Conservation Biology

Essay

A roadmap for knowledge exchange and mobilization research in conservation and natural resource management

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Abstract: *Scholars across all disciplines have long been interested in how knowledge moves within and beyond their community of peers. Rapid environmental changes and calls for sustainable management practices mean the best knowledge possible is needed to inform decisions, policies, and practices to protect biodiversity and sustainably manage vulnerable natural resources. Although the conservation literature on knowledge exchange (KE) and knowledge mobilization (KM) has grown in recent years, much of it is based on context-specific case studies. This presents a challenge for learning cumulative lessons from KE and KM research and thus effectively using knowledge in conservation and natural resources management. Although continued research on the gap between knowledge and action is valuable, overarching conceptual frameworks are now needed to enable summaries and comparisons across diverse KE-KM research. We propose a knowledge-action framework that provides a conceptual roadmap for future research and practice in KE/KM with the aim of synthesizing lessons learned from contextual case studies and guiding the development and testing of hypotheses in this domain. Our knowledge-action framework has 3 elements that occur at multiple levels and scales: knowledge production (e.g., academia and government), knowledge mediation (e.g., knowledge networks, actors, relational dimension, and contextual dimension), and knowledge-based action (e.g., instrumental, symbolic, and conceptual). The framework integrates concepts from the sociology of science in particular, and serves as a guide to further comprehensive understanding of knowledge exchange and mobilization in conservation and sustainable natural resource management.*

Keywords: interdisciplinary, knowledge-action gap, knowledge management, knowledge sharing, science action, science communication, science policy, social network

Un Mapa para el Intercambio del Conocimiento y la Movilización de la Investigación en la Conservación y el Manejo de Recursos Naturales

Resumen: *Durante mucho tiempo, los investigadores de todas las disciplinas se han interesado en cómo se mueve el conocimiento dentro y más allá de sus comunidades de pares. Los cambios ambientales rápidos y el llamado por prácticas sustentables de manejo significan que el mejor conocimiento posible es necesario para informar las decisiones, políticas y prácticas para proteger a la biodiversidad y para manejar sustentablemente los recursos naturales vulnerables. Aunque la literatura de conservación sobre el intercambio de conocimiento (IC) y la movilización del conocimiento (MC) ha aumentado en años recientes, la mayor parte está basada en estudios de caso específicos para un contexto. Esto presenta un reto para aprender lecciones acumulativas a partir de la investigación del IC y la MC y así utilizar efectivamente el conocimiento en la conservación y el manejo de recursos naturales. Aunque la investigación continua acerca del vacío entre el conocimiento y la acción es valiosa, ahora se requieren marcos de trabajo conceptuales globales para permitir resúmenes y comparaciones entre diversas investigaciones de IC-MC. Proponemos un marco de trabajo de conocimiento-acción*

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Paper submitted July 20, 2016; revised manuscript accepted October 16, 2016.

Conservation Biology, Volume 31, No. 4, 789–798

DOI: 10.1111/cobi.12857

que proporcione un mapa conceptual para las próximas investigaciones y prácticas de IC/MC con miras a sintetizar las lecciones aprendidas de los estudios de caso contextuales y a guiar el desarrollo y la prueba de hipótesis en este dominio. Nuestro marco de trabajo conocimiento-acción tiene tres elementos que suceden en niveles y escalas múltiples: producción de conocimiento (p. ej.: academia, gobierno), mediación del conocimiento (p. ej.: redes de conocimiento, actores, dimensión relacional, dimensión contextual) y acción basada en el conocimiento (p. ej.: instrumental, simbólica y conceptual). El marco de trabajo integra conceptos de la sociología de la ciencia en particular, y sirve como guía para aumentar el entendimiento comprehensivo del intercambio y la movilización del conocimiento en la conservación y el manejo sustentable de los recursos naturales.

Palabras Clave: acción científica, compartir conocimiento, comunicación de la ciencia, interdisciplinario, manejo del conocimiento, política de la ciencia, red social, vacío conocimiento-acción

The Gap within the Knowledge-Action Gap

Nearly 20 years ago, Gary Meffe (1998: 741) suggested that "if we—the premier conservation scientists in the world who seek and possess the best scientific information on the state of nature—do not actively and aggressively put our knowledge to use in development of public policy and legislation, and do not do it soon, then we are failing society and posterity in what should be a major responsibility." There is little doubt that conservation scientists want their research to influence conservation and environmental policies and practices (Singh et al. 2014). However, this has not been an easy task, particularly because policy makers, resource managers, and stakeholders often rely on experiential, tacit, and informal knowledge rather than scientific knowledge in formulating their opinions and in their decision making (e.g., Pullin et al. 2004; Sutherland et al. 2004; Cvitanovic et al. 2014). The difficulties experienced by both scientists and knowledge users in mobilizing conservation action based on science suggest that significant cultural and structural barriers are impeding the flow of knowledge into action (e.g., Gibbons et al. 2008; Cook et al. 2010; Young et al. 2013). This phenomenon has been described as a science-action, research-implementation, and knowledge-action gap and has recently gained significant interest among conservation-science scholars (e.g., Cowling 2005; Knight et al. 2008; Cook et al. 2013).

Although existing research into the knowledge-action gap has been fruitful, scholars believe that they are only scratching the surface in gaining a comprehensive understanding of the causes and potential remedies of the knowledge-action gap (e.g., Cowling 2005; Fazey et al. 2012; Cook et al. 2013). Much of the existing research involves in-depth examination of case studies. Although these are highly useful, they often lack an overarching conceptual framework that aids generalizing and connecting findings to the wider community of theory and practice (Fazey et al. 2012, 2014; Reed et al. 2014). For this reason, we argue that there is a deficiency in understanding of the knowledge-action gap and hence a gap within the knowledge-action gap. We propose a framework for identifying, synthesizing, and comparing context-specific research on knowledge movement and implementation and connecting this research to broader analyses of relevant social processes. The framework is rooted in concepts and lessons from the study of the social aspects of science (i.e., sociology of science). It is intended as a starting point that may offer a theoretically informed roadmap to research into the knowledge-action gap and that may assist in advancing understanding of knowledge movement in conservation and natural resource management as more empirical evidence accumulates.

Knowledge Movement from a Sociological Perspective

Research on the knowledge-action gap across multiple fields shows that scientific knowledge has less of an impact on decision making than is generally assumed (Arlettaz et al. 2010; Rose 2015). The impacts of knowledge are, however, difficult to trace. In some cases, impacts are immediate and direct, but most of the time the impacts of knowledge unfold indirectly and over a long period (Levin 2013). The frustration that scientists feel when their findings are not implemented or taken seriously makes more sense when one considers knowledge from a sociological perspective (Fazey et al. 2014). Sociologists view knowledge as embedded in social relations. This means that people rely on one another to access knowledge (via social connections and networks) and that people interpret knowledge based on shared social constructs such as beliefs, values, culture, norms, and other social influences (Pohl 2008; Levin 2013; Clark et al. 2016). Knowledge communicated through peer-reviewed journals is unlikely to enter the social networks of, for instance, relevant user groups of practitioners. Similarly, knowledge that does not connect immediately with users' priorities and practices is not likely to have a substantial impact on users' opinions or decision making (Yamamoto 2012). We used these insights from sociology and the broader social sciences as a starting point for building our conceptual framework.

In the realm of conservation and natural resource management, research on the knowledge-action gap is not as well developed as in other sectors such as the social sciences, health sciences, education, and business management (Fazey et al. 2012). Although we have seen a marked upswing in research on knowledge movement in the conservation literature over the last few decades, the portrait remains incomplete. The effectiveness of knowledge on conservation practices and natural resource management depends on how knowledge moves, how it is exchanged, how it is used, and how it interacts with the social world (e.g., Cash et al. 2003; Pullin & Knight 2003; Francis & Goodman 2011). Researchers increasingly recognize that knowledge is not an inert object that can trickle down or transfer and translate through a linear pipeline from the knowledge producers to the knowledge users (Roux et al. 2006; van Kerkhoff & Lebel 2006); rather, it moves in a dynamic, iterative, and nonlinear fashion. Thus, we focused on 2 concepts that capture the fact that moving knowledge across social boundaries is challenging and is a multiway exchange between the knowledge generators and potential users (Gainforth et al. 2014; Young et al. 2016*b*): knowledge exchange (KE), which has recently been adopted in the environmental management literature (Fazey et al. 2012), and knowledge mobilization (KM), which is more commonly used in the social sciences and education literature (e.g., Bennet et al. 2007; Levin 2013). Here, knowledge exchange and mobilization are meant to capture the social dimensions of knowledge creation diffusion and application, as well as to describe the process and mechanisms of knowledge movement (Cash et al. 2003, Fazey et al. 2012, Young et al. 2016*a*). Knowledge action, on the other hand, is used to describe the phenomenon at hand: the knowledge-action gap in conservation and natural resource management.

A wide range of terms and concepts have been presented across disciplines and literatures to describe the process of knowledge movement. Examples include *knowledge transfer*, *knowledge translation*, *diffusion of innovation*, and *knowledge management*. Each has its own nuances, emphases, and applications (Greenhalgh & Wieringa 2011; Fazey et al. 2012). At root, however, each of these terms has a similar referent and purpose: to facilitate analysis of the conditions in which knowledge moves and is applied by a range of social actors. In the context of this paper, the term *knowledge management* merits particular attention. As a concept, knowledge management originates in the business and organizational studies literature and refers to practices for managing intellectual capital and information flows to achieve organizational objectives, particularly enhanced market competitiveness (Alavi & Leidner 2001; Bennet et al. 2007). However, the term has recently entered the environmental management literature with a slightly different connotation. Reed et al. (2013:311) define *knowledge management* as the "process of generating, storing and circulating *new* knowledge and identifying [and] bringing together and applying *existing* knowledge to achieve a specific objective" (emphasis added). This definition is more in line with KE and KM research and with the core dilemma at the heart of the knowledge-action gap, namely, how to integrate new knowledge into practices that are highly influenced by existing bodies of experiential, tacit, and informal knowledge. For the sake of conceptual clarity, we used the terms *knowledge exchange* and *knowledge mobilization* but acknowledge the existence of other terms that have similar meanings (particularly *knowledge management*).

Need for a Knowledge-Action Framework

Although there has been an increase in KE and KM research in the field of environmental management, little synthesis exists of lessons learned and actions required (but see Fazey et al. 2012; Reed et al. 2014). For instance, the majority of new information and early research is case-study based and context specific. Case-based findings related to KE and KM have not been reported in a manner that can assist the wider community of theory and practice to improve on KE and KM processes in the future. This makes it challenging to organize new knowledge on KE and KM so as to facilitate comparability and applicability across different contexts and situations (Ostrom 2009; Fazey et al. 2012. Frameworks are therefore needed to help organize and compare results of new research on the processes of KE and KM so as to improve understanding of the knowledge-action gap and provide guidance for future research in conservation and natural resource management.

Knowledge-Action Framework

The goal of a framework is to provide structure to a field of ideas and research in a way that demonstrates applications and provides guidance for future work (Ostrom 2009). Without a framework to organize relevant KE and KM information, isolated observations and findings from KE and KM research are unlikely to result in a coherent body of knowledge. The knowledge-action framework we devised is based on our reading of the broader literature on knowledge exchange, mobilization, translation, transfer, and management across multiple fields and disciplines (e.g., business management, education, health sciences, social sciences, and others). The framework is not meant to be prescriptive or a complete systematic review of knowledge-action research. Rather, we sought to provide a dynamic framework to help build empirical evidence in an organized manner and further understanding

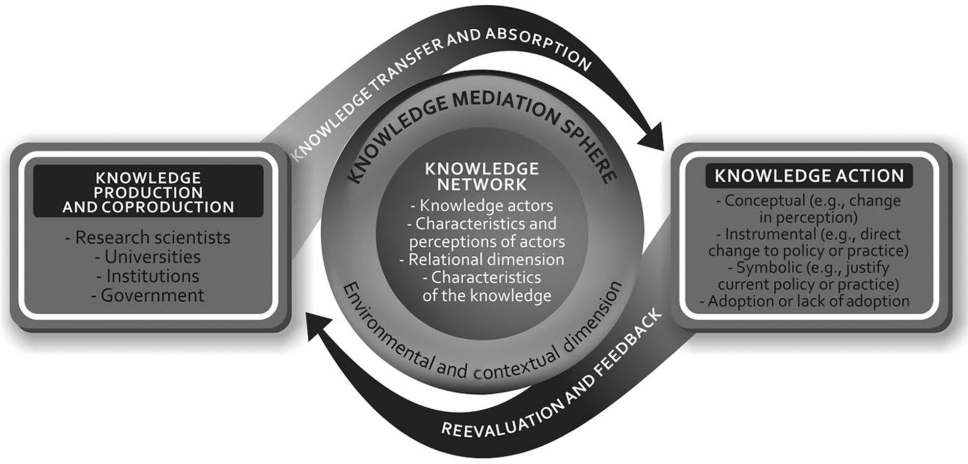

Figure 1. The knowledge-action framework. It shows the processes of knowledge movement within a knowledge system at a dynamic temporal scale and at individual and institutional levels. The mediation sphere encompasses factors that ultimately influence whether knowledge is absorbed and transferred, adopted into a knowledge action, reevaluated, and looped back to the knowledge producers or absorbed and transferred but not adopted. The entire framework operates on various scales and levels, where processes are dynamic and framework components may interact.

of knowledge movement in the context of conservation and natural resource management.

Three Elements of the Knowledge-Action Framework

Three core elements form the basis for moving knowledge into action: the knowledge production; an intermediary where knowledge is acquired, retained, and processed; and a knowledge action or inaction (Argote et al. 2003; Contandriopoulos et al. 2010; Fazey et al. 2012; Phelps et al. 2012). We adapted the 3 core elements to our proposed framework (Fig. 1) as knowledge production or coproduction; the knowledge mediation sphere (i.e., the knowledge action gap); and the knowledge action outcome, respectively (Fig. 1). There are nonlinear processes that connect these 3 elements such as the strategies used to mobilize and exchange knowledge and capacity to absorb the knowledge (i.e., absorption and transfer [Fig. 1]) and social learning as a byproduct of reevaluation and feedback of the KE and mobilization processes (Fig. 1). The components of the framework are summarized in Table 1.

Knowledge Production

In the world of conservation science, academic institutions and other researchers (e.g., governments and environmental consulting groups) are typically the source of scientific knowledge production in a knowledge system or social network (Fig. 1 & Table 1). However, the recent trend toward cocreation and coproduction of knowledge involving collaboration between scientists and knowledge users has transcended the boundaries between knowledge producers and users (e.g., Berkes 2009; Hegger et al. 2012; Phillipson et al. 2012). There has also been an increased inclusion of citizen science and local and traditional ecological knowledge in tackling conservation problems (Raymond et al. 2010). This recent shift does not necessarily mean that changes in practice have occurred. Many scientists continue to work in traditional ways with clear and hierarchical divisions between producer and user, an approach that continues to be favored by current institutional norms, structures, and reward systems (Shanley & Lopez 2009). Nonetheless, knowledge production in this framework can also include coproduction with the end users in anticipation of increased participatory approaches in conservation and natural resource management (Fazey et al. 2014).

Knowledge Mediation Sphere

In our proposed framework, knowledge enters a knowledge mediation sphere (Fig. 1) in which knowledge can be absorbed, retained, bounced around, transferred, reinterpreted, shared, and potentially misappropriated or stuck (Reed et al. 2014). The mediation sphere is essentially that gap between knowledge and action. The mediation sphere fits with the concepts of KE and mobilization because it stresses the multidirectional and iterative movement of knowledge in forms such as reevaluation and feedback, which may begin at the same time as knowledge production, as under participatory

Table 1. Summary of the components of the knowledge-action framework pictured in Fig. 1 and potential variables hypothesized to influence knowledge exchange and knowledge mobilization.[a]

Component	*Description*	*Variable (individual, group, and institutional level)*	*Example sources across disciplines*
Knowledge production	Generation of new knowledge either in isolation by research institutions or cocreated through participation and engagement with knowledge users.	primary research; citizen science; adaptive comanagement syntheses; technological innovations; systematic reviews; and other knowledge claims and production	Berkes 2009; Jasanoff 2010; Hegger et al. 2012
Knowledge mediation sphere	Mediation of knowledge created and its fate, which may include the formation of boundary objects. The circular (i.e., sphere) shape in Fig. 1 emphasizes the nonlinearity and dynamic processes of knowledge flow and movement.		
Knowledge network	A complex social network of interactions between knowledge actors and the knowledge produced as well as among the actors. The dynamics and interactions within the network can occur at multiple levels and scales.	social ties (e.g., direct vs. indirect and weak vs. strong); network connectivity; social capital; network position (i.e., individual's social proximity to others in the network); social cohesion (i.e., length and strength of paths that connect individuals); ego network structure (patterns of ties within a focal individual's immediate set of contacts); whole network structure (patterns of ties among all individuals in a bounded population); homogeneity/heterogeneity of network; and level of conflict	Inkpen & Tsang 2005; Bodin et al. 2006; Mitton et al. 2007; Fliaser & Spiess 2008; Bodin & Crona 2009; Phelps et al. 2012
Knowledge actors	individual players involved in the exchange and mobilization of knowledge	who, what, and how many stakeholders involved; facilitator; change agents; champions, knowledge broker; boundary organization; and social status	Argote et al. 2003; Jasanoff 2010; Hegger et al. 2012; Phelps et al. 2012; Young et al. 2016*b*
Characteristics and perceptions of actors	Who and where do the actors come from? Actors' characters, perception, and how they are perceived may influence how knowledge is exchanged or mobilized.	personality; skills (communication and leadership); social status; role; willingness to receive or facilitate knowledge exchange or mobilization; individual motivations; background (e.g., education, experience, and expertise); person's power and authority; absorptive capacity; knowledge transfer capacity; diversity of network contacts; knowledge ownership; values, attitudes, and beliefs	Argote et al. 2003; Mitton et al. 2007; Gibbons et al. 2008; Wang & Noe 2010; Phelps et al. 2012
Relational dimension	relationship and ties between knowledge actors	tie strength; interpersonal trust; reciprocity norms between individuals; mutual respect; collaborations and partnerships; social costs and benefits; and engagement with other actors	Argote et al. 2003; Mitton et al. 2007; Phelps et al. 2012; Reed et al. 2014; Cvitanovic et al. 2015; Hilary 2016
Characteristics of the knowledge	The type and attributes of knowledge that is entering the knowledge network can have influence on how it is perceived and mobilized.	tacitness and complexity; explicitness (simple and codified knowledge); traditional knowledge; local knowledge; scientific knowledge; experiential knowledge; perceived benefits and costs of	Gibbons 1999; Argote et al. 2003; Cash et al. 2003; Hessels et al. 2009; Phelps et al. 2012; Young et al. 2016*a*

Continued

Table 1. Continued

Component	*Description*	*Variable (individual, group, and institutional level)*	*Example sources across disciplines*
		knowledge; socially robust; politicized; relevance, fit, and applicability of knowledge; uncertainties; reliability, legitimacy, and credibility; multi-, inter-, transdisciplinary; accessibility; political knowledge; and perceived usefulness	
Environmental and contextual dimension	factors external to the knowledge network that can influence the movement of knowledge such as culture, institutional norms, economic context, and political context	culture or climate; institutional norms; economic context; governance; political context; geographic location; institutional or organizational structure and support; rewards and incentives; human and financial resources (capacity)	Pullin & Knight 2005; Mitton et al. 2007; Arlettaz et al. 2010; Wang & Noe 2010; Driscoll et al. 2011; Cvitanovic et al. 2015
Knowledge action outcomes	outcome of the knowledge which may or may not be measured because some may be less tangible such as perception change or lack of action or lag in action	Knowledge actions may be conceptual (raising awareness and changing beliefs, perceptions, or thinking), instrumental (direct changes to policy or practice and the use of boundary objects), or symbolic (justifying existing policy or practice). Successful knowledge actions are context dependent and vary with conservation objectives.	Amara et al. 2004; Star 2010; Rudd 2011; Reed et al. 2014

[a]*All components may operate on various scales and levels, which may also interact.*

approaches and knowledge coproduction (Cvitanovic et al. 2015; Schuttenberg & Guth 2015). The factors that make up the mediation sphere may influence the destination of the knowledge that enters the sphere and may include or form boundary objects. Boundary objects are artifacts such as best practices, strategies, and plans that exist at the frontiers of 2 social worlds and help bridge them (Star 2010). In other words, the sphere includes the processes that influence and mediate the flow of knowledge from knowledge production to knowledge action, such as developments or changes to policy or practice (discussed in more detail below in "Knowledge Action").

The Knowledge Network of Knowledge Mediation Sphere

The knowledge mediation sphere is composed of components that may help one understand the mechanisms of knowledge flow. First, knowledge can enter a knowledge network (Fig. 1), which is a social network composed of complex interactions of knowledge actors with the knowledge itself and with each other at potentially multiple levels (e.g., Inkpen & Tsang 2005; Crona & Bodin 2006; Phelps et al. 2012). The multilevel actors in the network range from individuals to groups to institutions. The actors (e.g., creators, brokers, practitioners, and users) individually and collectively all have a role in the mobilization and application of knowledge (Phelps et al. 2012; Young et al. 2016*b*). Recent research emphasizes the importance of social capital (i.e., the networks and norms that facilitate social engagement) for collective action (Ostrom 2014) in conservation action and potentially knowledge action. Thus, the structure and content of social relationships and interactions influence the access, transfer, diffusion, and application of knowledge. Furthermore, each actor has characteristics (i.e., characteristics and perceptions of actors) that may have an effect on knowledge flow (Table 1). The role and social status of the actors, their position within their social network, power, and credibility, and each of their individual social networks can influence the flow of knowledge (Argote et al. 2003; Borgatti & Cross 2003; Bodin & Crona 2009). For example, actors with the status of an opinion leader could have important social influence and social interactions within their social network and thus have great influence on whether a certain knowledge claim is viewed as credible or legitimate. Furthermore, the actors' motivational factors (to create, transfer, absorb, or adopt knowledge) and their backgrounds (i.e., expertise, experience, and discipline), values, beliefs, culture, norms, and habits all play a role in shaping the perception of the

knowledge (e.g., Estabrooks et al. 2008; Fazey et al. 2012; Young et al. 2016*b*).

Understanding the relationships among knowledge actors (i.e., the relational dimension) and the factors that influence these relationships, such as interpersonal trust, social norms, openness, and contact (proximity and frequency, intensity of communication, connection, and social similarity) (e.g., Mitton et al. 2007; Reed et al. 2014; Cvitanovic et al. 2015) is critical to understanding the underlying processes that mediate knowledge and action (Table 1). An example comes from the west coast of Canada and the contested Pacific salmon fisheries. Young et al. (2016*b*) report that knowledge viewed as credible and reliable is more often trusted and used by knowledge users, and the perceived reliability of knowledge can be based on the perceived character and motivation of the knowledge claimant, which reinforces the importance of the social interactions among actors.

The characteristics of the knowledge contain factors that influence knowledge movement (Table 1). For example, there are 2 types of knowledge: tacit knowledge (i.e., knowledge that is difficult to articulate or formalize and communicate), which often is complex and exists in the mental models and expertise gained over time and through personal insight (Goh 2002; Collins 2010) and explicit knowledge (i.e., knowledge that is readily codified, articulated, and captured), which is what is written or recorded in manuals, patents, reports, documents, assessments, and databases and is easier to mobilize because it is tangible and easier to articulate (Goh 2002; Collins 2010). Other dimensions or properties of knowledge include whether it is codified, ambiguous, internally or externally sourced, shared or uniquely possessed by individuals, soft or hard, and public or private (Argote et al. 2003). The perceived quality of the knowledge with respect to its credibility, legitimacy, accuracy, trustworthiness, and reliability may affect how it is received and communicated within a knowledge network (Cash et al. 2003; Jacobson & Goering 2006; Young et al. 2016*b*).

Environmental and Contextual Dimensions of Knowledge Mediation Sphere

There are forces external to the knowledge network that may affect the mediation of knowledge to action. We refer to these factors as the environmental and contextual dimensions of the mediation sphere, such as political and economic circumstances, governance procedures, institutional structures, and other contextual factors (e.g., social harmony or acrimony that may constrain or facilitate knowledge flow) (e.g., Weingart 1999; Roux et al. 2010; Cvitanovic et al. 2015). For instance, laws often restrict flexibility in managing and authority over natural resources. The organizational structure of management agencies may range from centralized to relatively autonomous, local decision making, which may ultimately affect knowledge flow and its impact on knowledge outcomes (Cash et al. 2003). More research is needed on the influence of context and external forces on KM outcomes.

Knowledge Actions

The goal of the knowledge-action framework is to use knowledge effectively to advance conservation and maintain long-term sustainability of natural resources. This requires interactions between the knowledge producers and potential knowledge users. In conservation and natural resource management, potential knowledge users include, for example, conservation practitioners, resource managers, decision makers (including elected officials), resource users, researchers, and environmental educators. A successful knowledge-action outcome is not necessarily a one-way linear action. More often, it involves a multidirectional and iterative reevaluation and feedback process whereby knowledge users and producers deliberate about research priorities and real-world constraints on management. This process often results in more salient and legitimate production of knowledge and conservation solutions because it is based on an extended exercise of problem-focused thinking that encourages collaborative social learning (Pahl-Wostl 2006; Cook et al. 2013).

One example of a successful knowledge-action outcome is the implementation of policy or practice based on scientific evidence (Pullin et al. 2004; Sutherland et al. 2004). For instance, the mission-oriented science conducted with support from a coordinated binational science-based organization (i.e., the Great Lakes Fishery Commission) to identify a selective lampricide treatment as part of the invasive sea lamprey (*Petromyzon marinus*) control program is heralded as a success in that it restored native fish populations and supports livelihoods (Wagner et al. 2006). A second example of a successful knowledge-action outcome involves the engagement and commitment of both scientists and practitioners to implement the conservation action. Arlettaz et al. (2010) demonstrated that the practical involvement of researchers, in close collaboration with stakeholders, in the implementation of the researchers' proposed recovery strategies for an endangered hoopoe (*Upopa epops)* population in the Swiss Alps was highly successful in bridging the knowledge-action gap. A third example of a successful knowledge-action outcome involves changing behaviors of knowledge users so as to lead to long-term sustainability and conservation of the natural world (De Young 1993; Schultz 2011). Human behavior and people's actions have increased anthropogenic pressures on Earth's ecosystems and natural resources (Vitousek et al. 1997). Thus, successfully changing human behavior to proenvironmental and proconservation behaviors (e.g.,

how they vote, how they purchase or consume, and how they interact with the environment) is a successful knowledge action. Overall, knowledge outcomes and impact on conservation and natural resource management can be grouped into 3 broad theoretical categories: conceptual (raising awareness, behavioral change, and changing beliefs and thinking); instrumental (direct impacts on policy or practice); and symbolic (justifying existing policy and practice) (Amara et al. 2004; Rudd 2011).

Although examples of successful knowledge actions exist, a desirable knowledge action or outcome is nonetheless context dependent, and a universal method to evaluate a successful knowledge action is likely not possible or desirable (Hulme 2010; Fazey et al. 2014). There are almost always different objectives and measures of success held by different actors (Roux et al. 2010). A proposed knowledge action is thus dynamic and varies with context.

Scales, Levels, and Interactions

The processes in our framework can occur at different scales and levels and there is the potential for interactions among the different elements of the knowledge-action framework. For instance, KE and KM processes can occur at the individual and institutional or group level and are dynamic through time, where both levels can interact (e.g., individual-level perceptions can influence institutional-level perceptions and vice versa). Thus, the level of analysis (e.g., interpersonal, intragroup, and intergroup) in KE and KM research should be taken into consideration because, often, institutional norms and culture can play a substantial role in fostering collective action, group thinking, and environmental stewardship (Ostrom 2014), which emphasizes the importance of considering the factors that influence KE and KM at both individual and institutional levels (Mitton et al. 2007; Phelps et al. 2012). It is important to look at the relationships between individuals and among collective groups (e.g., stakeholders) to understand how knowledge moves within and between these multilevel actors. Cash et al. (2006) further describe the application of knowledge and knowledge of processes at different scales. Although knowledge of ecological processes may be more useful at larger spatial and temporal scales, often it can only be applied at smaller scales and higher resolutions (i.e., zooming into a big picture), implying that scales and resolutions of knowledge application are important.

The various dimensions (e.g., actors, relationships, and context) in the knowledge-action framework are not isolated from one another; they interact with each other in ways that may influence the knowledge outcome (Chen & Mohamed 2007). For example, the perceptions and values of the knowledge actors (activities within the knowledge network) may interact with the political context in which actors are embedded (Young et al. 2016*a*). These interactions (much like interactions in social-ecological systems) may be additive, synergistic, or antagonistic in ways that may delay or enhance the integration and use of knowledge (Folt et al. 1999; Milner-Guland 2012). Very little empirical research has addressed directly these interactions because they are difficult to observe and document (but see Chen & Mohamed 2007; Young et al. 2016*b*). Given their importance, however, we expect that this will become a substantial area of research that we hope can be used to improve the framework in the future.

Guide to Knowledge Exchange and Mobilization Research

The study of the knowledge-action gap as it applies to understanding of the movement of knowledge is still disparate and scattered, and there has been little reflection on how to organize, synthesize, and move the field forward. To that end, we hope our framework will provide a roadmap to identify and summarize relevant variables and ideas for studying the knowledge-action gap using KE and KM concepts (see Supporting Information for implementation scenarios). The knowledge-action framework is a starting point for developing and testing hypotheses, designing data-collection methods, and analyzing findings related to conservation knowledge-action research (Supporting Information) because it illuminates the social nature of knowledge, even in an era of evidence-based decision making (Sutherland et al. 2004). With a theoretical framework, there is a common map that can enable context-specific research to contribute to the wider body of scholarship and be used to build on a body of evidence relevant to mechanisms of knowledge flow and potential knowledge-action outcomes. Our proposed framework is presented in broad and generic terms because it must allow for flexibility so that it can be built on further as more empirical evidence and emerging theories are directed toward this relatively new concept. We encourage researchers to start here and build empirical evidence on what works and what does not work when attempting to narrow the gap between knowledge and action so that progress can be made in conserving biodiversity and sustainable management of natural resources.

Supporting Information

Framework implementation scenario (Appendix S1) is 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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