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.

[1]Department of Zoology, University of British Columbia, Vancouver, V6T 1Z4, Canada
[2]Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ 85721, USA
[3]Department of Wildlife Ecology and Conservation, University of Florida, PO Box 110430, Gainesville, FL 32611-0430, USA
[4]Center for Latin American Studies, University of Florida, PO Box 11530, Gainesville, FL 32611-5530, USA
[5]Harvard Forest, Harvard University, Petersham, MA 01366, USA
[6]Department of Entomology, University of Kentucky, Lexington, KY 40546-0091, USA
[7]Department of Biological Sciences, Dartmouth College, Hanover, NH, USA
[8]Department of Genetics, University of Georgia, Athens, GA 30602, USA
[9]Department of Biology, Duke University, Durham, NC 27708, USA
[10]Department of Botany, University of British Columbia, Vancouver, V6T 1Z4, Canada
[11]School of Biology, University of St Andrews, St Andrews, KY16 9AJ, UK
[12]Department of Ecology, Evolution and Behavior, University of Minnesota, Minneapolis, MN 55108, USA

*Correspondence: whitlock@zoology.ubc.ca (M.C. Whitlock).

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Letter

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

James A. Mills,[1,53,*] Céline Teplitsky,[2,3,53] Beatriz Arroyo,[4] Anne Charmantier,[3] Peter. H. Becker,[5] Tim R. Birkhead,[6] Pierre Bize,[7] Daniel T. Blumstein,[8] Christophe Bonenfant,[9] Stan Boutin,[10] Andrey Bushuev,[11] Emmanuelle Cam,[12] Andrew Cockburn,[13] Steeve D. Côté,[14] John C. Coulson,[15] Francis Daunt,[16] Niels J. Dingemanse,[17,18] Blandine Doligez,[9] Hugh Drummond,[19] Richard H.M. Espie,[20] Marco Festa-Bianchet,[21] Francesca D. Frentiu,[22] John W. Fitzpatrick,[23] Robert W. Furness,[24] Gilles Gauthier,[14] Peter R. Grant,[25] Michael Griesser,[26] Lars Gustafsson,[27] Bengt Hansson,[28] Michael P. Harris,[16] Frédéric Jiguet,[2] Petter Kjellander,[29] Erkki Korpimäki,[30] Charles J. Krebs,[31] Luc Lens,[32] John D.C. Linnell,[33] Matthew Low,[34] Andrew McAdam,[35] Antoni Margalida,[36] Juha Merilä,[37] Anders P. Møller,[38] Shinichi Nakagawa,[39] Jan-Åke Nilsson,[27] Ian C.T. Nisbet,[40] Arie J. van Noordwijk,[41] Daniel Oro,[42] Tomas Pärt,[34] Fanie Pelletier,[21] Jaime Potti,[43] Benoit Pujol,[12] Denis Réale,[44] Robert F. Rockwell,[45]

Yan Ropert-Coudert,[46] Alexandre Roulin,[47] Christophe Thébaud,[12] James S. Sedinger,[48] Jon E. Swenson,[49] Marcel E. Visser,[41] Sarah Wanless,[16] David F. Westneat,[50] Alastair J. Wilson,[51] and Andreas Zedrosser[52]

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.

[1]10527A Skyline Drive, Corning, NY 14830, USA
[2]CESCO, UMR7204 Sorbonne Universités-MNHN-CNRS-UPMC, CP51, 55 rue Buffon, 75005 Paris, France
[3]Centre d'Ecologie Fonctionnelle et Evolutive UMR 5175, Campus CNRS, 1919 route de Mende, 34293 Montpellier Cedex 5, France
[4]Instituto de Investigacion en Recursos Cinegeticos (IREC) (CSIC-UCLM-JCCM), Ronda de Toledo s/n, 13005 Ciudad, Real, Spain
[5]Institute of Avian Research, "Vogelwarte Helgoland", An der Vogelwarte 21 D26386 Wilhelmshaven, Germany
[6]Department of Animal and Plant Sciences, University of Sheffield, Sheffield, UK
[7]Institute of Biological and Environmental Sciences, University of Aberdeen, Aberdeen, UK
[8]Department of Ecology and Evolutionary Biology, University of California, 621 Young Drive South, Los Angeles, CA 90095-1606, USA
[9]CNRS, Université Lyon 1, Université de Lyon, UMR 5558, Laboratoire Biométrie et Biologie Évolutive, 43 boulevard du 11 Novembre 1918, F-69622 Villeurbanne Cedex, France
[10]Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9, Canada
[11]Department of Vertebrate Zoology, Faculty of Biology, Lomonosov Moscow State University, Leninskie Gory 1/12, 119234 Moscow, Russia
[12]UMR 5174 EDB Laboratoire Évolution et Diversité Biologique, CNRS, ENFA, Université Toulouse 3 Paul Sabatier, Toulouse 31062 Cedex 9, France
[13]Department of Evolution, Ecology, and Genetics, Research School of Biology, The Australian National University, Canberra, Australia

[14]Département de Biologie and Centre d'Études Nordiques, Université Laval, 1045 avenue de la Médecine, QC G1V 0A6, Canada
[15]29St Mary's Close, Shincliffe, Durham DH1 2ND, UK
[16]Centre for Ecology and Hydrology, Bush Estate, Penicuik EH26 0QB, UK
[17]Behavioural Ecology, Department of Biology, Ludwig Maximilian University of Munich, Planegg-Martinsried, Germany
[18]Evolutionary Ecology of Variation Research Group, Max Planck Institute for Ornithology, Seewiesen, Germany
[19]Departamento de Ecología Evolutiva, Instituto de Ecología, Universidad Nacional Autónoma de México, AP 70-275, México DF 04510, México
[20]Technical Resource Branch, Saskatchewan Ministry of Environment, 3211 Albert Street, Regina, SK S4S 5W6, Canada
[21]Département de Biologie, Université de Sherbrooke, 2500 boulevard de L'Université, Sherbrooke, QC J1K 2R1, Canada
[22]School of Biomedical Sciences and Institute of Health and Biomedical Innovation, Queensland University of Technology, Kelvin Grove, QLD 4059, Australia
[23]Cornell Laboratory of Ornithology, 159 Sapsucker Woods Road, Ithaca, NY 14850, USA
[24]Graham Kerr Building, University of Glasgow, Glasgow G12 8QQ, UK
[25]Department of Ecology and Evolutionary Biology, Princeton University, Princeton, NJ 08544-1003, USA
[26]Anthropological Institute and Museum, University of Zürich, Zürich, Switzerland
[27]Department of Animal Ecology, Evolutionary Biology Center, Uppsala University, Uppsala, Sweden
[28]Department of Biology, Lund University, Ecology Building, 223 62 Lund, Sweden
[29]Grimso Wildlife Research Station, Department of Ecology, Swedish University of Agricultural Sciences (SLU), SE-73091 Riddarhyttan, Sweden
[30]Section of Ecology, Department of Biology, University of Turku, FI-20014 Turku, Finland
[31]Department of Zoology, University of British Columbia, Vancouver, BC V6T 1Z4, Canada
[32]Terrestrial Ecology Unit, Department of Biology, Ghent University, Ledeganckstraat 35, B-9000 Gent, Belgium
[33]Norwegian Institute for Nature Research, PO Box 5685 Sluppen, N-7485 Trondheim, Norway
[34]Department of Ecology, Swedish University of Agricultural Sciences, 75007 Uppsala, Sweden
[35]Department of Integrative Biology, University of Guelph, Guelph, ON N1G 2W1, Canada
[36]Faculty of Life Sciences and Engineering, University of Lleida, E-25198 Lleida, Spain
[37]Ecological Genetics Research Unit, Department of Biosciences, PO Box 65 (Biocenter 3, Viikinkaari 1), FIN-00014 University of Helsinki, Finland
[38]Laboratoire Ecologie, Systématique, et Evolution, Equipe Diversité, Ecologie et Evolution Microbiennes, Bâtiment 362, 91405 Orsay Cedex, France
[39]Evolution and Ecology Research Centre and School of Biological, Earth, and Environmental Sciences, University of New South Wales, Sydney, Australia
[40]ICT Nisbet & Company, 150 Alder Lane, North Falmouth, MA 02556, USA
[41]Department of Animal Ecology, Netherlands Institute of Ecology (NIOO-KNAW), PO Box 50, 6700 AB Wageningen, The Netherlands
[42]Institut Mediterrani d'Estudis Avançats IMEDEA (CSIC-UIB), Miquel Marques 21, 07190 Esporles Mallorca, Spain
[43]Departamento de Ecologia Evolutiva, Estación Biológica de Doñana-CSIC, Av. Américo Vespucio s/n, 41092 Seville, Spain
[44]Département des Sciences Biologiques, Université du Québec à Montréal, CP 8888-succursale Centre-Ville, Montreal, QC H3C 3P8, Canada
[45]Vertebrate Zoology, American Museum of Natural History, New York, NY 10024, USA
[46]Institut Pluridisciplinaire Hubert Curien, CNRS UMR7178, 23 rue Becquerel, 67087 Strasbourg, France
[47]Department of Ecology and Evolution, University of Lausanne, Lausanne, Switzerland
[48]Department of Natural Resources and Environmental Science, University of Nevada Reno, Reno, NV 89512, USA
[49]Department of Ecology and Natural Resource Management, Norwegian University of Life Sciences, PO Box 5003, NO-1432 Ås, Norway and Norwegian Institute for Nature Research, PO Box 5685 Sluppen, N-7485 Trondheim, Norway
[50]Department of Biology, Center for Ecology, Evolution, and Behavior, University of Kentucky, Lexington, KY, USA
[51]Centre for Ecology and Conservation, College of Life and Environmental Sciences, University of Exeter, Cornwall Campus, Penryn TR10 9EZ, UK
[52]Faculty of Arts and Sciences, Department of Environmental and Health Studies, Telemark University College, N-3800 Bø i Telemark, Norway
[53]These authors contributed equally

*Correspondence: dmills@stny.rr.com (J.A. Mills).

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Letter

Resilience in the Studies of Biodiversity–Ecosystem Functioning

Akira S. Mori[1,*]

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