Table 1. Fifteen Benefits of Collaborative Management of a Biodiversity Database

To science	To users	To the database editors
1. Improved quality control in biodiversity science	1. Ease of access to an electronic, standardised, authoritative species list that is classified hierarchically for use in their own data management	1. Focussed collaboration with colleagues internationally that can aid their personal knowledge and know-how
2. Gaps in knowledge are more visible and encourage researchers and funding agencies to fill them	2. Automated tools to classify and check spelling of species names	2. Information organised and archived, reducing the need for the expert to have his or her own database
3. Reduction in misspellings and incorrect use of species nomenclature	3. More time-efficient to consult a single authoritative source than to research and assess accuracy of numerous disparate sources	3. Citable electronic publication that is digitally archived
4. Rapid conversion of outdated species names into state-of-the-art name, particularly outside a researcher's own field of expertise	4. Contact details of experts easily found	4. Peer recognition; it is prestigious to be invited as an expert to edit the database
5. Easy access to the reference for the original species description, many of which are rarely cited elsewhere	5. Relieves initiatives focussing on other (non-taxonomic) aspects of biodiversity of the need to keep track of taxonomic changes themselves	
6. Standardisation and integration makes it easier to conduct global syntheses of information		

updated. However, the current GBIF implementation plan (https://www.gbif.org/document/36j6HhbR4kOMY6oqcamEMk/gbif-implementation-plan-2017-2021-and-annual-work-programme-2018) involves collaboration with CoL and others to provide a complete, literature-referenced, automated, and expert-validated world species list (D. Hobern, personal communication.).

We suggest that the WoRMS model of international collaboration should be used to provide a quality-assured taxonomy for all species on Earth and to support other biodiversity-related databases to make expert knowledge openly available to society. An additional benefit of this collaboration is that it becomes easier to conduct global syntheses of taxa because the information is standardised in the database [5]. For example, WoRMS enabled a world synthesis of how many marine species are named and might exist (e.g., [12]) (Table 1). A global-scale, expert-driven, collaborative, and centralised open-access database could thus be available for all species on Earth and was recently called for by conservation biologists and taxonomists [4,13]. This is essential to provide a current taxonomy for all other biodiversity databases and publications. Following this, perhaps the next gap to be filled will be an identification guide to all life on Earth that links databases with literature and images: a 'key to all life'.

[1]Institute of Marine Science, University of Auckland, Auckland 1142, New Zealand
[2]National Oceanography Centre, University of Southampton, Waterfront Campus, European Way, Southampton SO14 3ZH, UK
[3]Natural History Museum Vienna, Department of Geology and Palaeontology, Burgring 7, 1010 Vienna, Austria

*Correspondence:
m.costello@auckland.ac.nz (M.J. Costello).

https://doi.org/10.1016/j.tree.2018.08.006

References

1. Hobern, D. *et al.* (2014) Advancing online databases and information systems for biodiversity conservation. *Biol. Conserv.* 173, 65–67
2. Costello, M.J. *et al.* (2013) Can we name Earth's species before they go extinct? *Science* 339, 413–416
3. Wheeler, Q.D. *et al.* (2012) Mapping the biosphere: exploring species to understand the origin, organization and sustainability of biodiversity. *Syst. Biodivers.* 10, 1–20
4. Garnett, S.T. and Christidis, L. (2017) Taxonomy anarchy hampers conservation. *Nature* 546, 25–27
5. Costello, M.J. *et al.* (2013) Global coordination and standardisation in marine biodiversity through the World Register of Marine Species (WoRMS) and related databases. *PLoS One* 8, e51629
6. Costello, M.J. *et al.* (2013) Data should be published, cited and peer-reviewed. *Trends Ecol. Evol.* 28, 454–461
7. Vandepitte, L. *et al.* (2018) A decade of the World Register of Marine Species – general insights and experiences from the Data Management Team: where are we, what have we learned and how can we continue? *PLoS One* 13, e0194599
8. Costello, M.J. *et al.* (2015) Biological and ecological traits of marine species. *PeerJ* 3, e1201
9. Horton, T. *et al.* (2017) Improving nomenclatural consistency: a decade of experience in the World Register of Marine Species. *Eur. J. Taxon.* 389, 1–24
10. Vandepitte, L. *et al.* (2015) How Aphia – the platform behind several online and taxonomically oriented databases – can serve both the taxonomic community and the field of biodiversity informatics. *J. Mar. Sci. Eng.* 3, 1448–1473
11. Costello, M.J. *et al.* (2014) Strategies for the sustainability of online open-access biodiversity databases. *Biol. Conserv.* 173, 155–165
12. Appeltans, W. *et al.* (2012) The magnitude of global marine species diversity. *Curr. Biol.* 22, 1–14
13. Thomson, S.A. *et al.* (2018) Taxonomy based on science is necessary for global conservation. *PLoS Biol.* 16, e2005075
14. Costello, M. J. *et al.*, eds (2001) European Register of Marine Species. A check-list of marine species in Europe and a bibliography of guides to their identification. *Patrim. Nat.* 50, 1–463
15. O'Dor, R. *et al.* (2012) A census of fishes – and everything they eat: how the Census of Marine Life advanced fisheries science. *Fisheries* 37, 398–409

Scientific Life

The Art of Scientific Performance

Ralf Seppelt,[1,2,3,*] Michael Beckmann,[1] Tomáš Václavík,[1,4] and Martin Volk[1,2]

Humanity builds upon scientific findings, but the credibility of science might be at risk in a 'postfactual' era of advanced information technologies. Here we propose a systemic change for science, to turn away from a growth paradigm and to refocus on quality, characterized by curiosity, surprise, discovery, and societal relevance.

Modern Science: A 350-Year-Old Success Story

Modern science is characterized by a well-established system of self-control by peers. It has not substantially changed since the first publication in the *Philosophical Transactions of the Royal Society of London* in 1665. The launch of this first modern outlet for scientific achievements was only one event in a long-lasting success story. Throughout its entire history, humanity has built upon scientific findings. Being able to understand functional principles of the environment made it possible for humankind to know when and where to plant and harvest, how to best fertilize and irrigate, fight pests, trade efficiently, build houses and dams, optimize transport, and stay or get healthy. While there are multiple examples of scientific findings that had negative consequences (e.g., industrial emissions, weapons) or are questionable within ethical standards (e.g., genetic modifications), today – more than ever – good science is part of what is needed to solve the most pressing environmental challenges, such as coping with climate change, maintaining the functioning of ecosystems, halting biodiversity loss while feeding 10 billion people and improving the well-being for diverse societies. Despite such potential, science has been lately criticized for lacking societal relevance. The most recent proclamations of the 'postfactual era' indicate that humanity might be turning away from its most trusted source of knowledge.

We here provide a short history of science and synthesize the various facets of the recent 'scientific crisis'. From this analysis we infer that systemic changes are needed in academia. We propose several guidelines for everybody working in academia which may not only help re-evaluate our understanding of the 'quality of science' but also amplify academia's role in society.

Causes and Consequences: A Great Acceleration, Databases, and Metrics

The 350-year-old systematic approach of science to self-assess its outputs in the form of peer review is currently undergoing a transformation due to globalization and advances in information technologies. Short research summaries, called papers, have replaced books because of their much faster publication process. Online publications and Web-based marketing have resulted in negligible production costs and stimulated a substantial growth in the number of journals. Publishing has changed from a philanthropic idea to a business model that rests on the shoulders of tax payers, as all three aspects involved in creating a scientific publication (research, paper writing, and reviewing) are done largely by tax-funded scientists. All this has led to a 'Great Acceleration in Science' (Box 1).

At the same time, global publication networks provide new options for collaboration by offering access to almost everything that is published. Open science and open access were kick-started together with pleas for more transparency and openness [1], which has given researchers the opportunity to disseminate scientific knowledge in a global village. Scientific databases have led to the development of indicators, which, allegedly, measure scientific performance. Most prominently the h-index was proposed to measure the productivity and impact of a scientist, while the impact factor is supposed to measure the outreach and impact of a journal [2]. However, a major disconnect evolved between the original purpose and the way researchers and administrators apply such metrics today [2,3]. Single indicators are used for too many purposes: evaluating individuals in academia, promoting faculty members, and deciding on funding schemes. New indicators have been proposed, suggesting that major innovations can occur throughout a scientist's lifetime [4,5]. However, even new and highly comprehensive indicators cannot resolve the issue, as all metrics refer primarily to some measure of quantity. Goodheart's law in economics – 'Any observed statistical regularity will tend to collapse once pressure is placed upon it for control purposes.' – unequivocally leads to 'the natural selection of bad science' [6].

The scientific community seems to have decided for a simple growth paradigm on all levels, from institutions and universities down to individual scientists. Scientists, publishers, and institutions are measured by the sheer amount of output and citations.

Writing many papers and being active on social media are now perceived as being more crucial for career advancement than adhering to quality. For a scientist, time not spent on publications will simply lower performance if measured by a simple output metric of papers and citations. A hundred years after its first use in the modern sense, the phrase 'publish or perish' has changed to 'impact or perish' [3]. Sadly, it seems that the original meaning of the old Jesuits' proverb 'publish lest the knowledge should perish with you' has been forgotten.

Transitioning Back from Quantity to Quality

Science is inherently capable of self-reflection and self-critique. The change that is needed is systemic but achievable: overcome our addiction to quantity, re-learn, trust in quality, and minimize our distance to society. However, optimizing the work in an institute might be prone to

Box 1. 'The Great Acceleration in Science' and Outstanding Examples of Bad Practices

In 2015 the top five publishers held 40% of all journals (Figures I and IIB), continuously increasing profits (Figure IIC) and determining licence models: A 'Publishers Oligopoly' [9,10]. This was accompanied by an exponential increase in the number of journals as well as published papers (Figure III), exceeding 50 million published papers in 2008 given the extrapolation in [11], while the number of papers read as reported by scholars was only linearly increasing (Figure IIC), which could simply be due to the reduction of the average paper size.

Given the vast quantity of papers, it can be reasonably expected that not all publications followed the principles of good scientific practice; a noncomprehensive list of examples include the following:

- Lack off 'reproducibility': Only 36% of controlled experiments in psychology were reproducible and confirmed earlier findings [7]. Less prominent was the failure to reproduce findings from a simple Excel sheet analysis, which resulted in questioning the foundation of European fiscal 'austerity' politics [12].
- Publishing 'fake-papers': Sokal-style hoax articles receive positive reviews in credible journals (e.g., [13]).
- Fostering 'cross citation': Editors promote citations between journals to boost impact factors (e.g., [14]).
- Misuse of metrics: The obsession with metrics motivates trickery such as 'h-index farming', or even 'misconduct' [3].
- Emergence of 'Predatory journals': Open access publishing models are increasingly used to generate money and offer easy publishing without quality assurance, reported on the 'black-list' by Jeffrey Beall until 2017 [15].

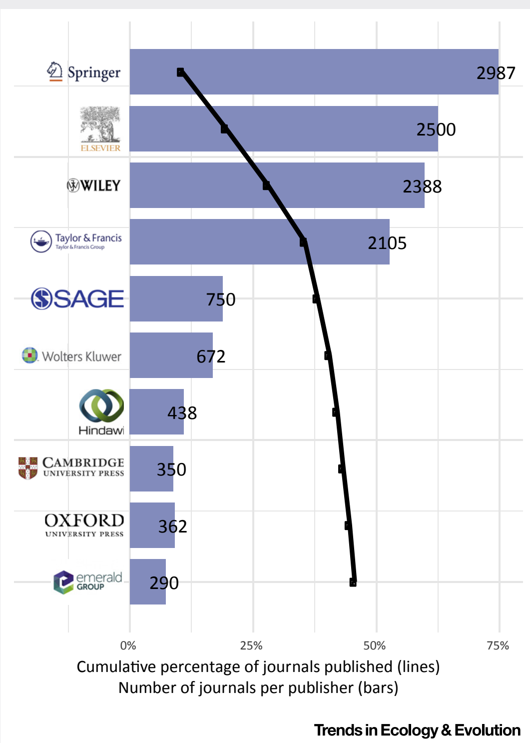

Figure I. A 'Publishers Oligopoly'. Numbers of journals published by each of the 10 largest publishers and their cumulative percentage of the total number of published journals, data from 2015 [9].

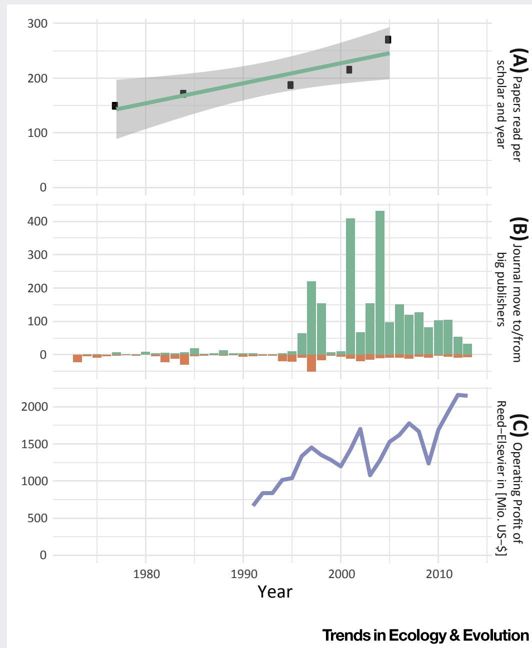

Figure II. Recent Trends of the 'Great Acceleration of Science'. While the number of published papers increased exponentially (Figure III), the number of papers read pear years as reported by scholars increased linearly (A). A major portion of journals moved to large publishers (B, green bars), while only a few moved to smaller publishers (orange). This increased publishers' profits: operating profit of Reed-Elsevier as example (C); average profit margin of Reed-Elsevier in this period was 20% (range from 13% to 26%). Data sources [9,10].

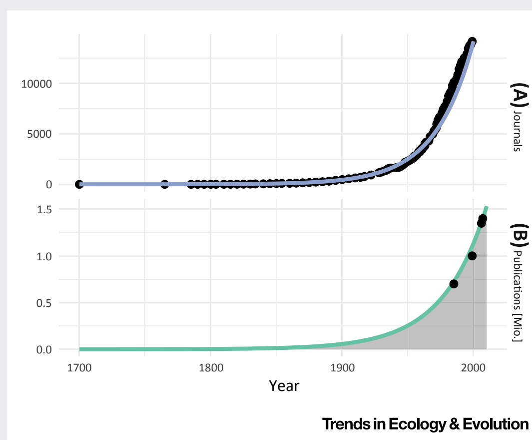

Figure III. Exponential Growth of Journals and Published Papers. (A) Development of Peer-Reviewed Journals and (B) extrapolated number of published papers since 1700, estimating approximately 50 Mio. published papers till 2008 (shaded area). Data and regression functions from [10,11].

Box 2. Easy-to-Adopt Guidelines for Authors, Reviewers, and Science Administrators to Transition Back from Quantity to Quality and Support a Systemic Change in Science

To authors, editors and reviewers	To evaluation committees and science administrators
(1) Stop putting too much pressure on yourself. Creativity originates from free time. (2) Limit yourself to the two most exciting, most relevant papers with respect to what you lead. (3) Make materials, data, analysis scripts, and results open access. To avoid confirmation bias, preregister your study and hypotheses before data collection. (4) Acknowledge reviewers, support quality check of reviews, publish reviews, and responses. (5) Select a journal for the licence and review model of a publisher of journal rather than the impact factor. (6) State (your view on) scientific quality an obligatory element in education. (7) Be prepared to explain discoveries, significance, and merits of your research to a wider public.	(8) Reserve sufficient time to discuss and agree on a suite of suitable indicators that capture quality for the decisions at hand. (9) Do not use quantitative indicators in synopses. Let members of evaluation committees openly select appropriate performance indicators. (10) Do not award purely based on the number of papers or the impact factor of the journal they appear in. (11) Treat candidates equal if they achieved the doable, see (2). (12) After decisions are made, be patient: Creativity can happen at each point in time throughout a scientist's lifetime. (13) Research is supported best, if money invested in research provides free time, rather than requesting to increase output, see (1).

failure if this is not orchestrated with changes in education, promotion, and incentive systems. We suggest a handful of easy-to-adopt guidelines for authors, editors, and reviewers, but also science administrators to overcome the erroneous practice of measuring quality with quantity-based indicators (Box 2).

To Authors, Editors, and Reviewers

Drastically change assessments of individual performance, starting with your self-perception. Limit yourself to the most exciting, most relevant publication projects with respect to what you want to lead. Creativity and innovations originate from free time, so stop putting too much pressure on yourself. Do not get distracted by too many coauthorships. Aim at highest standards for transparency and reproducibility and make results, data, and methods openly accessible, transparent, and long-lasting [1]. Correspondingly, editors and publishers should allow the publication of repetitions as well as failed experiments. Studies on the reproducibility of critical findings should be fostered (e.g., [7]). Reviews should be made public together with the paper to guarantee the quality of the review. This should be accompanied by adopting open science principles, fostering open data exchange, and finding a fair payment system, which does not exclude research from financially less equipped institutions. Similarly, aim at highest standards for publishing your work: rather than focussing on a journal's impact factor, select publication outlets with the best-suited open access standard, low publication cost, fast, constructive, and perhaps open review [Box 2; cf. Faculty of 1000 (F1000)].

Evaluation Committees and Science Administrators Need to Change Their Perception

Do not judge applications by the simple number of publications but focus on which are the most exciting and achievable goals. Do not use quantitative indicators in synopses and avoid sorting a list of applications simply by the number of papers, h-indices, or grants acquired. Let members of the committee openly select their own indicators of quality or performance and reserve sufficient time to discuss and agree on a suite of suitable quality indicators. The productivity of applicants should be considered equal if a maximum of about two papers as lead author per year is achieved. More papers mostly indicate good collaboration skills. Finally, a focus on sheer numbers of performance can discriminate against women in science [8]. Clarivate Analytics, Scopus, and Google Scholar will continue to be with us, but we need to revisit the complex incentive system that science has developed: Use these systems correctly in synthesis reports as well as for measuring performance [4]. If at all, indicator systems such as Eigenfactor® should be used more widely as they are less prone to being used for cheating [5]. After decisions are made, be patient: Creativity can happen at each point in time throughout a scientist's lifetime [4], and research is supported best if money spent provides time for being creative rather than demanding more output.

Reducing Distance to Society

While the previous recommendations address academia's internal organization, the scientific community also needs to be aware of its role within society. Science will likely continue to be funded by donors and taxpayers, which entails certain agendas, but this does not necessarily affect academic freedom. Creativity, innovation, and consequently economic growth were and still are the general arguments that support science and research. However, societies do request evidence-based solutions to pressing problems, which range from place-based environmental management problems to global change. Consequently, scientists must be able to collaborate with stakeholders or be part of a science-policy process and be ready to act as 'Honest Brokers' without compromising the quality of scientific findings. In global change research this has led to the implementation of science-policy advisory bodies of the United Nations: The Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

Contributing to this transdisciplinary and interdisciplinary process of knowledge synthesis and dissemination is demanding even for senior scientists and often poorly supported by academic institutions. Funders and science administrators need to acknowledge that these emerging tasks require additional time and a broad range of competences. To get promoted, however, scientists usually develop profiles through specialization rather than evolving into generalists – as scientists did in the times of Humboldt or Newton. This inherent demand to be unique counteracts demands for integrative research that is relevant for society. While research topics of modern science are highly specialized, this should not keep a scientist from aiming at explaining the discoveries and societal relevance of his or her topic to a broader audience. Scientists need to be prepared to explain the significance and merits of their own research to a wider public, to a layman, your grandma (Box 2).

A Joint Effort: Enabling Academia to Re-evaluate Quality

A plea to foster quality in science opens a can of worms. Quality is multifaceted, an aspect that science managers might not find helpful. There is no such thing as a generic measure of scientific ingenuity, repeated but futile attempts to measure it notwithstanding [4]. Like the protagonist of the 1974 novel *Zen and the Art of Motorcycle Maintenance: An Inquiry into Values* by Robert Pirsig, academia needs to re-evaluate what is understood by the quality of science and acknowledge that the current scientific system hampers the assessment of quality. We need to recognize that our understanding of quality might evolve even throughout one scientist's lifetime. Its constituting elements, however, remain the same: curiosity, surprise, discovery, but also societal relevance for problem solving.

The changes needed in our current science system should affect scientists of all career stages, funders, publishers, reviewers, and science administrators and must be orchestrated among these groups. This joint effort can rely on a simple basic principle: anybody who works in science does this with a tremendous intrinsic motivation, curiosity, and voluntary hard work. But at the end of the day, everybody is confronted with some very basic requirements: to get a grant, get promoted, get tenure, earn one's livelihood, and possibly support a family. No matter what the specific next steps are, we need to acknowledge the fact that the system is made up of human beings. To save modern science from being a candidate for the United Nations Educational, Scientific and Cultural Organization (UNESCO) list of intangible cultural heritage, we all need to recognize that it is time to stop promoting quantity and instead take our time to assess quality.

Acknowledgments

We thank Monika Baker for stimulating this work. Tim Parker, Stefan Schmukle, and Florian Cord provided very helpful comments on earlier versions of the manuscript. The authors express their regret about not being unaffected by the developments criticised, but pledge to follow their own guidelines in Box 2.

[1]UFZ – Helmholtz Centre for Environmental Research, Leipzig, Department Computational Landscape Ecology, Permoserstraße 15, 04318 Leipzig, Germany
[2]Institute of Geoscience & Geography, Martin-Luther-University Halle-Wittenberg, 06099 Halle (Saale), Germany
[3]iDiv – German Centre for Integrative Biodiversity Research, 04103 Leipzig, Germany
[4]Palacký University Olomouc, Faculty of Science, Department of Ecology and Environmental Sciences, 78371 Olomouc, Czech Republic

*Correspondence: ralf.seppelt@ufz.de (R. Seppelt).

https://doi.org/10.1016/j.tree.2018.08.003

References

1. Nosek, B.A. *et al.* (2015) Promoting an open research culture. *Science* 348, 1422–1425
2. Abbott, A. *et al.* (2010) Metrics: do metrics matter? *Nature* 465, 860–862
3. Biagioli, M. (2016) Watch out for cheats in citation game. *Nature* 535, 201–201
4. Sinatra, R. *et al.* (2016) Quantifying the evolution of individual scientific impact. *Science* 354, aaf5239
5. Davis, P.M. (2008) Eigenfactor: does the principle of repeated improvement result in better estimates than raw citation counts? *J. Am. Soc. Inf. Sci. Technol.* 59, 2186–2188
6. Smaldino, P.E. and McElreath, R. (2016) The natural selection of bad science. *R. Soc. Open Sci.* 3, 160384
7. Open Science Collaboration (2015) Estimating the reproducibility of psychological science. *Science* 349, aac4716
8. Larivière, V. *et al.* (2013) Global gender disparities in science. *Nature* 504, 211–213
9. Larivière, V. *et al.* (2015) The oligopoly of academic publishers in the digital era. *PLoS One* 10, 1–15
10. Ware, M. and Mabe, M. (2015) *The STM Report,* International Association of Scientific, Technical and Medical Publishers
11. Jinha, A.E. (2010) Article 50 million: an estimate of the number of scholarly articles in existence. *Learn. Publ.* 23, 258–263
12. Herndon, T. *et al.* (2014) Does high public debt consistently stifle economic growth? A critique of Reinhart and Rogoff. *Cambridge J. Econ.* 38, 257–279
13. Lindsay, J. and Boyle, P. (2017) The conceptual penis as a social construct. *Cogent Soc. Sci.* 3, 1–7
14. Savenije, H. (2017) Announcement by EGU and Copernicus. *Cryosphere* 11, 5194
15. Beall, J. (2012) Predatory publishers are corrupting open access. *Nature* 489, 179

Science & Society

Expanding the Role of Targets in Conservation Policy

Tim S. Doherty [1,*]
Lucie M. Bland,[1]
Brett A. Bryan,[1] Timothy Neale,[2]
Emily Nicholson,[1]
Euan G. Ritchie,[1] and
Don A. Driscoll[1]

Conservation targets perform beneficial auxiliary functions that are rarely acknowledged, including raising awareness, building partnerships, promoting investment, and developing new knowledge. Building on these auxiliary functions could enable more rapid progress towards current targets and inform the design of future targets.

Conservation targets are a primary policy mechanism for addressing the global extinction crisis [1]. Targets provide time-bound goals against which to