Strengthening conservation science as a crisis discipline by addressing challenges of precaution, privilege, and individualism

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Strengthening Conservation Science as a Crisis Discipline
addressing challenges of precaution, privilege and individualism

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Abstract
Like public health epidemiology, conservation science deals with crises, supporting policy interventions to mitigate highly uncertain threats of serious and irreversible harm. In circumstances in which conventional policy tools such as quantitative risk assessments may be insufficient, the precautionary principle provides a practical framework and range of robust heuristics. Yet, precaution is often resisted in many policy arenas, especially in those involving powerful self-interests, compounded by structures of privilege and a growing climate of competitive individualism in science. This paper documents these effects in conservation science and recommends steps to mitigate them: more open recognition of the pressures exerted by power inside science; greater recognition for the value of the precautionary principle under uncertainty; deliberate measures to resist competitive individualism; support for blind review, open science and data sharing; and a shift from hierarchical multidisciplinarity towards more egalitarian transdisciplinarity. Their adoption will accelerate advances in conservation science.
Introduction

Crises overturn conventional certainties. Conservation science, in many key areas of its work, shares much with public health as a ‘crisis discipline’ (Soule 1985). In both fields, practitioners typically seek to implement effective ‘solutions’ before irreversible events take hold. Conservation scientists measure such challenges in terms of species extinctions and ecosystem collapse (Keith et al. 2013). These have obvious parallels with human morbidity and mortality in public health (Jordan et al. 2016), not least as played out by the unfolding of the global COVID-19 pandemic between 2019 and 2021.

In conservation science and public health as in other fields, imminent crises impose imperatives to combine efficacy with precaution. Whilst many crucial insights have arisen concerning relevant methods and practices in crisis disciplines, there has been less attention to how institutional structures and disciplinary cultures affect crisis response. In this paper, we explore the implications for precautionary action, of entrenched patterns of privilege and competitive individualism in conservation science.

Of course, both public health and conservation scientists are also concerned with less critical outcomes such as disease prevalence, and in conservation science, the long-term management of currently abundant species, cultural and experiential values, albeit usually with primary aims of avoiding losses of species and ecosystems (Manfredo et al. 2016). Both health and conservation science acknowledge the importance of culture, social context and human psychology in forming effective policy, and both embrace the humanities, social and biological sciences (Bennett et al. 2017, Villalonga et al. 2018).

Acute challenges create imperatives that transcend the measured and deliberate progress that typifies much conventional science. Yet, all crisis disciplines are characterised by deep uncertainty and a need for decisive, timely action. Their core mission is reflected in the precautionary principle under which, during crises, actions are often required to protect the environment or human health, even in the absence of full scientific knowledge (Harremoës et al. 2001, IRGC 2006, CEC 2000, 2017).

Under uncertainty, precise data and understandings necessary to measure problems and solutions satisfactorily are typically unavailable, incomplete, dated or biased – limiting the value of calculation as the sole means to justify action (Stirling 2010). A variety of quantitative tools can assist in consideration of variabilities, sensitivities and ambiguities in decision-making under uncertainty in crisis situations (Aldred 2013), including various forms of stochastic modelling, scenario analysis (Lindgren & Bandhold 2009, Law et al. 2017), and sensitivity analysis (Saltelli et al. 2008). The problem is that few, if any, quantitative analyses embrace uncertainty comprehensively (Burgman 2005). When relatively comprehensive analyses are attempted, sensitivities to judgements can become impractically large (Beer et al. 2013).

In the face of crisis, more precautionary approaches offer to “broaden out” what is taken into account in the appraisal of uncertainty and to “open up” how the resulting more plural pictures are communicated to policy makers (Ely et al. 2010). In doing this, a key obstacle can arise in the entrenched patterns of power, privilege and patronage within the discipline’s
institutions and cultures. By restricting the pool of expert perspectives, precaution may be eroded by narrowing the inputs to analysis and restricting the communication of results (O’Brien, 2000). Where unjustified claims are made that the challenges of uncertainty are already fully addressed, especially when made on behalf of particular epistemologies and methodologies, then crisis responses can be severely compromised.

In this paper, we explore how challenges of precaution in crisis disciplines can link with deeply pervasive cultural norms around the privileging of quantitative methodologies. To this end, we first investigate some of the issues around precaution. We then survey the roles played by power and self-interest in decisions under uncertainty, intensified by pressures to seek closure. We examine the compounding effects of incentives for competitive academic individualism in conservation science. We then explore means to mitigate the adverse influences of power and self-interest. In particular, the final discussion centers around a possible move away from hierarchical and competitive forms of multi-disciplinarity, towards more egalitarian and cooperative trans-disciplinarity.

**The precautionary principle**

Uncertainty comes to the fore when it is not possible confidently to assert a particular model of cause and effect, nor the relative likelihoods of different outcomes (Knight 1921, Keynes & Lewis 1922, Shackle 1968, Funtowicz & Ravetz, 1990, Faber & Proops 1990). It arises especially where precise functional forms, distributional assumptions, dependencies or scalar values for relevant probabilities and effect magnitudes are difficult to estimate reliably (Wynne 1992, Burgman 2005). Robust and rational decisions under such circumstances require greater deliberation (rather than just calculation) (Aldred, 2013). This involves wider and deeper reflection over alternative interpretations of problems and solutions, as well as consideration of how processes of appraisal and decision-making themselves should be structured (Stirling 2017). Precautionary approaches offer means to broaden the kinds of expertise and evidence that are taken into account (Harremoës et al., 2001) and enhance the candor with which the resulting more diverse possibilities are appreciated by decision makers and wider policy debates (Stirling, 2008).

Unfortunately, instead of providing a vehicle to explore uncertainty, quantitative analyses sometimes provide an aura of unjustifiably narrow scientific primacy, cloaking uncertainty. We argue below that under conditions in which quantities, processes, aggregations or trade-offs are highly uncertain, transparency and accountability about assumptions, values and interests of those involved become paramount. Here, the precautionary principle has long played a successful, practical role in governance frameworks (Fisher et al. 2006), emphasising public interests in decision making when health or the environment face serious or irreversible harms, and mitigating possible erosion by privately-held values and interests (Martuzzi & Tickner 2004, Cranor 2011).

Social studies of science have much to offer, by illuminating the social dynamics of expert communities and the implications of different institutional structures, disciplinary cultures and community practices, especially in relation to the more intractable and open
challenges in conservation science (Burgman et al. 2011a, Turnhout et al. 2012, Beck et al. 2014). This reinforces the above insight, that being rational and precautionary under uncertainty, means comparing with equal attention the full scope of pros and cons across all alternative actions and scenarios – not just those favored by the loudest voices or most powerful interests, or those colored by the cultural backgrounds and self-interests of the analysts themselves (Stirling 1999, O'Brien 2000).

This challenge to incumbent interests has led some to intensify their criticism of precaution (Marchant & Mossman 2004, Sandin et al. 2002), precipitating efforts to counterpose precaution and science as if they are somehow in tension (Holm & Harris 1999, Pittinger & Bishop 1999, Miller & Conko 2001, Tagliabue 2015). Accordingly, precaution is sometimes accused of being ‘anti-innovation’ (Luj et al. 2013), a call for ‘zero risk’ (Sunstein 2005), or a recipe for ‘business as usual’ (Taverne 2005).

We argue that these are misunderstandings (Stirling 2017). To conclude that some uncertainty is unquantifiable, or that it may not usefully be quantified, does not equate to a call for zero risk (Funtowicz et al. 2000). Precautionary appraisal applies to pros and cons of all relevant strategies (Raffensperger & Tickner 1999). It involves questioning which actions to pursue, rather than focusing on a particular action, encouraging consideration of all innovations, rather than impeding or privileging any particular one (GOS 2014). Precaution accepts that uncertainty can limit calculative forms of evidence accumulation, reduction and aggregation. It highlights decision criteria that are sometimes sidelined in risk assessments, such as diversity, flexibility, robustness, resilience and agility (Hommels et al. 2014).

In this way, the relative transparency and accessibility of more precautionary approaches helps to stimulate healthy scientific scepticism, encouraging a communitarian culture and egalitarian relations in science, and dampening the disruptions arising from disciplinary structures, divides and hierarchies (Stirling 1999). This is because, in our view, arguments against precaution often reflect attachments to particular methodologies or decision options, which may then be imposed regardless of efficacy by structures of power and privilege. Precaution by contrast, encourages openness, humility and reflexivity about the shaping effects of social context on knowledge. This requires active questioning of uncertainties and disciplinary blinkers. It is through this more open, broad-based and self-critical stance (as well through its methods and principles), that precaution can assist the community of conservations scientists to become more effective. This may result in more robust decisions than those based solely on reductive, deterministic or probabilistic disciplinary approaches that may privilege particular probability-weighted views of a problem (Stirling 2017). In short, precaution encourages more egalitarian critical questioning, leading to more rational consideration of social pressures, undue precision and overconfidence.

**Power and self-interest in decisions under uncertainty**

Crucially, the precautionary principle highlights the importance of deliberately counteracting the potentially biasing effects of power and privilege inside processes of knowledge production and decision making (Maasen & Wengart 2005). This means recognising the importance of

'speaking truth to power', and how 'power shapes truth' (Wilsdon & Doubleday 2015). Structures of privilege, patronage and status between institutions, disciplines and individuals can emphasise particular questions and suppress others, privileging some demographic groups at the expense of others (Gibbons et al. 1994, O’Brien 2000). What is seen in a given situation to be ‘true’ is partly shaped by social context, even in ostensibly ‘pure’ science (Irwin & Wynne 1996; e.g., Byrne et al. 2016).

When scientists resist a new result that turns out to be true, in general they are perceived to be judiciously sceptical. Their demands for additional evidence are lauded. However, when they support a new result that turns out to be false, they are often ridiculed for being gullible. Such reputational incentives introduce asymmetries between propensities to commit Type I and Type II errors (Jablonskowski 2006). This imbalance has major implications for conservation science. When Type I errors arise, environmental experts may be seen to have been unnecessarily restrictive, concluding something was impactful, when it later turns out to be benign. Type II errors involve an opposite tendency in which scientists infer that there has been no impact from a human activity, when in fact an unacceptable impact has occurred (Harremoës et al., 2001). Type II error rates in ecology and conservation present a serious disciplinary problem (Fidler et al. 2017). These effects may be especially pronounced when political pressures to ‘reduce’ uncertainty erode countervailing evidence or reasoning.

Asymmetries with respect to Type I and Type II errors illustrate the importance of cultural contexts within science as a whole, as well as ecology and conservation (Soentgen & Wehling, 2006, Rocchini & Neteler, 2012). Of course, cultures of science can exert a constructive influence on political decisions, encouraging careful attention to available evidence. For example, Sutherland & Wordley (2017) noted the increased numbers of open-access papers and the development of free repositories that have made evidence more accessible over the last decade. This is clearly preferable to decisions based on the private interests of elite decision makers. Despite these advances, they also note a culture of ‘evidence complacency’ in which, despite availability, often evidence is not used to make decisions, and the impact of actions is not tested.

Yet justifiable support for ‘evidence based policy’ can sometimes spill over into a kind of ‘scientism’ (Welsh & Wynne 2013), implying that science alone can be expected to prescribe a singular course of action, in the definitive fashion that uncertainty (by definition) precludes (Stirling 2010). At its worst, this can amount to an irrational and harmful form of uncertainty denial (O’Brien 2000, Saltelli et al. 2020).

There is substantial political value in justifying decisions by over-claiming the definitive, prescriptive powers of science. Similar, essentially political dynamics can operate within science. Privileged interests in wider society exercise disproportionate influence over funding processes. Patronage structures in academia and science governance shape the directions for research that yield the relevant evidence in the first place. It is difficult otherwise to explain the discrepancies in public funding levels between genomics and soil science, nuclear and renewable energy, and curative and preventive medicine (GOS 2014).

Many other hierarchies of privilege persist within scientific cultures, for example, around gender, class, ethnicity and global north/south geographies (Hilgartner et al. 2015). For
example, Wilson et al. (2016) noted less conservation science is undertaken in the world’s most biodiverse countries, and where it is, it is often not led by in-country researchers. They advocate reforming open access publishing policies, enhancing science communication, changing author attribution practices, and strengthening infrastructure and human capacity for research in biodiverse, developing economies. These suggestions resonate clearly with our recommendations below.

Science is an intrinsically social activity. It does not escape the kinds of hierarchies, stratifications and inequalities of wider political cultures. However, scientific institutions have evolved to some extent to resist these forces (Bucchi 2004). Scientific struggles to realise ‘Mertonian norms’ of communalism, universalism, disinterest and organised scepticism can partially counterbalance political and social sources of bias (Ziman 1984). Even where such values remain only partly delivered, the mere aspirations themselves can counter the distorting effects of privileged interests, if these norms are acknowledged as aspirational struggles, rather than as achievements (Stirling 2012). Otherwise, misleading hypocrisy may emerge, rather than enlightened realism.

A sign of this dilemma can be found in the seventeenth century motto of one of the world’s founding scientific associations, the British Royal Society: ‘nullius in verba’ – ‘not on authority’ (May 2002). It is ironic that this motto nowadays more frequently appears on documents specifically aimed at asserting authority, illuminating the pressures acting on contemporary science (Stirling 2011). Conservation disciplines may be especially vulnerable to dynamics of power and privilege under uncertainty along these kinds of political fault-lines (Brockington 2009, Sullivan 2013).

The compounding effects of incentives for individualism

Forms of organisation in science labelled as ‘neoliberal’ (Mirowski 2001, Lave et al. 2010) or ‘new public management’ (Boden et al. 2004, Schimank 2005) impose further political pressures on the way knowledge is produced, and the forms taken by the results. They represent ways in which authority and privilege can pre-shape ‘truths’ that are ‘spoken to power’ (Pellizzoni & Ylonen 2012). For example, Frodeman (2011) noted that the pursuit of disciplinary rigour in universities has led to ever-expanding specialization, with intradisciplinary squabbles becoming more common. While economic, political and technological challenges might place limits on knowledge production for environmental sustainability, he notes ‘these may be matched or even exceeded by a set of social and epistemological dilemmas internal to academic research’ (Frodeman 2011, p. 110).

One of these pressures is growing individualism (Zahle & Collin 2014, Beck & Beck-Gernsheim 2002). Hofstede (1991) defined individualism as pertaining to societies in which individuals tend to look after themselves and their immediate family. In the context of expert communities, this term refers to a propensity to frame understandings of scientific processes in terms of individuals, conceiving of advances primarily as a quality of individuals; and so tending to prioritise actions by individuals (Berkling and Knowlton, 1998). Collectivism, by contrast, pertains in this context to a more cooperative understanding of scientific processes, a
more distributed conception of resulting knowledge, and a more communitarian approach to the values, behaviors and ends (Westen, 1985). In a scientific context, individualism can erode the communalism, universalism, disinterest and organised scepticism upheld in the Mertonian values discussed above (Porter, 1995). It can favor instead competitiveness, private interests, partisan patronage and a propensity to relax scepticism when it is convenient to do so.

Individualism is growing in contemporary science, including in conservation science (Harris et al. 2001, Büscher et al. 2012, Medina et al. 2014, Lansing et al. 2015, Pearce 2016). Of course, some countries, cultures and social contexts tend more towards collectivism and others towards individualism (see, for example, Hofstede 1980, 1983). It would be interesting to explore such patterns in conservation science.

Scientific prizes and society memberships encourage competitive individualism. Reputations, appointments and academic promotions are driven by personal achievements and citation metrics (Van Raan 2001, Lentsch & Weingart 2011). These tend overwhelmingly to be framed in terms of individuals, focusing especially on individualized rankings without due attention to the more distributed contexts (Rafols et al., 2012). As documented in the ‘Matthew Effect’, standing may be amplified in scientific peer review (Merton 1968, 1988). Processes of individualisation, stratification and segregation of credit and reward are entrenched in science in general (Jansen 2007), and in conservation science in particular (Ernstson & Sörlin 2013). The effects are reinforced by self-fulfilling processes acting on structures of privilege, such as the coaching of ‘future leaders’ (Morse & Buss 2008).

Individualism is enhanced by social incentives to document personal influence on public policy (Jasanoff 2013, Spruijt et al. 2014). In this, recognised domain experts are deferred to in making judgements about policy outcomes and the efficacy of interventions. The formation of expert opinion may be opaque, making it difficult to challenge (e.g., Li & Sakamoto 2015). Especially in contentious social contexts, technical arguments about ‘evidence-based’ interpretations can quickly become appeals to expert authority (Walton 2010, e.g., Goodwin & Honeycutt 2009) in which the most revered expert enjoys a privileged position.

Scientific institutions also become stratified by ‘excellence’, weighted disproportionately by university ranks. With post-war trends towards egalitarianism in academia now evidently exhausted, the pendulum is swinging among universities towards elitist identities and exclusive assertions of excellence (Evetts et al. 2006). So, contrasting with the communitarian values of science discussed above, patterns of privilege and entitlement may become even more strongly entrenched (Tyfield 2012). The threats to robust, precautionary conservation science are correspondingly intensified.

If individual experts were able to be the objective, impartial and competent people we expect them to be, then this may not be problematic. Unfortunately, this is rarely if ever the case. Scientific experts are subject to a host of cognitive and contextual biases and frailties, many of which they are unaware (Burgman 2015). O’Brien (2000) claimed that scientific processes such as risk assessments often embody an illegitimate exercise of power by scientists and vested interests, allowing selective assumptions, data and assertions, while creating an aura of unassailable authority. Arguments from authority may be further amplified or distorted by
the ideological filters applied by the press and mass media in deciding what scientific stories are newsworthy, what the facts are and who the legitimate experts are (Carvalho 2007).

Individualism is also visible in data deposition and sharing. Readily available data encourage verification, replication, differing interpretations and data integrity, protecting against scientific misconduct (Tenopir et al. 2011). Despite these advantages, most environmental scientists do not share their data (Soranno et al. 2014). Even though 98% of more than 1300 environmental scientists agreed that if research is publicly funded, the results should be public property, only 36% reported sharing their data (Tenopir et al. 2011). Some of this discrepancy may be driven by individualism, and some by convention, available time and knowledge. Soranno et al. (2014) argue that environmental scientific culture should develop a ‘truly inclusionary and democratic approach to science’ that would include both the machinery and motivation to share data sets publicly.

**Mitigating the influence of power and self-interest**

Knowledge production is better understood as a distributed and relational process, than as a restricted, individually located one, a point made by many others (Bateson 1972, Bohm, 1980, Maturana et al. 1980, Dyson 1997, Whatmore 2002, Skrbina 2005, Ziatev et al. 2008, Knappett & Malafouris 2008, Bennett 2010). When properly managed, groups outperform individuals on a broad range of judgmental, cognitive and logical tasks. In general, the greater the psychological, demographic, disciplinary, social and cultural diversity of the group, the stronger this advantage (Page 2007). Groups can assimilate data, reason and solve problems faster and generally can make more accurate forecasts than the best credentialled individuals (Burgman et al. 2011a). These findings suggest that conservation science should invest in modes of research and practice that use distributed activities amongst diverse groups (Martin 2012, Vercammen & Burgman 2019).

There is widespread recognition that complex social-ecological problems demand cross-disciplinary collaboration involving stakeholders, social, biological and physical scientists, and managers (Redman et al. 2004, Bammer et al. 2020). ‘Network-level’ science has the potential to integrate the research and resources of hundreds of scientists and stakeholders from dozens of institutions, to address complex social-ecological problems (Vercammen & Burgman 2019). Typically, effective, acceptable solutions depend on the co-creation of knowledge and options (Pooley et al. 2013). Nevertheless, these prospects present new challenges. For example, Romolini et al. (2013) noted that graduate students faced many institutional, cultural, and logistic barriers in conceptualizing and practicing social-ecological research.

Gradients of power within science are not necessarily always bad. Highly credentialled and well-regarded individuals may have privileged access to senior decision-makers in government or industry, providing a voice for environmental values that may otherwise not be heard. Unfortunately, as we have argued, the evidence required for most environmental decisions is incomplete or unavailable. Often, well-credentialled individuals fill this evidentiary gap as ‘chief scientists’ or through less formal dynamics of entitlement and
patronage. When the people filling these roles act in relative isolation, the resulting judgements typically are sub-optimal compared to more inclusive and distributed modes. Distinguished individuals can provide a mantle of scientific objectivity for decision-makers that is difficult to challenge. Privilege can thus operate directly to reduce precaution.

Discussion

So, what is the answer to these conundrums around precaution, privilege and power in crisis disciplines? Although it is clear that there are no panaceas – and many devils lurk in details – the general direction of practical responses is clear. Arguably the most important is to strengthen resistance to competitive individualistic hierarchies, with an emphasis instead on greater cooperativeness, collectivism and egalitarianism.

This dynamic is clear in debates over the roles of disciplinary boundaries and identities. Where these structures remain unchallenged, collaboration remains susceptible to the hierarchical ordering of research, often led by a single discipline or institution. As we have seen, these restrictive blinkers can militate against more broad-based, precautionary interpretations.

‘Multidisciplinarity’ applies to interactions within conventional (rather steep) gradients of scientific power and privilege. It dominates the organisation of international science (Miller 2007, Turnhout et al. 2012, Beck et al. 2014) especially in relation to global assessments such as climate change (IPCC 2015), energy (GEA 2012), agriculture (IAASTD 2009), public health (Woolhouse & Farrar 2014), social progress (IPSP 2018) and conservation (IPBES 2019).

In ‘interdisciplinarity’ (Alvargonzález 2011), cross-disciplinary relations transcend permeable boundaries and are less hierarchical, affording greater acceptance of contrasting paradigms, ideally relatively free from organisational and cultural stratifications (Frodeman et al. 2010). In interdisciplinary settings, it is more difficult for one set of framings or epistemologies to ‘trump’ another. The resulting tolerance for pluralism may impede orderly closure but it can result in more robust decisions. The term ‘interdisciplinarity’ can refer to a levelling of power relations and privilege structures between scientific disciplines (Stirling 2015). Conservation science has embraced broader and more inclusive scientific perspectives, with a growing focus on the interactions between people, cultures, places and biodiversity that has broadened the suite of contributors to conservation practice (Mace, 2014). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), for example, created a task force on indigenous and local knowledge systems, which generates reports on how local ecological knowledge contributes to effective environmental management (e.g. Baptiste et al. 2017).

In the same vein, ‘transdisciplinarity’ equalises power and privilege across the more acute divides between academic science and more diverse forms of public knowledge (Hirsch et al. 2007). As we have argued, this is consistent with the appreciations for deeper uncertainties, broader perspectives and alternative options that define precautionary approaches. Transdisciplinarity argues for collective research, opening the door to knowledge sources that are conventionally not considered to be scientifically expert (Huntington 2000,
Burgman et al. 2011b). The history of conservation science shows that diverse sources of understanding offer crucial ecological, cultural and management insights, supporting the growing recognition that citizen science, indigenous knowledge and the experience of people engaged in day-to-day conservation practice contribute legitimately and effectively to conservation science (Miller-Rushing et al. 2012).

Transdisciplinary science should not romanticise the merits of any form of knowledge but ensure they are respected and afforded appropriate opportunities to contribute effectively. Discussions around cross-disciplinary initiatives should not shy away from considerations of hierarchy and patronage. If conservation science is to be more effectively precautionary, then we argue the answer lies in making different kinds of scientific power and privilege more explicit, transparent and accountable.

Conservation science has already done a pretty good job of incorporating mathematical modelling, stochastic simulation, risk analysis, cost-effectiveness and return-on-investment analysis, spatial planning, machine learning and optimisation, decision theory and deliberative decision making. More recently, it has embraced ethics, psychology, organisational theory, social policy analysis, indigenous knowledge and citizen science (among others). Since each of these disciplines typically comes with distinctive methods, institutional and epistemic culture, then each can help interrogate and compensate for others. But if this is to be effective in the interests of precaution, two important condition need to hold.

The first is that the range of included disciplines needs to be as varied and disparate as possible, extending beyond conventional quantification to critical, interpretive, qualitative interrogation. The second condition is that the social norms applied within this more transdisciplinary setting need to encourage equality (between disciplines and individuals), pluralism (in the mutual respect and attention across difference) and diversity (in opening up the range of alternative interpretations conveyed to decision makers and wider debates). To these ends, it is our view that as conservation science evolves its own cultures and structures, precautionary results will best be served by encouraging collective, cooperative science and discouraging individualism.

We have taken the view that privileges afforded to quantitative aggregation over participatory deliberation and qualitative reasoning are intensified by narrowing perceptions of research excellence and political pressures for justification. These trends are amplified by a growing culture of competitive individualism. Together the resulting pressures can militate against precautionary rationality under uncertainty. Quantification can inadvertently reinforce the particular perspectives and interests of more privileged disciplines, and marginalize less powerful voices and cultures. Individualism can intensify competitive pressures for closure and reinforce narrower pictures of problems and possible solutions. The result can be a severe erosion of precautionary capabilities, the inefficient use of scarce resources and the loss of values that might otherwise have been avoided. Conservation researchers, like other crisis disciplines, have good reasons to think hard about the implications.

So, conservation science should eschew personal citation rates, individual grant success metrics and other individual performance scores. Unfortunately, academic institutions especially struggle to measure the impact of research in terms other than these. Evidence of
constructive, cooperative behaviour could include records of contributions to collaborative and multidisciplinary research, social policy, regulatory and monitoring data bases, government panels and reports. Of course, more traditional cooperative roles include mentoring responsibilities, memberships of learned societies, organising conferences and workshops, and advising and training decision-makers. University teaching should invest more in group activities, encouraging and rewarding behaviors that build group performance and enhance collective problem-solving. Teaching should provide students with examples of and experience in cross-disciplinary and transdisciplinary thinking. All journals and funding bodies should implement double blind review and open data.

Beyond this, what might be prescribed under this diagnosis will vary with political, institutional and disciplinary settings. However, irrespective of circumstances, there is a need to make power and privilege within science a focus for explicit reasoning and management. In general, the interests of conservation will best be served by collective, cooperative and distributed science. Given entrenched interests, the greatest hope for effective, reliable and precautionary knowledge creation and decision making under uncertainty, is to encourage a stronger culture of scientific egalitarianism and democracy. To deal effectively with its grave, urgent – but often deeply uncertain – imperatives, conservation scientists must strive to make relations more equal between regions, organisations, disciplines and individuals.

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