Researchers must be aware of their roles at the interface of ecosystem services science and policy

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Abstract Scientists working on ecosystem service (ES) science are engaged in a mission-driven discipline. They can contribute to science-policy interfaces where knowledge is co-produced and used. How scientists engage with the governance arena to mobilise their knowledge remains a matter of personal choice, influenced by individual values. ES science cannot be considered neutral and a discussion of the values that shape it forms an important part of the sustainability dialogue. We propose a simple decision tree to help ES scientists identify their role and the purpose of the knowledge they produce. We characterise six idealised scientific postures spanning possible roles at the science-policy interface (pure scientist, science arbiter—guarantor, issue advocate—guardian, officer, honest broker and stealth issue advocate) and illustrate them with feedbacks from interviews. We encourage ES scientists to conduct a reflexive exploration of their attitudes regarding knowledge production and use, with the intention of progressing toward a higher recognition of the political and ethical importance of ES assessments.

Keywords Ecosystem services · Mission-driven discipline · Science-policy interface · Scientific postures · Scientific reflexivity

INTRODUCTION

Researchers who enter the ecosystem service (ES) arena are faced with a mission-driven discipline, with the

objectives to raise awareness about human dependence on ecosystems, address biodiversity decline and progress towards sustainable ecosystem management (Díaz et al. 2015). ES scientists have opportunities to experience close relationships with governance arenas through providing knowledge that contributes to environmental sustainability, e.g. via participation to environmental commissions from local to global scales or to protected area scientific advisory committees. Governance is defined as “all the institutional arrangements and processes aiming at identifying and enacting collectively acceptable principles” (Primmer and Furman 2012), and includes organisations in civil society from public and private sectors. ES governance thus involves the multi-layered social arrangements that enable management of environmental resources over time and space for instance on collective pastures or watersheds.

Scientific expertise has become increasingly important in shaping governance and has been called “the fifth branch of government” (Jasanoff 1990). Production of ES research and knowledge fits this trend; one of its key objectives is to orientate actions and support decision-making (Mace 2014). This relevance to policy and management means that ES science may be implemented in science-policy interfaces (SPIs) (van den Hove 2007). SPIs are dynamic, two-way interactions between science and governance. They represent ways in which scientists, policy-makers and others exchange ideas and co-produce knowledge for policy, decision-making and research. In SPIs, the boundary between research and governance in knowledge production is blurred (Wilhere 2012). Science and policy overlap in ways that are “moving and negotiable” (Turnhout et al. 2007): activities and responsibilities of each domain are socially constructed, context-dependent and highly politicised (Fernández 2016).

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Boundary work (Gieryn 1983) can help characterise the contributions by scientists and policy-makers and make explicit the negotiation processes taking place at the SPI (Turnhout et al. 2007). Examples from the ES domain include communities of practice in the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), the Belgium Ecosystem Services (BEES) network or the Economics of Ecosystems and Biodiversity (TEEB) community.

Production and use of ES knowledge involves complex interactions between facts, values, emotions and rationality (Turnhout et al. 2007). Given that such science is a “value-laden social process” (van den Hove 2007), scientists cannot be expected to hold a neutral posture. By ‘posture’ we mean the perspective scientists hold regarding their contributions to governance-relevant questions (also known as ‘attitudes’, ‘stances’ or ‘perspectives’). The plurality of values underpinning the ES concept (Luck et al. 2012) and of personal scientist values implies that researchers can contribute in diverse ways to environmental governance solutions (Mace 2014) and may develop one or more postures in the process. By engaging in SPIs, ES scientists become active participants in decision-making processes. The notion of scientists who, by their objective knowledge and integrity, could speak truth to power is now challenged: “value judgments...pervade all aspects of science”, including the choice of research questions and the means to answer them (Wilhere 2012). Like other SPI participants, scientists engage in SPIs with their own subjective values (Fernández 2016), raising issues of transparency regarding values and interests. The normative position is for values to be made explicit to ensure accountability (Gupta 2008, 2010) and effective communication between actors (Young et al. 2014). Disclosure of values and motivations may help avoid inadvertent advocacy, whereby personal preferences are unwittingly presented as scientific facts (Wilhere 2012). Reflexive thinking about the influence of research cultures, funding mechanisms, values and beliefs can aid such disclosure (Garrard et al. 2015) and is likely to encourage constructive outcomes from SPIs.

In this paper, we invite ES scientists, in particular young researchers, to a reflexive exploration of their postures in SPIs because the scientific information they generate is so connected with both decision-making and their individual values. First, we explain why ES scientists should be aware of, and explicit about, their scientific postures. Secondly, we describe six idealised scientific postures embodying the range of relationships ES scientists might adopt in the policy arena. These postures, synthesised from the literature and supported by interviews with ES scientists, hold different positions on

a continuum from knowledge generation to advocacy for particular policies or political philosophies (Donner 2014). We propose a simple decision tree to help ES scientists identify their postures in relation to knowledge production and use.

WHY VALUES MATTER IN ES SCIENCE

The ES concept is increasingly used to inform planning and policy for conservation and management (Fisher and Brown 2014) and, as a social construct (Barnaud and Antona 2014), is “mobilized by diverse actors in real-life situations that lead to complex, regionally particular and fundamentally political outcomes” (Kull et al. 2015).

Given the controversial and political nature of the ES concept, we detail below why ES scientists need to define their scientific postures.

ES science is ‘science in-the-making’ and subject to major uncertainties

ES science seeks to address the current environmental crisis to preserve human well-being, from local to global scales (Jax et al. 2013) and represents a ‘crisis discipline’ or ‘mission-driven discipline’ (Sandbrook et al. 2011), with the need to make and implement recommendations even though the underpinning knowledge is controversial. ES knowledge is highly uncertain because socio-ecological systems are complex, adaptive and inherently unpredictable (Barnaud and Antona 2014). Definitive interpretations are few: ambiguity and ignorance of the unknown and the unknowable are predominant (Stirling 2010).

Uncertainty is due to our limited capacity to characterise the outcomes of an action and the probability these outcomes will occur. Uncertainty assessments are needed to capture the influence of socio-ecological dynamics on management decisions and to assess the impact of an intervention on the system (Pielke 2007) and yet such assessments remain scarce to date (Boerema et al. 2017). With increased uptake in policy and management (Jax et al. 2013), there is a risk that ES science, as *science in-the-making* (Latour and Woolgar 1979), would be regarded as *ready-made science*, expected to deliver complete understandings (Barnaud and Antona 2014). However, accounting for uncertainty is gaining traction (Schulp et al. 2014), including the discussion of its implications for decision-makers: “when the intrinsically plural, conditional nature of knowledge is recognized...science advice can become more rigorous, robust and democratically accountable” (Stirling 2010).

ES science is part of a participatory landscape of diverse values, rules and knowledge

Participatory planning and co-management are common in environmental management, resulting from concerns by civil society on governance of environmental resources and biodiversity (Pade-Khene et al. 2013). The politics of environmental negotiation now includes multiple groups and interests, though the extent of inclusion is highly variable and its results diverse (Turnhout et al. 2010). ES scientists can expect to develop learning partnerships with many actors (van den Hove 2007), including other scientists, practitioners, decision-makers and community groups. Co-construction of policy-relevant knowledge can help change behaviours of all SPI partners, as participation represents a performative practice (Turnhout et al. 2010) that creates a non-neutral space where multiple sources of knowledge are legitimated and exchanged (van der Hel 2016). Beyond intended outcomes, such as stakeholder empowerment and decision legitimacy, stalled discussions, frustration due to conflictual viewpoints or reinforcement of dominant power relationships are some unexpected consequences arising from participation (Turnhout et al. 2010).

Participatory, co-constructed research entails interacting with groups holding diverse opinions and world views (Pade-Khene et al. 2013, Davies et al. 2015). Participatory processes draw on the tacit knowledge of participants, i.e. their intuitive and experiential understanding of how to deal with particular issues (Hulme 2014). Such knowledge interacts with their interests, values and social rules to produce a context for decision-making that participants consider credible and legitimate (Gorrdard et al. 2016). By engaging with these messy and difficult transdisciplinary processes, ES scientists are challenged by the plurality of values, rules and knowledge (Sandbrook et al. 2011). These processes, where science can influence decision-making, emphasise the need for ES scientists to clarify personal commitments and scientific posture.

ES science is controversial, but presents opportunities for transdisciplinary research

The adoption of the ES concept by policy-makers and stakeholders (Guerry et al. 2015) has led to it being considered in some circles as tangible, measurable and manageable (Barnaud and Antona 2014). Yet, the ES concept remains normative and is not value-free for the following reasons. First, viewing socio-ecological systems through an ES lens invokes an anthropocentric metaphor (Luck et al. 2012; Fisher and Brown 2014) that reaffirms a nature-culture dichotomy that is not universally held (Raymond et al. 2013). Secondly, some of the ES controversies remain

unresolved, including the ethics of relationships between people and nature, valuation methodologies and the commodification of nature (Barnaud and Antona 2014; Kull et al. 2015). Thirdly, ecological, social and economic valuations assess ES differently (Martín-López et al. 2014), though the language of quantitative science tends to be preferred over qualitative socio-cultural explorations. Finally, some aspects of ES science remain neglected, such as cultural ES (Chan et al. 2012) and the demand side of ES (Crouzat et al. 2016). An integrated, consensual perspective of socio-ecological systems based on the analysis of ES thus appears highly challenging, and is perhaps unrealistic.

Yet, the ES concept presents opportunities for engagement with values pluralism. First, it can serve as a value-articulating institution (Martín-López et al. 2014), enabling inclusion of multiple values (Luck et al. 2012). Secondly, the ES concept can represent a ‘boundary object’ (Barnaud and Antona 2014; Kull et al. 2015), which is interpreted differently amongst stakeholders but contains enough commonly agreed content to facilitate dialogue. Thirdly, ES science is inherently interdisciplinary and transdisciplinary, which helps foster co-constructed, legitimate understanding of complex issues (Guerry et al. 2015). These characteristics make the ES concept appealing to diverse groups of actors for progressing sustainable management of socio-ecological systems.

DEFINING SCIENTIFIC POSTURES

Environmental governance can involve intense mobilisation of scientific expertise for constructing public policies on conservation and sustainability (Coreau et al. 2013). The strategy of ‘speaking truth to power’ (Jasanoff 1990) is one of many options open to ES scientists, but how they choose to engage with the governance arena remains a personal choice, influenced by personal values. Policy processes and how knowledge is structured and used will influence the roles scientists can play in the SPI (Turnhout et al. 2007).

Here, we combine the general scientific postures described by Pielke (2007) (pure scientist, science arbiter, issue advocate, honest broker, stealth issue advocate) and Coreau et al. (2013) (guarantor, guardian, officer) to formulate six idealised scientific postures (Fig. 1) which are relevant to understand possible roles of ES scientists in SPIs. We illustrate our typology with excerpts from in-depth interviews conducted with 12 prominent ES European scientists, selected to cover a broad range of involvement in governance processes (Appendix S1). We started with scientists working in our research institutions and used snowball sampling to identify other informants.

Fig. 1 Defining personal scientific postures from a simplified tree of options (inspired by Pielke 2007 and Coreau et al. 2013)

The interviews lasted one to 2 h; questions concerned their experience of ES research and its use in governance processes. Notably, interviewees were invited to express their motivations to do ES research and their views concerning their role in governance processes. The interviews were transcribed and coded to identify the postures of ES scientists.

The conceptual model (Fig. 1) can help ES scientists to identify their posture(s) in different aspects of their research and encourage self-reflexion. The knowledge objectives (vertical axis) range from increasing understanding to supporting decision-making. Within each objective, roles in the SPI are distinguished according their scientific versus policy polarisation (horizontal axis).

The typical scientific postures are defined below, supported with quotes (in *italics*) from informants.

Pure scientist

The *pure scientist* describes a researcher motivated by scientific curiosity to gain greater understanding of socio-ecological systems (Courchamp et al. 2015). “*I think [what prompts my research] is mostly knowledge. This is what*

mainly motivates me” (ES scientist#2). Pure scientists regard their research as contributing to the common pool of knowledge, available to anyone. By seeking knowledge as their objective, they place themselves outside the SPI and do not engage in decision-making (Question 1, Fig. 1). Values and ethics are not considered part of research. In ES research, pure scientists include those who focus on modelling and methodological improvements as ends in themselves and also in particular ‘niches’ of the ES cascade (Haines-Young and Potschin 2010), such as functional ecology and the linkages between plant functional traits and ES (Lavorel et al. 2011). Acting as pure scientists can be only part of the several postures individual ES researchers take.

Some pure scientists saw opportunistic advantages in mobilising the ES concept: “*At some point, ‘ES’ was in all project calls; obviously everybody [...] used the word in their answer. [...] When asking people what they are actually doing on ES, a good part of them answered same as before, only under a different name... I consider myself as belonging to the category saying ‘I work a bit on ES, without really doing it’*” (ES scientist#1). Even if critical of the ES concept, they may use it to acquire funding:

“European funders are highly driven by this [ES] approach. Therefore, it’s quite hard to propose doing research without ‘ES’; research that would be just for trying to understand ecosystem functioning for fundamental purposes” (ES scientist#2). However, some may be unaware or doubtful about the contribution of their work to environmental governance: *“I have the feeling that as our knowledge is quite limited, we must make huge simplifications... I sometimes wonder whether it is useful to pretend saying something on ES while in fact we understand almost nothing”* (ES scientist#2).

Science arbiter or guarantor

The *science arbiter* or *guarantor* group includes scientists whose main interest is to increase the understanding of socio-ecological systems. They do not seek building close relationships to governance but recognise their knowledge can aid decision-making in situations with low uncertainty and no values conflicts (Question 2, Fig. 1). In their vision, when research contributes to policy, it is likely to be via the ‘information deficit’ model (Fernández 2016), whereby a unidirectional flow of knowledge from scientists to end-users should help solve the problem. *“The topic of this project was anyway interesting for us [scientists] and would be necessary tomorrow to feed the park management plan. We were not equipped to answer [this need], we had no sufficient knowledge. It was important to be able to talk about this topic, so that tomorrow we could enter a more operational phase”* (ES scientist#12). Low uncertainty is required to provide credible answers regarding the expected outcomes of alternative options. Low value conflicts protect arbiters from the pathological politicisation of science, as described by Pielke (2007), whereby conflicting value-driven desires for particular outcomes cannot be reconciled by scientific arguments.

Science arbiters see themselves as independent providers of robust knowledge that helps answer value-neutral, positivist questions where knowledge is a limiting factor in reaching consensus: *“Now, there is much stronger scientific evidence. Twenty years ago, people didn’t know [about ES]. Now, they are provided with arguments that enlighten the debate, to take an informed decision”* (ES scientist#4). These scientists engage in SPIs and contribute to technocratic decision-making based on ensuring scientific validity of the options proposed: *“Our contribution mostly relates to reconciling ES; it’s about how, by managing an ecosystem, we can both optimise a target ES which is to be ensured, like wood production in a production forest while certifying that other ES are not too negatively impaired”* (ES scientist#3). Some environmental scientists engaged with the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) are science arbiters. Their

priority is to reduce knowledge gaps on biodiversity and ES to provide scientific evidence supporting environmental decision-making at international and national levels (Brooks et al. 2014).

Issue advocate or guardian

The *issue advocate* or *guardian* uses research to support particular policy options. Science and expertise are regarded as pragmatic tools for mounting convincing arguments to support certain normative actions (Coreau et al. 2013): *“You see very clearly the importance [of nature conservation] for the future of humanity and you wonder why the message is so slow to get across. As a scientist, I try to answer questions, and ES have been part of the response elements that seemed interesting to look at”* (ES scientist#5). Issue advocates may seek to reduce policy options to ones they support (Question 3, Fig. 1), using knowledge in highly strategic and selective ways (McKenzie et al. 2014): *“You can say to farmers: ‘if you do that, biodiversity will benefit from it, you will benefit from it yourself, and we’re going to look for ways that it does not cost you anything.’ If you use [your knowledge] that way, a large group of farmers is likely to change their practises”* (ES scientist#7).

Issue advocates assume that ES science is not neutral: *“Our objective is quite normative regarding the fate of biodiversity”* (ES scientist#6). Issue advocates interlink expertise and engagement, and interaction with conservationists, NGOs or the private sector is accepted. Advocacy may be viewed as an exposed, uncomfortable posture (Wilhere 2012): *“we are bound to a doubly rigorous posture: at the same time as rigorous as any scientist and in addition, as we hold the image of a discipline... we cannot undermine this discipline by talking rubbish, by letting our activism getting past what we can say”* (ES scientist#6). However, legitimised discourses of advocate scientists can contribute to the SPIs “with integrity, in a responsible, transparent, evidence-based way” (Garrard et al. 2015): *“Our bias is to communicate on the environmental resources of the area and to show that in a land planning project these aspects cannot be overlooked and need to be discussed. So, we have a posture that is more involved, more forthright, which is explicit”* (ES scientist#10).

Issue advocates have been part of controversial debates, such as the monetary valuation of ES. For example, Gómez-Baggethun and Ruiz-Pérez (2011), for whom “economic valuation is likely to pave the way for the commodification of ecosystem services with potentially counterproductive effects in the long term for biodiversity conservation” hold the opposite stance to Pavan Sukhdev, former Study Leader of TEEB (The Economics of

Ecosystems and Biodiversity) who advocates nature to be given a value in order to be conserved (Sukhdev 2009).

Stealth issue advocate

The *stealth issue advocate* holds an intermediate, inexplicit posture between scientific understanding and advocacy. They claim their commitment as disconnected from decision-making and their main interest as increasing knowledge in a neutral conception of science (Question 1, Fig. 1). However, the axiological content of their research might be greater than it appears, because stealth issue advocates blend ethical judgments and personal policy preferences with scientific outputs indivisibly (Wilhere 2012). Suspicion of facing stealth issue advocates can hinder the confidence other participants in the SPI grant to the knowledge discussed: “I went to an [ecological economics] conference where lots of [economists] were activists... they talked about nature as being ‘harmony’; that we should mimic its harmonious relationships. But this is not nature. This is not ecological economics” (ES scientist#6).

This posture can be adopted by ES scientists as an opportunistic strategy, by capitalising on their assumed legitimacy and neutrality so as to orientate themselves within the decision-making process (Sandbrook et al. 2011; Coreau et al. 2013). Stealth issue advocates include ‘inadvertent advocates’, who express opinions or policy preferences as scientific judgements (Wilhere 2012): “I have the feeling that we are at risk of skewing the scientific approach as, in the end, all people working on [ES science] are overall for conserving ecosystems” (ES scientist#2).

Whether intentional or not, this posture is found where science is invoked to fill a policy void or to adjudicate on a values conflict. While stealth issue advocacy might seem appealing, it has pitfalls, such as in sustaining scientific arguments as a front for an implicitly political policy battleground. Documented examples in the ES domain are rare because stealth issue advocates tend either to ignore this situation or to conceal themselves and, if questioned, may reject their assignment to this posture.

Officer

Knowledge produced and used by *officers* is instrumental, as they seek to use environmental science within governance processes (McKenzie et al. 2014): “Our idea is that [ES valuation] should be a tool supporting the state in its national policies... So we have a real ambition: to serve biodiversity policies” (ES scientist#9). Officers hold a central place in SPIs because they are comfortable with the research and the decision-making process. Their role is perceived as neutral, providing scientific insights to defined sets of expert-approved governance and management

options (Question 4, Fig. 1): “My role is to contribute to capacity building among stakeholders, so that they become able [to make decisions]” (ES scientist#8). Officers are appreciated for their effective contributions to decision-making processes, achieved by use of ‘reliable’ knowledge to support political choices: “We enter the operational domain with the intention for our work to be useful.... Our work should serve to assess public policies, above all for ex-ante assessments. This means that we are to use the ES concept to perform multi-criteria assessments of the impacts of this or that governance option on a diversity of ES” (ES scientist#9).

The main difference from the science arbiter posture is that officers are deeply engaged with decision-makers in the SPI: “My will is really to work with actors to make things change, at least a bit... Initially, my mission was above all to integrate ecology within [ES science]... now, it’s more complex and richer... linked to my social involvement, which is something that evolved” (ES scientist#8). If scientific insights are partial or favour a particular policy, officers might shift towards a (stealth) advocate posture, possibly in association with lobbyist figures. In the ES domain, many officers work as research liaison staff in public sector agencies charged with ES assessments (e.g. the French EFSE or the Belgium BEES platforms). In these agencies, scientists can increase the inclusion of knowledge in policy via their close connection with decision-makers. Such relationships are built on understanding and trust and enable officers to understand the structures and functions of the institutional system to which they contribute.

Honest broker

The *honest broker* is a challenging posture that differs from the officer by having the firm intention of expanding the range of proposed policy alternatives (Question 4, Fig. 1) (Pielke 2007). Honest brokers use science to anticipate outcomes of ‘classical’ policy options, and propose additional options that might be outside the initial problem framing: “Valuation economists often valued the wrong part of the ecosystem. So this methodology came out of my work to try to identify which part of the ecosystem really mattered to decision makers and then whether or not we should even try to value the different kind of ES being provided, or whether we should find other ways of quantifying these ES... I think this was a response to our habit of collecting the wrong information and of not being able to provide decision makers with the information they need to make choices” (ES scientist#11).

Teams can be more successful as honest brokers than individuals (Pielke 2007) because a range of perspectives are required to generate policy alternatives (Barnaud and

Antona 2014). Although hard to identify, honest brokers are likely to be found in participatory ES assessment settings, where they combine diverse sources of knowledge to achieve consensual and innovative outcomes: *“I have the feeling that by shifting the discourse a bit and by presenting [decision-makers] with this composite ES information, it creates novel opportunities for dialogue that wouldn’t have arisen through sectoral approaches or by working on issues that had already been formally raised previously”* (ES scientist#10). As an additional example of honest brokering, McKenzie et al. (2014) synthesised findings from spatial planning processes where co-production of knowledge on ES enabled novel approaches to environmental management. In contexts where knowledge users and producers become barely distinguishable, ES scientists can be identified as participatory knowledge producers, an additional category proposed by Turnhout et al. 2013 that we consider an extended version of honest brokers involved in transdisciplinary projects (van der Hel 2016). *“Today we are engaged in a logic of partnership through an active network, with the objective to diffuse ES knowledge and operationalize the results of our study. This operationalization is made possible with the process of project co-construction, enabling to integrate expert and precise knowledge of the actors about the area and their specific expectations, but also through the diffusion of knowledge in projects of the territory”* (ES scientist#8).

DISCUSSION AND CONCLUDING REMARKS

Our conceptual model of scientific postures acknowledges that ES scientists cannot be considered as neutral or outsiders in environmental governance. They possess values and have agency, i.e. the capacity to make their own choices according to those values. Scientists will always adopt a specific posture, consciously or not, which will affect the way other actors understand and make use of the knowledge available. Despite constraints on stealth issue advocacy, all the scientific postures we describe can contribute to environmental governance (Pielke 2007). As shown by our quotes of the interviews, individual ES scientists can adopt several postures depending on the issues addressed and the governance context in which they operate in given projects. However, once ES scientists are identified as issue advocates or stealth issue advocates, they may not be able to convincingly change their posture in subsequent SPI deliberations (Donner 2014). The career advancement of ES scientists influences the degree of confidence partners in the SPIs grant them. Early career scientists usually speak in their own names while more advanced ES scientists might be considered to legitimately represent their institution or research field (Donner 2014).

Transparency of ES information and of postures is considered a prerequisite for negotiating policy options when values are contested (van den Hove 2007) and can influence power relationships in the SPI (Gupta 2008). However, disclosure also increases the information content for participants and diverts from issues at hand (Gupta 2008, 2010). Paradoxically, transparency may create mistrust between knowledge holders and users, arising from unequal disclosure or differing subjective interpretations of the same information (Tsoukas 1997). “Transparency by whom, for whom and to what end” are thus important questions in the decision context for disclosure (Gupta 2008). Transparency is insufficient for empowerment and productive interactions in the SPI because information, of itself, cannot resolve political and ethical issues (Pielke 2007; Fernández 2016). The apparent contestability of transparency may prompt ES scientists to consider the merits of disclosing their postures. However, such disclosure may aid negotiation where plural standpoints and values exist (van den Hove 2007; Garrard et al. 2015). This might be particularly useful for ES scientists involved in SPIs dealing with complex or contested issues as well as in large research projects, to mitigate tensions associated with the diversity of postures and knowledge uses.

The involvement of ES scientists in SPIs leads to intentionally engaging non-academic actors in knowledge production. The question remains whether the diversity of postures taken by scientists will overcome the linear, information-deficit model of science to actually proceed towards a more interactive co-production of knowledge (van der Hel 2016). This further challenges ES scientists to ensure the actual and perceived quality, effectiveness and legitimacy of their contributions (Turnhout et al. 2013).

We encourage ES scientists to conduct a reflexive exploration of their attitudes regarding knowledge production as a first step towards intentional disclosure of policy-relevant information in SPIs. This would help clarify the logics of knowledge co-production, i.e. its purposes, methods and justifications (van der Hel 2016). We contend that it would be timely and positive for ES scientists to address the normative dimension of their involvement in SPIs (Elias 1956) and to consider the political and ethical components of ES assessments. Ultimately, by strengthening collective capacity to “learn from, replicate and convey compelling stories of impact” (McKenzie et al. 2014), reflexive assessment of ES science may contribute to the portfolio of options for governance for transformative change and sustainability.

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