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Conservation Biology

Essay

Using knowledge mapping to rethink the gap between science and action

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Abstract: Scholars have long stressed the need to bridge the gap between science and action and seek the most efficient use of knowledge for decision making. Many contributors have attempted to consider and understand the sociopolitical forces involved in knowledge generation and exchange. We argue, however, that a model is still needed to adequately conceptualize and frame the knowledge networks in which these processes are embedded. We devised a model for knowledge mapping as a prerequisite for knowledge management in the context of conservation. Using great ape conservation to frame our approach, we propose that knowledge mapping should be based on 2 key principles. First, each conservation network results from the conglomeration of subnetworks of expertise producing and using knowledge. Second, beyond the research-management gradient, other dimensions, such as the scale of operation, geographic location, and organizational characteristics, must also be considered. Assessing both knowledge production and trajectory across different dimensions of the network opens new space for investigating and reducing the gap between science and action.

Keywords: biodiversity, conservation network, knowledge management

Uso del Conocimiento del Mapeo para Replantear la Separación entre la Ciencia y la Acción

Resumen: Durante mucho tiempo los académicos han hecho énfasis en la necesidad de cerrar la brecha entre la ciencia y la acción, así como encontrar el uso más eficiente del conocimiento para la toma de decisiones. Muchos contribuyentes han intentado considerar y entender las fuerzas sociopolíticas involucradas en la generación e intercambio de conocimiento. Sin embargo, argumentamos que todavía se necesita un modelo para conceptualizar y enmarcar adecuadamente las redes de conocimiento en las que están incorporados estos procesos. Diseñamos un modelo para el mapeo del conocimiento como prerrequisito para el manejo del conocimiento como parte del contexto de la conservación. Usamos la conservación de los grandes simios para enmarcar nuestra estrategia y proponemos que el mapeo del conocimiento debería estar basado en dos principios clave. Primero, cada red de conservación es resultado de la conglomeración de subredes de experiencias que produce y usa conocimiento. Segundo, más allá del gradiente de manejo de investigaciones, otras dimensiones como la escala de operación, la ubicación geográfica y las características de organización también deben considerarse. La evaluación de la producción y la trayectoria del conocimiento a través de diferentes dimensiones de la red de conservación abre un nuevo espacio para la investigación y la reducción de la brecha entre la ciencia y la acción.

Palabras Clave: biodiversidad, manejo del conocimiento, red de conservación

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摘要: 长期以来, 学者们一直强调应填补科学与行动之间的鸿沟, 并寻求在决策中最有效地利用知识。许多研究者试图考虑和理解在知识产生和交流中涉及的社会政治力量。然而, 我们认为仍需要用模型来充分概念化并构建嵌入这些过程的知识网络。我们设计了一个保护背景下的知识图谱模型, 以作为知识管理的前提条件。本研究利用类人猿保护来构建相关方法, 并提出知识图谱应基于两个关键原则。第一, 每一个保护网络都是由生产和使用知识的专业知识子网络聚集而成的。第二, 必须考虑除研究管理梯度之外的其它维度, 如保护行动的规模、地理位置和组织特征。评估网络中不同维度的知识生产和知识轨迹, 将为研究和缩小科学与行动之间的差距开辟新的空间。**翻译: 胡怡思; 审校: 聂永刚**

关键词: 知识管理, 生物多样性, 保护网络

Introduction

In recent decades, scientific knowledge has been the cornerstone of strategies to preserve Earth's biosphere (Balmford et al. 2005). However, despite massive investments in "knowing in order to conserve" (Vimal 2017), the environmental crisis has not been solved and biodiversity continues to decline (Butchart et al. 2010). In seeking the most efficient use of knowledge for action, scholars conceptualized the existence of a gap that should be bridged between producers and users of knowledge. Literature on this topic alternatively refers to the knowledge–action gap (Cook et al. 2013), knowing–doing gap (Hulme 2014), research–implementation gap (Knight et al. 2008; Arlettaz et al. 2010), science–management divide (Roux et al. 2006), gap between science and practice (Cabin 2011), and gap between research and practical management (Armstrong & McCarthy 2007).

However, the way academics frame this gap and the solutions they conceive to narrow it rely on and reflect 2 major conceptions of the relationship between science and society (Toomey et al. 2017; Bertuol-Garcia et al. 2018). Ecologists and conservationists commonly adhere to a positivist approach and consider predominantly the gap between researchers as producers and practitioners as users of academic knowledge. Accordingly, they focus on knowledge transfer, which they consider the delivery and reception of information following a one-way process (Pregernig 2014). This conception has been widely criticized (e.g., Roux et al. 2006; van Kerkhoff & Lebel 2006) because it is based on the assumption of a linear and unidirectional movement of scientific knowledge and fails to consider complex entanglements between knowledge production and decision making as well as between scientific knowledge and other sources of information.

In contrast, the emergence of environmental humanities, which considers the social issues related to human–nature relationships (Sörlin 2012), paved the way to reframing the science–policy interface and, accordingly, to reconceptualizing the gap. From this perspective, science and technology studies provide key concepts to capture the relation between science and society and between knowledge production and decision making (Latour 1987; Porter 1996; Carolan 2006; Jasanoff 2012). Building on a constructivist approach, scholars in the field have particularly stressed the need to consider the production of scientific facts as socially and politically embedded. Rather than being static and independent from social realities, science relies on processes shaped across complex interactions within networks of various actors (Callon 1984; Latour 2005). This conception is particularly true for policy-driven sciences, such as conservation science (Meine et al. 2006), and calls for a broad and integrative perception of scientific knowledge, whereby expertise in policy implementation, management, and monitoring is of equal importance to research-oriented activity (Cook et al. 2013; Cvitanovic et al. 2016). Concepts, such as contextualized, postnormal, and regulatory science, capture this idea that knowledge production is not just an academic activity but may also be fully embedded in bureaucratic, administrative, and management contexts (Funtowicz & Ravetz 1993; Gibbons 2000; Jasanoff 2009).

In opposition to the rationalist model of knowledge transfer from research to practice, such framing suggests new ways of knowledge management at the science–practice interface (Reed et al. 2013). Based on this perspective, scholars have stressed the need to understand the processes involved in the "sharing, generation, co-production, co-management and brokerage" of knowledge (Fazey et al. 2013).

Over the last decade, a number of contributions have been made to foster knowledge exchange among stakeholders by considering the effect of power, cultural norms, trust, social interactions, and values in shaping the production and movement of knowledge (e.g., Hegger et al. 2012; Boswell & Smith 2017; Knight et al. 2019; Scarano et al. 2019). Scholars alternatively refer to the research-implementation space (Toomey et al. 2017; Buschke et al. 2019), knowledge mediation sphere (Nguyen et al. 2017), knowledge system (Cash et al. 2003), and knowledge network (Phelps et al. 2012) in which such processes are involved and where knowledge should be managed.

In support of this approach, we argue that effective knowledge management additionally requires an

understanding and a conceptualization of the knowledge network in itself. Environmental issues involve networks of various stakeholders (Reed 2008; Bodin & Crona 2009), and a comprehensive model is still required to investigate the multiple sources and the flow of information within these networks. Literature on social network analysis in the context of environmental management has been increasingly fruitful over the last 2 decades (e.g., Prell et al. 2009; Guerrero et al. 2013; Wood et al. 2014). By investigating relationships between stakeholders, social-network analysis can provide insights, such as how frequently interactions between actors are taking place and for what purpose (Morgans et al. 2017; Guerrero et al. 2020). Conversely, knowledge mapping has been proposed as a process to survey knowledge and its connections in a system such that the mapping itself also creates additional knowledge (Vail III 1999; Wexler 2001). The aim of the map is, therefore, to make visible the expertise of a given organization, considered as the pool of knowledge and skills used to drive action and decision. Although environmentalists have identified knowledge mapping as key for knowledge management (Reed et al. 2009; Jetz et al. 2012; Pascual et al. 2016), a conceptual model is still required to adequately capture the complexity of the relationship between knowledge production and action.

We devised a model for knowledge mapping as a prerequisite for effective knowledge management in the context of conservation. We considered a conservation network as a conglomeration of different subnetworks of expertise in which knowledge is produced and used and examined the various dimensions across which knowledge production and trajectory can be assessed. Finally, we considered key issues in investigating the science–action gap and managing knowledge.

A Model for Managing Knowledge in a Conservation Network

Originally developed for and applied in business management, knowledge mapping was proposed as a technique to foster knowledge management in organizational contexts to increased innovation and performance (Liebowitz 2005). Overall, such mapping aims to mobilize, diffuse, and evaluate intellectual capital in a given organization (Wexler 2001). It is based on a "knowledge audit process" and helps identify needed skills and information, encourages reuse of ideas, prevents reinvention, highlights islands of expertise and emerging practices, and suggests bridges for sharing (Liebowitz et al. 2000). Different mapping techniques are used (Balaid et al. 2013), and it is widely accepted that organizations must decide what knowledge should be mapped and for which purpose (Jafari et al. 2009). The map can, for instance, reveal who holds what type of knowledge, how it is stored and maintained, and what medias are used to disseminate and transfer it (Burnett et al. 2004).

We sought to adapt the concept of knowledge mapping in the field of conservation with the aim of bridging the gap between science and action. Our goal was thus to provide a model through which to map the production and trajectory of scientific knowledge across a given conservation network. Knowledge mapping here is understood as a conceptual approach aiming to garner knowledge across complex networks, rather than a method for visualizing different knowledge on a map. Thus, we did not aim to provide concrete methods of how to map knowledge; rather, we highlighted critical principles that can be applied to assessing knowledge in a conservation network and managing it accordingly. We hope that practitioners and academics can use our model to foster future experimentations with knowledge mapping in conservation. As an illustration, we show how the model can be applied to identify potential knowledge gaps and to manage knowledge in the context of great ape conservation.

We considered a conservation network, a network in which various expertise is mobilized to manage a given problem (Table 1). Our model can be applied to different case studies as diverse as, for instance, as conservation of a species worldwide, restoration of landscape corridors at a district level, management of fish stocks in a coastal region, and preservation of invertebrates in a context of intensive farming. Here, a conservation network can thus refer to a "knowledge network" as proposed by Phelps et al. (2012).

We believe the proposed model can be applied to different kinds of knowledge as far as they can be described. Following Raymond et al. (2010), this can include experiential, local, scientific, or hybrid knowledge. To simplify the demonstration and coherence of the illustrations used to build the model, we focused on scientific knowledge. *Scientific knowledge* refers to any information that emanates from scientific study and adheres to the criteria of reliability and validity. Considered explicit knowledge, it is generated through a formalized process and articulated in written or spoken form (Nonaka 1994). To illustrate our approach, we focused mainly on the spatial dimension of expertise within the great ape conservation network (Table 2). We made this choice because of our experience in this field and the recent publication of several articles related to spatial monitoring practices and knowledge exchange in great ape habitats (Morgans et al. 2017; Vimal 2017; Vimal et al. 2018a, 2018b). We used this material to frame our model and provide illustrative examples, rather than to properly map knowledge in the great ape conservation network.

Table 1. Definitions of the terms used in the article.

Terms	*Definition*
Conservation network	combination of interdependent subnetworks that produce and use knowledge in relation to one conservation issue
Subnetwork	specific entity defined by different attributes across various dimensions and aiming to produce a given knowledge
Expertise	process mobilizing and producing a pool of knowledge at a subnetwork level
Knowledge distribution	both knowledge production and knowledge trajectory
Cluster	broad grouping of subnetworks based on shared attributes
Dimension	means of classifying a subnetwork
Attribute	characteristic of a subnetwork following a given dimension
Headquarter	location of the leading organization
Topic	topic of interest of the expert
Operationality	degree of application of expertise

Conceptualizing Knowledge within a Conservation Network

A conservation network can be assessed as the conglomeration of various, fully interdependent subnetworks of expertise that aim to produce specific items of knowledge (Fig. 1a). Table 2 contains examples of such expertise related to great ape conservation in varying capacities. Our approach, therefore, values a large vision of science, whereby knowledge production does not only rely on academics but more generally on every organization involved in a scientific process (Enengel et al. 2012). Following this conceptualization, monitoring programs in national parks and International Union for Conservation of Nature species red-list assessment (Table 2), for instance, thus become part of the scientific activities implemented for great ape conservation.

In the process of creating new knowledge, each subnetwork of expertise relies on a pool of existing knowledge (Phelps et al. 2012). Consequently, knowledge can be the output of one subnetwork and the supporting information in some others. Each subnetwork involves both the use and the production of knowledge. For instance, the recent assessment of the impact of resource use and land-use changes on the density distribution of Bornean orangutans (*Pongo pygmaeus*) (Table 2) relied on existing remote-sensing and field-survey data, various information related to the ecology of the species, and spatial distribution models (Voigt et al. 2018). As outputs, this expertise produced new data on orangutan density based on which a causal relationship between the state of the population and the rate of logging, deforestation, and plantations has been found. Through this process, the authors improved the modeling technique used to address problem of sparse data on wildlife distribution.

Knowledge mapping should not be based on a dualist representation with knowledge producers on one side and knowledge users on the other side. Rather, we propose that each subnetwork produces and uses knowledge. Far from the consideration of a unidirectional transfer from one entity to the other, our approach, therefore, highlights two main issues in terms of knowledge mapping. First, knowledge can be assessed across the conservation network according to its production to determine what knowledge is produced in which subnetwork. Here, the distribution of knowledge is assessed independently of its destination. Second, knowledge can be assessed across the conservation network according to its movement to determine what knowledge is used in which subnetworks. We sought to identify connections between subnetworks. Because each subnetwork produces knowledge, the movement of information must be considered multidirectional.

Knowledge mapping usually focuses on assessing who holds which skills and knowledge in a given organization (Burnett et al. 2004). Designed to address the problem of the knowledge–action gap, our approach emphasizes processes and focuses on who generates knowledge, who mobilizes knowledge, and how knowledge flows.

Assessing Knowledge Distribution Through Different Dimensions

Although scholars are increasingly investigating the processes involved in what we here called a subnetwork of expertise (e.g., Tengö et al. 2017; Lacey et al. 2018; Buschke et al. 2019), an understanding of the multiple dimensions around which each subnetwork can be shaped and described is still needed. Indeed, it is increasingly recognized that knowledge exchange is more than a 1-dimensional interaction between academics and practitioners. Beyond the individual organization leading the expertise, knowledge distribution can be conceptualized across multiple additional dimensions, such as the scale of operation, geographic location of the study, focal topic, degree of operationality, and discipline mobilized (Fig. 1b). Several studies have shown how some of these dimensions can be crucial in investigating knowledge

Table 2. Examples of subnetworks of expertise and their classification according to different dimensions.*.

		Organizational characteristics			*Study system characteristics*			*Knowledge characteristics*			
Subnetwork of expertise	*Reference*	*Type*	*headquarte*	*main partner*	*spatial scale*	*location*	*object*	*Topic*	*operationality*	*knowledge type*	*discipline*
Taï National Park survey	parcnationaltai.com	governmental organiza-tion	Ivory Coast	research institute	local	Ivory Coast	large mammals and birds	distribution's predictors and evolution	high	data, knowledge per se	ecological planning
Pan African Program: The Cultured Chimpanzee (PANAF)	panafrican.eva.mpg.de	research institute	Germany	governmental organiza-tion and NGO	regional	Africa	chimpanzee	behavior and ecology	Low	data, knowledge per se	evolutionary anthropol-ogy
REDD+ cobenefit for great apes	apescarbon.eva.mpg.de	IGO	Kenya	research institute	global	Africa	great ape	conservation gaps, threats, and priorities	high	technique, data	ecological planning
Human and Gorilla monitoring (HuGo)	ugandawildlife.org	governmental organiza-tion	Uganda		local	Uganda	gorilla	human–wildlife conflict	high	data, knowledge per se	environmental science
Recent decline in great apes	Junker et al. 2012	research institute	Germany	research institute and NGO	regional	Africa	great ape	distribution's predictors and evolution	medium	knowledge per se, technique	ecological planning
IUCN Red List assessment	iucnredlist.org	IGO	USA	research institute and NGO	global	tropics	great ape	distribution and its evolution	high	knowledge per se	ecological planning
Eastern lowland gorilla survey	Plumptre and Nixon, 2016	NGO	Uganda	research institute	local	Congo DR	gorilla	distribution and its evolution	medium	data, knowledge per se	ecological planning
Western lowland gorilla habituation program	wwf-congobasin.org	NGO	Cameroon	governmental organiza-tion	local	Cameroon	gorilla	spatial structure and dynamic	high	knowledge per se, data	primatology

Continued

Table 2. Continued.

		Organizational characteristics			*Study system characteristics*			*Knowledge characteristics*			
Subnetwork of expertise	*Reference*	*Type*	*headquarter*	*main partner*	*spatial scale*	*location*	*object*	*Topic*	*operationality*	*knowledge type*	*discipline*
African apes coexisting with logging	Morgan et al., 2018	research institute	USA	NGO	regional	Congo R	great ape	impact of habitat change	medium	data, knowledge per se	primatology
Bukit Barisan Selatan Tiger survey	Pusparini et al., 2018	NGO	Indonesia	research institute	local	Indonesia	tiger	distribution and its evolution	high	data, knowledge per se	ecological planning
Mapping trees potentially used by large mammals	interholco.com	private company	Congo R	NGO	local	Congo R	large mammals	impact of habitat change	high	data, knowledge per se	ecological planning
Chimpanzee survey in oil-palm concession	goldenveroleumliberia.com	private company	Liberia		local	Liberia	chimpanzee	conservation gaps, threats, and priorities	high	data, knowledge per se	ecological planning
Locating chimpanzee nests with drones	van Andel et al. 2015	research institute	Netherlands		local	Gabon	chimpanzee	distribution and its evolution	medium	technique	ecological planning
Great ape illegal trade monitoring	database.un-grasp.org	IGO	Kenya	governmental organization	global	world	great ape	illegal trade	high	technique, data	environmental science
Land-use change monitoring in apes habitat	sumatranorangutan.org	NGO	Indonesia	research institute	local	Indonesia	orangutan	impact of habitat change	high	data, knowledge per se	ecological planning
Impact of resource use on Bornean orangutans	Voigt et al. 2018	research institute	Germany	research institute, NGO	regional	Indonesia	orangutan	distribution's predictors and evolution	medium	knowledge per se, technique	ecological planning

Abbreviations: REDD, Reducing Emissions from Deforestation and Forest Degradation; IUCN, International Union for Conservation of Nature; IGO, international governmental organization; NGO, nongovernmental organization; Congo R, Congo Republic; Congo DR, Democratic Republic of Congo.

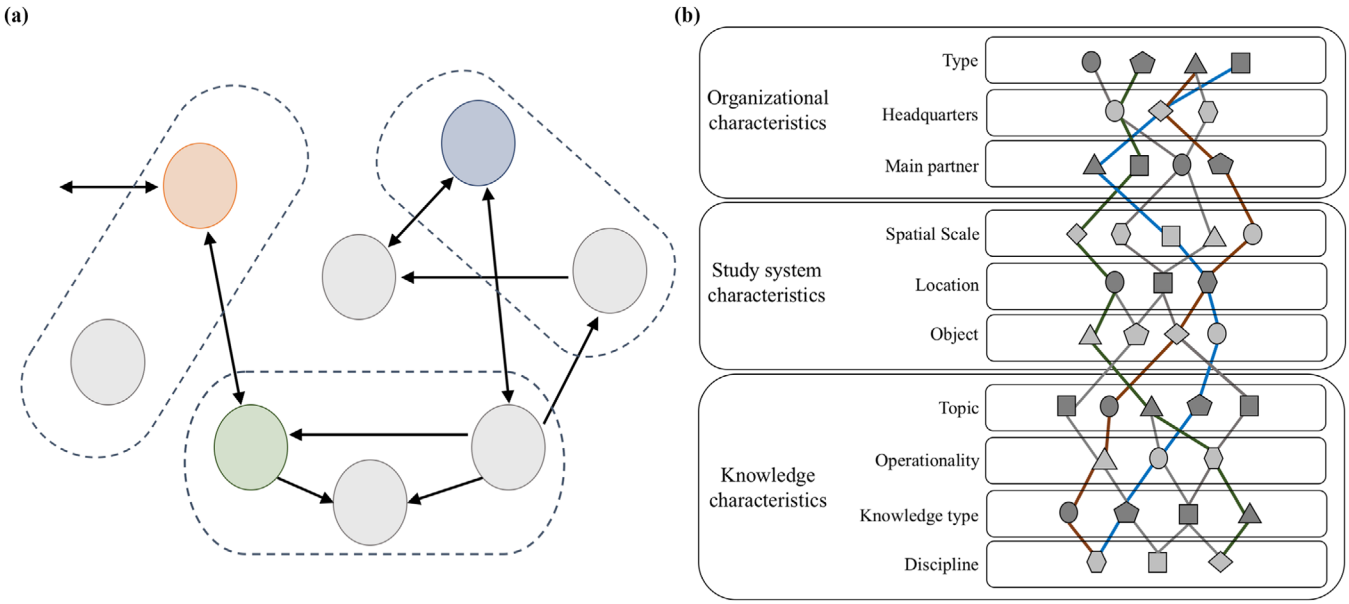

Figure 1. A conservation network of expertise represented as the conglomeration of different subnetworks: (a) knowledge trajectories (arrows) in the movement of knowledge from the subnetworks where it is produced to the subnetworks where it is used (each subnetwork is represented as a circle in [a] and as a line connecting different attributes in [b]; dashed lines, clusters of subnetworks that share similar attributes) and (b) various dimensions of subnetworks (different symbols represent different attributes across the various dimensions (not all circles of the lightest gray in [a] are represented in [b]).

distribution across networks (e.g., Stevens et al. 2007; Soberon & Sarukhan 2009; Cook et al. 2013; Habel et al. 2013; Fleischman & Briske 2016).

We proposed a set of the main dimensions to be considered when dealing with assessing knowledge distribution in a given conservation network. However, many other dimensions can be identified, such as social context (political system, degree of poverty, education level, etc.) and environmental conditions (ecoregions, elevation, climate, etc.) in which a given expertise is developed and implemented.

Although each subnetwork is unique, different subnetworks can be clustered according to the dimensions considered (Fig. 1a & Table 2). For instance, despite their differences, the survey of eastern lowland gorillas (*Gorilla beringei graueri*), the habituation program of Campo Ma'an National Park, and the tiger survey in the Gunung Leuser all involve nongovernmental organizations (NGOs) (Table 2) and therefore can be considered as belonging to a single cluster (i.e., expertise run by NGOs) in the dimension type of organization. Clusters can also be defined based on several dimensions. For instance, the wildlife survey of the Taï National Park and the human and gorilla monitoring program in Uganda are both applied to direct management implemented at a local scale. They can, therefore, be considered as belonging to a single cluster (i.e., expertise run locally by governmental organizations with high degree of operationality) in the dimensions scale, type of organization, and operationality. Clusters thus offer rough classification of different subnetworks of expertise that can then be used to describe knowledge distribution.

Such an approach calls for consideration of a conservation network as open and without clear borders. Indeed, interdependencies can potentially reveal connections between seemingly distant subnetworks of expertise. For instance, the Pan-African program, which aims to provide fundamental knowledge on chimpanzees culture, can be considered related to the survey of chimpanzees in the high-conservation-value areas of Liberian oil-palm concessions. These subnetworks share the same study object (i.e., chimpanzee).

Considering the dimensions around which subnetworks or clusters of subnetworks can be described provides useful insights into how to assess knowledge distribution across a given conservation network. Knowledge mapping should not be based only on a one-dimensional representation of knowledge but rather on a multidimensional approach able to depict the complexity of the considered network.

Toward Rethinking the Gap

Over the last 2 decades, scholars mainly considered a single dimension of a conservation network in which knowledge movement was unidirectional and stressed

the need to bridge the gap between researchers as producers and practitioners as users of knowledge. Alternatively, our model calls for a broader consideration of the gap based on 2 key principles that shape the way knowledge can be assessed across a given conservation network. First, a conservation network arises from the conglomeration of different subnetworks of expertise in which knowledge is produced and used. Second, each subnetwork of expertise can be described according to several dimensions. We thus argue that knowledge management should rely on an assessment of both knowledge production and trajectory across different dimensions of the network.

Beyond the usual question of how is knowledge produced by researchers being used by practitioners, multiple issues can, therefore, be investigated in relation to the distribution of knowledge in a given conservation network. The examples below illustrate different ways of assessing knowledge across the great ape conservation network and alternatively across the tropical national parks conservation network. Both production and trajectory can be questioned according to one or several dimensions.

Assessing Knowledge Production

What knowledge is produced on different chimpanzee subspecies (example 1, study object)? The chimpanzee range includes 4 subspecies with different behavior, protection status, and ecology. It is, therefore, crucial to assess whether knowledge production is balanced between these different subspecies. In this respect, the Pan-African program, a research project investigating behavioral traits of poorly known populations across the entire chimpanzee range (Table 2), can be identified as key to filling potential gaps.

What knowledge is produced on different study objects and different degrees of operationality in tropical national parks (example 2, study object and operationality)? In a recent study (Vimal et al. 2018a), we assessed the nature and operationality of monitoring programs conducted across different national parks in Africa and Asia. Overall, we found that such programs focus much more on large mammals and following long-term protocols than on other taxonomic groups and short-term interventions.

These 2 examples illustrate the potential use of knowledge mapping in assessing knowledge production across various dimensions. Previously, researchers stressed the need to consider the heterogeneity of knowledge production in conservation sciences between disciplines (Bennett et al. 2017a, 2017b), between data quantity and quality (Bayraktarov et al. 2019), and between among topics (Di Marco et al. 2017). Example 1 shows how a subnetwork of expertise (a cluster of scientific activities implemented through the Pan African program) can play a key role in balancing knowledge production in one dimension (i.e., different chimpanzee subspecies). Example 2 demonstrates how knowledge production is not neutral but reveals preferences and perception according to various dimensions (i.e., a rather rationalist approach to nature conservation focused on a fragmented portion of ecosystems). Overall, beyond providing a critical view on scientific activities, assessing knowledge production can help support existing scientific activities or orient and prioritize future knowledge development and exchange.

Assessing Knowledge Trajectory

What is the trajectory of knowledge according to different scales and different organizations in the context of great ape conservation (example 3, scale and organization)? Data collected by the Taï National Park in the Ivory Coast to inform its law enforcement strategy were used by Junker et al. (2012) to assess the factors shaping the decline of great apes regionally (Table 2). Knowledge transfer was then operated from a subnetwork involving governmental institutions and NGOs at a local scale to a subnetwork involving a research institute at a regional scale.

What is the trajectory of knowledge according to different knowledge types and different organizations in tropical national parks (example 4, organization and knowledge type)? The Wildlife Conservation Society invested a large amount of money to develop the Spatial Monitoring and Reporting Tool (SMART smartconservationtools.org) and trained national park rangers to use the tool to produce data on law enforcement (Vimal et al. 2018a). The transfer of knowledge is operated from an international NGO providing tools and techniques to local managers for producing data.

In terms of knowledge trajectory, although the transfer of knowledge from research to management remains at the forefront, multidirectional movement of knowledge must also be considered across various dimensions. Examples 3 and 4 illustrate the potential of knowledge mapping as a way to assess knowledge flows across various dimensions. Example 3 shows how research activities, even if fundamental, heavily rely on knowledge produced by practitioners in the context of wildlife management. It reveals existing interdependencies across a given conservation network and the multidirectional flow between research and management. Example 4 provides useful insights into how specific kinds of knowledge associated with specific organization can structure and homogenize the way local practitioners produce knowledge for action. Mapping knowledge flows may thus help in understanding which collaborations are key to maintain, which ones may be questionable, and which ones should be developed further.

Conclusions

Using a network perspective, our model suggests key considerations for knowledge mapping as a prerequisite of knowledge management in the context of conservation. The production and use of knowledge is not the result of a single, one-dimensional network; rather, it relies on a multitude of interdependent subnetworks. Over the last decades, many scholars have stressed the need to understand and manage the sociopolitical issues involved within and between these networks. Our primary message is that such approaches should be based on a diversity of representations depicting the complexity of a given conservation network and highlighting both a multitude of potential gaps and opportunities for further knowledge development and use.

Assessing both knowledge production and trajectory across the diverse dimensions of a conservation network opens new spaces for further investigating the gap and accordingly managing knowledge. It helps in adjusting, prioritizing, and optimizing investments of scarce resources in conservation science. Although our model provides insights into how to adapt the concept of knowledge mapping for environmental conservation, different approaches may be considered further. What makes up the map can, therefore, alternatively range from qualitative description to semiquantitative and quantitative indicators of knowledge distribution. Although knowledge maps can provide a diagrammatic representation, necessarily simplistic, of reality, care should be taken to avoid oversimplification. In particular, knowledge development follows a continuous process, whereby knowledge is constantly transformed while it is exchanged. Although it is meant to assess knowledge at a network scale and facilitate its management accordingly, our approach should not hinder understanding of complex processes involved in knowledge generation and movement or discount the existence of tacit and nonmappable knowledge.

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