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Fortalecimiento de las Ciencias de la Conservación como Disciplinas de Crisis

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Palabras clave: individualismo, principio de precaución, privilegio disciplinario, poder en la ciencia, política de conservación

Resumen. Las ciencias de la conservación tratan con crisis y respaldan a muchas intervenciones políticas para mitigar las amenazas altamente inciertas que representan un daño irreversible. El principio de precaución proporciona un marco práctico y una gama de heurística sólida cuando son insuficientes las herramientas convencionales de políticas como las evaluaciones cuantitativas de riesgo. Aun así, con frecuencia se niega el uso de la precaución en muchas arenas políticas, especialmente en aquellas que involucran intereses propios de mucho poder, y esta negación se agrava con las estructuras de privilegio y el individualismo competitivo presentes en la ciencia. Describimos los factores y efectos clave de dicha resistencia en las ciencias de la conservación. Estos incluyen la pérdida del rigor bajo la incertidumbre, un desgaste de las capacidades de respuesta a la crisis y un reforzamiento más profundo de los intereses privilegiados en las políticas de conservación. Recomendamos que se realice una aceptación abierta de las presiones ejercidas por el poder dentro de la ciencia; un mayor reconocimiento del valor del principio de precaución bajo la incertidumbre; que se lleven a cabo medidas deliberadas para oponerse al individualismo competitivo; que se apoye a las revisiones a ciegas, la ciencia abierta y la difusión de datos; y que se realice un cambio de la multidisciplinariedad jerárquica a una transdisciplinariedad más igualitaria para acelerar los avances dentro de las ciencias de la conservación.

Strengthening conservation science as a crisis discipline

by addressing challenges of precaution, privilege, and individualism

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Abstract

Conservation science deals with crises and supports policy interventions devised to mitigate highly uncertain threats that pose irreversible harm. When conventional policy tools, such as quantitative risk assessments, are insufficient, the precautionary principle provides a practical framework and range of robust heuristics. Yet, precaution is often resisted in many policy arenas, especially those involving powerful self-interests, and this resistance is compounded by structures of privilege and competitive individualism in science. We describe key drivers and effects of such resistance in conservation science. These include a loss of rigor under uncertainty, an erosion of crisis response capabilities, and a further reinforcement of privileged interests in conservation politics. We recommend open

acknowledgement 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 toward more egalitarian transdisciplinarity to accelerate advances in conservation science.

Introduction

Crises overturn conventional certainties. Conservation science shares much with public health as a "crisis discipline" (Soule 1985). In both fields, practitioners typically seek solutions before a situation becomes irreversible. 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).

In conservation science and public health, imminent crises impose imperatives to combine efficacy with precaution. Attention to how institutional structures and disciplinary cultures affect crisis responses is lacking. Thus, we explored the implications of precautionary action, entrenched patterns of privilege, and competitive individualism in conservation science.

Of course, conservation scientists are also concerned with less critical outcomes, such long-term management of currently abundant species, albeit usually with the primary aim of avoiding species and ecosystem losses (Manfredo et al. 2016). Conservation scientists acknowledge the importance of culture, social context, and human psychology in forming effective policy and embrace the humanities and 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 characterized 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 taken 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). Quantitative tools can assist in consideration of variabilities, sensitivities, and ambiguities in decision-making under uncertainty in crisis situations (Aldred 2013), including stochastic modelling, scenario analysis (Lindgren & Bandhold 2009, Law et al. 2017), and sensitivity analysis (Saltelli et al. 2008). The problem is that few quantitative analyses address 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, precautionary approaches may "broaden out" what is attended to in the appraisal of uncertainty and "open up" the pictures provided to policy makers (Ely et al. 2010). In so doing, a key obstacle can arise in the entrenched patterns of power, privilege, and patronage in the discipline's institutions and cultures. These can restrict the pool of expert perspectives and so erode precaution by narrowing inputs to analysis and restricting communication of results (O'Brien, 2000). When particular disciplines and epistemologies make unjustified claims that uncertainty has been fully addressed, then crisis responses can be severely compromised.

We explored how challenges of precaution in crisis disciplines link with deeply pervasive cultural norms around the privileging of quantitative methods. We investigated some problems with precaution and surveyed the roles of power and self-interest in decisions under uncertainty. We examined the compounding effects of incentives for competitive academic individualism in conservation science and explored means to mitigate the adverse influences of power and self-interest.

Precautionary principle

Uncertainty comes to the fore when one cannot confidently assert a particular model of cause and effect or the relative likelihoods of different outcomes (Knight 1921, Funtowicz & Ravetz, 1990). It arises 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 on alternative interpretations of problems and solutions and consideration of how processes of appraisal and decision-making should be structured (Stirling 2017). Precautionary approaches offer means to broaden the kinds of expertise and evidence taken into account (Harremoës *et al.*, 2001) and thus enhance transparency and accountability in informing policy and wider politics.

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

Social studies of science illuminate the social dynamics of expert communities and the implications of different institutional structures, disciplinary cultures, and community practices, especially relative to intractable challenges in conservation (Burgman et al, 2011a, Turnhout *et al.* 2012, Beck *et al.* 2014). This reinforces the insight that being rational and precautionary under uncertainty means attending equally to the pros and cons across all alternatives– not just those favored by the loudest voices or most powerful interests or those colored by the cultural backgrounds and self-interests of analysts (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 were somehow in tension (Holm & Harris 1999, Pittinger & Bishop 1999, Miller & Conko 2001, Tagliabue 2015). Accordingly, precaution is sometimes labeled as 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 these are misunderstandings (Stirling 2017). To conclude that some uncertainty is unquantifiable, or that it may not usefully be aggregated, 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). Application of precaution is based on the assumption 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).

The relative transparency and accessibility of precautionary approaches helps stimulate healthy scientific skepticism, encouraging a communitarian culture and egalitarian relations in science and dampening disruptions from disciplinary structures, divides, and hierarchies (Stirling 1999). This is because, in our view, arguments against precaution often reflect attachments to particular methods or decision options, which may then be imposed regardless of efficacy by structures of power and privilege. Application of precaution by contrast encourages openness, humility, and reflexivity toward the effects of social context on knowledge. This requires active questioning of uncertainties and disciplinary blinkers. Through this more open, broad-based, and self-critical stance, precaution can help conservation scientists 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). 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

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 & Weingart 2005). This means recognizing the importance of speaking truth to power, as well as how power shapes truth (Wilsdon & Doubleday 2015). Structures of privilege, patronage, and status in institutions and disciplines and among individuals can emphasize particular questions and suppress others, privileging some groups at the expense of others (Gibbons et al. 1994, O'Brien 2000). What is seen to be true in a given situation, is, thereby, partly shaped by social context, even in ostensibly pure science (Irwin & Wynne 1996; Byrne et al. 2016).

When scientists resist a new result that turns out to be true, they are generally perceived as judiciously skeptical. Their demands for additional evidence are lauded. However, when they support a new result that turns out to be false, they are often ridiculed. Such judgements introduce asymmetries between propensities to commit type I (false inference of an effect) and type II (false inference of no effect) errors (Harremoës et al., 2001, Jablonowski 2006). This imbalance has major implications for conservation science. When Type I errors arise, experts may be seen as unnecessarily restrictive. Type II errors in ecology and conservation present a serious disciplinary problem (Fidler et al. 2017). Type II errors may be especially prevalent 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 in science as a whole (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 and Wordley (2017) note an increase in open-access articles and development of free repositories have made evidence more accessible over the last decade. This is preferable to decisions based on the private interests of elite decision makers. Despite these advances, they also note ”evidence complacency” exists, in which, despite availability, often evidence is not used to make decisions, and the impact of actions is not tested.

Justifiable support for evidence-based policy can sometimes spill over into a kind of “scientism” (Welsh & Wynne 2013), implying that only science can prescribe a 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 overclaiming 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 directions for research. 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 in science, for example, gender, class, ethnicity, and north-south geographies (Hilgartner et al. 2015). Wilson et al. (2016) note less conservation science is undertaken in the world’s most biodiverse countries and where it is, it is often not led by national researchers. They advocate reforming open-access publishing policies, enhancing science communication, changing author attribution practices, and strengthening infrastructure and human capacity for research developing economies.

Science is an intrinsically social activity. It manifests the hierarchies, stratifications, and inequalities of wider political cultures. However, scientific institutions have evolved to resist these forces (Bucchi 2004). Scientific struggles to realise Mertonian norms of communalism, universalism, disinterest, and organized skepticism can partially counterbalance political and social sources of bias (Ziman 1984). Even where such values remain only partly delivered, the aspiration can counter the distorting effects of privileged interests if these norms are acknowledged as goals (Stirling 2012). If such aims become claims, however, then more hypocrisy may emerge than enlightened realism.

This dilemma is illustrated in the seventeenth century motto of one of the world's founding scientific associations, the British Royal Society: "*nullius in verba*" (i.e., not on authority) (May 2002). This motto nowadays appears frequently 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 political fault lines (Brockington 2009, Sullivan 2013).

Compounding effects of incentives for individualism

So-called neoliberal (Mirowski 2001, Lave et al. 2010) or "new public management" (Boden et al. 2004, Schimank 2005) scientific organizations impose further political pressures on the way knowledge is produced and the forms results take. They can pre-shape truths that speak to power (Pellizzoni & Ylonen 2012). For example, Frodeman (2011) notes that pursuit of disciplinary rigor in universities has led to ever-expanding specialization and increased intradisciplinary squabbles. While economic, political, and technological challenges may place limits on knowledge production for environmental sustainability, he notes "these may be matched or…exceeded by…social and epistemological dilemmas internal to academic research (Frodeman 2011:110).

One of these pressures is growing individualism (Zahle & Collin 2014). In individualistic societies, individuals tend to look after themselves and their immediate family (Hofstede 1991). In the context of expert communities, *individualism* 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 prioritize actions by individuals (Zahle & Collin 2014). Collectivism, by contrast, pertains to a cooperative understanding of scientific processes, a distributed conception of resulting knowledge, and a community approach to values, behaviors, and ends (Westen, 1985). In a scientific context, individualism can erode the communalism, universalism, disinterest, and organized skepticism of Mertonian values. It can favor instead competitiveness, private interests, partisan patronage, and a propensity to relax skepticism when it is convenient.

Individualism is growing in contemporary science (Büscher et al. 2012, Medina et al. 2014, Lansing et al. 2015). Some countries, cultures, and social contexts tend toward collectivism and others individualism (e.g., Hofstede 1980, 1983).

Scientific prizes and society memberships encourage competitive individualism. Reputations, appointments, and academic promotions are driven by personal achievements (Van Raan 2001, Lentsch & Weingart 2011), potentially suppressing interdisciplinary research (Rafols *et al.*, 2012). Professional standing may be amplified in scientific peer review (Merton 1968, 1988). Processes of individualization, 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, recognized domain experts are deferred to in making judgements about policy outcomes and efficacy of interventions. The formation of expert opinion may be opaque, making it difficult to challenge (e.g., Li & Sakamoto 2015). In contentious social contexts, technical arguments about evidence-based interpretations can become appeals to expert authority (Walton 2010; Goodwin & Honeycutt 2009), which can unduly privilege the most revered expert.

Scientific institutions also become stratified by so-called excellence, weighted disproportionately by university ranks. Trends toward egalitarianism in academia are evidently exhausted because universities are moving toward elitist identities and exclusive assertions of excellence (Evetts et al. 2006). In contrast to the communitarian values of science, 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 can be the objective, impartial, and competent people one expects them to be, then this may not be problematic. Unfortunately, this is rarely 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) claims that scientific processes, such as risk assessments, often embody an illegitimate exercise of power by scientists and vested interests, allowing for selective assumptions, data, and assertions and creating an aura of unassailability. Arguments from authorities may be further amplified or distorted by the media's ideological filters in deciding on the story to cover, 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 over 1300 environmental scientists agreed that if research is publicly funded, the results should be public property, only 36% report sharing their data (Tenopir et al. 2011). Some of this discrepancy may be driven by individualism and some by convention, time, and knowledge. Soranno et al. (2014) argue that environmental scientific culture should develop a “truly inclusionary and democratic approach to science” that includes the machinery and motivation to share data publicly.

Mitigating the influence of power and self-interest

Knowledge production is better understood as a distributed and relational process, than as restricted and individual (e.g., Bateson 1972, Whatmore 2002, Bennett 2010). When properly facilitated, 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 a group, the stronger this advantage (Page 2007). Groups can assimilate data, reason, and solve problems faster and generally make more accurate forecasts than the best credentialed individuals (Burgman et al. 2011a). These findings suggest conservation science should invest in modes of research and practice that use distributed activities among diverse groups (Martin 2012, Vercammen & Burgman 2019).

There is widespread recognition that complex social-ecological problems demand cross-disciplinary collaboration involving stakeholders and social, biological, and physical scientists and managers (Redman et al. 2004, Bammer et al. 2020). Network-level science has the potential to integrate 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 co-creation of knowledge and options (Pooley et al. 2013). Nevertheless, these prospects present challenges. For example, graduate students face many institutional, cultural, and logistic barriers in conceptualizing and practicing social-ecological research (Romolini et al. 2013).

Gradients of power within science are not necessarily bad. Highly credentialed and well-regarded individuals may have privileged access to senior decision makers in government or industry, providing a voice that may otherwise not be heard. Unfortunately, the evidence required for most environmental decisions is incomplete or unavailable. Often, these 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 are typically suboptimal compared with more inclusive and distributed modes. Distinguished individuals can provide a mantle of scientific objectivity for decision makers that is difficult to challenge. Privilege thus operates 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 there are no panaceas, the general direction of practical responses is clear. Arguably the most important is to strengthen resistance to competitive individualistic hierarchies, emphasizing instead 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 organizational 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 therefore refer to a leveling 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, 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 equalizes 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 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 romanticize 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 modeling, stochastic simulation, risk analysis, cost-effectiveness and return-on-investment analyses, spatial planning, machine learning and optimization, decision theory, and deliberative decision-making. More recently, it has embraced ethics, psychology, organizational theory, social policy analysis, indigenous knowledge, and citizen science. Since each of these disciplines typically comes with distinctive methods and 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, 2 important conditions 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 and qualitative interrogation. The second condition is that the social norms applied in 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 take 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 behavior could include records of contributions to collaborative and multidisciplinary research, social policy, regulatory and monitoring data bases, and government panels and reports. Of course, more traditional cooperative roles include mentoring responsibilities, memberships of learned societies, organizing 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. 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, organizations, disciplines, and individuals.

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