Ensuring that tests of conservation interventions build on existing literature

William J. Sutherland[1] , Sergio Ticul Alvarez-Castañeda[2], Tatsuya Amano[3], Roberto Ambrosini[4], Philip Atkinson[5], John M Baxter[6], Alexander L. Bond[7], Philip J Boon[8], Katherine L Buchanan[9], Jos Barlow[10], Giuseppe Bogliani[11] , Olivia M. Bragg[12], Mark Burgman[13], Marc W. Cadotte[14], Michael Calver[15], Steven J. Cooke[16], Richard T. Corlett[17], Vincent Devictor[18], John G Ewen[19], Martin Fisher[20], Guy Freeman[21], Edward Game[22], Brendan J. Godley[23], Christian Gortázar[24], Ian R. Hartley[25], David L Hawksworth[26], Keith A. Hobson[27], Ming-Lun Lu[28], Berta Martín-López[29], Keping Ma[30], Antonio Machado[31], Dirk Maes[32], Marco Mangiacotti[33], Dominic J. McCafferty[34], Victoria Melfi[35], Sanjay Molur[36], Allen J. Moore[37], Stephen D. Murphy[38], Darren Norris[39], Alexander P.E. van Oudenhoven[40], Jennifer Powers[41], Eileen C. Rees[42], Mark W. Schwartz[43], Ilse Storch[44] and Claire Wordley[1]

1 Conservation Evidence, Conservation Science Group, Department of Zoology, University of Cambridge, David Attenborough Building, Cambridge CB2 3QZ, UK

2. Therya, Sergio Ticul Alvarez-Castañeda, Centro de Investigaciones Biológicas del Noroeste, La Paz, BCS 23096, México

3. School of Biological Sciences, The University of Queensland, Brisbane, 4072 Queensland, Australia

4 Avocetta - Journal of Ornithology , and Department of Environmental Science and Policy, University of Milan, Via Celoria 26, I-20133, Milan, Italy.

5 Bird Conservation International, British Trust for Ornithology, The Nunnery, Thetford, Norfolk IP24 2PU, UK

6 Aquatic Conservation, School of Biology, Scottish Oceans Institute, East Sands, University of St Andrews, St Andrews, Fife, KY16 8LB, Scotland

7 Avian Conservation and Ecology, Natural History Museum at Tring, The Walter Rothschild Building, Akeman St, Tring HP23 6AP, UK

8 Aquatic Conservation: Marine and Freshwater Ecosystems, The Freshwater Biological Association, The Ferry Landing, Far Sawrey, Ambleside, Cumbria LA22 0LP, UK

9 Emu - Austral Ornithology, Kate Buchanan School of Life & Environmental Sciences, Faculty of Science, Engineering & Built Environment, Deakin University, Geelong, VIC 3220, Australia

10. Journal of Applied Ecology, Lancaster Environment Centre, Lancaster University, Lancaster LA1 4YQ, UK

11. Rivista italiana di ornitologia-Research in Ornithology, Department of Earth and Environmental Sciences. University of Pavia, Via Adolfo Ferrata 9, 27100 Pavia -Italy

12 Mires and Peat, Geography, University of Dundee, Dundee DD1 4HN, UK.

13 Conservation Biology, Centre for Environmental Policy, Imperial College, London Weeks Building, 16-18 Princes Gardens, London SW7 1NE, UK

14 Ecological Solutions and Evidence, University of Toronto Scarborough, Toronto, ON, M1C 1A4, Canada

15 Pacific Conservation Biology, Environmental and Conservation Sciences, Murdoch University, Murdoch, WA, Australia 6150

16 Conservation Physiology, Department of Biology and Institute of Environmental and Interdisciplinary Science, Carleton University, Ottawa, ON, Canada, K1S 5B6

17 Global Ecology and Conservation, Center for Integrative Conservation, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Menglun, Mengla, Yunnan 666303, China

18 Biological Conservation, ISEM, Univ Montpellier, CNRS, EPHE, IRD, Montpellier, France

19 Animal Conservation, Institute of Zoology, Zoological Society of London, Regents Park NW1 4RY London, UK

20. Oryx, Fauna & Flora International, The David Attenborough Building, Pembroke Street, Cambridge, CB2 3QZ, UK

21 Conservation Land Management, NHBS Ltd, 1-6 The Stables, Ford Road, Totnes, Devon, TQ9 5LE UK

22 Conservation Letters, The Nature Conservancy, Brisbane, Australia

23 Endangered Species Research, Centre for Ecology and Conservation University of Exeter, Penryn Campus, Cornwall, TR10 9FE, UK

24. European Journal of Wildlife Research, Ronda de Toledo 12, 13005 Ciudad Real, Spain

25 Bird Study, Lancaster Environment Centre, Lancaster University, Lancaster LA1 4YQ, UK

26 Biodiversity and Conservation, Comparative Plant and Fungal Biology, Royal Botanic Gardens, Kew, Surrey TW9 3DS, UK.

27. Avian Conservation and Ecology, Dept. Biology and Environment and Climate Change Canada, University of Western Ontario, Room 2025 BGS Building,1151 Richmond St. N., London, Ontario, N6A 5B7

28. Taiwan Journal of Biodiversity, Division of Management, Taiwan Endemic Species Research Institute, Nantou, Taiwan

29 Ecosystems and People, Faculty of Sustainability, Leuphana University of Lüneburg, 21335 Lüneburg, Germany

30 Biodiversity Science, 20 Nanxincun, Xiangshan, Haidian District, Beijing 100093

31 Journal for Nature Conservation, Chopin 1, 38208 La Laguna, Tenerife, Canary Islands, Spain

32. Journal of Insect Conservation, Species Diversity Group, Research Institute for Nature and Forest (INBO), Brussels, Belgium

33. Acta Herpetologica, Department of Earth and Environmental Sciences, University of Pavia, Via Taramelli 24, 27100, Pavia, Italy

34 IBIS, British Ornithologists' Union, P.O. Box 417, Peterborough PE7 3FX, UK

35 Journal of Zoo and Aquarium Research, Hartpury University, Gloucester, GL19 3BE UK

36 Journal of Threatened Taxa, 12 Thiruvannamalai Nagar, Kalapatti-Saravanampatti Road, Saravanampatti, Coimbatore, Tamil Nadu 641035, India

37. Ecology and Evolution, College of Agricultural and Environmental Sciences, The University of Georgia, 109 Conner Hall, Georgia USA

38. Restoration Ecology, School of Environment, Resources & Sustainability, University of Waterloo, Waterloo, ON Canada

39 Tropical Conservation Science, School of Environmental Sciences, Federal University of Amapá, AP, Brazil, 68903-419

40 Ecosystems and People, Institute of Environmental Sciences CML, Leiden University, Einsteinweg 2, 2333 CC, Leiden, The Netherlands

41 Biotropica, College of Biological Sciences, University of Minnesota, 1987 Upper Buford Circle, St. Paul, MN 55108, USA

42. Wildfowl, WWT Martin Mere Wetland Centre, Fish Lane, Burscough, Lancashire L40 0TA, UK

43. Conservation Science and Practice, Department of Environmental Science and Policy, University of California, Davis 95616, United States.

44. Wildlife Biology, Faculty of Environment and Natural Resources, University of Freiburg, D-79085 Freiburg, Germany

Testing conservation actions will improve practice, policy and outcomes. Studies must be informed by the pertinent literature, especially by papers testing the same management actions. Limited and selective citing of previous studies can hamper the effective use of

collective knowledge. Forty conservation journals are addressing this, by asking authors to reflect on existing evidence and to place their study in context.

Scientific knowledge grows by building on previous understanding, summarised by Isaac Newton's phrasing of a much older idea, 'If I have seen further it is by standing on the shoulders of giants'. However, in science, we often do not always clamber as high as we could because we fail to consider previous work. Multiple factors beyond quality and relevance affect the likelihood of a paper being cited, including the author's status, country and affiliation (Leimu & Koricheva 2005), number of authors (Neiminen et al. 2007, Sala and Brooks 2008), journal prestige (Tahamtan et al. 2016), length (Neiminen et al. 2007, Stanek 2008), language (van Leeuwen et al. 2001), geographical location of authors and readers (Nunez et al. 2019), direction and strength of the results (Neiminen et al. 2007), whether open access and whether the paper is a self-citation (Schreiber 2009). Furthermore, even those papers that are cited are not always used correctly: in ecology (Todd et al. 2007) and marine biology (Todd et al. 2010), 16-18% of citations offer either ambiguous or no support for associated assertion. Even when papers are "debunked" the original papers continue to be cited 17 times more than the rebuttal (Banobi et al. 2011).

We suggest that such failings distorts knowledge. Few conservation practitioners cite original studies (Pullin et al. 2004, Sutherland 2004), although there is some evidence that this is starting to change (Wainwright et al. 2018). Furthermore, most conservation scientists use previous literature selectively, leading to bias (Gossa et al. 2015). We checked the most recent issue of five major conservation journals and found 23 papers testing conservation interventions. Together, these papers failed to cite at least 51 other studies, collected on www.conservationevidence.com, which tested the same interventions in similar environments. Such underutilisation exaggerates the originality of new findings and distorts impressions of existing knowledge and may result in actions being biased towards the single latest study.

Poor citation practices have distorted ideas (Smith and Banks 2017), such as that Darwin developed his theory of evolution by looking at Galapagos finches, despite not mentioning them in *The Origin of Species* (Sulloway 1983); that exotic ants in Madeira were responsible for the extinction of native ants, which never actually went extinct (Wetterer 2006); or that black rats were important predators of Australian mammals, based on a study that found no significant effect of rats on native mammal numbers (Smith and Banks 2017). The failure to assess the existing evidence base fully can lead to an overemphasis on outlying, well publicised or even discredited studies, or those published in prestigious outlets. Effective policy and management rarely emerge from single, definitive experiments. Rather, reliable knowledge accumulates from diverse sources of evaluated evidence that persuade communities of professionals (Collins and Pinch 2012; Roche et al. 2019).

We can best understand how to employ interventions by evaluating how they have worked in a range of circumstances. For example, a paper testing the efficacy of streamer lines in reducing bycatch of seabirds should incorporate previous studies of streamer lines in different locations, with different species, and with different numbers of lines or types of line, providing a comprehensive picture of whether the action is generally effective, or is more effective in some situations than others. In this way, the 'giant' is assembled, and new

studies can avoid pitfalls and target knowledge gaps. Reliability is important and conservation science should encourage studies that replicate interventions (Baker 2016).

One solution is the Conservation Evidence website (www.conservationevidence.com) (Sutherland et al 2019), which was developed to collect, curate and summarise tests of conservation interventions. It provides a means of checking the literature; authors may summarise the existing literature either by referring to the individual papers or, if the literature is extensive, make use of the review provided. We envisage a simple routine of checking Conservation Evidence and then adding other relevant literature. Researchers can use it to check they have not missed key references, and may reference the webpage to avoid adding references to their manuscript. Conservation Evidence focuses exclusively on conservation solutions, and does not, for example, collect papers describing threats, or compile or summarise conceptual and theoretical papers for hypothesis generation and inference. It has not yet covered interventions for all habitats and taxa and there may be relevant papers published since the literature was synthesised by Conservation Evidence.

Other options for extracting the relevant literature include systematic reviews (especially those collated by the Collaboration for Environmental Evidence, www.environmentalevidence.org), other specialist websites for specific topic areas such as the Resource database of the Society for Ecological Restoration https://www.ser-rrc.org/resource-database or the CABI Invasive species compendium https://www.cabi.org/isc, standard literature searches (ideally with the search process specified) or the forthcoming Applied Ecology Resources (https://www.britishecologicalsociety.org/publications/applied-ecology-resources/), which will host a searchable and citable grey literature repository.

Forty conservation-focused journals (are listed in Table 1) have decided to request that authors outline how they have placed the literature in context, for example by searching Conservation Evidence, by incorporating this in the submission process or in instructions to authors. The lead editors of these journals are the authors of this paper.

This solution of asking authors testing interventions to explain how they have placed their paper in context will help ensure conservation science reduces the perils of cherry picking scientific evidence and will improve the design of future work. It will not provide a complete remedy to bias in conservation papers. Ideally, the impact of this measure will grow as the evidence base grows, so that we can have the extended vision that comes from standing on the shoulders of giants rather than the limited vision from standing on their toes.

We thank Arcadia for funding and the referees for improving this piece.

References

Baker, M. (2016). 1,500 scientists lift the lid on reproducibility. Nature News, 533(7604), 452.

Banobi, J. A., Branch, T. A., & Hilborn, R. (2011). Do rebuttals affect future science? Ecosphere, 2(3): 1-11.

Collins, H. M., and T. Pinch. (2012). The Golem: What you should know about science. Cambridge University Press.

Eysenbach, G. (2006). Citation advantage of open access articles. PLoS biology, 4(5): e157.

Gossa, C., M. Fisher, and E. Milner-Gulland. 2015. The research–implementation gap: how practitioners and researchers from developing countries perceive the role of peer-reviewed literature in conservation science. Oryx 49:80-87.

Leimu R, Koricheva J (2005) What determines the citation frequency of ecological papers? Trends Ecol Evol 20:28–32

Nieminen P, Rucker G, Miettunen J, Carpenter J, Schumacher M (2007) Statistically significant papers in psychiatry were cited more often than others. J Clin Epidemiol 60:939–946

Nuñez, M. A., J. Barlow, M. Cadotte, K. Lucas, E. Newton, N. Pettorelli, and P. A. Stephens. 2019. Assessing the uneven global distribution of readership, submissions and publications in applied ecology: Obvious problems without obvious solutions. Journal of Applied Ecology 56:4-9.

Pullin, A. S., Knight, T. M., Stone, D. A., & Charman, K. (2004). Do conservation managers use scientific evidence to support their decision-making? Biological conservation, 119: 245-252.

Roche, D.G., Bennett, J.R., Provencher, J., Rytwinski, T., Haddaway, N.R., & Cooke, S.J. 2019. Environmental sciences benefit from robust evidence irrespective of speed. Science of the Total Environment. 696:134000.

Sala SD & Brooks J (2008) Multi-authors' self-citation: a further impact factor bias? Cortex 44:1139–1145

Smith, H. M., & Banks, P. B. (2017). How dangerous conservation ideas can develop through citation errors. Australian Zoologist, 38: 408-413.

Soulé, M. E. (1985). What is conservation biology?. BioScience, 35: 727-734.

Stanek, K. Z. (2008). How long should an astronomical paper be to increase its Impact? arXiv preprint arXiv:0809.0692.

Sulloway, F. J. 1983. The legend of Darwin's finches. Nature 303: 372.

Sutherland, W. J., Pullin, A. S., Dolman, P. M., & Knight, T. M. (2004). The need for evidence-based conservation. Trends in Ecology & Evolution, 19: 305-308.

Sutherland, W.J., Taylor, N.G., MacFarlane, D., Amano, T., Christie, A.P., Dicks, L., Lemasson, A.J., Littlewood, N.A., Martin, P.A., Ockendon, N., Petrovan, S.O., Robertson, R.J., Rocha, R., Shackelford, G.E., Smith, R.K., Tyler, E.H.M. and Wordley, C.F.R. (2019) Building a tool to

overcome barriers in research-implementation spaces: the Conservation Evidence database. Biological Conservation. 235: 93-101.

Tahamtan, I., Afshar, A. S., & Ahamdzadeh, K. (2016). Factors affecting number of citations: a comprehensive review of the literature. Scientometrics, 107: 1195-1225.

Todd, P. A., Yeo, D. C., Li, D., & Ladle, R. J. (2007). Citing practices in ecology: can we believe our own words? Oikos, 116: 1599-1601.

Todd, P. A., Guest, J. R., Lu, J., & Chou, L. M. (2010). One in four citations in marine biology papers is inappropriate. Marine Ecology Progress Series, 408: 299-303.

Van Leeuwen, T. N., Moed, H. F., Tijssen, R. J., Visser, M. S., & Van Raan, A. F. (2001). Language biases in the coverage of the Science Citation Index and its consequences for international comparisons of national research performance. Scientometrics, 51: 335-346.

Wainwright, C. E., T. L. Staples, L. S. Charles, T. C. Flanagan, H. R. Lai, X. Loy, V. A. Reynolds, and M. M. Mayfield. 2018. Links between community ecology theory and ecological restoration are on the rise. Journal of Applied Ecology 55:570-581.

Wetterer, J. K. 2006. Quotation error, citation copying, and ant extinctions in Madeira. Scientometrics 67: 351-372.

Table 1. The 40 journals that have agreed to require authors of papers testing conservation interventions to state how they searched for evidence of the outcomes of other similar interventions.

Acta Herpetologica	Endangered Species Research
Animal Conservation	
Aquatic Conservation: Marine and Freshwater Ecosystems	European Journal of Wildlife Research
Avian Conservation and Ecology	Global Ecology and Conservation
Avocetta - Journal of Ornithology	Ibis
	Journal of Applied Ecology
Biodiversity Science	Journal of Insect Conservation
Biodiversity and Conservation	Journal for Nature Conservation
Biological Conservation	Journal of Threatened Taxa
Biotropica	Mires and Peat
Bird Conservation International	Journal of Zoo and Aquarium Research
Bird Study	Oryx
Conservation Biology	Pacific Conservation Biology
Conservation Evidence	Restoration Ecology
Conservation Letters	Rivista Italiana di Ornitologia- Research in Ornithology
Conservation Physiology	Therya
Conservation Science and Practice	Taiwan Journal of Biodiversity
Conservation Land Management	Tropical Conservation Science
Ecological Solutions and Evidence	Wildfowl

Ecology and Evolution
Ecosystems and People
Emu - Austral Ornithology
Wildlife Biology