

depositors on new data analyses. However, we do not feel that this should be a mandatory policy, and such consultation will be less needed when the data are reused as a part of a larger meta-analysis (see [5]).

- For substantial reanalyses of data sets that do not include original data collectors as authors, journals should endeavor to enlist one or more of the original data collectors as reviewers, as Mills *et al.* suggest [3]. Obviously, this practice has the potential for abuse. However, reviews from data collectors will, in most cases, be invaluable for assessing the appropriateness of the data set for the questions being addressed in the new analysis.
- Scientific funders should make clear that long-term projects are valued, especially when the data from them are broadly available for reuse within a reasonable time frame. All scientific products made possible by the data sets, whether produced by the original data collectors or others, should be counted when assessing the return on investment of grants supporting long-term projects. We also think that it is reasonable and responsible for funders to set stricter standards on the openness of data than we suggest above for journals.

Data archiving allows the scientific community to produce new results economically [6] and permits the essential verification of existing results [7]. Without public archiving, data are lost [8] or simply not shared [9]. If journals provide more clarity, unity, and flexibility for longer embargoes for long-term data sets, the incentive to collect long-term data can be retained while still ensuring that the valuable data from long-term studies will not be lost to the broader scientific community.

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## Letter

### Solutions for Archiving Data in Long-Term Studies: A Reply to Whitlock *et al.*

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In our recent paper [1], we discussed some potential undesirable consequences of public data archiving (PDA) with specific reference to long-term studies and proposed solutions to manage these issues. We reaffirm our commitment to data sharing and collaboration, both of which have been common and fruitful practices supported for many decades by researchers involved in long-term studies. We acknowledge the potential benefits of PDA (e.g., [2]), but believe that several potential negative consequences for science have been underestimated [1] (see also [3,4]). The objective of our recent paper [1] was to define practices to simultaneously maximize the benefits and minimize the potential unwanted consequences of PDA.

Commenting on our paper, several former and current editors of major ecology and evolution journals [5] acknowledge the need to improve data archiving practices to account for the concerns presented in [1]. The fact that editors of several journals were willing to comment on our paper underlines the importance of this issue and we are keen to continue this dialogue to identify potential solutions. Following our [1] and Roche *et al.*'s [6] suggestions, Whitlock *et al.* [5] endorse as good practice longer embargos (5 years) and encourage cooperation or collaboration with data providers. Both steps are major advances as many of the Principal Investigators (PIs) in [1] have been denied longer embargos, and the practice of consulting PIs to ensure that data files are properly interpreted is not a formal policy in any scientific journal.

We welcome these positive developments but underline three concerns, two of which extend beyond the purview of individual journals.

Whitlock *et al.* [5] mention that current policies 'require only that authors make available the data necessary to recreate the analyses and results in the published manuscript'. For an article that includes an analysis based on a pedigree and individual data or on lifetime reproductive success and potential predictor variables, this requirement involves providing a detailed database of the breeding performance of individuals and their progeny over decades. The costs of data gathering, including resources beyond monetary ones, are borne by the data providers and their institutions not by those who would use the data; consequently, providing such extensive datasets is sustainable if the data are used only to verify the original analysis. Extending an embargo to 5 years for such data is a good step, but for studies that extend over decades a longer embargo is warranted, notably to further encourage potential users to contact PIs to get the latest version of the data, and ideally collaborate.

Databases from long-term studies are an evolving infrastructure that underpins numerous publications. New data are added each year and errors and omissions are corrected regularly. Over time, archives often include various versions of fragmented datasets that: (i) could be combined by others in ways that the data collectors were already doing or planning to do themselves; or (ii) may differ from each other in ways that are likely to lead to misinterpretation of the data. A single journal's PDA policy cannot ensure that data from long-term studies are not misused. It must be a community decision. Some potential solutions include archiving at institutional servers with separate policies for the distribution of data necessary to reproduce previously published analyses and data requests for additional analyses. The additional analyses would require collaboration with the PI.

Finally, journal editors do not control the policies of funding agencies but their stature in the community can be influential. Whitlock *et al.* [5] suggest that funders should set standards for openness. However, long-term studies typically involve several grants and multiple funding agencies, sometimes from different countries. Hence, any discrepancy between their policies can lead to potentially insoluble conflict. Institutions that fund a significant proportion of the research, potentially over decades, may also question the value of continued funding if the data are freely available to individuals from other organizations.

We are encouraged by the letter from Whitlock *et al.* [5], but believe that there are additional issues that need to be addressed. Some of these may be solved by a more explicit and flexible policy on longer embargos, data storage on institutional servers, and involvement of the principal investigators in new analyses using the data they produced, through collaboration or reviews. We hope that this important dialogue will continue.

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## Letter

# Resilience in the Studies of Biodiversity–Ecosystem Functioning

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The concept of 'resilience', which helps describe system responses to change, is

increasingly attracting attention [1–3]. Biodiversity is often thought to be a key feature underpinning the resilience of ecosystems [4–7]. Importantly, one of the primary focuses of biodiversity studies has been to elucidate the mechanisms by which biodiversity stabilizes ecosystem functions under environmental changes (disturbance) [4,5,8]. However, it is still not feasible to incorporate knowledge of diversity–stability relationships into the real-world situations of ecosystem management [9] and thus the application of this research remains severely limited.

The multiple meanings and measures of resilience currently in use make it difficult to determine whether and how biodiversity, or other system features, influence resilience. According to the resilience theory of Holling [10], changes are ubiquitous in ecosystems and the resilience of a system determines its capacity for absorbing changes to maintain fundamental controls on function and structure [2,3]. An important feature of this concept is the emphasis on possible alternative system properties that are associated with renewal and reorganization after disturbance [2,3]. Although this perception of 'ecological resilience' [3] is widely used, many policy and management documents, as well as academic literature, use another definition of resilience, 'engineering resilience' [3], which is defined as the time taken to return to close to the pre-disturbance state [11]. A recent synthesis by Nimmo *et al.* [12] proposed that engineering resilience has much to offer conservation science and practice. Other syntheses by Oliver *et al.* [7] and Connell and Ghedini [13] have similarly identified numerous management implications based on a focus on resistance and recovery (i.e., engineering resilience). Some of these syntheses and others have concluded that biodiversity is crucial for resilience, which is not necessarily consistent with empirical evidence. A global synthesis of plant diversity experiments found that biodiversity did not consistently