



On the theory-practice gap in the environmental realm: perspectives from and for diverse environmental professionals

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Abstract

The theory-practice gap (TPG) is well known in the environmental realm, referring to disconnects between knowledge generated through scientific research and the needs, expectations, and practices of knowledge users for environmental decision-making and practice. While the presence of the TPG is well established, we have yet to fully implement mechanisms for overcoming its challenges. Thus, our goal is to characterize the TPG and identify practical recommendations for minimizing it. Here, a diverse group of experts in the environmental realm (spanning landscape planning, conservation science, environmental sociology, resource management, political science, and anthropology, among others) present our perspectives on the TPG. More specifically, we share an organized framework for understanding the TPG and suggest recommendations that can help make progress in one or more dimension(s). Conceptual topics discussed are the implications of the gap and its persistence. Organizational/institutional topics include the implications of the overabundance, inaccessibility, and uncertainty of scientific information, and a need for mainstreaming boundary spanning activities. Lastly, cultural topics include differences in culture and epistemologies across knowledge generators and users, shifting cultures through co-production, and changes in educational curricula. Recommendations for minimizing the TPG include conceptually recasting what is considered ‘success,’ institutional reform, enhanced information delivery, leveraging knowledge brokers and boundary organizations, leveraging ‘champions’ in policy, using co-production and/or integrative research, confronting the contemporary ‘fake news’ phenomenon, and rethinking researcher and practitioner training and development. By sharing our framework and recommendations, we provide insight, as well as a starting point for those looking to narrow the TPG and improve knowledge generator-user relationships.

Keywords Knowledge mobilization · Co-production · Knowledge-action gap · Science policy · Environmental practice

1 Introduction

The volume of scientific knowledge is expanding by the day, with near-exponential increases in the number of peer-reviewed papers published annually (Bornmann and Mutz 2015, p. 2217). In addition, there is a growing appreciation for diverse ways of knowing—such as indigenous or experiential knowledge—as well as approaches to consider the contributions to these diverse knowledge systems and western science together (Ogar et al. 2020; Reid et al. 2020). This

all coincides with a period in which humans have dominated the Earth and transformed as much as 50% of the landscape (Rockström 2009; Vitousek et al. 1997, p. 495). It is now argued that we have entered a new geologic epoch called the Anthropocene (Steffen et al. 2011), reflecting the fact that human civilization is now a defining driver of environmental change and that the planetary boundaries that offer a safe operating space for humanity are being challenged (Nash et al. 2017). Human well-being and ecological integrity are inherently linked (Dasgupta 2001; Díaz et al. 2006) which emphasizes the need to address the pressing issues facing the environment and to achieve a ‘good Anthropocene’ (Dalby 2016; Jeanson et al. 2019). To do so will require the collective effort of all (e.g., researchers, stakeholders,

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rightsholders, practitioners, and decision-makers) as society undertakes activities including environmental and urban planning, regulatory development, restoring degraded systems, and day-to-day decision-making. It is therefore imperative that knowledge users have the best available evidence (derived from diverse forms of knowledge) to guide them. Unfortunately, this is often not the case, due to many factors that we will explore in this work (including: individual and organizational perspectives and cultures around sharing environmental evidence, and the overabundance and inaccessibility of environmental evidence).

Significant effort over the past ten years by knowledge generators and users alike has resulted in incremental, yet significant advances in the ways in which evidence has been incorporated into decision-making processes (e.g., Cvitanovic and Hobday 2018). However, given the highly dynamic, interconnected, and uncertain ways in which social-ecological challenges are manifesting, there remains an urgent need to transform and routinize this relationship to ensure that evidence-based knowledge helps humanity steer toward desirable futures (McDonald et al. 2016, pp. 22–24). Social science research suggests knowledge users rarely make full use of available evidence in decision-making, relying instead on personal experiences, organizational directives, and advice from social networks (especially colleagues; Cook et al. 2010, pp. 183–184; Pullin et al. 2004, pp. 250–251; Young et al. 2013, pp. 342). The reasons for this are many, but often relate to accessibility, time pressures, relevance/veracity, applicability, institutional barriers, among others (Walsh et al. 2019). Critiques are often directed at knowledge generators for failing to appreciate or understand what knowledge users really need, or for failing to communicate their evidence in a useful manner (Coutinho and Young 2016, pp. 148–150). However, the issue is far more complex, and knowledge users and their institutions must also take some of the responsibility as it is now well understood that knowledge moves in complex ways (West et al. 2019).

The issue of needing to translate fundamental research to action is not a new one (Lubchenco 1998, p. 495). An entire field related to knowledge mobilization and knowledge exchange has emerged in an attempt to understand and address the gap between knowledge generators/holders and knowledge users (Cvitanovic et al. 2015a; Young et al. 2016). Much of this work has been pioneered in the realms of health care (Nicolini et al. 2008; Straus et al. 2013) and education (Levin and Cooper 2012) but we are now seeing much activity in the environmental realm (e.g., conservation of biodiversity, urban planning, natural resource management, environmental remediation; Cvitanovic et al. 2015a; Durant et al. 2019; Schiller et al. 2001; Wardman et al. 2020). Knowledge mobilization in environmental management is still an emerging area of inquiry with a pressing need

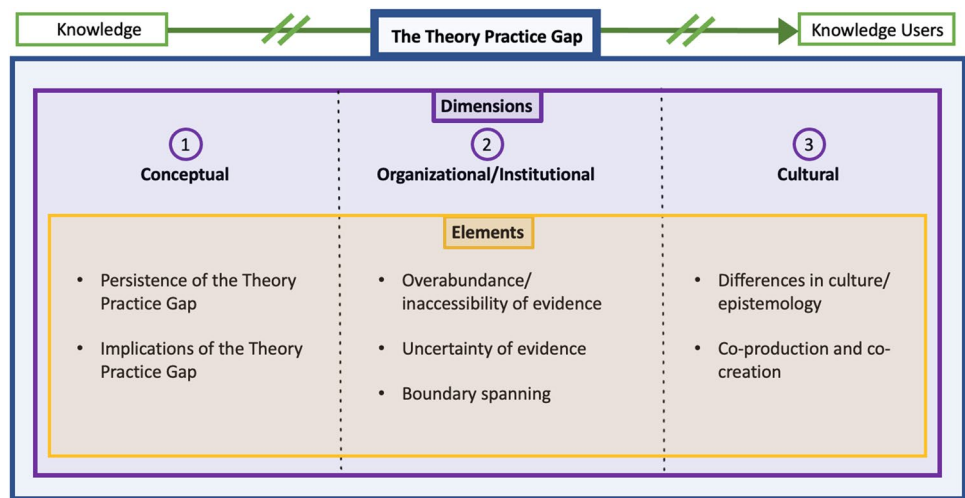
to bridge or minimize the gap between knowledge generators and users given the urgent and complex nature of looming current environmental crises. However, the persistence of research discussing this gap between theory and practice since Lubchenco's (1998) call for a social contract for science indicates that this gap still exists and has not been sufficiently addressed within the context of the environmental realm. Based on the scope and scale of current environmental problems, it is imperative that if knowledge that can solve or mitigate environmental problems exists, then it must be accessible to those that can use it (Cooke et al. 2020). Emerging research on sustainable transitions provide an example of the potential impact environmental scientific evidence can have when incorporated into decision-making. That body of work demonstrates how such evidence can be used to shift production and/or consumption methods to become more sustainable (Leuderitz et al. 2016; Abson et al. 2019). Our goal for this work is to characterize the range of perspectives on this gap between theory and practice and identify practical strategies to minimize it within the context of the environmental realm.

2 Methods

2.1 Building the framework

To build our framework and identify recommendations to minimize this gap, we adopted an expert elicitation approach. We, the diverse group of experts that comprise this author list (who were mostly speakers at the 1st Socio-Ecological Practice Research Conference held in Shanghai, China in June of 2019), all contributed input and ideas in several ways. First, several co-authors provided short written works (~500 words) on how they defined the TPG. A document compiling these short works was then sent to all co-authors via email, which allowed for comments and continued written input on the TPG. Informal written correspondence (email) containing further discussion on the TPG also resulted from circulating the main document via email. From the resulting collective body of knowledge found within email correspondence, the main document, and relevant literature, we collaboratively identified and agreed upon emergent topics (i.e., elements) within shared descriptions of the TPG and synthesized them under three dimensions: conceptual, organizational/institutional, and cultural (see Fig. 1). We discuss these dimensions in detail in the following section. Fitting into these dimensions are the elements: *persistence of the TPG*, and *implications of the TPG* (conceptual); *overabundance/inaccessibility of evidence*, *uncertainty of evidence*, and *boundary spanning* (organizational/institutional); and *differences in culture/epistemology*, and *co-production and co-creation* (cultural) (Fig. 1).

Fig. 1 Framework on defining the theory-practice gap, with identified dimensions (conceptual, organizational/institutional, and cultural) and corresponding elements explored in this manuscript



Shared recommendations that could potentially help us make progress in one or multiple dimensions were also identified and are included in our manuscript.

Our authors are all from the environmental realm (spanning landscape planning, conservation science, environmental sociology, resource management, political science, and anthropology, among others), and reside in seven different countries (Canada, Australia, China, USA, New Zealand, Italy, Germany).

2.2 Defining terms

The literature uses various terms to describe the challenge of mobilizing knowledge for specific outcomes (e.g., knowledge-action gap, science-policy divide; see Table 1), but for the purposes of this paper, we refer to this as the theory-practice gap (TPG). We chose this term as it predates all of the other terms in Table 1 by a significant length of time, and it also succinctly describes the issue at hand without using potentially ambiguous terminology.

In this paper, we use the terms “knowledge generator” and “knowledge user.” By knowledge generator, we include all practitioners, stakeholders, and rightsholders that generate or hold relevant knowledge for conservation decision-making. By knowledge user, we include all practitioners that look to use or could benefit from knowledge-based decision-making in an environmental context (e.g., environmental planning, resource management, etc.).

3 Findings

3.1 Defining the gap

We recognize variation in how individual scholars define the TPG in the literature. In general, this gap is regarded as the

Table 1 List of terms used in literature to describe the so-called gap or divide along with an example reference. All term entries are listed in alphabetical order

Term	Example Reference
Academic-Policy-making Divide	Talbot and Talbot 2015
Knowing-Doing Gap	Esler et al. 2010
Knowledge-Action Divide	Robinson and Wallington 2012
Knowledge-Action Gap	Barth et al. 2012
Knowledge-Practice Divide	Chan 2016
Knowledge-Practice Gap	Toomey 2016
Research-Implementation Divide	Jenkins and Maxwell 2011
Research-Implementation Gap	Arlettaz et al. 2010
Research-Management Gap	Maggs et al. 2019
Research-Practice Divide	Korthagen 2007
Research-Practice Gap	Smith and Wilkins 2018
Science-Action Divide	Cockburn et al. 2016
Science-Action Gap	Moser and Dilling 2011
Science-Management Divide	Roux et al. 2006
Science-Management Gap	Gaylard and Ferreira 2011
Science-Practice Divide	Dickens and Suding 2013
Science-Practice Gap	Bertuol-Garcia et al. 2018
Science-Policy Divide	Reid 2004
Science-Policy Gap	Godfrey et al. 2010
Theory-Action Divide	Björkman and Harris 2018
Theory-Action Gap	Kretz 2012
Theory-Practice Divide	Ahern 2011
Theory-Practice Gap	Allmendinger et al. 1997
Theory-Practice Tension	Forester 2020

failure for evidence to inform policy, especially that which is now critical to planetary and human welfare, or when policies informed by evidence-based knowledge does not generate collective benefits (Walker et al. 2001). There are many dimensions to why this gap exists, which can include

institutional or organizational disincentives to collaborate, or a breakdown in communication channels between researchers and practitioners. The TPG is also sometimes perceived as a limitation to successful evidence-informed policy and decision-making. Given the urgency of these issues (e.g., the need to “bend the curve” for biodiversity loss; the UN Decade for Ecosystem Restoration), we think it irresponsible to simply give up and accept the status quo as sufficient. Indeed, the TPG contributes to potential loss of trust in the policy-making process by community members, especially from marginalized groups, administrators, politicians, and also policy-makers themselves.

We agree that the TPG often occurs at the interface of knowledge generators/holders and knowledge users, yet it may differ in form across disciplines. For example, one co-author working in landscape architecture suggested that ecology provides an important theoretical base and approach to understanding the landscape, but it is difficult to apply ecological knowledge and theory in landscape planning and design. Another co-author working in sustainable planning explains that the TPG exists between theory (science generated knowledge) and practice (subjects who are supposed to use this knowledge) when planning decisions informed by scientific knowledge do not generate environmental successes—although specific social-political situations can substantially interfere in the actual implementation of the planning choices.

3.2 Dimensions of the TPG

3.2.1 The conceptual dimension

We define conceptual in this context to mean theoretical. Conceptual topics on the TPG we identify as noteworthy are the implications of the TPG, and the persistence of the TPG. Across our co-authors, perspectives on the implications of the TPG vary. One of us working in conservation science explains that its presence means that biodiversity continues to be lost and ecosystems continue to degrade while potentially transformative knowledge that could help address these issues and achieve a good Anthropocene remains undiscovered or unused. Another suggests that there is value in having knowledge generators develop innovative and visionary ideas and come up with new methods to minimize the TPG, even if these are not recognized and honored immediately by knowledge users. In contrast, it may not be appropriate to eliminate the TPG completely since different perceptions are necessary from a strategic (disciplinary) and operational (practice) perspective (Kieser and Leiner 2009). Social-ecological research may suffer from being only responsive to information needs perceived by practice, and progress for practice may be stopped if no visionary ideas on how to

interpret and understand the systemic approach, and how to develop it further, are implemented.

Perspectives on the persistence of the TPG is also somewhat disputed among our team. One possibility is that the TPG may never be fully closed given the inherent realities of human behavior and psychology, while conversely, another is that it may not always be present, and that approaches to mitigate it are situational and dependent on attitudes. The TPG is believed to exist as a result of the limitation of our knowledge, which often is located between or among several knowledge fields. Under this logic, when knowledge limitations exist, the TPG also exists. Conversely, it may not exist in cases in which no knowledge limitations are known, or where knowledge limitations do not interfere with success. The TPG may be perceived differently across individuals, groups, and other collectives, for instance, a person can do work in a specific field that does not require them to grasp all knowledge.

3.2.2 The institutional/organizational dimension

Here, we define this dimension to encompass structural issues within organizations, both at the level of knowledge generators and of knowledge users. Institutional/organizational TPG topics we find of relevance in this context are the overabundance and inaccessibility of scientific evidence, uncertainty within environmental evidence, and the need for mainstreaming boundary spanning. The overabundance and inaccessibility of available information, and the uncertainty of science are institutional/organizational sources of the TPG, in our opinion. These factors inhibit knowledge users wanting to incorporate evidence from finding relevant and impactful evidence to drive decision-making.

The academic publishing framework that exists today is a considerable barrier to knowledge dissemination. Many journal articles are only accessible through institutions that pay excessive subscription fees (Bosch et al. 2020), or for a disproportionately high one-off access fee (e.g., USD \$39.95 to rent an article for 48 h in one journal; GBP £29.95 to rent for 24 h in another). Knowledge generators who lack an affiliation with such an institution are unable to access the latest articles and are consequently unaware of the latest advances in their field. For example, less than 10% of papers in conservation science journals are available as freely downloadable (Fuller et al. 2014, p. 1554). Open access publishing purports to solve this problem, however, publishing costs associated with this may be prohibitive for research institutions (Shafer 2021, p. 541). This also presents as an issue of equity and privilege. Research institutions in developing countries are less able to afford journal subscriptions or open access fees than their counterparts in developed countries (Tai and Robinson 2018, p. 2). Intersectional inequality may also present; Vuong et al. (2021) reported a negative

relationship between papers which have women authors and open access publications in Vietnam. Additionally, scientific journals and publications of varying quality and rigor have increased by orders of magnitude in recent decades as researchers from around the world join environmental debates and conversations (Frandsen 2017; Gu and Blankmore 2016, p. 696). There has been a concomitant increase in contributions and arguments in non-peer-reviewed fora such as reports, websites, databases, social media platforms, alternative media, and interest group networks (e.g., Anderson and Öhman 2017, pp. 480–481). As Sarewitz (2004, pp. 388–390) observed in the early days of this radical expansion, the biggest contemporary problem facing environmental managers and policymakers is not always a lack of information, but ‘an excess of objectivity.’

We feel that the gap between theory and practice is hard enough to bridge when there is bountiful trusted research and that it is even harder when the base is constantly evolving. This is because it opens the door for vested interests to cite so-called experts with evidence-less claims, which can result in a loss of trust in science (see an example of such an event in Parascandola 2002). For example, the idea that climate change is a hoax has been floating around regardless of continued studies demonstrating the phenomena (Jang and Hart 2015, pp. 14–16). It is uncertain at what point the research becomes sufficiently compelling to diminish special interests, and if researchers are partly responsible for publishing non-replicable findings or failing to acknowledge the true uncertainty in their own conclusions. These new kinds of problems are less ones of deficiency (i.e., not knowing), and more one of interpretation and classification (i.e., how to know what is good and applicable knowledge). To further complicate the matter, one of our co-authors posits that problems of interpretation are stubbornly intractable: They cannot be solved by commissioning or conducting new research, and opinions on knowledge quality and applicability are highly variable across disciplines and practitioners.

We propose that insights from social science research can help with mitigating the gap caused by institutional and organizational failures. A wide range of studies have been conducted on how knowledge travels within and across communities and networks (e.g., Cvitanovic et al. 2015a; Nguyen et al. 2018; Young et al. 2016). A common finding from these studies is that people take important cues from trusted others (often peers and colleagues—people who are both accessible and work on the same types of problems as oneself). These individuals are better placed to share the value, meaning, and applicability of different types of knowledge and information (Long et al. 2013, p. 10). Trusted peers and colleagues can give excellent guidance on how to find and interpret knowledge, but exclusive reliance on in-group members can lead to the problem of homophily (excessive similarity and lack of diversity) in the sources

and types of knowledge used in decision-making (Mascia et al. 2013, p. 6). We therefore suggest that mainstreaming boundary spanning through the use of knowledge brokers, champions, and boundary organizations can contribute to minimizing the TPG.

3.2.3 The cultural dimension

In the context of the TPG, the cultural dimension is best understood as a divergence or mismatch of application between knowledge generators and users. Cultural TPG topics of importance include differences in cultures and epistemologies between knowledge generators and users and shifts in cultures through co-production models. Knowledge generators and users may differ in cultures and not epistemologies (i.e., knowledge systems and values on knowledge), despite academics often believing otherwise (for example, scientific vs. experiential), and that this differentiation should be considered when looking to minimize the TPG. Yet to assign them to rival epistemological camps seems too simplistic, as both value forms of testing, criticism, and the refinement of techniques. The TPG might come to be less problematic and more productive if we can find ways not to alter either of their epistemologies, but instead to cultivate much more well-informed relationships of respect and recognition between them. This has happened as the old ‘technical assistance’ model (research first, application to follow) has given way to partnerships, joint research, participatory action research (Honadle et al. 1983), and adaptive management.

We believe one way to shift cultures is through the engagement of new models that tackle environmental challenges while accounting for the TPG, such as co-production or co-creation (this can also fit under the organizational/institutional dimension above). We think this can be done by rethinking practitioner and researcher training to: (i) recognize that the TPG exists, and (ii) adjust the curricula to share best practices on how to mitigate the gap. Some co-authors thought that the adoption of co-production methods should be the norm for environmental research, while others suggested that some separation between knowledge generators and knowledge users may be beneficial, and that we should instead be striving to reduce, but not to eliminate the TPG between science and practice through ‘integrative research’ (Stark and Mandl 2007, pp. 250–253). Either way, the collective effort of knowledge generators and knowledge users to successfully develop policies and solutions is agreed among all authors as a necessary approach to reducing the TPG. The caveat on this is that the communicators are continually checking in with the knowledge generators to ensure their messaging is accurate. Social-ecological systems are highlighted by one of our co-authors as a theoretical construct that can help us to build bridges across disciplines,

and generators and users of knowledge (Ostrom 2009), thus facilitating such co-production efforts.

3.3 Recommendations to minimize the TPG

3.3.1 Minimizing the gap by conceptually recasting successes and with better communication

Rethinking what successful uptake of evidence-based knowledge looks like can bridge the TPG by fostering an understanding between knowledge generators and knowledge users (Cooke et al. 2020). Knowledge generators regularly produce detailed findings and expect decision-makers to adopt scientific recommendations to the letter. However, knowledge users typically adapt evidence and may take on board the essence of recommendations rather than the details. In this process, detailed evidence-based information is considered alongside all of the other social-political, cultural, institutional, and economic factors and constraints that influence decisions. In this way, shared findings may have an impact, but in a different way to how knowledge generators anticipate. For example, a research team in Australia investigated alternative social-economic and environmental futures for the Lower Murray region in southern Australia (Bryan et al. 2011). Their team collaborated with dozens of scientists and stakeholders from numerous academic, government, and private organizations and produced multiple quantitative trajectories for the future of the region including patterns and trends in key indicators of sustainability over space and time. Their intention was for all this detailed data to form the core of their natural resource management partners' future regional plans and climate adaptation strategies (Summers et al. 2015), yet almost none of it did. An investigation (i.e., Pettit et al. 2011) revealed that the agency (a knowledge user in this context) had very little capacity to use the quantitative information generated, yet the project had fundamentally changed how they thought about people and nature and the interlinkages and trade-offs involved in management interventions under the uncertainties presented by global change. Partners reported that this thinking underpinned almost every aspect of the core business from then on.

Knowledge generators should therefore recognize the social-economic, social-political, cultural, and institutional limitations to the adoption of all evidence-based information and/or recommendations (Meyer et al. 2016, p.745). These limitations could be overcome by identifying where levers and barriers are within their institutions, or which systemic dimension the problem needs to be addressed. An understanding that generated knowledge is a consideration for knowledge users, and not the ultimate outcome can help knowledge generators create a realistic idea of what successful uptake of knowledge looks like. This can better prepare

knowledge generators for presenting their findings to knowledge users, as an understanding of limitations and realistic successes may better foster communication between groups.

3.3.2 Minimizing the gap through institutional reform

Significant and systemic institutional reform by research institutions, decision-making agencies, and research funders/donors alike can contribute to bridging the TPG by reducing institutional limitations. Doing so would allow for evidence to be routinely incorporated into decision-making processes as a significant barrier is suggested to be deeply entrenched institutional cultures (e.g., Cvitanovic et al. 2015a, pp. 41–43; Shanley and López 2009, p. 537). For research institutions, changes are needed to ensure that outreach and engagement efforts by research staff are prioritized and supported on equal footing to more traditional metrics of academic success such as publication rates. For example, a recent survey of Australian marine scientists spanning 19 research organizations found that although research organizations expected, and in some cases required their research staff to engage with diverse decision-makers to achieve impact, very little (if any) institutional resources were available to support such endeavors (Cvitanovic et al. 2015b, p. 30). Further, career progression is often solely associated with traditional academic metrics such as numbers of publications and funding success. For decision-making agencies (a knowledge user), changes are needed to eliminate barriers to research uptake. For example, a recent evaluation of a participatory research program aimed at generating new knowledge to inform the management of the Ningaloo Marine Park in Australia found that unsupportive leaders (i.e., leaders that do not value science, leaders who do not empower staff to engage with scientists, and leaders who do not set a clear mandate focused on science engagement), and hierarchical organization structures prevented effective and efficient knowledge exchange among scientists and local resource managers (Cvitanovic et al. 2016, pp. 867–869). Similar findings have been reported elsewhere, for example, in relation to climate adaptation efforts in U.S. National parks and forests (Jantarasami et al. 2010, p.39). Finally, for funding agencies, changes are needed to strengthen the relationship between social-ecological research and policy. For example, Arnott et al. (2020) found that research funding played a key role in strengthening connections between research outcomes and knowledge use in research funded between 1998 to 2014 through the U.S National Estuarine Research System.

Research institutions (i.e., knowledge generators) should look to: (i) develop new metrics of academic success that recognize engagement and impact efforts on equal footing with traditional scientific metrics of success; (ii) provide training opportunities for academic staff in effective

stakeholder engagement (efforts in this space have been documented, see Alanson et al. 2020), and (iii) provide mechanisms to facilitate communication and the co-production of knowledge between scientists and decision-makers, for example, via the employment of knowledge brokers, who are individuals that form relationships with, and translate knowledge between knowledge generators and knowledge users (for a more in depth description of knowledge brokers refer to Cvitanovic et al. 2017). Decision-making agencies (i.e., knowledge users) should look to: (i) develop a clear and agreed mandate among all levels of staff in relation to the role of science for decision-making purposes and ensure that leaders are supportive of this mandate, and (ii) develop initiatives to empower and enable staff to engage with science (e.g., funding to attend conferences, allowing decision-makers to fully engage within participatory research approaches, etc.). Finally, funding agencies (who enable knowledge generation) should continue to look to: (i) establish new criteria for awarding research funds that focus on measures of stakeholder engagement, (ii) provide dedicated resources for knowledge exchange activities (e.g., the employment of a knowledge broker over the course of a project) separately from research funding to ensure that research activities do not consume the allocated engagement component of the funding, and (iii) adequately monitor and evaluate the implementation of funded knowledge exchange strategies so as to make researchers more accountable for undertaking the engagement that was outlined within their grant applications.

3.3.3 Minimizing the gap by leveraging knowledge brokers and boundary organizations

The leveraging of ‘boundary-spanners’ such as knowledge brokers and boundary organizations who can draw on knowledge from multiple communities can contribute to bridging the TPG by broadening the basis for access and interpretation (Bednarek et al. 2018). The social science of knowledge movement is paying increasing attention to actors (referred to as knowledge brokers) and organizations (referred to as boundary organizations) that span boundaries and networks (Guston 2001; Meyer 2010). Knowledge brokers and boundary organizations have familiarity with the norms and needs of the communities and networks they span, assisting in cross-cultural knowledge interpretation and synthesis (Cvitanovic et al. 2018, p. 7). Knowledge brokers and boundary organizations are not only transmitters but interpreters of knowledge, particularly on questions of applicability. They are essential for linking knowledge needs with existing knowledge resources. Yet, their effectiveness in moving knowledge is dependent on high levels of trust (Lacey et al. 2015, p. 306, 2018; Lindenfeld et al. 2012, pp. 32–36). Without trust in the epistemic and ideological independence of

these actors to act as intermediaries, the brokerage breaks down (Long et al. 2013, pp. 9–13).

Knowledge users and generators should look to mainstream knowledge brokering and boundary organizations by creating dedicated roles within environmental governance processes. This includes investing tangible financial and technological resources into the activities of these actors and organizations. Knowledge brokering is often done ad hoc and informally, by individuals with talents or interests, rather than being a dedicated job or role within environmental agencies (Young et al. 2013, p. 342). Similarly, boundary organizations are often (yet not always) created and maintained by voluntary or outside agencies and remain underfunded. Environmental agencies, government ministries and departments would have much to gain from embracing the critical human role in knowledge movement and interpretation in an age of information excess, specifically by seeing brokerage and boundary spanning as part of official knowledge management processes. Formalizing and funding such roles would go a long way to addressing the ongoing challenges of matching the right knowledge to the right problem at the right time (Lightowler and Knight 2013, p. 318).

3.3.4 Minimizing the gap by leveraging ‘champions’ in policy

The leveraging of champions acting as catalysts for impactful change and innovation can also contribute to bridging the TPG by mobilizing scientific knowledge into policy decision-making. Champions have been widely discussed in the innovation and organizational literature, and within contexts of health, education, and business management (Thompson et al. 2006). However, much less is known about champions in the field of environmental management and conservation (but see the work on ‘environmental champions’ in Mumford and Harvey, 2014; Taylor 2007, 2010; Taylor et al. 2012). The concept of champions was first documented by Schon (1963) who examined their role in promoting transformations within organizations or broader institutions. Schon concluded that, “where radical innovation is concerned, the emergence of a champion is required. Given the underground resistance to change the new idea either finds a champion or dies” (p.84). Similarly, scientific knowledge, ideas, and solutions can die if there is no champion to take it to the end, particularly when the governance system is hierarchical, inflexible, and bureaucratic. The emergence of champions results from the congruence between their personal values and the issues requiring leadership, rather than their formal roles (Howell and Higgins 1990). Often, champions have high level of personal power (to influence others) because of their personal attributes (rather than their position), such as their expert knowledge (Taylor et al. 2012, p. 85) and are passionate individuals with a strong commitment to

promoting change such as the adoption of new philosophy, technology and/or work-related process (Howell and Higgins 1990). There is recognition that these key individuals play important roles in influencing the uptake of science into policy and practice (Jacobs et al. 2005; Mumford and Harvey 2014; Pannell and Roberts 2009).

Knowledge generators and users should look to find, support, create space for, and welcome such environmental champions into knowledge production and the environmental decision-making frameworks. Given that the role of champions is often informal, champions can emerge from anywhere-any level, position, organization, or community. For example, a champion can be an angler, a farmer or community member who is an influencer, or opinion leader who is trusted and respected by their peers and community. On the other hand, it can be a policy analyst or public servant passionate about the topic and determined to see change. Knowledge generators should work strategically with champions within user groups and organizations to bridge the gap between theory and practice and better engage with knowledge users (e.g., Pannell and Roberts 2009). Building rapport and working with these individuals from the beginning can help bridge the TPG and ensure someone is pushing evidence to the front. Given knowledge often mobilizes through people (e.g., Nguyen et al. 2017, 2018; Young et al. 2016), it is evident that champions can play a key role in reducing the TPG.

3.3.5 Minimizing the gap by engaging in co-production

The engagement of knowledge users and generators in knowledge co-production and/or integrative research can contribute to bridging the TPG as it brings both groups together and requires collaboration. The term ‘co-production’ can be used in the practical and analytical sense (van der Hel 2016, p. 166) and is defined as the inclusion and co-development of mutually beneficial knowledge between researchers and others that can provide social context to help guide the process (Moser 2016, pp. 106–107; Norström, 2020, pp. 182–183). During co-production, scientific findings are considered under real-world scenarios where societal needs and requirements are of importance (van der Hel 2016) and are properly considered. This process leads to increased successes over other traditional models (i.e., elitist, top-down scientific expert knowledge or ‘pipeline model’; van der Hel, 2016, p. 166) and is viewed as a required innovation for navigating conservation challenges in a complex world of the Anthropocene (Harvey et al., 2019, p. 115; Miller and Wyborn 2018, p. 90; Moser 2016, p. 111).

The goal of co-production/co-creation is to obtain scientific outputs beneficial to knowledge generators, as well as other outputs that benefit society at large. Co-production often leads to the development of new, and sometimes more

impactful scientific findings over other models (Harvey et al. 2019, p. 108), and considers knowledge and action as interdependent (Miller and Wyborn 2018, p. 90), thus removing the space between knowledge generators and knowledge users. Removing this space necessitates addressing impediments between knowledge generators and knowledge users to allow for collaboration. Co-production can therefore lead to the transformation of cultures, institutions, and systems to support mutual successes and beneficial outputs for both knowledge users and generators (Moser 2016, p. 107). Like co-production, integrative research looks to conduct science with real-world applications and context and looks to answer specific problems with social considerations. Unlike co-production, integrative research does not specifically require continued collaboration or synchronous efforts by knowledge users and generators as it simply looks to generate knowledge that is, in the opinion of one co-author, more in line with the requirements of its’ users (Stark and Mandl 2007, pp. 250–252).

Knowledge generators should consider co-production and/or integrative research when looking to produce findings with real-world implications as these approaches have yielded much success when addressing ecological challenges in today’s world (Miller and Wyborn 2018, p. 94; Moser 2016, p. 107). Knowledge users should look to get involved in, or start projects using the co-production model in order to help develop outputs that suit their needs. Knowledge generators and users should also look to transform their own culture to foster co-production and integrative research. By engaging in projects that use the model of co-production and/or integrative research, knowledge users and generators will be actively reducing the TPG. However, it should be noted that while co-production offers many benefits, it can also be associated with increased risk (e.g., reputational damage) to scientists, decision-makers, and research funders alike, and thus strategies to manage these risks must also be implemented (Cvitanovic et al. 2019, p. 24).

3.3.6 Minimizing the gap by rethinking researcher and practitioner training

The rethinking of researcher and practitioner training across institutional boundaries can contribute to bridging the TPG by shifting cultures. It is quite common for academic programs to focus solely on the science rather than the process by which science is conducted when the goal is to be relevant to practitioners—which should be addressed (although we recognize that this is not the case for all environmental education programs across the board). Exactly what needs to be incorporated into curricula to address this is beyond the scope of this paper, but some key topics include knowledge mobilization, co-production, strategic communication, and partnership science. However, a useful starting

point for environmental researchers, and particularly early career researchers seeking to build their own capacity to engage with policy and practice is provided by Evans and Cvitanovic (2018). Evans and Cvitanovic (2018, pp. 5–7) suggest ECRs engage in activities such as (1) ‘building relationships’ with colleagues, supervisors, other relevant stakeholders involved with their research projects, as well as others outside their discipline, (2) engaging in informal/formal policy discussions, (3) keeping track of who is involved in policy processes (and why), (4) ensuring a strong public profile (especially online), and (5) taking advantage of policy internships/fellowships, and other opportunities.

There is also opportunity to learn from other fields where there have been meaningful advances in closing the TPG gap in recent years such as nursing. For example, Shoghi et al. (2019, p. 2) suggest that for nurse education, there is much benefit that can be derived from internships during training (not just at the end) to be able to consider how knowledge is applied in practice. Others like McCaugherty (1991, pp. 1059–1060) have emphasized the importance of mentoring by individuals astute in working across the TPG—both formally in classrooms as instructors but also in more practical settings such as in the work-world or during internships. In another example from the nursing literature, Scully (2011, p. 95) suggested that there is also a need for learners to take ownership of their own education with a particular focus on reflection and careful thinking about how to actively work to close the TPG.

Knowledge generators and users should not simply wait for the next generation to be trained but rather think about how current professionals can be ‘re-trained.’ This requires trying to understand the deficiencies with current training and identifying changes that can be made that will lead to closing the TPG. Recognizing the need for more urgent change can also leave room for workshops and other professional development opportunities focused on environmental professionals that have completed their formal academic training.

4 Synthesis and conclusion

Our team is a diverse group of expert scholars in many fields, which itself is revealing. For example, views on the TPG in say conservation science and practice, can be quite different from efforts adopted in urban planning or landscape esthetics. There are several different conceptualizations of the TPG that come together in this work. One of the most important observations is that there is much to be learned from reading or learning beyond the traditional disciplinary boundaries that often define our scholarship. It is ironic that when discussing the TPG, one can learn much by reading and thinking across our disciplinary boundaries.

Nonetheless, there were some general ideas that emerged from our discussions that enabled us to build our framework for characterizing the TPG.

Within our framework, we explore a number of more theoretical topics relevant to the TPG. For example, we consider how there is a need for cultural change if we are to fully close the TPG. We also explore whether our collective goal should be narrowing, or closing the TPG, realizing that each of these approaches is somewhat different. Notably, we also consider the value in embracing the TPG which may initially seem counterintuitive but, it may be rather important in order to maintain diverse and visionary perspectives and allow knowledge generators to focus on those creative pursuits, while knowledge users focus on action through their specific lens. This is not to say that co-production and integrative research are not important (indeed, we argue for that), but rather there is value in recognizing different roles and maintaining some level of separation.

Beyond our framework, we also share recommendations—essentially, what we can do to reduce the TPG (building on our own perspectives as well as some perspectives presented elsewhere – such as Allmendinger and Tewdwr-Jones 1997; Cook et al. 2013; De Neufvill 1983). First and foremost is the need for continued communication across disciplines and between knowledge generators and knowledge users. The journal *Socio-Ecological Practice Research* represents a forum for such interactions in a formal context yet many of these interactions will best be served through conversations at the level of the individual, project, or program. Simply acknowledging the gap, understanding its basis, and committing to trying to address it are all foundational to making any meaningful progress. We also discuss rethinking how we train the next generation of problem solvers, mainstreaming the concept of boundary spanning, and thinking about how the champion model can lead to success. Underpinning all of this is the need to be relevant—for knowledge generators to actually address issues that are of direct relevance to knowledge users. Certainly, adoption of co-production models (Voorberg et al. 2015) can assist with this, but there is also a need for innovation. Nonetheless, rethinking institutional structures is one way to enable the exchange of knowledge between knowledge generators and knowledge users. This type of institutional reform must span funding agencies, the academy, and knowledge user organizations (e.g., government agencies, NGOs) if we are to meaningfully enable and support actions to reduce the TPG.

Twenty years ago, the idea of a TPG was just beginning to be discussed, whereas today we recognize that it indeed exists and is, in some cases, rather vast. The TPG is often a barrier for addressing the many pressing environmental issues of our time. From global climate change to the biodiversity crisis, and their collective implications for human

infrastructure planning and humanity, we need urgent action that is based on the best available evidence (Van der Leeuw et al. 2012). If these were easy issues to address, we would have done so, yet today, many of the Sustainable Development Goals (which are collectively underpinned by climate change and the environment; Reid et al. 2017) have seen little progress, leaving us to wonder the extent to which the TPG is at fault. The time is now to put considerable efforts toward addressing the TPG in the environmental sciences and allied fields. To do so will require effort and investment by researchers, practitioners, and institutions. We trust that some of the ideas here will help to guide these actors and institutions to do just that. Moreover, given that the TPG represents the interface between knowledge and action, it is imperative that we understand how to generate knowledge that will be used by knowledge users. We recommend additional research on this topic and more communication between knowledge generators and users, as well as across the different disciplines that struggle with this same issue. Perhaps the more fundamental issue is not just how to close the TPG, rather how to bridge the TPG through better communication and co-creation of integrated ideas (engagement with stakeholders and rightsholders in a collaborative way) and breaking down the powerful vested interests in the status quo (business as usual). That topic is beyond the scope of this paper but is certainly worthy of scholarly discourse.

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