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Contributed Paper

Shared ways of thinking in Brazil about the science–practice interface in ecology and conservation

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Abstract: The debate in the literature on the science–practice interface suggests a diversity of opinions on how to link science and practice to improve conservation. Understanding this diversity is key to addressing unequal power relations, avoiding the consideration of only dominant views, and identifying strategies to link science and practice. In turn, linking science and practice should promote conservation decisions that are socially robust and scientifically informed. To identify and describe the viewpoints of scientists and decision makers on how the science–practice interface should work in order to improve conservation decisions, we interviewed Brazilian scientists (ecologists and conservation scientists, n = 11) and decision makers (n = 11). We used Q methodology and asked participants to rank their agreement with 48 statements on how the science–practice interface should work in order to improve conservation decisions. We used principal component analysis to identify shared viewpoints. The predominant viewpoint, shared by scientists and decision makers, was characterized by valuing the integration of scientific and strategic knowledge to address environmental problems. The second viewpoint, held mostly by decision makers, was distinguished by assigning great importance to science in the decision-making process and calling for problem-relevant research. The third viewpoint, shared only by scientists, was characterized by an unwillingness to collaborate and a perception of scientists as producers of knowledge that may help decision makers. Most participants agreed organizations should promote collaboration and that actors and knowledge from both science and practice are relevant. Disagreements concerned specific roles assigned to actors, willingness to collaborate, and organizational and institutional arrangements considered effective to link science and practice. Our results suggest there is ample room for collaborations and that impediments lie mainly in existing organizations and formal institutional arrangements rather than in negative attitudes between scientists and decision makers.

Keywords: environmental policy, evidence-based conservation, knowing-doing gap, knowledge coproduction, operant subjectivity, policy making, Q sorting, research-implementation gap

Formas de Pensar Compartidas en Brasil sobre la Interrelación Ciencia-Práctica en la Ecología y la Conservación

Resumen: El debate en la literatura sobre la interrelación ciencia-práctica sugiere una diversidad de opiniones sobre cómo conectar a la ciencia con la práctica para mejorar la conservación. La comprensión de esta diversidad es clave para tratar con las relaciones desiguales de poder, evitar la considerar únicamente de los puntos de

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vista dominantes, e identificar las estrategias para vincular a la ciencia con la práctica. En cambio, la vinculación entre la ciencia y la práctica debería promover las decisiones de conservación que son socialmente fuertes y científicamente informadas. Entrevistamos a científicos (ecólogos y conservadores, n = 11) y tomadores de decisiones (n = 11) en Brasil para identificar y describir los puntos de vista de los científicos y de quienes toman las decisiones sobre cómo la interrelación ciencia-práctica debería trabajar con tal de mejorar las decisiones de conservación. Usamos la metodología Q y les pedimos a los participantes que clasificaran su acuerdo con 48 declaraciones sobre cómo la interrelación ciencia-práctica debería trabajar para mejorar las decisiones de conservación. Utilizamos un análisis de componentes principales para identificar los puntos de vista compartidos. El punto de vista predominante, compartido entre los científicos y quienes toman las decisiones, se caracterizó por el valor que le dio a la integración del conocimiento científico y el estratégico para tratar los problemas ambientales. El segundo punto de vista, compartido por la mayoría de quienes toman las decisiones, se distinguió por asignarle una gran importancia a la ciencia en cuanto al proceso de toma de decisiones y a la petición de investigación relevante para los problemas. El tercer punto de vista, compartido sólo entre los científicos, se caracterizó por el rechazo a colaborar y por la percepción de los científicos como productores de conocimiento que puede ayudar a quienes toman las decisiones. La mayoría de los participantes estuvo de acuerdo en que las organizaciones deberían promover la colaboración y en que los actores y el conocimiento científico y práctico son relevantes. Los desacuerdos estuvieron relacionados con los roles específicos asignados a los actores, el deseo de colaborar, y los arreglos institucionales y de organización considerados como efectivos para vincular a la ciencia con la práctica. Nuestros resultados sugieren que existe suficiente espacio para las colaboraciones y que los impedimentos se deben principalmente a las organizaciones existentes y a los arreglos institucionales formales en lugar de a las actitudes negativas entre los científicos y quienes toman las decisiones.

Palabras Clave: clasificación Q, conservación basada en evidencias, coproducción de conocimiento elaboración de políticas, política ambiental, subjetividad operante, vacío investigación-implementación, vacío saber-hacer

摘要: 文献中针对学科交叉点的争论就如何结合科学和实践来提高保护成效提出了多种多样的观点。理解这种多样性是处理不平等权力关系、避免只考虑主导观点, 以及确定科学和实践相结合战略的关键。反过来, 科学和实践的结合应促成社会上坚稳可靠、科学上考虑周全的保护决策。为了确定和描述科学家和决策者关于科学和实践如何交叉来改善保护决策的观点, 我们采访了巴西的科学家 (生态学家和保护科学家11人) 和决策者 (11人) 。我们利用 Q方法学, 要求参与者给出他们对48 条 科学和实践如何交叉来改善保护决策的表述的赞同度。我们用主成分分析找出了他们共同的观点。科学家和决策者都同意的最主要观点是要重视科学和战略知识的整合来解决环境问题。第二个观点主要由决策者持有, 是在决策过程中要重视科学, 并呼吁进行更多与问题相关的研究。只有科学家认同的第三个观点的特点是不愿意合作, 并认为科学家创造了可以帮助决策者的知识。大多数参与者都同意组织机构应该促进合作, 行动者与来自科学和实践的知识均有重要关系。分歧则在于实践者应担负的具体角色、合作的意愿和组织或机构如何安排才能有效结合科学和实践。我们的结果表明科学家和决策者尚有很大的合作空间, 目前的障碍主要在于现有组织和正式机构的协调安排, 而不是二者之间的消极态度。; **【翻译: 胡怡思; 审校: 聂永刚】**

关键词: 研究-实施缺口, 知识-实践缺口, 环境政策, 基于证据的保护, 合作产生知识, 政策制定, Q排序, 操作主观性

Introduction

The science–practice interface (i.e., the relationship between science and decision making across different policy and management contexts) is a contentious topic. In political science, for instance, science has gone from being the sole basis of relevant information in decision making to being a minor part of complex political processes (Nutley et al. 2007). Similarly, there are different perspectives on the relationship between science and policy; science is described as autonomous or as influencing, being shaped by, or coproduced with policy (Boswell & Smith 2017).

In the ecological and conservation literature, diverse framings of the science–practice interface have also been identified (Pregernig 2014), such as those represented by unidirectional or bidirectional models of science communication and knowledge production (Bertuol-Garcia et al. 2018). An evidence-based approach to systematically collate and disseminate scientific evidence has been proposed to solve the "research-implementation" gap (Sutherland & Pullin 2004) or alleviate "evidence complacency" in decision making (Sutherland & Wordley 2017). Yet these concepts have been criticized for emphasizing one-way linkages between science and practice, neglecting other knowledge types and intricate processes of decision making (Adams & Sandbrook 2013; Toomey et al. 2016; Evans et al. 2017). To overcome this simplification and unidirectionality in science communication, some argue for reframing the presentation of scientific evidence on the basis of improved understanding of policy making (Rose 2015) or for social learning and joint knowledge production by scientists and decision makers (Shackleton et al. 2009; Pardini et al. 2013; Young et al. 2014).

Such debates suggest ecologists and conservation scientists may hold diverse opinions on how the science–practice interface should work in order to improve conservation decisions. Moreover, viewpoints of scientists and decision makers may differ because they come from different organizational cultures with distinct shared values and working routines (Roux et al. 2006). Yet, the debate has involved primarily scientists, and few researchers have incorporated opinions of decision makers (but see Neff & Larson 2014; Cvitanovic et al. 2016; Rose et al. 2018).

Understanding the opinions of scientists and decisions makers on the science–practice interface is important for 3 main reasons. First, openly discussing divergent opinions is key to dealing with unequal power relations (Peterson et al. 2005), which commonly arise when scientific knowledge is used in decision making (Collingridge & Reeve 1986). Second, discussing different opinions can avoid considering only dominant views and thus help find ways to link science and practice (Carpenter et al. 2009). Finally, understanding different viewpoints helps identify which strategies for linking science and practice will receive support and from whom (Durning 2006). In turn, linking science and practice should promote better conservation decisions by making them socially robust and scientifically informed (Scholz & Steiner 2015; Enquist et al. 2017).

Assessing viewpoints on how the science–practice interface should work in order to improve conservation decisions is particularly important in tropical developing nations. These nations harbor great biodiversity that is threatened by deep social, political, and economic challenges (State of the Tropics 2014). Moreover, approaches of scientists in former tropical colonies may differ from researchers in developed nations (Lafuente 2000), but their work and perspectives are underrepresented globally (Di Marco et al. 2017; Zabala et al. 2018).

We aimed to identify and describe viewpoints on how the science–practice interface should work in order to improve conservation decisions by interviewing relevant actors, both scientists (ecologists or conservation scientists) and decision makers (who rely on basic and conservation-oriented ecological knowledge to make decisions). We examined agreements and disagreements among the identified viewpoints to help guide strategies to link science and practice and achieve socially robust and scientifically informed conservation decisions. By focusing on key aspects of the science–practice interface (i.e., relevant actors, knowledge types, and processes and activities perceived as important to improve conservation decisions), our results are relevant across a range of conservation issues. We used Brazil as an example of a tropical developing nation with rising scientific production (van Noorden 2014) and where recent changes in environmental policies have led to debates on the role of science in decision making (Ferreira et al. 2014; Fearnside 2016).

Methods

We used Q methodology, which was developed to identify shared viewpoints among individuals (Watts & Stenner 2012). In Q method, participants assign meaning to a set of statements (the Q set) on a topic by evaluating each statement in relation to all others. The process produces a distribution of statements across a ranked scale of agreement (called the Q sort) (Fig. 1). Similar views are then identified based on resemblance among Q sorts. The Q method reveals existing viewpoints, agreements, and disagreements and is particularly suited for the study of controversial topics (Durning 2006).

Set of Statements

To allow participants to freely express their viewpoints, the Q set must represent existing ideas on the topic (known as *concourse*). We defined our concourse as ideas on how the science–practice interface should work in order to improve conservation decisions, which can be related to the relationships among people, organizations, and knowledge types involved in science and practice (Fig. 1 & Table 1). We used a structured approach to assure representativeness in which we broke down the concourse into different categories and created statements for each category (Watts & Stenner 2012). The categories were based on the 3 conceptions of the science–practice interface developed from a literature review of causes of the science–practice gap in ecology and conservation (Bertuol-Garcia et al. 2018) (Supporting Information). For each conception, the statements described which processes, knowledge types, and actors are assumed to be relevant in the science–practice interface and activities that actors or organizations are supposed to engage in or promote (Supporting Information).

For additional statements, we searched relevant articles and consulted 2 decision makers with vast experience in bridging the science–practice gap (Supporting Information). The final Q set had 48 statements and was tested on 5 scientists and 2 decision makers to fine-tune wording and interview procedures.

Participants

Scientists included prominent, active Brazilian researchers in ecology or conservation science who were advisors in highly ranked graduate programs (CAPES 2015). Decision makers included analysts in the federal environmental-enforcement agency (IBAMA). These analysts were responsible for implementing and execut-

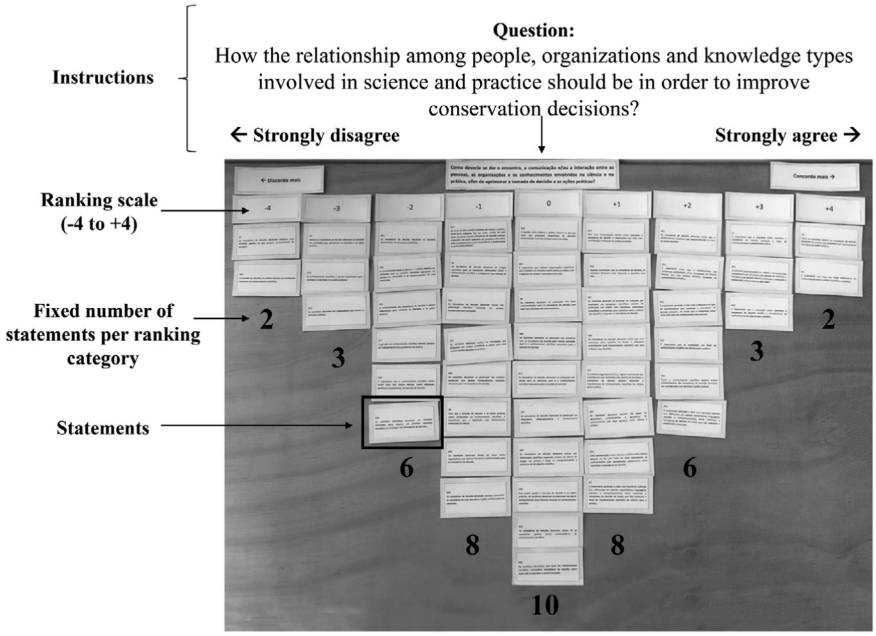

Figure 1. Example of a Q sort (a distribution of statements across a ranked scale of agreement) and instructions provided to participants to express their opinion on how the science–practice interface should work in order to improve conservation decisions. Definitions in Table 1 were available to participants during the procedure to restrict the proposed question and the information on all statements to the science–practice interface in ecology and conservation.

Table 1. Definitions of key terms used to delimit the science-practice interface in ecology and conservation presented to participants before and during interviews to identify their way of thinking on how the science-practice interface should work in order to improve conservation decisions.

Term	*Definition*
Science (in ecology and conservation)	structures, processes, products, and people involved directly in the systematic production of knowledge in ecology and conservation science* within academia
Scientists	people directly involved in science, as defined above
Practice (in ecology and conservation)	structures, processes, products, and people directly involved in action and decision making in public, private, and nonprofit organizations responsible for the development and implementation of environmental policies or the conservation or management of biodiversity and of ecological and socioecological systems
Decision makers	people directly Involved in practice, as defined above. Includes, for example, analysts, managers, legislators, and policy makers.
Science-practice interface	relationship (encounter, communication, and/or interaction) among people, organizations, and knowledge types involved in science and practice, as defined above

We use the terms "ecology" and "conservation science" to encompass basic ecological knowledge and conservation-oriented ecological knowledge. The latter is considered one of the many areas contributing to the interdisciplinary conservation science.

ing environmental policies. Their decisions can be informed by knowledge from ecology and conservation science and greatly affect conservation. For example, people in these positions are responsible for evaluating environmental impacts and licensing development projects. Other common tasks concern the regulation of natural resource use and enforcement of environmental laws .

Because Q-method studies aim to identify existing viewpoints rather than generalize findings to wider populations, participants are chosen to represent varied ways of thinking (Watts & Stenner 2012). We chose participants with purposeful sampling (Zabala et al. 2018) and stratified the sample by region because of marked differences in environmental and socioeconomic contexts (Supporting Information). Within each region, we selected scientists who either had or had not previously engaged in activities related to practice and decision makers who either had or had not previously engaged in activities related to science (Supporting Information). We interviewed 11 scientists and 11 decision makers in October and November 2016.

Data Collection

The same researcher (D.B.G.) conducted all face-to-face interviews with participants. To clarify the context of the investigated topic (Fig. 1), participants consulted a list of definitions before and during the interview (Table 1). They produced a Q sort by ranking the statements (provided on separated and randomly numbered cards) based on how they thought the science–practice interface should work in order to improve conservation decisions (Fig. 1). Participants explained why they strongly agreed or disagreed with statements and were audio-recorded to further interpretation. To support working hypotheses regarding how viewpoints might arise, we used self-administered questionnaires to collect information on educational and professional background, scientific productivity (i.e., number of published articles), and engagement in activities related to either science or practice (Supporting Information).

Interviews were conducted in Portuguese and approved by the Research Ethics Committee from the Institute of Biosciences - University of São Paulo (CAAE 58664616.2.0000.5464). We translated statements and quotations as literally as possible into English for publication (Supporting Information).

Data Analyses

To identify shared viewpoints among participants on how the science–practice interface should work in order to improve conservation decisions, we searched for groups of highly correlated Q sorts. We performed a principal components analysis on the participant-by-participant correlation matrix of Q sorts, and, based on criteria described in Watts and Stenner (2012) (details in Supporting Information), extracted 3 components (or factors), each associated with a group of participants with similar thinking. To interpret these viewpoints, we determined how participants associated with each factor, on average, ranked each statement by producing an ideal-typical Q sort for each factor (Table 2). The ideal-typical Q sort for each factor was calculated through a weighted normalized sum of the Q sorts that were highly correlated to that factor only (Watts & Stenner 2012) (Supporting Information).

To describe viewpoints, we qualitatively interpreted typical Q sorts based on 3 information sources. First, following Neff and Larson (2014), we identified agreements and disagreements among viewpoints, which were statements representing strongly held views regarding the science–practice interface that had, respectively, similar or divergent rankings across typical Q sorts. We estimated how strongly each statement was ranked across typical Q sorts (i.e., the statement salience) and the level of disagreement across typical Q sorts (Supporting Information). Agreements and disagreements are the most salient (above average) statements that presented either the lowest (below average) or the highest (above average) level of disagreement across typical Q sorts. Second, we examined recorded explanations of the rank of statements of participants whose Q sorts were highly correlated to each factor (i.e., high loadings). Third, we used questionnaire information to look for patterns in responses of participants associated with each factor (Supporting Information).

We used the qmethod package (Zabala 2014) in R environment (R Development Core Team 2008) for calculations (original data and R scripts in Supporting Information). Complete resulting narratives of each viewpoint (Supporting Information) were then summarized for publication. Although viewpoints are presented using general terms for simplicity, opinions referred specifically to how the science–practice interface should work in order to improve conservation decisions (Fig. 1 & Table 1).

RESULTS

Three factors explained 69.1% of total variance among Q sorts (Table 2 & Supporting Information). Typical Q sorts were moderately correlated with each other ($0.57 < r < 0.62$), indicating agreements across viewpoints.

Interactive Partners

Six scientists and 4 decision makers, from all Brazilian regions, were associated with factor 1 (Supporting Information) and were named *interactive partners* (i.e., possible partners in collaborations). They argued that the science–practice interface should be a space for collective creation of solutions to environmental problems. They differed from other participants in their recognition of bidirectional knowledge flows in collaborative partnerships, of mutual learning, and of joint knowledge production between scientists and decision makers as highly important (statement [Table 2], rank: 36, +4; 42, +3; and 16, +1). Thus, they believed scientists and decision makers hold important knowledge and should be involved in activities to improve decision making (43, +4; 33, +2; 1, −2; 24, −3; 10, −3; 23, −4; 5, −4).

Interactive partners thought scientists had much to learn from decision makers (e.g., viability of potential actions, administrative and political constraints) and decision makers could learn from scientists how science contributes to informed decisions. Hence, as mutual learning progresses, effectiveness of solutions to decision-making problems increases. For example, one participant stated: “Interaction should always be bidirectional, with knowledge generated in academia and knowledge decision makers bring from their experience being considered with the same weight.” Because knowledge integration was deemed fundamental, interactive partners reasoned science should not necessarily have more weight than other factors (e.g., political interests) in final decisions (47, −2).

Interactive partners thought, however, that scientific knowledge should at least be considered in decision-making processes (44, +2). That is, the complexity of problems faced by decision makers, encompassing different interests, should not serve as a pretext to ignore

Table 2. Average statement ranking of participants associated with the 3 identified viewpoints (IP, interactive partners; IU, interactive users; DP, detached producers) on how the science–practice interface should work in order to improve conservation decisions.

Statement number [a]	*Statement text*	*IP* [b]	*IU* [b]	*DP* [b]	*Salience* [c]	*Disagreement* [d]
1	The knowledge of decision makers is of little importance to support decision making.[e]	−2	−2	−3	1.48	0.06
2	Scientists should, based on scientific knowledge, advice decision makers on which decisions to make.	0	+1	0	0.31	0.08
3	Learning to deal with cultural barriers (i.e., differences in values, expectations, languages, attitudes and behaviors) between scientists and decision-makers is important to establish collaborations between them.[e]	+2	+2	+2	1.04	0.11
4	An intellectual contribution from both parties is important for effective communication between scientists and decision makers.	+1	+1	+1	0.47	0.11
5	Decision making should be based solely on scientific knowledge.[e]	−4	−3	−3	1.85	0.14
6	Scientists should stop acting as experts who only provide knowledge for decision makers.	−1	−1	0	0.09	0.14
7	The organizational and institutional context (i.e., structures and rules establishing which activities are viable) of scientists and decision makers should promote the transference of scientific knowledge from science to practice.	+1	+1	+2	0.70	0.19
8	Decision-makers should be directly involved in scientific research.[e]	−2	−2	−1	0.81	0.21
9	Decision makers should always communicate the results of their decisions and actions to scientists.	−1	−1	−1	0.36	0.23
10	Scientific knowledge is of little importance to support decision making.[e]	−3	−3	−3	1.71	0.24
11	Decision makers should stop acting only as consumers of scientific knowledge.	0	−1	−1	0.21	0.24
12	The generation of scientific knowledge should always be independent of the problems of practice.[e]	−2	−3	−3	1.61	0.28
13	When talking to decision makers, scientists should be willing to learn from them.	+1	0	+1	0.49	0.28
14	Learning to deal with cultural barriers (i.e., differences in values, expectations, languages, attitudes, and behaviors) between scientists and decision makers is important to establish the flow of scientific knowledge from science to practice.	+1	0	0	0.35	0.28
15	Scientific questions should first be resolved so that afterwards a complete scientific product can be delivered to decision-makers.[e]	−2	−2	−4	1.54	0.29
16	Science and practice will be more effectively brought together through knowledge coproduction with collaborative learning between scientists and decision makers.	+1	0	−1	0.28	0.29
17	Decision makers should search for translated scientific information by reading articles in newspapers and blogs or attending scientific talks.	0	0	−1	0.24	0.30
18	Learning to deal with differences in the type of knowledge of scientists and decision-makers is important to allow for integration between these 2 types of knowledge.[e]	+2	+1	+2	0.85	0.31
19	Scientists should worry about making recommendations for decision makers based on their research results.	0	−1	−1	0.24	0.31
20	Scientists should report their research results in scientific articles and let others make decisions in practice.[e]	−1	−2	−2	0.87	0.32
21	Decision makers should be concerned with telling scientists what scientific knowledge is needed for decision making.	0	0	+1	0.32	0.33
22	Establishing a flow of knowledge from science to practice is important.	+2	0	0	0.36	0.35

Continued

Table 2. Continued.

Statement number [a]	*Statement text*	*IP* [b]	*IU* [b]	*DP* [b]	*Salience* [c]	*Disagreement* [d]
23	Decision-makers should base their decisions only on their own knowledge of the situation.[e]	−4	−4	−2	1.84	0.39
24	Only decision-makers should be involved in activities to improve decisions-making.[e]	−3	−4	−2	1.53	0.39
25	Scientists should be responsible for making decisions in practice.[e]	−3	−2	−2	1.50	0.40
26	Decision makers should read scientific articles to stay informed on scientific knowledge and to support their decisions.	−1	+1	0	0.40	0.43
27	Decision makers should worry about correctly interpreting scientific knowledge.	0	+1	+2	0.59	0.46
28	Legislation being effectively grounded on science is important to assure decision making will be supported by scientific knowledge.	−1	+1	+2	0.49	0.47
29	Decision makers should search for scientific information by contacting scientists directly.	−1	−1	+1	0.33	0.47
30	The link between science and practice should occur by sequential processes of generation, communication and use of scientific knowledge.	0	0	−1	0.31	0.47
31	Decision-makers should avoid letting the complexity of problems they face prevent them from making decisions based on scientific knowledge.[f]	+2	+2	+4	1.12[d]	0.48
32	Scientists should get involved in translating scientific research results by publishing in nonscientific media, giving interviews to journalists, and giving talks for nonscientific audiences, such as decision makers.	+1	0	+2	0.50	0.50
33	Both scientific knowledge and knowledge of decision makers should be considered in decision making.	+2	0	+1	0.73	0.52
34	Scientists should take on the role of learners, collaborators, and knowledge generators in a partnership between science and practice.	+1	−1	0	0.46	0.55
35	The disconnection between science and practice should be resolved with scientists putting into practice the results and recommendations of their research.[f]	−2	−2	−4	1.33	0.57
36	Establishing a bidirectional flow of knowledge between science and practice is important.[f]	+4	+2	+1	1.04	0.61
37	The organizational and institutional context (i.e., structures and rules establishing which activities are viable) of scientists and decision-makers should promote interactions and mutual collaborations between them.[f]	+3	+3	+0	0.86	0.62
38	Decision makers should avoid being influenced by their interests or opinions when choosing which scientific knowledge to use to support their decisions.	+1	+2	+4	0.96	0.63
39	Scientists should talk to decision makers to better understand which scientific knowledge is necessary for decision making.[f]	0	+2	+3	0.92	0.64
40	Interactions between scientists and decision makers should facilitate the transference of scientific knowledge to decision makers.	+3	0	0	0.53	0.66
41	To support decision making, scientists should generate knowledge to fill gaps in scientific knowledge.	0	+1	+3	0.79	0.68
42	Interactions between scientists and decision makers should promote knowledge exchange and mutual learning.[f]	+3	+3	0	0.97	0.74
43	Both scientists and decision makers should be involved in activities to improve decision making.	+4	−1	+1	0.78	0.83
44	Decision makers should avoid disregarding scientific knowledge when making decisions.[f]	+2	+4	0	1.06	0.85
45	Specific organizations working in the interface between science and practice, with the specific goal of mediating interactions, should be established.	0	−1	+3	0.68	0.91

Continued

Table 2. Continued.

Statement number [a]	Statement text	IP [b]	IU [b]	DP [b]	Salience [c]	Disagreement [d]
46	Scientists should conduct research that generates scientific knowledge relevant to decision makers.	−1	+4	0	0.78	0.95
47	Scientific knowledge having more weight than other factors, such as political and economic interests, in decision making is important.[f]	−2	+2	−1	0.99	1.10
48	Instead of 2 distinct fields of science and practice, there should be a single field with scientists and decision makers engaged in generating relevant research questions, creating knowledge to answer them and implementing practical protocols.[f]	−1	+3	−2	0.91	1.33

[a] *Statements are ordered from lowest to highest level of disagreement among typical Q sorts.*
[b] *Rankings range from −4 to +4, indicating, respectively, highest discordance or concordance with each statement.*
[c] *Salience measures how strongly (in terms of either concordance or discordance) each statement was, in average, ranked across typical Q sorts.*
[d] *Level of disagreement measures differences in the ranking of each statement across typical Q sorts.*
[e] *Statements with above-average salience and below-average level of disagreement across viewpoints (i.e., agreements across viewpoints).*
[f] *Statements with above-average salience and above-average level of disagreement across viewpoints (i.e., disagreements across viewpoints).*

scientific considerations (31, +2). Thus, they perceived an important role for science in decision making (10, −3). Nonetheless, they assigned less importance to science communication and use (30, 0) than to 2-way knowledge flows and mutual learning between scientists and decision makers (36, +4; 42, +3).

To facilitate collaborations, interactive partners recognized that cultural and epistemological differences between scientists and decision makers must be addressed (3, +2; 18, +2). They emphasized that collaborations should be promoted by formal institutions (i.e., rules and reward systems) within organizations (37, +3), instead of depending on personal initiatives. Yet, interactive partners did not prefer any particular type of organization or formal institutional arrangement to promote interactions (45: 0, 48: −1). Scientists in this group had diverse levels of productivity and engagement with practice, but decision makers had engaged in the last 5 years more directly with science than decision makers from other groups (Supporting Information).

Interactive Users

Five out of 6 participants associated with factor 2 (named *interactive users*) were decision makers, most of whom worked with environmental impact assessment (Supporting Information). Interactive users stressed science should prevail over other issues (e.g., economic interests) and determine final decisions (statement [Table 2], rank: 47, +2). They emphasized that decision makers should use science (44, +4), irrespective of their personal interests (38, +2) or interests arising from complex sociopolitical and economic demands (31, +2). Several participants justified this opinion with previous disappointing experiences, as complained by a decision maker: "I've seen several times [. . .] because of political forces, we are forced to leave it [scientific knowledge] aside."

They believed neither scientists nor decision makers should act alone to solve problems faced by decision makers. However, they rejected more strongly the idea of decision makers acting alone based solely on their knowledge (23, −4; 24, −4) than ideas of scientists acting alone or decisions being based solely on scientific knowledge (5, −3; 25, −2). Thus, they recognized the importance of other knowledge types (1, −2) but attributed more weight to scientific knowledge (10, −3).

Given the fundamental role they believed science should have in decision making, interactive users explained that scientific research should focus on questions relevant for decision makers (46, +4). For them, science could not be disconnected from issues of practice (12, −3). They believed that, as important actors in the science–practice interface, scientists should, beyond reporting information in scientific journals, engage with decision makers (39, +2; 20, −2).

Interactive users valued the need for knowledge exchange and mutual learning between scientists and decision makers (42, +3; 4, +1), but less so than interactive partners (36, +2; 33, 0). Moreover, while interactive partners perceived decision makers as holders of knowledge regarding administrative or political constraints, interactive users emphasized decision makers have specific knowledge of local conditions. Interactive users thought scientists should learn about local conditions from decision makers and use this knowledge to inform science, an action they believed establishes bidirectional knowledge flow. They emphasized that, to establish collaborations, one needs to address cultural differences between scientists and decision makers (3, +2; 18, +1) and establish organizations and formal institutions that stimulate interactions (37, +3). Specifically, they argued for establishing a single field, encompassing organizations of both science and practice that share the goal of answering scientific questions relevant to decision makers and implementing practical protocols (48, +3). Decision makers in this group had diverse levels of engagement with science. The only scientist in the group had one of the highest levels of engagement with practice (Supporting Information).

Detached Producers

Three scientists were associated with factor 3 (named *detached producers*) (Supporting Information). Although they agreed with interactive users that scientists cannot remain disconnected from practice (statement [Table 2], rank: 12, −3; 39: +3), detached producers perceived changes in scientific research as unnecessary (46, 0). Detached producers saw their role as producers of knowledge that may help decision makers (41, +3). Although they recognized the importance of all actors and knowledge types (5, −3; 1, −3; 23, −2; 24, −2; 10, −3), they were less willing to engage with decision makers and were the least concerned of all participants with the need for bidirectional knowledge flows and joint knowledge production (42, 0; 37, 0; 36, +1; 16, −1).

They were concerned, however, with how science is interpreted, emphasizing that decision makers should pay attention to how scientific arguments are incorporated in their analyses (38, +4; 27, +2) and should consider scientific knowledge despite the complexity of problems (31, +4). Detached producers emphasized the strength of science to solve such complex problems, but also perceived the limits of science to support decision making. Detached producers did not care whether other interests (e.g., political or economic) outweigh scientific knowledge in final decisions (47, −1) and were neutral to scientific knowledge being disregarded in decision making (44, 0).

Nonetheless, these participants considered somewhat important that scientists be involved in translating scientific knowledge (32, +2), not just publishing in scientific journals (20, −2). Yet, they also acknowledged that research is time-consuming because "in academia we [scientists] are already overloaded [. . .]" Thus, detached producers considered organizational and institutional arrangements to stimulate transference of scientific knowledge as important (7, +2), particularly specific organizations to mediate the interaction between science and practice (45, +3). Such organizations would provide "a structure of technical support for translation [. . .] sparing the researcher who has to prepare for it." Detached producers were among the most productive scientists and varied in their engagement with decision makers (Supporting Information).

Agreement and Disagreement Across Viewpoints

There were many agreements across viewpoints, mainly concerning the relevance and roles of science, scientists, and decision makers (Table 3). Highly salient statements with low disagreement across typical Q sorts (Table 2) indicated consensus in considering as highly undesirable that decision making be based solely on 1 type of knowledge—either scientific (statement 5 [Table 2]) or from decision makers (23). Neither knowledge type was considered irrelevant to support decision making (1, 10). Participants across viewpoints contested the idea of science as completely independent of practice (12). They thought scientists should do more than publish their work in scientific journals (20) or deliver products to decision makers after resolving scientific questions (15). Participants also rejected the idea of decision makers working alone to improve decision making (24). Hence, participants agreed that scientists and decision makers hold relevant knowledge and thus are important actors in the science–practice interface. Moreover, due to high rejection of notions that scientists should act as decision makers (25) or decision makers should act as researchers (8), participants agreed that each actor should have a distinct role in the interface. However, the primary disagreement across viewpoints was the specific roles assigned to science, scientists, and decision makers in the science–practice interface (Table 3).

Another agreement concerns certain aspects of interactions between scientists and decision makers (Table 3). Participants across viewpoints agreed on the need to address differences between scientists and decision makers in knowledge, values, expectations, languages, attitudes, and behaviors (18, 3). However, participants with alternative viewpoints differed in willingness to interact and deal with these differences (Table 3). Finally, participants were equally concerned with creating organizations and formal institutional arrangements to facilitate interactions (7, 37) but preferred different types of organizations (Table 3).

Discussion

We identified 3 viewpoints on how the science–practice interface should work in order to improve conservation decisions. Inclusion of other participants or contextualizing the science–practice interface by specifying a particular conservation issue could reveal distinct viewpoints. However, this would not challenge the relevance of viewpoints described here (Brown 1980) concerning key aspects of the interface that are common to a range of conservation problems.

The identified viewpoints cannot be directly associated with proposed conceptualizations of the science–practice interface in the ecological and conservation literature (Pregernig 2014; Bertuol-Garcia et al. 2018). Although the interactive partners' viewpoint resembled integrative conceptions based on social learning and joint knowledge production by scientists and decision makers (e.g., Shackleton et al. 2009; Young et al. 2014), interactive users and detached producers cannot be fully linked

Table 3. Main areas of agreement and disagreement among the 3 identified viewpoints on how the science–practice interface should work in order to improve conservation decisions.

Area of agreement and disagreement	*Interactive partners*	*Interactive users*	*Detached producers*
Relevance and roles of science, scientists and decision makers	Scientists and decision makers are important actors in the science–practice interface with relevant knowledge but different roles and responsibilities.		
	Science is one of the factors to be considered and integrated with strategic* knowledge.	Science is the most important factor that should determine final decisions.	Science is important to understand complexity, and is one of the factors to be considered.
	Scientists are partners and holders of scientific knowledge.	Scientists are supporters of practice by producing relevant knowledge.	Scientists are producers of scientific knowledge.
	Decision makers are partners and holders of strategic* knowledge.	Decision makers are users of science with knowledge of local conditions.	Decision makers are interpreters of science.
Interactions between scientists and decision makers	Learning to deal with differences between scientists and decision makers is important.		
	High willingness to interact.	Medium willingness to interact.	Low willingness to interact.
Organizations and formal institutional arrangements	Organizations and formal institutional arrangements should promote collaborations.		
	Indifferent to any specific organization type.	Prefer establishing a single field, encompassing organizations of both science and practice.	Prefer specific organizations for mediation.

**Strategic knowledge: knowledge regarding administrative or political restrictions (Hulme 2014).*

to any specific conceptualization. To a certain degree, their view was analogous to unidirectional models of science as the sole provider of information to decision making (Bertuol-Garcia et al. 2018) because they stressed either a primacy of scientific knowledge in decision making (interactive users) or the importance of transferring scientific knowledge to decision makers (detached producers). However, their views also resembled integrative conceptions in that they valued nonscientific knowledge and, as the interactive users did, emphasized bidirectional knowledge flows. Moreover, unlike naïve perspectives concerning decision making processes common in the ecological and conservation literature (Bertuol-Garcia et al. 2018), all identified viewpoints recognized the complexity and multitude of interests involved in decision making, as often emphasized in political science (Nutley et al. 2007; Cairney 2016) and more recently in conservation (Evans et al. 2017; Rose 2018). Hence, studies such as ours are key to systematic assess the complex and multifaceted nature of shared ways of thinking.

The decision makers we interviewed were either interactive partners (assigned equal importance to scientific and strategic knowledge [sensu Hulme 2014]) or interactive users (emphasized a primacy of scientific knowledge in decision making). Decision makers in the former group engaged more frequently in scientific research, and those in the latter group were mainly analysts responsible for environmental impact assessments, which in Brazil are subject to strong political pressures (Fearnside 2016). On the one hand, this suggests exposure to science fosters perception of limits to science and acknowledgment of the need to integrate scientific and strategic knowledge for effective decision making. Some characteristics of science, such as disciplinarity and uncertainty, may complicate public debate and decision making, mostly because scientific evidence is filtered through the values and beliefs of varied actors (Collingridge & Reeve 1986; Sarewitz 2004). On the other hand, the great reliance on science of some decision makers may be associated with a frustration with situations where interests of specific powerful groups prevail, a frequent complaint among interactive users.

In turn, interviewed scientists were mainly divided between interactive partners (highly willing to collaborate with decision makers) and detached producers (less willing to do so). These 2 groups of scientists did not clearly differ in engagement with practice, but the detached producers were among the most productive scientists. Moreover, they perceived scientists as responsible for producing scientific knowledge that may or may not help decision making, acknowledged that research is time-consuming, and preferred organizations and formal institutional arrangements that mediate the transference of scientific knowledge. This may suggest their unwillingness to engage with decision makers relates to higher acceptance and value ascribed to current academic reward systems, which have been reported as a major hindrance for scientists' engagement outside academia (Shanley & López 2009).

Implications for Linking Science and Practice

In ecology and conservation, and other disciplines (e.g., Nutley et al. 2007), reported barriers to science–practice linkages range from intra- and interpersonal aspects to aspects of organizations and institutions (Cvitanovic et al. 2016; Bertuol-Garcia et al. 2018). The former encompasses ingrained negative attitudes arising from cultural differences between scientists and decision makers in terms of values, languages, and working routines (e.g., Roux et al. 2006), whereas the latter includes lack of formal institutional incentive for collaborations (Shanley & López 2009). Our results suggest the establishment of close interactions between scientists and decision makers may be hindered mainly by organizations and formal institutional arrangements rather than individual attitudes.

Several lines of evidence indicate individual attitudes are a less relevant obstacle for linking science and practice. First, we encountered substantial agreement on fundamental characteristics of the science–practice interface because all actors and knowledge types were considered relevant across viewpoints. Divergences were subtler than expected based on the debate in the literature (Adams & Sandbrook 2013; Toomey et al. 2016; Bertuol-Garcia et al. 2018): the encountered divergences refer to how (rather than whether) scientists and decision makers should participate in the science–practice interface. Second, by combining scientists and decision makers in a single analysis, we identified one viewpoint shared by both groups (interactive partners). This shows consonant views between scientists and decision makers exist, which has already been described for certain issues, such as assisted colonization (Neff & Larson 2014) and conservation policy making in general (Rose et al. 2018). Finally, although some of our results suggest negative attitudes between scientists and decision makers (e.g., detached producers criticized decision makers for misinterpreting scientific knowledge), there was general agreement that addressing cultural differences is important for linking science and practice effectively. Thus, although certain attitudes of scientists and decision makers may complicate dialogue, both sides seemed willing to tackle this issue.

Our results also suggest the lack of formal institutional incentives for linking science and practice may be a primary factor hindering collaborations because several participants complained of lack of time and incentive. Detached producers, who were less willing to interact with decision makers, complained of commitments required by scientific organizations. Interactive partners, who were committed to collaborations, thought it was a problem that this engagement frequently relied on individual initiatives with no formal incentives. All viewpoints assigned great importance to creating organizations or formal institutional arrangements that facilitate interactions.

Hence, rethinking current organizations and formal institutional arrangements appears essential to fostering productive science-practice linkages. Two main options exist for this. First, formal institutional arrangements could be modified to reward engagement in the science–practice interface (Young et al. 2014; Cvitanovic et al. 2016; Rose et al. 2018). Publication incentives are one of the most important science policies, but they can restrict scientists from producing useful science (Neff 2018) and from participating in collaborations (Shanley & López 2009). To overcome these limitations, several authors have recommended to organizations and funders, for example, rewarding alternative career paths, participation in expert groups, publishing in gray literature (Young et al. 2014; Cvitanovic et al. 2016) and investing additional resources in policy-impact plans developed in collaboration with decision makers (Tyler 2017). Because scientists themselves are relevant science policy makers, rethinking scientific reward systems may be feasible (Neff 2018) insofar as young scientists become familiar with engagement in the science–practice interface (e.g., training suggestions in Young et al. [2014] and Toomey et al. [2018]).

Second, new organizations aiming at mediating interactions between science and practice could be fostered. Such boundary organizations include professionals who have accountability to both scientists and decision makers and thus can facilitate dialogue between them (Guston 2001; Cash et al. 2003). The creation of boundary organizations was advocated by the detached producers, but may also satisfy participants with other viewpoints because joint knowledge-production activities (as proposed by interactive partners) and collaborative identification of emerging topics to guide research agendas (as emphasized by interactive users) can occur within these organizations (e.g., Cash et al. 2003; White et al. 2008).

Besides creating conditions for science-practice linkages within organizations, our results suggest the need to openly debate expected roles—for scientific knowledge, scientists, decision makers and organizations—at the onset of collaborations because these varied across viewpoints. Multiple research areas delve into how to stimulate effective collaborative projects to produce orientations toward conservation and sustainability (e.g., Scholz and Steiner's [2015] transdisciplinarity mode 2, knowledge integration and exchange [Raymond et al. 2010], and translational ecology [Enquist et al. 2017]). Despite the recognition that conflicting expectations among participants hinder partnerships (Stokols et al. 2008), discussions on the roles of distinct actors, knowledge types, and organizations are often left out of guidelines to collaborative projects (e.g., Cvitanovic et al. 2016). We suggest such discussions be an explicit first stage when setting collaborative enterprises and be based on argumentation instead of aiming for simple consensus, which may obscure deeper disagreements (Peterson et al. 2005; Carpenter et al. 2009). The agreements identified here may provide a baseline for scientists and decision makers to discuss divergences without escalating possible conflicts (Durning 2006).

Exploring and making diversity of opinions explicit, as we did in our study, allows the identification of agreements and disagreements across relevant actors and thus helps delineate strategies to link science and practice to improve decision making. However, ways of thinking about the science–practice interface will vary across regions and countries, given the variety of values, cultures, and social-political contexts. Differences in practices between scientists from former European colonies in Latin America and scientists from European metropolises (Lafuente 2000), for instance, may partly explain why observed divergences on the science-practice interface in Brazil were subtler than those reported in the ecological and conservation literature dominated by developed countries (Di Marco et al. 2017). We hope our study stimulates similar research in other countries so that conservation can be improved through proper, context-relevant science–practice linkages.

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Supporting Information

Methodological details (Appendix S1), original statements and quotations in Portuguese (Appendix S2), additional information on participants and on the 3 viewpoints (Appendix S3), original data and scripts (Appendix S4), and detailed narratives of identified viewpoints (Appendix S5) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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