play as well, through their publications and editorial processes, to set and communicate

standards to their members and to require that grey literature is adequately available.

3 | SOLUTIONS FOR LONG-TERM STORAGE OF GREY LITERATURE

There are several document archives that host grey literature permanently and for low cost. Figshare (www.figshare.com), Zenodo (www.zenodo.org), as well as university repositories like Scholarworks, developed by the California State University (https://scholarworks.calstate.edu/), all provide permanent archiving, are free to download and provide unique identifiers, making the material citable. However, we argue that it is preferable to have conservation and applied ecology materials housed together, making it easier to search and identify relevant material. Below we discuss the British Ecological Society's *Applied Ecology Resources* as this platform.

4 | APPLIED ECOLOGY RESOURCES

While *Ecological Solutions and Evidence* (ESE) provides a venue for practitioners to publish peer-reviewed articles that describe project outcomes, new methods and important insights through flexible article types like *Practice Insights*, *Applied Methods* and *Data Papers*, it does not suit all types of grey literature. Best practices for projects should include a strategy for the storage and dissemination of resulting reports and other materials not submitted to peer-reviewed journals. *Applied Ecology Resources* (*AER*: https://www.britishecologicalsociety.org/applied-ecology-resources) is ESE's companion resource that serves as a grey literature repository and adheres to the OGL principles described above (Cadotte et al., 2020). *AER* is a permanent, searchable and citable repository that is free to read, easy to submit materials, and flexible enough to host a diversity of grey literature materials in multiple languages. As such, *AER* is a logical venue for grey literature material produced by organisations and practitioners, and its widespread use could lead to greater resource efficiency, such as freeing funds used to maintain individual data servers. Even if one of the goals of a project is to produce a peer-reviewed article, supporting grey literature materials can still be submitted to *AER*, cited and linked in the peer-reviewed article.

5 | BENEFITS OF PUBLISHING GREY LITERATURE

There are several direct and indirect benefits to practitioners for publishing their grey literature in a repository like *AER*. Indirectly, as stated above, grey literature adds to our collective knowledge base and expands our understanding of applied interventions and ecology.

Additional important direct benefits of publishing grey literature include:

1. *Improved funding applications*: More robust justifications of past and future management actions and decisions can be achieved through access to and use of the greater sources of citable evidence available in grey literature. Further, a commitment to submit materials to a repository like *AER* can be a critical component of the dissemination plan in a proposal.
2. *More comprehensive annual reports*: Meaningful qualitative or quantitative elements of broader impact for annual reports are increased when data from grey literature is included. This could encompass quantitative measures such as the number of publications, page views and downloads. Qualitatively, there could be narratives about usage and impact resulting from wider dissemination of results. Further, sharing annual reports shows a commitment to ensuring that work that is funded by the public (from taxes and donations) is made available.
3. *Increased profile and visibility*: The profiles of organisations and individuals conducting important and impactful management- and conservation-related research are raised when grey literature is more widely available. Further, these groups can receive credit for their work. This recognition can help ensure that those working on a particular topic are recognised as leaders, thus opening new doors for projects and collaboration.
4. *Enhanced network building*: The creation of broader networks of applied management practice is more likely with increased access to grey literature, which can lead to new opportunities or events to share knowledge and experience.
5. *Heightened trust and transparency*: Trust in management outcomes and actions is increased when the ecological science used to address a potentially controversial subject is widely available, thus alleviating potential grounds for conflict.

6 | LIMITATIONS

Some limitations need to be considered when publishing grey literature in repositories such as *AER*.

As mentioned previously, grey literature describes a myriad of information and document types, and this heterogeneity can make evaluation difficult. Further, grey literature that is generated for specific audiences or stakeholders could contain proprietary information, intellectual property or other sensitive material such as the locations of rare species or that which compromises individual privacy. Thus, care must be taken by the document authors to determine that which can be shared responsibly with the public.

Grey literature repositories are outside of the traditional peer-reviewed process, thus the materials they host do not meet the same standard of credibility as journal articles (Kelly et al., 2014). *AER* has a dedicated staff ensuring that items are legitimate documents and that they contain metadata for searches, but this staff do not evaluate the rigour or scientific validity of the submissions. Therefore, users of grey literature are required to assess the reliability of the documents, and this can be done by evaluating several criteria (Cadotte, 2020; Tyndall, 2010), such as:

1. *Authority and reliability*: Who authored the document? Is it from a reputable organisation or one that has a clear agenda that might bias conclusions?
2. *Knowledge context*: Does the document reference other sources of information or context?
3. *Timeliness*: When was the document produced and how recent is the information?
4. *Transparency*: Does the document state transparent methodology and criteria for evaluating outcomes and generating inferences?
5. *Fairness*: Does the work seem balanced in its presentation?

The adherence of grey literature authors to the OGL principles detailed above will contribute to increased alignment with these criteria.

7 | CONCLUSIONS

A wealth of information produced by individuals and organisations that perform and assess applied ecological and conservation projects does not appear in peer-reviewed articles but is instead the substance of grey literature. This often-hidden resource can provide immense value as evidence to inform related regulatory policy and management actions and as data for use in subsequent hypothesis tests. As with peer-reviewed articles, grey literature should aspire to be permanent, discoverable, citable and free to read and, in doing so, policy, management and evidence will become more robust and repeatable. Here we outline the need for open grey literature that ascribes to open science norms, and we present four key principles for ensuring quality of grey literature reporting, underscore the multiple benefits inherent to more available grey literature, and recommend solutions for long-term storage and accessibility of this valuable resource.

AUTHOR CONTRIBUTIONS

MWC conceived of this article. All authors contributed to the concept and manuscript text.

CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

No data was used in this article.

FUNDING INFORMATION

MWC thanks the generous support from the Natural Sciences and Engineering Research Council of Canada (#386151).

PEER REVIEW

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1002/2688-8319.70031.

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