Geoforum 84 (2017) 354–367

Contents lists available at ScienceDirect

Geoforum

journal homepage: www.elsevier.com/locate/geoforum

Unfolding scientific expertise and security in the changing governance of Ecosystem Services

M. Pasgaard [a,*], G. Van Hecken [b], A. Ehammer [a], N. Strange [c]

[a] University of Copenhagen, Faculty of Science, Department of Geosciences and Natural Resource Management, Øster Voldgade 10, DK-1350 Copenhagen K., Denmark
[b] University of Antwerp, Institute of Development Policy and Management (IOB), Prinsstraat 13, B-2000 Antwerp, Belgium
[c] University of Copenhagen, Faculty of Science, Department for Food and Resource Economics, Center for Macroecology, Evolution and Climate, Rolighedsvej 23, DK-1958 Frederiksberg C, Denmark

ARTICLE INFO

Article history:
Received 30 May 2016
Received in revised form 31 January 2017
Accepted 1 February 2017
Available online 23 February 2017

Keywords:
Expertise
Self-reflectivity
Bibliometric analysis
Ecosystem Services
IPBES
Securitization

ABSTRACT

Within the past few decades, the idea of global Ecosystem Services (ES) has moved center stage in environmental and sustainability debates. The academic and policy discourse behind Ecosystem Service protection appears to have changed from a more ecological focus on habitat restoration to a predominantly economic one revolving around human well-being. The aim of this paper is to unfold the coupling between scientific expertise and security in the changing governance of ES. We employ a 'securitization' lens to advance our understanding of the recent change in the governance of ecosystems, as we reflect on the role of scientific expertise at the boundary between science and security. Empirically, we analyze how scientific experts, as securitizing actors, frame the degradation and loss of ES as an existential threat to human security thereby justifying measures to reverse these trends. In order to trace how the voices of scientific experts shape policies to govern ES we apply bibliometric analysis and an opinion-based survey to first identify *who* produces the scientific knowledge published, and then follow *how* key scientific experts link to policy-making arenas and use security framings. Lastly, we discuss the implications of the shifting discourse surrounding ES, and we reflect on our own positionality and approach, as we string together our findings to contribute to the debate about environmental expertise and governance, and the authority of scientific knowledge.

1. Introduction: The link between Ecosystem Services, security, and expertise

Environmental crises often take center stage in political and academic debates on threats to our planet and human societies (e.g. IPCC, 2014; Latour, 2011; Steffen et al., 2015). It is therefore important to unfold the coupling between the environment, security, and the role of scientific experts in this. In this paper we specifically examine how scientific experts, through their security framing of environmental degradation, shape environmental governance in the case of Ecosystem Services (ES).

The academic and policy discourse on ES has changed from being predominantly eco-centric to being more anthropocentric and economic, although different discourses are present at the same time (Barnaud and Antona, 2014; Raymond et al., 2013; Sandbrook et al., 2013). Méral (2012) traces the origins of the ES concept and notes that since the mid-2000s there has been a growing trend to include the notion in political agendas, branching out in several directions, including the monetary valuation of ES, its introduction in agricultural and environmental policies, and payments for ecosystem services (PES).[1] Similarly, Coralie et al. (2015) describe the move from ecologically-driven approaches to an economic and market lexicon; and specifically show a change in concern from ecological restoration and habitat creation to more economic concerns from mid-2000s. In a critical tone, Spash (2015) notes what he calls a shift in conservation from the protection of Nature for non-instrumental and eco-centric reasons (e.g. duty of care, prevention from harm, and protection of non-humans) to an anthropocentric, instrumental and economic focus, where the role of Nature is exclusively that of value provision in

* Corresponding author.
E-mail addresses: mapa@ign.ku.dk (M. Pasgaard), gert.vanhecken@uantwerpen.be (G. Van Hecken), andrea.ehammer@ign.ku.dk (A. Ehammer), nst@ifro.ku.dk (N. Strange).

[1] The terms 'ecosystem services' and 'environmental services' are often taken as interchangeable despite some differences between them, such as whether the 'services' can be seen as products of human activities or only as products of ecosystems (Barnaud and Antona, 2014).

http://dx.doi.org/10.1016/j.geoforum.2017.02.001
0016-7185/

the global economy supporting market governance (see also Lele et al., 2013). The advocates of this shift on the other hand argue that until we can show that nature is essential for economic growth and development the degradation of ecosystems will continue (Juniper, 2014). This also explains why 'much of the ES literature tacitly or explicitly accepts an economic valuation framework for assessing human well-being' (Lele et al., 2013, p. 351). Parallel to this, Roth and Dressler (2012) note a growing commitment to markets as a means of meeting conservation objectives and livelihood *security*; promoting the idea that social well-being, rural livelihoods and economic development must not be at odds with conserving valued species and ecological systems. De Freitas et al. (2015) emphasize that these developments are presented "as a welcome 'greening' of capitalism that will resolve *critically urgent environmental crises*" (p. 239–240, emphasis added). Other scholars even go so far as to compare this ecological crisis with war (Latour, 2011, p. 75; Spash, 2015) and several highlight the "*urgen[cy]* for societies to act towards mitigating the effects of multiple environmental and natural resource *crises* and prevent or minimize further *damages*" (Thiel et al., 2015, p. 81, emphasis added). Kremen (2005, p. 477) concludes that ecologists should campaign to convince society of the importance of ecosystem services since "nothing less than our human future is at stake". With these notions by scientists of "crisis", "urgency", "damage" and even the use of war terminology, the changing discourse around ES can be coupled to notions of security and expertise: core topics of the present paper.

Within traditional security studies, however, security was not about the protection of ES, it was about states and survival of the state, and security experts were those who understood state apparatuses and state relations (Buzan et al., 1998; Dalby, 2002; Halfon, 2015; Owen, 2010). Only newer articulations have shifted security expertise from its traditional state-centric realms to other areas, such as human development and environmental protection (Dalby, 2002; Halfon, 2015). Scholarly work has for instance focused on the securitization of broad environmental issues such as climate change (e.g. Trombetta, 2008) and biodiversity conservation through processes of 'green militarization' (e.g. Lunstrum, 2014; Massé and Lunstrum, 2016; Verweijen and Marijnen, 2016), revealing how security practices are transformed and risks of dispossession and displacement rise (Fairhead et al., 2012; Duffy, 2016; Neumann, 2004; Peluso and Vandergeest, 2011; Ybarra, 2012). Indeed, the threats that states are asked to mitigate on behalf of their citizens require the assessment of complex trajectories of social, technological and environmental change (Jasanoff, 2005). In that way, *scientific* experts can become *security* experts, since their inputs are an unavoidable part of any discussion on environmental or security politics (Dalby, 2002). Experts provide means to identify what is dangerous and what is not, for instance by deciding whether an alert status should be moved from green to yellow, or even red (Berling and Bueger, 2015). This occurs for instance when lead scientists define the boundaries of our planet "within which humanity can operate safely", stating that transgression of these boundaries may be "deleterious or even catastrophic" (Rockstrom et al., 2009, see also Milkoreit et al., 2015, and Castree, 2015). This also happens when prominent ES scholars propose essential principles to ensure "scientific integrity in environmental interventions", predicting that *without* these principles, social and ecological benefits may be "undermined" (Naeem et al., 2015). Likewise this happens when comprehensive scientific meta-assessments couple Ecosystem Services (ES) to human well-being, stating that the degradation of natural capital has substantial harmful effects on human livelihoods, security, health, and economy (Costanza et al., 1997; Kremen, 2005; MEA, 2005; Fig. 1) taking the planet "to the edge of a massive wave of species extinctions, further threatening our own wellbeing" (MEA, 2005, p.3). Avoiding environmental catastrophe as a result of human activity then requires and justifies "significant changes in policies, institutions, and practices that are not currently underway" (MEA, 2005, p. 1; see also Danley and Widmark, 2016). Today it seems like the security threat of ES degradation is widely accepted as a fact in the scientific community, like an implicit undercurrent we take for granted and no longer need to make explicit, or what Berling (2011) calls a scientific 'objectivation' closing down controversy, even if contemporary uses of terms like "environment" and "security" should arguably be continuously challenged (Dalby, 2002).

Experts and expertise have become indispensable to the politics of nations, and indeed to transnational and global politics. The weight of political legitimation rests increasingly on the shoulders of experts, and yet they occupy at best a shadowy place, in terms of how final policy decisions are made (Jasanoff, 2005). *Scientific* experts are, as already mentioned, increasingly involved in environmental security politics (Halfon, 2015), but their role and the sites of science-security encounters have gone largely unrecognized and are under-researched (Berling, 2011). There is a need to examine the individuals and social and professional groups, rooted in evolving national and transnational societies, who govern in global governance (Kauppi and Madsen, 2014), and specifically, there is a need to actively engage with the moves and practices of science towards practical (security) politics (Buger and Villumsen, 2007). Recent scholarship has increasingly focused on the (discursive) ways in which different involved (expert) actors (such as project consultants, government officials, NGOs, scholars, etc.) increasingly draw upon 'green economy' ideas and accompanying ecological crisis narratives to justify and further the "marketization" or "financialisation" of ES (Büscher, 2012, 2014; Fairhead et al., 2012; Robertson, 2012; Sullivan, 2013). However, to our knowledge, the explicit security framing that accompanies these processes in the context of ES governance has remained largely unexplored, as has the role of scientific experts (see however Lund, 2015, on the professionalization of participatory forestry and its un-democratic and social consequences; or Büscher, 2014 on the construction and 'epistemic circulation' of value in conservation and development projects). While adopting the language of value and economic impacts offers obvious advantages in advancing the argument that ES are currently undervalued (Costanza et al., 1997), it is important to acknowledge that 'ES does not spring from a simple narrative of marketization' (Dempsey and Robertson, 2012, p. 759). Knowledge around ecosystems services is composed of normative beliefs, cause-and-effect claims, agreed methodological standards and socially-necessary abstractions, as well as policy aspirations (Haas, 1992; Dunlop, 2014; Robertson, 2012). This makes it all-the-more important to scrutinize the multiple ways in which evidence and discourses inform policy-making, and the different discursive strategies that 'experts' might deploy to negotiate the knowledge-policy interface (Dunlop, 2014, p. 208; Robertson, 2012; Van Hecken et al., 2015b). In this paper, we respond to these calls by examining how scientific experts are linked to environmental governance and security with the case of ES, and we discuss the consequences for society and nature. In order to explore how interpretative frames and related interests unfold through the coupling between ES, security, and expertise, we identify key scientific experts in ES through the use of bibliometric analysis and an opinion-based survey, and we follow some of their voices as they impact on ES governance and interrogate their security framings.

While previous critical scholarship has already engaged with the socio-political consequences of a world reduced to a collection of quantifiable ecosystem services (Robertson, 2012; Dempsey and Robertson, 2012; Sullivan, 2013; McAfee, 1999), or have dealt with ways to govern emergencies and attend to security affects as geographers (Adey et al., 2015; Anderson, 2015), we examine

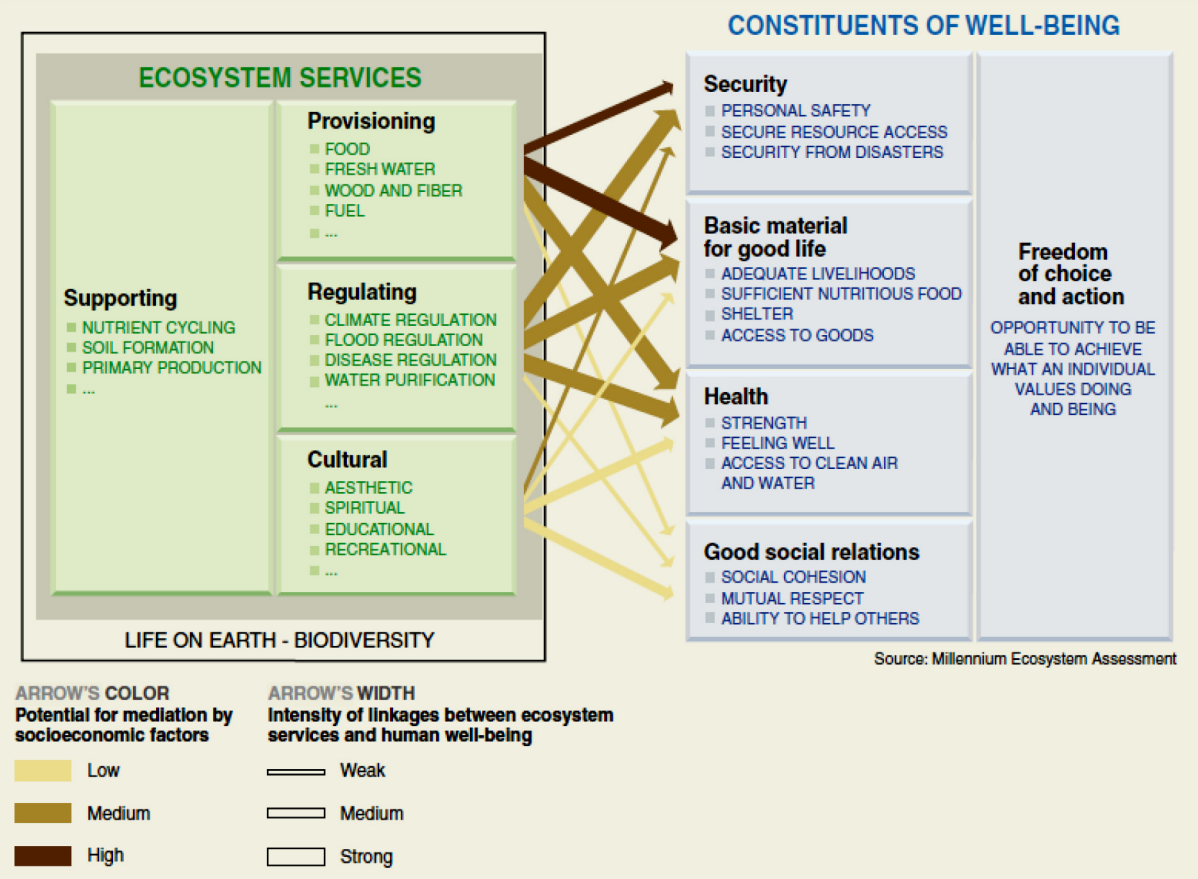

Fig. 1. Perceived links between ES and well-being constituents, including security in the upper right box. The security framing of ES is clearly illustrated by the emphasizing what is at stake, namely people's personal safety. *Source:* MEA, 2005.

environmental expertise at the boundary between science and security from the 'inside' by studying experts through their own knowledge forms and approaches (see Mosse, 2011), which we are familiar with as environmental scientists ourselves. Hence, we, the authors of this paper, *practice* scientific expertise and *speak* security concerning environmental governance (e.g. Pasgaard, 2013; Strange et al., 2011; Van Hecken and Bastiaensen, 2010a), while proposing to simultaneously *examine* this area of expertise. Therefore, this paper contains explicit self-reflections about our positionality and the approaches we apply (Section 5.2).

The paper is organized as follows. We take our point of departure in the coupling between ES, security and expertise. In Section 2 we outline our theoretical background as inspired by boundary-work, political ecology, "securitization" theory, and reflexive thinking. In Section 3 we describe our empirical frame, which in a novel and unique way, combines bibliometric analysis with a survey approach in order to quantitatively identify experts by their attribution. We present our analysis in Section 4, before a discussion in Section 5, which includes our self-reflections.

2. Theoretical frame: Expertise at the boundary between science and security (politics)

To better grasp the linkages between the governance of ES, security, and scientific expertise, we employ a broad theoretical frame drawing first on Gieryn's conception of the boundaries between science and non-science, which we relate to the coupling between science and policy (as governance of ES) from a political ecology lens. We then turn to "securitization" and expertise as processes, which can inform an analysis of the discourses and actors at the boundary between science and governance of ES. Here, we explicitly focus on the scientific expert as a potential securitizing actor. Lastly, we include some notions about reflexivity in research, which direct at our own positions and practices.

2.1. The contested boundaries of science

According to Gieryn (1983) the boundaries of science are ambiguous, flexible, historically changing, contextually variable, internally inconsistent, and sometimes disputed. Construction of a boundary between science and non-science is however useful, according to Gieryn, for several reasons, including scientists' pursuit of career opportunities, for acquisition of intellectual authority, for denial of "pseudo-scientists", and for the protection of the autonomy of scientific research from political interference. However, instead of such an ideologically clear boundary around science, where scholars are being seen as only 'speaking truth to power', a more cynical interpretation sees scientific advisers as following their own interests, and sees politicians as asking for advice only to support and legitimize their pre-formed political decisions (Hoppe, 2005). As such, science and politics have long collaborated to co-produce dominant understandings of nature. Behind the public face of environmental science, nation-states are continually at work, setting baseline conditions for whose knowledge counts and when knowledge is sufficient for action (Jasanoff, 2010; Hajer, 1995; Scott, 1998). This also leads us to acknowledge that 'truths' about the environment are inevitably 'shaped by the relationship between the subject and object of research, such that different actors, like scientists or others, may construct the same

environment in very different ways' (Blaikie, 1999). Indeed, understandings of nature and society are open to multiple – often contested – framings, i.e. different ways of understanding or representing specific problems and corresponding sets of solutions (Leach et al., 2010). The broad and interdisciplinary field of political ecology provides useful frameworks to critically analyse how environmental knowledge is produced, represented and contested (Bryant, 1998; Peet and Watts, 1996). In particular, some of the political ecologists influenced by Foucault's conceptualizations of power, knowledge and discourse (e.g. Blaikie, 1999; Escobar, 1996) provide crucial insights into how knowledge and power interrelate and mediate political-ecological outcomes (Bryant, 1998). They demonstrate that social–ecological conflicts are both struggles over meaning and battles over material practices (ibid). These insights have spurred political ecologists to turn to discourse, or the analysis of particular narratives promoted by and interlocked with governance processes (Adger et al., 2001; Hajer, 1995; Leach et al., 2010). The emphasis on narratives as particular ways of framing problems and solutions is held to promote a shift from descriptive to more critical and reflexive modes of explanation that 'help illuminate how knowledge claims derived from particular instances and sites are spread and consolidated by enrolling other actors and institutions into knowledge/power networks' (Leach et al., 2010, p. 74).

While science is indeed politics, research does not necessarily or easily translate into policy practice on the ground (Buger and Villumsen, 2007). According to Jasanoff (2005), science operates within a thick web of social constraints, and it is important to understand who has the right to define how, when, by whom, and to what extent science will be integrated into the solution of public problems, and *who*, indeed, will frame those problems in the first place. Inevitably, she says, there are boundary conflicts over where the role of science ends and that of politics or policy begins. These boundary issues are visibly illustrated in our analysis of the evolving discourse, expertise and governance of ES (Section 3), the security dimensions of which we now turn to.

2.2. Securitization and scientific expertise

According to security scholars of the so-called "Copenhagen School", security does not have a fixed meaning – security issues are socially constructed in a process called "securitization". A socially relevant *securitizing actor* uses certain *speech acts* – a particular discourse or narrative – to proclaim something an *existential threat* for a *valued referent object*, for instance a state or human welfare and economy. If this securitizing move is accepted by a relevant *audience*, such as the public or politicians, the securitizing actor may initiate and apply *extraordinary measures* which lie beyond the normal political realm and implies the use of force in order to tackle the threat. The issue in question then moves from being non-politicized or politicized to be a *securitized issue* (e.g. Buzan et al., 1998; Waever, 2011). Scholars studying such securitization processes in various contexts point out that security framing has implications; it can bring about exclusionary and stigmatizing effects, it may lead to selective policies or mismanagement, and it limits an open democratic debate (e.g. Balzacq, 2011; Elbe, 2006; Trombetta, 2008). Importantly, the problematic side effects of applying a security mindset should always be weighed against the possible advantages; for instance, securitization can have tactical attractions as a way to obtain sufficient attention to environmental problems (Buzan et al., 1998).

Having briefly unfolded how *security* is conceptualized in our analysis of ES, the notion of *expertise* remains to be unpacked. An expert can be understood as a person who holds a certain type of knowledge, or who achieves an authoritative position through claims of knowledge (Berling and Bueger, 2015; Jasanoff, 2005). Expert status can be produced by *acquisition* of certain skills or through *attribution*; the latter meaning someone being recognized as an expert by an audience (Berling and Bueger, 2015). In the latter view, expertise is not possessed, but designates authoritative knowledge (Halfon, 2015), similar to the notion of "power", which can be viewed as only existing when perceived by others (see Haugaard, 2003; Sikor and Lund, 2009). Importantly, expertise mediates between different forms of knowledge and occupies a boundary position by navigating positions and relations, and by translating between different domains, such as between science and politics (Berling and Bueger, 2015, p. 9). According to Jasanoff (2005) scientists are expected to function as experts, that is, as people possessing analytical skills grounded in practice and experience, rather than as truth-tellers with unmediated access to ascertainable facts. In other words, what is increasingly expected from experts in decision-making processes is to manage heterogeneous bodies of knowledge and offer balanced *opinions*. In the face of uncertainty, the central question is no longer which scientific assessments are *right*, but *whose* recommendations the public should accept as credible and authoritative. With the shift from science (as 'speaking truth to power') to expertise, and from knowledge to judgment, (scientific) experts have become indispensable to the politics of nations, and indeed to transnational and global politics, including security politics. The weight of political legitimation rests increasingly on the shoulders of such experts, and yet they occupy at best a shadowy place in the evolving discourse of democratic theory, says Jasanoff (2005) (for a discussion of expertise in the age of post-factual politics, see Berling and Bueger, 2017). In relation to Gieryn's boundary work, scientists attempt to construct a boundary around themselves contrasting themselves favourably to non-scientific activities in order to protect their professional autonomy and the claim that science carries its own intellectual authority. In turn, "different concepts and arguments are socially constructed and legitimated through complex processes that have produced new forms of expertise" (Aguilar-Stoen, 2015, pp. 40–41), and these processes in the end determine how problems and solutions are framed, constructed and circulated (Büscher, 2014). This paves the way to govern the environment by the management of 'risks' through the 'modulation of control' in a 'society of control', usually through practices of 'rendering technical' (Li, 2007a,b) or by securitizing the environment to 'render it governable' (Büscher, 2014; Nel, 2015). Thus, as noted in the definition of expertise above, scientific knowledge must be widely accepted in society as a preferred truth in descriptions of natural and social reality to maintain its authority (Gieryn, 1983) and describe solutions. How some scientific experts on ES portray themselves, construct boundaries to other scientists and non-scientists, and propose solutions to counter ES destructions, is exemplified in our analysis, and this boundary work is strongly coupled to (self-)reflectivity of research positions and practice.

2.3. (Self-)reflectivity at the boundary between science and security

Being an expert at the boundary between science and security can be an "uneasy position of the academic" potentially opening up important reflexive questions about expert practices and the production of scientific knowledge (Berling and Bueger, 2015). Adding to the unease, academics are in a constant situation of 'science in the making', where many decisions have to be made without a full understanding and predictability of causal effects (Barnaud and Antona, 2014, p. 115). The "awkward tension" between the maintenance of professional modes of thought and identities, and the world with which these have to engage, makes professional subjectivity and even self-ethnography increasingly relevant with studies of experts through their own knowledge forms and modes of sociality (Mosse, 2011).

While *social* scientists oftentimes direct their critical gaze towards other scientific experts and technicians operating in the *natural* sciences (Kauppi, 2014, see also Section 5.2), natural scientists can be accused of the same (e.g. Naeem et al., 2015; see Pasgaard, 2013). Thus, ideological self-descriptions constructed by scientists to monopolize professional authority and resources in the hands of some scientists by excluding others as "pseudoscientists" is not limited to demarcations of science from non-science. One epistemic group of scientists can draw a boundary to exclude another group also claiming to be scientific thereby making ideological demarcations of disciplines, specialties or theoretical orientations *within* science (Gieryn, 1983). As such, methods of science do reflect back on themselves, making science the unwilling target of its own methodological skepticism (Jasanoff, 2010), but this skepticism occurs mostly between disciplines within science instead of within scientific disciplines. Hence, it is ever more justified to investigate the status of science in society by pointing the finger at *ourselves* as researchers, by calling for practical reflexivity on the part of the scientist (Berling, 2011) and encouraging reflections about underlying predispositions, beliefs, and understandings that frame and guide scientific inquiries (Greene, 2007; Pasgaard et al., 2017). One way to do this is to foster reflexive empirical work on researchers' own practices, including how researchers' sayings and doings play out in concrete situations and contribute to the securitization of issues (Buger and Villumsen, 2007). Such practical reflexivity is needed to equip us with tools to capture relations between academia and policy, and to address dilemmas and challenges in concrete everyday situations (Berling and Bueger, 2017). Specifically, research approach and design, and researchers' positionality and stance within it, is a process which requires sensitivity, reflexivity, application and ongoing dialogue between the researcher and social actors (Prowse, 2010). The issue and appropriateness of value-driven science is of particular relevance and highly contested within areas such as ecosystem protection, and scholars themselves wish to initiate reflection and debate in the science community concerning their own role in growing the middle ground between science and politics, as they conduct science within that "hybrid space" (Milkoreit et al., 2015, p. 87; Kolinjivadi et al., in press; Pasgaard et al., 2017). In this study, we go beyond wishing and beyond reflexivity as merely a tool of critique (Berling and Bueger, 2017), and expose ourselves as awkward, but willing, targets of our own sensitive self-reflections.

In sum, our reflexive analysis of expertise and the changing governance of ES at the boundary between science and security lean on securitization and expertise as key parts of our theoretical frame. At the center of this frame stand the scientific experts on ES, and the following section outlines how we operationalize and examine their expertise, policy linkages and security framing.

3. Empirical approach: Operationalizing (security) expertise in Ecosystem Services

3.1. Examining (security) expertise in Ecosystem Services

Exploring the politics of expertise is not about what experts *know*, but rather what they *do*, meaning their systems for producing knowledge and the *practices* that they are able to institutionalize (Halfon, 2015). As mentioned earlier, expert status is produced through *attribution*, meaning that an expert needs to be *recognized* as an expert (Berling and Bueger, 2015). We operationalize this concept of expertise attribution quantitatively through bibliometric analysis and a qualitative opinion-based survey. We apply these methods as briefly explained below (see also Supplementary Materials) in order to identify key scientific ES experts and then trace their practices to policy arenas and expose their security framings.

For the bibliometric analysis we use article citations as our proxy to identify key scientific experts within ES research. In more detail, our citation proxy is operationalized as the top ten *most cited* scientific articles each year over more than a decade (2005–2015) using the search terms 'ecosystem service∗' or 'environmental service∗' in Scopus (extracted on 5th January 2016). For these most cited articles (110 in total) we list all first, second, second-last and last authors (335 in total), since those are perceived most important, i.e. the last author is oftentimes the head of the laboratory or research team. Authors who did not publish any of the 110 articles as first author were eliminated from the list. The citations were then added and the authors were ranked accordingly (Table 1). To supplement and compare this list of key experts derived from bibliometrics, we conducted an anonymous online survey among academics, practitioners and policy-makers within the fields of ES, and asked them to identify key experts (Table 2). The survey respondents were identified and contacted based on their engagement in recent publications[2] and events[3] related to ES. Based on the bibliometric analysis and the survey, we then explored the backgrounds and affiliations of four selected key experts, their links to policy design and execution, and importantly, the use of security framings in their work. Moreover, the survey approach itself gave rise to interesting comments from the invited respondents, some of which are included in our summarizing reflections (Section 5.2).

3.2. Methodological considerations

As we employ a bibliometric approach with a focus on highly cited articles we use publication performance indicators as novel measures of expert attribution. Here, we measure authors' scientific weight to label them as experts, rather than any other criteria (e.g. research grants, keynote talks, public outreach, networks – such criteria might be used by media or government). With this approach we run the risk of including publications by authors who are well-cited because other scholars *criticize* their work, possibly *questioning* their status as experts. This bias is balanced by comparison with the key experts identified in the opinion-based survey. With the bibliometric approach, we also run the risk of overlooking influential and politically-engaged researchers with relatively older, few, or less-cited scientific publications, as they fall out of our bibliometric radar, which is designed by people and biased in these regards. However, we explicitly aim to trace voices of experts operating at the boundaries between *science* and security, and we understand expertise as *attribution* (Berling and Bueger, 2015). Therefore we identify scientific experts based on their/our own commonly used valuation metric (namely highly-cited publications) in combination with subjective opinions collected through the online survey. Cynically speaking, we are less concerned with identifying *the* top scientific experts on ES, since such a list will differ with slight changes in the setup and timing of the bibliometric analysis and the survey. Although interesting discussions can be connected to the credibility of creating "a top list", we are more concerned with *the way* our identified experts (highly cited and recognized by an audience) link to policy and frame ES. In other words, exactly *who* features on our expert list is less relevant in this study, as opposed to exemplifying *how they practice* their expertise on ES.

[2] Corresponding authors that recently (2012 till present) published on "ecosystem services" or "environmental services". We extracted 3655 unique email addresses from Scopus on November 9th, 2015.

[3] For instance the "Ecosystem Services Partnership conference 2015" and "A Community on Ecosystem Services Linking Science, Practice and Decision Making" (ACES 2014 conference).

Table 1
Results from the bibliometric analysis, including citations (see Thomson Reuters, 2009), number of articles, H-indices (see also NCAR, 2015), and author position (1 = first author; 2 = second author; 3 = second last author; 4 = last author). The most cited author and publication is Hooper et al. (2005). Experts featuring in both Table 1 (bibliometrics) and Table 2 (survey) are marked with a star. Experts selected for Table 3 (links to policy and security) have a grey background.

Bibliometric analysis of publications	Author	Citation of article(s)	No. of articles	H-index (Scopus)	Author Position
1	Hooper, David U.	2496	1	22	1
2	Ricketts, Taylor H.*	2426	6	39	3,4,2,4,1,3
3	Barbier, Edward B.	2094	3	38	2,1,1
4	Tscharntke, Teja	1874	4	73	1,2,1,1
5	Pagiola, Stefano	1552	4	11	1,2,4,1
6	Worm, Boris	1433	1	40	1
7	De Groot, Rudolf S.*	1326	4	28	3,1,1,2
8	Wunder, Sven*	1261	4	25	1,4,1,4
9	Folke, Carl	1243	1	69	1
10	Allen, Craig D.	1215	1	28	1
11	Daily, Gretchen C.*	1053	3	55	2,1,1
12	Kremen, Claire*	980	3	45	1,1,3
13	Engel, Stefanie	939	2	10	1,2
14	Hein, Lars M.	934	2	18	1,3
15	Balvanera, Patricia*	878	1	19	1

Finally, we note that our empirical approach is further discussed as part of our reflections (Section 5.2).

4. Analysis: Expertise, security and governance of Ecosystem Services

Having sketched out in our Introduction the shift in the broader ES discourse from a mainly ecological focus towards a more economic one, we here direct our analysis at the security framings and the role of scientific experts. We first examine the changing discourse and governance of ES from a securitization lens by presenting speech acts by securitizing actors, in this case the scientific experts, who point to valuable referent objects and call for certain measures to reverse the proposed destructive trajectories of ES. Two governance platforms, namely PES and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), are used as further examples to connect ES, security, and expertise. We then identify key experts, follow the practices of four selected key experts related to ES policies, and exemplify their security framings. To supplement these analyses and examples, an anecdote from a recent conference on ES provides a more personal illustration of the heated discursive struggles among experts about the governance of, and science in, ES.

4.1. Security framings of Ecosystem Services and governance implications

Gomez-Baggethun et al. (2010) and Norgaard (2010) note that the rationale behind the use of the ES concept was mainly pedagogic, aiming to demonstrate how the disappearance of biodiversity directly affects ecosystem functions that underpin *critical* services for *human well-being*. In other words; by using a security language that reflects dominant political and economic views as a tool to communicate ecosystem functioning, the concept or metaphor of ES was applied in the search for short term policy actions to halt ES loss, as traditional narratives of conservation largely failed to influence economic decision making (ibid; see also Barnaud and Antona, 2014; Bonie and Hulme, 2015; Vadrot, 2014). While examples of security framings in relation to ES are plentiful to the point that the security threat of ES degradation today is a widely accepted fact (see Section 1), we emphasize here two publications, both issued in 2005, which seem to have played a key role in the changing discourse on ES, namely Wunder (2005) and the Millennium Ecosystem Assessment on Ecosystems and Human Well-being (MEA, 2005). It is around this time topics linked with ES and market-based instruments became significant concerns (see Section 1 and bibliometric results in Supplementary Information). We bring attention to these two influential publications, since they both reflect and have further ignited a turn from a more ecologically-driven discourse to a more economically-driven one (see also Méral, 2012; Spash, 2015; and Van Hecken et al., 2015a, who among others point out the importance of these publications). Importantly, as evident from the brief analysis below, both Wunder (2005) and the MEA (2005) use a security framing of ecosystem destruction or environmental crisis to legitimize and justify the type of governance they suggest.

The economist Sven Wunder (2005) "demystif[ies] PES for non-economists" arguing that it is part of a new conservation paradigm and that "PES best suits intermediate and/or projected *threat* scenarios" (p. 1, emphasis added). Wunder clearly notes that "[a]

Table 2
Most frequent responses to the question "In *your opinion*, who are the key scientific experts on Ecosystem Services? (in random order, list 1–5 names, possibly including your own)". N = 560. Experts featuring in both Table 1 (bibliometrics) and Table 2 (survey) are marked with a star. Experts selected for Table 3 (links to policy and security) have a grey background. See Supplementary Materials for additional results and analyses from the survey.

Survey results	Key expert	Times mentioned
1	Constanza, Robert	175
2	de Groot, Rodolf S.*	157
3	Daily, Gretchen*	139
4	Polasky, Stephen	45
5	Maes. Joachim	43
6	Bennett, E.	36
7	Burkhard, Bejamin	35
8	Carpenter, Stephen R.	23
9	Kremen, Claire*	21
	Bateman, Ian	21
11	Chan, Kai	20
12	B. Fischer	19
13	Boyd, James	18
	Martin-Lopez, Berta	18
14	Balvanera, Patricia*	17
	Potschin, Marion	17
15	Ricketts, Taylor H.*	16
	Wunder, Sven*	16
	Braat. Leon C.	16

s wilderness and natural habitats shrink, environmental services (ES) previously provided free by Mother Nature are becoming increasingly *threatened*. This *emerging scarcity* makes them potentially subject to trade" (p. 1, emphasis added). According to Google Scholar, Wunder's paper has been cited more than 1400 times (as of April 2016), and Sven Wunder also features on both our lists of key experts as identified by the bibliometric analysis and survey, respectively (see Tables 1–3). The other key publication, the MEA (2005), is authored by over a thousand experts from different scientific disciplines, and the publication applies "the judgment of [these] experts to existing knowledge to provide scientifically credible answers to policy-relevant questions (p. v)" by synthesizing information from the scientific literature and relevant peer-reviewed datasets and models. The MEA explicitly couples ES and human well-being, noting that "[e]veryone in the world depends completely on Earth's ecosystems and the services they provide".[4] According to the MEA, these ecosystem services are specifically linked to the security constituent of human well-being in terms of personal safety, secure resource access and security from disasters (p. vi, see Fig. 1 portraying these security dimensions at the top of the graphics). The MEA states in a non-controversial and fact-based manner that "the *harmful effects* of the degradation of ecosystem services on livelihoods, health, and local and national economies are *substantial* (p. 6, emphasis added)". Economic and financial interventions, including greater use of market-based approaches and transfer of subsidies to payments for non-marketed ES, are suggested in the MEA as powerful instruments to regulate the use of ecosystem goods and services. Indeed, the MEA has contributed much to putting ES on the political agenda (e.g. Gomez-Baggethun et al., 2010; Vadrot, 2014). According to Google Scholar, the MEA is cited more than 11,000 times (as of April 2016).

From a securitization lens, we show above and in Table 3 how some socially relevant securitizing actors (selected scientific experts) attempt to proclaim that the destruction of ES is an existential threat to a valued referent object (all humans; livelihoods, health, economies). The securitizing actors in question suggest applying certain measures (such as monetary valuation of ES, or implementing market-based approaches) in order to tackle the threat (e.g. Costanza et al.'s (1997) attempt to capture the entire economic value of the Earth; and Wunder's (2005) or Engel et al.'s (2008) plea to set up payment mechanisms for securing the provision of ES). Examples of such measures are further illustrated by PES and IPBES below. If the attempted securitization of the issue in question (namely ES) is accepted by a relevant audience and fully securitized, it is moved from being non-politicized or politicized (centered on ecological restoration, biodiversity and species protection), to be a securitized issue with the possibility to apply extraordinary measures. Whether ES can be considered fully securitized and whether the governance turn towards marketization can be perceived as "extraordinary" is indeed interesting, and will be further explored in Section 4.2. But first we direct our attention to scientific expertise.

From an expertise perspective, the speech acts or particular narratives exemplified above attempt to shift not just the discourse, but also the realm of problematization and thus the realm of policy expertise, *away* from the "traditional" nature conservation experts with roots in biological/ecological science *towards* environmental economists. This requires the adoption of a new range of socially-necessary abstractions of nature that allow for the translation of parts of nature into calculable (exchange) values for capitalist circulation (Robertson, 2012). Just to clarify; the "traditional" experts do not suddenly disappear, rather they might take up another role in the policy process, as they become the deliverers of necessary data to inform the stock-flow ES models in order to 'get the science right' (Naeem et al., 2015), when particular policy models are proposed. For instance, economic concerns about "additionality" (protecting *more* ES than a projected baseline or business-as-usual) raise the need to predict what the world would have been like without environmental protection, and this need inevitably promotes a strong role for economic experts, as well as requires the imposition of technical standards related to for instance carbon credits (measured as "tonnes of CO_2 equivalent") (e.g. Fairhead et al., 2012; Robertson, 2012). This process of "rendering technical" (Li, 2007a,b) and the use of "calculative devices" (Latour, 1987) results in a specific approach to environmental problems, where experts are empowered to design policy initiatives that direct government action (Spash, 2015). Wunder (2005) himself also notes that with PES replacing previous integrated conservation and development projects "a whole *different skill set would be required*, such as land-use and *service monitoring*, facilitating negotiation, and *financial intermediation*" (p. 2, emphasis added). This framing implies the involvement of a whole new set of (intermediary) actors, playing a crucial role in the 'management' of the complexities of, for example, the monitoring of carbon sequestration, and the design of PES schemes (Fairhead et al., 2012). Indeed, such meso-level actors largely shape how conserva-

[4] Categorized in the MEA (2005) as *provisioning*, *regulating*, *cultural*, and *supporting* services.

Table 3
Selected experts and their disciplinary backgrounds, examples of links to policy, and security framings. *Source:* Compiled from email signatures, publications, and web-based searches.

	Background, activities and policy links	Examples of security framings
R. Costanza	**Discipline**: Ecological Economist **Affiliations** (selected): Crawford School of Public Policy, The Australian National University; Fellow, Asia and the Pacific Policy Society, Distinguished Visiting Professor, Lincoln University, NZ; Senior Fellow, Stockholm Resilience Center; Senior Fellow, National Council on Science and the Environment, Washington, DC. **Activities and policy links**: Editor in Chief of *Solutions.* Co-founder and past-president of the International Society for Ecological Economics and chief editor of the society's journal, Ecological Economics from its inception in 1989 until 2002. Present: – Co-chair, Ecosystem Services Partnership http://www.fsd.nl/about-fsd/, where it is stated that "[on] a global scale, ecosystem degradation and loss of biodiversity still continue at an alarming rate. An important reason for this is the undervaluation of the true importance of nature and a healthy natural environment in economic planning and decision-making", which largely mirrors Costanza et al. (1997), see right column. – Trucost, LLC, Chairman of Advisory Panel www.trucost.com – Earth Inc. Co, founder and Board Member www.earthinc.com Past (selected): – Conservation International (until 2009) and BioEra (until 2010)	Co-author of Planetary Boundaries (Rockstrom et al., 2009, see p. 3), which has a strong security framing. The authors behind the Planetary Boundaries state that transgressing a boundary increases the risk that human activities could inadvertently drive the Earth System into a much less hospitable state, damaging efforts to reduce poverty and leading to a deterioration of human wellbeing in many parts of the world, including wealthy countries. Co-authors with C. Folke (see below). According to Gomez-Baggethun et al. (2010) the study by Costanza et al. (1997) on the value of the global natural capital and ecosystem services was a milestone in the mainstreaming of ecosystem services. The monetary figures presented resulted in a high impact in both science and policy making, manifested both in terms of criticism and in the further increase in the development and use of monetary valuation studies. In the influential study from 1997, Costanza et al. describe ES as "critical to the functioning of the Earth's life-support system" (p. 253), the neglect of these services compromising human welfare. In a follow-up study with new estimations of the total global value of ES, the authors note that "probably the most important contribution of the widespread recognition of ecosystem services is that it reframes the relationship between humans and the rest of nature [. . .] emphasizes our natural assets as critical components of inclusive wealth, well-being, and sustainability [. . .] This reframing of the way we look at "nature" is essential to solving the problem of how to build a sustainable and desirable future for humanity" (Costanza et al., 2014, p. 153). The phrasing demonstrates the authors moving the topic into an area of global security concerns thereby legitimating extraordinary means needed against this socially constructed threat.
S. Wunder	**Discipline**: Economist (MSc. in economics, a doctorate in macroeconomics, and a DSc (habil) in forestry economics). **Affiliation**: Principal Economist at the Center for International Forest Research (CIFOR), head of the Brazil office. Has worked with CIFOR since 2000. Has previously worked for IUCN, the Center for Development Research in Denmark and Danida (Danish Aid agency). **Activities and policy links**: CIFOR is "committed to advancing human well-being, equity and environmental integrity by conducting innovative research, developing partners' capacity and actively engaging in dialogue with all stakeholders to inform policies and practices that affect forests and people" (http://www.cifor.org/about-cifor/what-we-do/). In this facility, Wunder has advised both small-scale PES initiatives and government programs, especially in Latin America, on development and design of the PES instruments he promotes in his scientific writings.	Author of an influential paper on PES (Wunder, 2005) and co-author of Naeem et al. (2015), see p. 10 and 3 respectively. Several other publications on ES, and PES in particular, which have security framings linked to policy solutions: "As ecosystems have become increasingly degraded worldwide, and the valuable environmental services (ES) that they provide lost or reduced, there has been a growing search for solutions. Among these, the payments for environmental services (PES) approach.." (Wunder et al., 2008, p. 834) Co-authors with S. Pagiola and S. Engel (see below and Table 2): ". . .the [MA] assessment revealed that nearly two thirds of global ecosystem services are in decline [. . .] natural capital depletion is often much greater than would be socially optimal [. . .] Payments for environmental services (PES) have attracted increasing interest as a mechanism to translate external, non-market values of the environment into real financial incentives for local actors to provide such services." (Engel et al., 2008, pp. 663–664)
S. Pagiola	**Discipline**: Environmental Economist **Affiliation**: Senior Environmental Economist at The World Bank, leading the Bank's work on payments for environmental services (PES). Affiliated with the World bank since 1997.Has previously taught economics at Stanford University and was a Research Associate at Washington State University. **Activities and policy links**: The World Bank supports several policies and projects Worldwide relying on economic incentive-based mechanisms, such as PES and REDD+ (incentives to Reduce Emissions from Deforestation and forest Degradation in developing countries). The selected citations in the right column shows a similar rhetoric in scientific as well as policy papers, i.e. mismanagement leads to problematic degradation of valuable environmental services - this can be counteracted by creating economic incentives through PES (and the World Bank as policy provider).	Co-authors with S. Wunder on several papers (Engel et al., 2008; Wunder et al., 2008), as mentioned above, and likewise couples (PES) policy with harmful environmental degradation, and human wellbeing and security: "In addition to the environmental problems caused by the initial deforestation, extensive grazing often suffers from declining yields, diminishing grass cover, soil erosion, water supply contamination, air pollution, and landscape degradation. Declining producer income results in continuing poverty and can lead to pressure to clear additional areas [. . .] PES approaches [. . .] have considerable potential for helping to increase the generation of ecosystem services in agricultural landscapes" (Pagiola et al., 2007) "The valuable environmental services provided by natural ecosystems are too often lost as a result of mismanagement and lack of incentives to preserve them. Helping countries find innovative solutions to such problems—which intersect with livelihood, vulnerability, and health issues—is a key element of the World Bank's Environment Strategy. The Bank's innovative work on payment for environmental services (PES) is an example of these efforts." (Pagiola and Platais, 2002)

(*continued on next page*)

Table 3 (*continued*)

	Background, activities and policy links	Examples of security framings
C. Folke	**Discipline:** Ecologist/Ecological Economist **Affiliations:** Science Director of the Stockholm Resilience Centre and Director of the Beijer Institute of Ecological Economics of the Royal Swedish Academy of Sciences (partner of the Stockholm Resilience Centre). Former Deputy Director of the Beijer Institute 1991–1996, former Director of Stockholm University's Center. **Activities and policy links**: Co- founder of the Resilience Alliance and serves on the Executive Committee. Involved in the development of the International Society for Ecological Economics (ISEE) and was engaged in the influential expert-driven Millennium Ecosystem Assessment (MEA, 2005), which is coupled to the inception of the science-policy platform IPBES (see Section 4.2). Transdisciplinary collaboration between natural and social scientists, and has worked with proactive measures to manage resilience. Emphasizes the role that living systems at different scales play in social and economic development and how to govern and manage for resilience in integrated social-ecological systems.	Co-author of Planetary Boundaries by Rockstrom et al. (2009, see p. 3) and the sequel by Steffen et al. (2015), which both have a strong security framing. Co-authors with R. Costanza on the book chapter *Valuing ecosystem services with efficiency, fairness and sustainability as goals (Costanza, 1997)*, stating that "Economic analysis is about making choices among alternative uses of scarce resources, and it is in this context that valuation becomes relevant [. . .]" As lead author, he states that production and maintenance of ecological services underpin human societies, and that ". . . forces in society that cause biodiversity loss need to be addressed directly. . . [S]ocial and economic policies that encourage biodiversity loss should be reformed, especially where there is a risk of irreversible damage to ecosystems and diversity. . . [I]t is necessary to create economic incentives [and] internalize the externalities of biodiversity loss. . . " (Folke et al., 1996)

tion policies trickle from global level down and *vice versa* when outcomes and knowledge are translated from local levels back to global decision makers (Pasgaard, 2015).

Concerns are raised that in practice, the economic discourse enables the empowerment of economic logic in public policy, including a presumption *against* direct regulation, legal restrictions, planning, public participation, and any form of government intervention that does not support private property rights or work through market-based approaches (Lewis, 2011; Spash, 2015). While the focus on monetary valuation and payment schemes has contributed to attract political support for conservation, it has also contributed to a growing number of attempts to commodify ES and to reproduce the use of a market logic to tackle environmental problems (Gomez-Baggethun et al., 2010). Other policy effects partly justified by the attempted securitization of ES are emphasized in the discussion below of PES and the IPBES as proposed measures to counteract the threat of ES destruction.

4.2. Security framing and expert influence in Ecosystem Services: The cases of PES and IPBES

In order to illustrate the security and expertise dimensions of ES, we look into Payments for Ecosystem Services (PES) as a new governance tool to protect or restore ecosystems considered valuable, and we focus on the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) as a site producing expert knowledge for global policies (see also Jasanoff, 2010 on IPCC).

In line with the changing discourse on ES noted in the Introduction, PES have become an extremely popular governance tool in the last 10 years; both in academic and policy circles (Wunder, 2015; McElwee, 2012). Applying the securitization vocabulary and exemplified with the influential works by Wunder (2005) and MEA (2005), PES can be perceived as a measure to combat ecosystem destruction as an existential threat to a valued referent object (in this case mainly human well-being, see Fig. 1). In that way, PES is partly justified by a security framing imposed by scientific experts as securitizing actors (see Table 3). In other words, the main argument for creating a PES mechanism is that ecosystems provide people with valuable and potentially marketable 'services' or positive externalities (Van Hecken and Bastiaensen, 2010b); the emerging scarcity of which makes them potentially subject to trade (Wunder, 2005).

According to critical scholars, the PES approach might appear innovative and appealing, and an attractive narrative about the causes and possible market solutions to the problem of the so-called under-provision of ES. These scholars argue that despite the apparent attractiveness of PES, it could eventually do more harm than good, especially if it promotes the market as a superior solution that can and should replace 'ineffective local or state governance' (Muradian et al., 2013; Van Hecken and Bastiaensen, 2010a). Harm could also be done when such market mechanisms are exported to developing countries and non-market societies where this economic logic is non-existent, or culturally discouraged by the existing institutional structures (Gomez-Baggethun et al., 2010; Muradian et al., 2010). According to some critics, the problematic nature of PES is not that it is a market per se, but that it is a powerful intervention masquerading as a market. Such market-style or neoliberal conservation can powerfully re-shape nature–society relations, in some instances by portraying communities (or individuals) as willing 'service providers' in market transactions, while the bottom-up considerations of empowerment or rights are obscured (Milne and Adams, 2012; Büscher, 2012). Such potential violation of rights bears notions of 'extraordinariness' according to the securitization vocabulary, as it implies use of force. Also, broadly speaking, the resolution of "market failures"

through payments tends to be seen as a technical matter, while in practice, PES is part of broader structures of power (Muradian et al., 2013; Büscher, 2014). This point resonates well with the view of 'rendering' complex matters of nature and development 'technical' (Li, 2007a,b).

Interestingly, among its proponents, the role of a certain type of science and expertise in PES has not gone unnoticed. A large group of prominent PES scholars, featuring Sven Wunder as last author and Shahid Naeem (director of Science at the Earth Institute Center for Environmental Sustainability and co-chair of the MEA, 2005) as lead author, recently published an article in *Science* about "Getting the science right when paying for nature's services" (Naeem et al., 2015). This article has a "focus on the natural science [as opposed to social science] because of growing concerns over scientific weaknesses" (p. 1206). The authors claim that the success of PES initiatives is reliant upon *scientific* knowledge on issues such as the methods for verifying delivery of services, the establishment of a relationship between natural resource practices and the generation of a service, and trade-offs with other beneficial non-target services. Without tools for identifying the *best* and most *affordable* metrics, the authors argue that PES proponents may struggle to collect *scientifically meaningful, cost-effective baseline* data and implement *effective* monitoring programs. To counteract the perceived limited scientific evidence and lack of empirical data on effectiveness, four *natural-science* principles are deemed essential, according to Naeem and his colleagues, in order to ensure *scientific integrity* in environmental interventions. These principles concern baseline data, monitoring of key environmental factors and services, recognizing that ecosystems are dynamic, and inclusion of metrics; specifically on risks such as climate change or invasive species. If any of these basic principles are not considered, the authors claim that the ability of PES mechanisms to generate ecological and social benefits may be undermined. Besides the security undercurrent, these statements can be viewed as an attempt to monopolize professional authority in the hands of one particular group of (natural) scientists, portraying others as (social) "pseudo scientists" (see Gieryn, 1983).

The IPBES is an expert institution expected to transform the governance of biodiversity and ecosystem services. The organization was established in 2012 and brings together 124 governments and more than 1000 international experts with the explicit objective of addressing the degradation of biodiversity and ES to improve human well-being (Montana and Borie, 2015). According to Vohland and Nadim (2015) the design of IPBES is partly a response to a call emerging in the mid-2000s for a more sustained and systematic approach that would actively support policy in the area. Beck et al. (2014) note that the platform was set up as a permanent intergovernmental science-policy organization in order to build on and further the work of the MEA (see also Bonie and Hulme, 2015; Vadrot, 2014). The conceptual framework of IPBES determines how the *problem* (loss of biodiversity and ecosystem function) is understood and *how to ameliorate* it (Vohland and Nadim, 2015), which in securitization vocabulary corresponds to the existential threat (as framed in the MEA) and the justification of certain measures, which are perceived by some as extraordinary (see below).

According to Vohland and Nadim (2015), the conceptualizations by IPBES distribute causation, agency and efficacy quite unevenly: nature is passive and only changed through human intervention; biodiversity loss is a problem of excessive pressures (rather than business as usual); and quantification is presented as the precondition for any remedial action. Adhering to this order, the authors suggest, denies many concrete experiences of biodiversity loss and destruction as well as other conceptions of diversity, nature, human intervention or evolution. As such, IPBES has been feared by some countries insofar as it could impinge on national sovereignty and prescribe a certain type of biodiversity governance as a tool for Western states to legitimize access to biological diversity at the expense of benefit sharing (Vadrot, 2014). Moreover, some scholars caution that IPBES might be used as a proxy to pursue agendas that are cursory or even detrimental, or that the work pursued in its name might cause hurt and damage elsewhere (Vohland and Nadim, 2015). In this light, IPBES can be perceived as an extraordinary measure due to concerns about additional pressures on sovereignty and resource access. In the establishment of IPBES, the use of the ES concept was, and probably still is, highly contested and controversial (Bonie and Hulme, 2015; Vadrot, 2014).

Jasanoff (2010) argues that efforts to understand natural and social processes at increasingly complex levels are producing new, boundary-crossing scientific representations. Global institutions have arisen to produce expert knowledge for global policy. Though 'intergovernmental' in name, they are not answerable to particular national traditions or institutions of policy legitimation. Instead, claims about the environment and its sustainability produced by such novel bodies inevitably function as sites of contestation among competing models of knowledge-making and governance (Jasanoff, 2010). Others believe that an international, *neutral* body, such as the IPBES, would be an ideal coordinator for regular review and assessment of *science* guidelines for PES (Naeem et al., 2015), and that the *credibility* of IPBES will be shown if assessment processes are *not impacted by political or economic interests* (Vohland and Nadim, 2015). In effect, IPBES is part of a development of an "authority of truth" with regards to stabilization and reinforcement of internal and external demarcation lines (Vadrot, 2014), for instance as it essentializes and makes explicit (with colour-coded diagrams) the distinction between science and indigenous and local knowledge (Bonie and Hulme, 2015, see also analysis by Robertson, 2012, of classification and categorization in the measuring and abstraction of ES). Thus, paradoxically, attempts to demarcate science from non-science are evident in a platform where the boundaries between science, security, politics, and economics are fluid and contested at the very least.

Returning again to the securitization process coined by Buzan et al. (1998), it is explicitly noted that the existential threat has to be argued and gain enough resonance to legitimize emergency measures "that would have been *impossible* had the discourse *not* taken the form of existential threats, point of no return, and necessity" (p. 25, emphasis added). Arguably, we have no way of knowing whether IPBES (or PES) would have been established or function differently *without* a security framing provided by for instance the MEA (2005) and by the experts we identify in the following.

4.3. Tracing key scientific experts to policy debates

According to Thiel et al. (2015), an increasing number of academics are now aspiring to take part in guiding purposeful institutional change. Or at least they should (Castree, 2015; Cornell et al., 2013). With the use of bibliometric analysis and an opinion-based survey, we have identified a list of key scientific experts (Tables 1 and 2). From our lists of key experts, we have selected four specific experts to follow in more detail. We trace their backgrounds and affiliations, activities and links to policy, as well as giving examples of their security framing of ES (Table 3). We have chosen these four experts since they provide good examples of how ES and urgency thinking has been used for particular policy proposals and practices (S. Wunder and S. Pagiola): some in a more conceptual way (R. Costanza), while still offering a more balanced view by recognizing integrated social-ecological systems, and how we should avoid panacea policy solutions through more adaptive governance ideas (C. Folke). Other experts would indeed have been equally interesting to follow, but we bring forward the science-policy rela-

tions of these four experts to illustrate the web of scientific expertise and security in the changing governance of ES.

Table 3 shows some common characteristics and arguments across our four selected experts. For instance, they have a similar disciplinary background as (environmental or ecological) economists; they co-author publications (e.g. Wunder-Pagiola, Costanza-Folke, and Wunder-Folke); they are active in policy platforms and policy advising (e.g. MEA and PES, CIFOR and World Bank); they all couple ES with (human) security; and the majority of them see the creation of economic incentives as a necessary solution to the degradation of ES.[5] Arguably, since we selected these experts (among others in Tables 1 and 2) to further examine these exact traits and linkages these findings come as no surprise, but do illustrate the linkages between science and security in the changing governance of ES in more detail.

4.4. An echo of the ongoing struggles between experts

We round up our analysis with a recent participant observation from a conference, namely the 27th International Congress for Conservation Biology (ICCB) in Montpellier, France, in August 2015, where more than a thousand scientists and experts with an interest in biodiversity conservation and ES met. Here, Professor Clive Spash, Chair of Public Policy and Governance at the WU Vienna University of Economics and Business, Austria, received a *standing ovation* at a plenary debate on the future of conservation. He questioned the usefulness of market-based instruments in conservation and stated that "conservation is already lost when it enters the world of corporate finance, economic trade-offs and the commensuration of all values". He continued: "The current neoliberal capitalist development model assumes limitless economic growth, and that market failures can be corrected by pricing Nature [...] This system is neither economically, socially nor ecologically sustainable. Allying with corporations is nothing more than supporting the old ideology of economic growth, neoliberalism and technocracy". In his recent academic writings, Spash (2015) notes that economists take preference satisfaction as being linked to welfare (being better-off), and welfare enhancement is taken as the moral good. Science is irrelevant for economic value, Spash claims, and what counts are the preferences of the individual: If people do not care then nature does not matter. On the contrary, ecologists and biologists often employ different justifications for why something should be conserved (or not), he says. The difference according to Spash is "that *experts* are meant to employ *scientific* argument and judgement rather than their own preferences, while, at least in theory, economists appeal to the public and their preferences" (Spash, 2015, p. 3, emphasis added). Thus, similar to Naeem et al. (2015), this rhetoric can be said to construct an ideological self-description and monopolize authority, but this time in favour of ecologists/biologists, while the economists are portrayed as 'pseudoscientists' (cf. Gieryn, 1983).

5. Discussion

5.1. Ecosystem services at the boundary between science and security

Nature lies in the political realm and issues about natural entities have become some of the hottest topics of public controversy - it is as if nature and geopolitics have been conflated (Latour, 2011). The marketization of nature and conservation action is said to depoliticize powerful interventions that attempt to change relationships between people and nature (Milne and Adams, 2012; see also Van Hecken et al., 2015a). New forms of value, new kinds of equivalence, new practices of calculation, new relations between human and the non-human, and new distinctions between what is real and its representation are created. This 'politics of calculation' favors certain kinds of expertise to improve the perceived defects of nature and repair the ills of society (Mitchell, 2002), as with carbon forestry interventions justified by reference to claims to sustain the life of populations of humans and non-humans (see also Nel, 2015).

At the boundary between environmental science and security, scientific experts increasingly have a proactive role in making their work part of a political discourse, and show a willingness to blur the lines between science and institutional change (see Castree, 2015; Milkoreit et al., 2015; Thiel et al., 2015). Indeed experts *construct* – they do not simply *find* – the knowledge base on which they rest their hybrid judgments (Jasanoff, 2005). Ish-Shalom (2015) argues that "once the environment is perceived as a security issue, *people with relevant knowledge* can be enacted and attributed as having expertise (p. 229, emphasis added)". We advance this notion as our study suggests that the attempted securitization of the environment has been part of setting the stage for *new* kinds of nature conservation experts - namely (environmental) economists - who have effectively entered this arena with market-based solutions and green neoliberalism (see Roth and Dressler, 2012; Wunder, 2005; Table 3). As with other issues being securitized and transformed from a (non-)politicized to a securitized issue (see for instance Elbe, 2006), this securitization attempt can serve positively to strengthen international initiatives by raising awareness and resources, for instance concerning the interdependencies of ES providers and beneficiaries, opening ways for negotiated agreements or collective action (see Barnaud and Antona, 2014). But it also risks pushing responses away from civil society towards private organizations and investors with the power to override local rights (Lewis, 2011; Milne and Adams, 2012). Arguably, while the appropriation of land and resources have long and well-known histories of resource alienation by state and non-state actors in the name of the environment, novel forms of valuation and commodification of nature are constructed through new discursive framings, introducing an extraordinary new range of actors and alliances, and imposing diverse implications and consequences for people and nature (Fairhead et al., 2012). We add to this debate that such novel forms of market-based or neoliberal governance, and the general economization of protection of ES as effectuated in PES-like policies, are partly legitimized and intensified by a security framing by scientific experts (see Table 3). We question whether the motivation and intentions behind the securitization of ES is always grounded in a "genuine" concern for the nature-human balance, or whether it, for some, is based on a blind belief in market mechanisms, or even a strategic move to position a certain kind of expert(ise) at the forefront of environmental protection with access to funds and political influence (see de Sardan, 2005; see Goldman, 2005). Either way, motives perceived as more "genuine" or justified, for instance conservation concerns by traditional ecologists/biologists (Spash, 2015), might rely on strategic positioning and lead to injustices (Fairhead et al., 2012). Revealing such underlying motives requires honest and sensitive self-reflections on the part of the scientists. We attempt to make a move in this direction before concluding.

5.2. Self-reflections: expert positions, disciplinary arrogance and types of knowledge

We, the authors of this paper, are all academically raised as natural or social scientists (within fields of biology, geography and forestry). With these backgrounds, we face a sort of internal

[5] See however Costanza et al. (2014, p. 152), who "emphasize that valuation of ecoservices (in whatever units) is not the same as commodification or privatization [...] conventional markets are often not the best institutional frameworks to manage them."

dilemma or unease when critically examining scientific expertise in ES, and simultaneously acting as scientific experts on these same issues, albeit with a critical stance (e.g. Dallimer and Strange, 2015; Pasgaard, 2015; Van Hecken and Bastiaensen, 2010b). By *examining* while *practicing* scientific expertise, we deal with very different research questions and problems at the same time, which requires different methodological approaches and theoretical frames (Greene, 2007; Prowse, 2010), which might display philosophical and ontological inconsistencies. We do however not see this "pragmatic eclecticism" of our work, a concept borrowed from Berling and Bueger (2015), as problematic or disqualifying as such. Rather, it reflects our personal progress and span as researchers. Constantly progressing, questioning and putting things in new perspectives is what science (and expertise) is about - or at least should be about in our minds. On a less romantic note, this "eclecticism" on our side also reflects how we strategically adapt to the current trends and flows in academia in order to keep up our publication output, since we also need to tap into the changing streams of funding to maintain our professions and paychecks (see de Sardan, 2005; Goldman, 2005; Hoppe, 2005).

Besides exposing these personal positions and motives, our novel methodological approach to studying expertise gives rise to other practical reflections. With the bibliometric analysis, we use a *quantitative* method of a natural science character to examine a social concept like (scientific) expertise. A brief excursion into the micro-cosmos of our own expert-making and knowledge-production processes reveals, to no surprise, that the internal allocation of tasks among us mirrored our individual skills and interests: The 'political ecologist(s)' conceptualized the study and wrote the main text, while the 'technical geographer' and the 'ecological economist' were mainly responsible for the quantitative data collection and analyses. During our process, we tried to pull the paper in our own favored directions. In the end though, and with our combined efforts, our study does use a technical scientific approach with quantitative indicators to expose and question scientific expertise. On top of that, the majority of us are natural scientists by training as we confess above. It all sounds contradictory, and this particular setup also gave rise to critical reflexive questions in the early phase of this project by one of the guest editors of the special issue: (How) could we use such methods for that purpose? We answer with a slightly provocative related question: Are some methods more legitimate to examine the boundaries of science and security? Is it only social or political scientists who are allowed to study and criticize the practices of the "hard" sciences with their ethnographic or other "soft" methods (as done in Science and Technology Studies and which we also apply by analyzing how experts frame ES and by our participatory observations)? Mirroring the comment by the guest editor, many natural scientists consider qualitative indicators and retrospective methods 'weak' compared to measurable quantifiable indicators and counterfactual methodologies, for instance in assessing the social impacts of environmental protection projects (Pasgaard, 2013). This attitude or even arrogance became very clear in our opinion-based survey to identify key experts. Several invited survey respondents replied back in person with concerns about the "subjectivity" and "bias" of the survey; many feeling uneasy pointing out experts, and suggesting that we examined publications instead (as we actually do). One of the top experts identified in our survey was early to reply with a personal email outlining these brief directions in order for us to properly identify the key experts in ES scholarship: "Go on Web of Science or Scopus, type in "ecosystem services" in the topic search, then sort results by author" (personal communication, November 11, 2015). Attached was a paper authored by the expert about the authorship structure of ES literature, clearly indicating *how* we should identify experts and that this was already *done* (by the expert). Moreover, several respondents issued concerns about the purpose and confidentiality of the survey being unsure if they could trust this sharing of "such kind of information" (about who they consider ES experts).

As our last reflection, we discuss authority of knowledge. The PES and IPBES cases show a favouring of certain kinds of knowledge over others, in turn arranging the object to be governed and reproducing specific modes of regulation (see Vadrot, 2014). According to Milkoreit et al. (2015) it is a problematic assumption that scientists who acknowledge subjectivity automatically practice "advocacy" if they engage in a policy process. For these authors, this boundary-blurring tendency to conflate *scientific* knowledge and facts with value or interest-laden *opinions* poses a *serious threat* to the *authority of science* as a foundation for policy-making and to the social contract between science, society and politics. While these concerns are very real and experienced by many scholars, we argue that this "blurring" cannot be undone, if it was ever "un-blurred" (see Hoppe, 2005; Jasanoff, 2010). It is important to recognize differences, and these differences should indeed be respected, but not to the extent that blurred boundaries are a threat "to the authority of science [...] as a truth-seeking enterprise" (Milkoreit et al., 2015, p. 93). Rather, we should acknowledge and expose differences through self-reflections and diminish divides through collaboration. As Milkoreit et al. (2015) themselves rightly state, we should "consider more explicitly the normative implications of [our] scientific approach (p. 89)", and specifically, each of us has to become aware of different cultures of science, paradigms and competing claims, instrumentations, research protocols and designs (Latour, 2011; see also Greene, 2007).

5.3. Concluding remarks

With this study we contribute to the emerging self-reflective discourse in security studies (Berling and Bueger, 2015; Kurowska and Tallis, 2013), in human geography broadly speaking (Castree, 2015; Hulme, 2015; Pasgaard et al., 2017; Saito-Jensen and Jensen, 2010), and across academic practices (Berling and Bueger, 2017). By exposing the securitization processes which can harm the functioning of deliberative and reasoned democracy (Ish-Shalom, 2015), and by examining key scientific experts as securitizing actors, we contribute to a wider understanding of the discourses that legitimize and bring authority to new (neoliberal) forms of environmental governance and practice. The examples of the PES and the IPBES indicate that there is a need and an opportunity to reflect on the very purpose and underlying rationale of global expert-driven policy schemes and organizations (see also Beck et al., 2014). Echoing Hoppe (2005) we find a need to rethink the role of scientific expertise in policymaking, and a need to better guide experts and policymakers in their day-to-day boundary work (Berling and Bueger, 2017). Specifically, since the appropriation of nature for green ends often operates through novel legal and market mechanisms, we face new methodological and analytical challenges, as well as new dilemmas for action (Fairhead et al., 2012). As our concluding remark, and in line with Ish-Shalom (2015), we stress the need to transparently reflect on our own sensitivities, experiences and biases, as we attempt to do in this study. Along with individual responsibility and judgement, self-reflexivity and transparency should be a constitutive and definitional feature of academic expertise and practice, allowing us to understand the biases and social settings that form our standpoints as we expose and disclose ourselves (ibid). However, as made clear in this study, demand for public visibility, openness and efforts to embrace transparency bring their own dilemmas, even eroding professional trust (Mosse, 2011).

Acknowledgements

We are very grateful for the detailed and encouraging comments from the four anonymous reviewers, from editor-in-chief Padraig Camody, and from the guest-editors of this special issue, Trine Villumsen Berling and Dagmar Rychnovská, whose support and enthusiasm have been outstanding. We also thank the many respondents for completing the online survey. Gert Van Hecken was funded by a postdoctoral research grant of the Flemish Fund for Scientific Research (FWO) and Niels Strange acknowledges the Danish National Research Foundation for funding for the Center for Macroecology, Evolution and Climate (grant-number DNRF96).

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.geoforum.2017.02.001.

References

Adey, P., Anderson, B., Graham, S., 2015. Introduction: governing emergencies: beyond exceptionality. Theory, Cult. Soc. 32, 3–17.
Adger, W.N., Benjaminsen, T.A., Brown, K., Svarstad, H., 2001. Advancing a political ecology of global environmental discourses. Dev. Chang. 32, 681–715.
Aguilar-Stoen, M., 2015. Global forest conservation initiatives as spaces for participation in Colombia and Costa Rica. Geoforum 61, 36–44.
Anderson, B., 2015. Boredom, excitement and other security affects. Dialogues Human Geogr. 5, 271–274.
Balzacq, T., 2011. Securitization Theory: How Security Problems Emerge and Dissolve. Routledge, London and New York.
Barnaud, C., Antona, M., 2014. Deconstructing ecosystem services: uncertainties and controversies around a socially constructed concept. Geoforum 56, 113–123.
Beck, S., Borie, M., Chilvers, J., Esguerra, A., Heubach, K., Hulme, M., Lidskog, R., Lovbrand, E., Marquard, E., Miller, C., Nadim, T., Nesshover, C., Settele, J., Turnhout, E., Vasileiadou, E., Gorg, C., 2014. Towards a reflexive turn in the governance of global environmental expertise the cases of the IPCC and the IPBES. Gaia-Ecol. Perspect. Sci. Soc. 23 (2), 80–87.
Berling, T.V., 2011. Science and securitization: objectivation, the authority of the speaker and mobilization of scientific facts. Security Dialogue 42 (4–5), 385–397.
Berling, T.V., Bueger, C., 2015. Security Expertise: Practice, Power, Responsibility. Routledge.
Berling, T.V., Bueger, C., 2017. Expertise in the age of post-factual politics: an outline of reflexive strategies. Geoforum. 84, 332–341.
Blaikie, P., 1999. A review of political ecology. Issues, epistemology and analytical narratives. Z. Wirtsch. 43 (3–4), 131–147.
Bonie, M., Hulme, M., 2015. Framing global biodiversity: IPBES between mother earth and ecosystem services. Environ. Sci. Policy 54, 487–496.
Bryant, R.L., 1998. Power, knowledge and political ecology in the third world: a review. Prog. Phys. Geogr. 22 (1), 79–94.
Buger, C., Villumsen, T., 2007. Beyond the gap: relevance, fields of practice and the securitizing consequences of (democratic peace) research. J. Int. Relat. Develop. 10 (4), 417–448.
Büscher, B., 2012. Payments for ecosystem services as neoliberal conservation: (reinterpreting) evidence from the Maloti-Drakensberg, South Africa. Conserv. Soc. 10, 29–41.
Büscher, B., 2014. Selling success: constructing value in conservation and development. World Develop. 57, 79–90.
Buzan, B., Wæver, O., de Wilde, J., 1998. Security: A New Framework for Analysis. Lynne Rienne.
Castree, N., 2015. Changing the anthropo(s)cene: geographers, global environmental change and the politics of knowledge. Dialogues Human Geogr. 5 (3), 301–316.
Coralie, C., Guillaume, O., Claude, N., 2015. Tracking the origins and development of biodiversity offsetting in academic research and its implications for conservation: a review. Biol. Conserv. 192, 492–503.
Cornell, S., Berkhout, F., Tuinstra, W., Tàbara, J.D., Jäger, J., Chabay, I., de Wit, B., Langlais, R., Mills, D., Moll, P., Otto, I.M., Petersen, A., Pohl, C., van Kerkhoff, L., 2013. Opening up knowledge systems for better responses to global environmental change. Environ. Sci. Policy 28, 60–70.
Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M., 1997. The value of the world's ecosystem services and natural capital. Nature 387 (6630), 253–260.
Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S.J., Kubiszewski, I., Farber, S., Turner, R.K., 2014. Changes in the global value of ecosystem services. Global Environ. Change 26, 152–158.
Dalby, S., 2002. Environmental Security. University of Minnesota Press.
Dallimer, M., Strange, N., 2015. Why socio-political borders and boundaries matter in conservation. Trends Ecol. Evol. 30 (3), 132–139.
Danley, B., Widmark, C., 2016. Evaluating conceptual definitions of ecosystem services and their implications. Ecol. Econ. 126, 132–138.
de Freitas, C., Marston, A.J., Bakker, K., 2015. Not-quite-neoliberal natures in Latin America: an introduction. Geoforum 64, 239–245.
de Sardan, J.-P.O., 2005. Anthropology and Development: Understanding Comtemporary Social Change. Zed Books.
Dempsey, J., Robertson, M.M., 2012. Ecosystem services: tensions, impurities, and points of engagement within neoliberalism. Progr. Human Geogr. 36, 758–779.
Duffy, R., 2016. War, by conservation. Geoforum 69, 238–248.
Dunlop, C.A., 2014. The possible experts: how epistemic communities negotiate barriers to knowledge use in ecosystems services policy. Environ. Plan. C: Govern. Policy 32, 208–228.
Elbe, S., 2006. Should HIV/AIDS be securitized? The ethical dilemmas of linking HIV/AIDS and security. Int. Stud. Quart. 50 (1), 119–144.
Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: an overview of the issues. Ecol. Econ. 65, 663–674.
Escobar, A., 1996. Constructing nature: elements for a poststructural political ecology. In: Peet, R., Watts, M. (Eds.), Liberation Ecologies: Environment, Development, Social Movements. Routledge, London, pp. 46–68.
Fairhead, J., Leach, M., Scoones, I., 2012. Green Grabbing: a new appropriation of nature? J. Peasant Stud. 39 (2), 237–261.
Folke, C., Holling, C.S., Perrings, C., 1996. Biological diversity, ecosystems, and the human scale. Ecol. Appl. 6, 1018–1024.
Gieryn, T.F., 1983. Boundary-work and the demarcation of science from non-science: strains and interests in professional ideologies of scientists. Am. Sociol. Rev. 48 (6), 781–795.
Goldman, M., 2005. Imperial Nature. The World Bank and Struggles for Social Justice in the Age of Globalization. Yale University Press.
Gomez-Baggethun, E., de Groot, R., Lomas, P.L., Montes, C., 2010. The history of ecosystem services in economic theory and practice: from early notions to markets and payment schemes. Ecol. Econ. 69 (6), 1209–1218.
Greene, J.C., 2007. Chapter 1. Mental Models and Mixed Methods Inquiry, Mixed Methods in Social Inquiry. Jossey-Bass.
Haas, P.M., 1992. Introduction: epistemic communities and international policy coordination. Int. Org. 46, 1–36.
Hajer, M.A., 1995. The Politics of Environmental Discourse. Ecological modernization and the policy process. Clarendon Press, Oxford.
Halfon, S., 2015. Contesting human security expertise: technical practices in reconfiguring international security. In: Berling, T.V., Bueger, C. (Eds.), Security Expertise: Practice, Power, Responsibility. Routledge.
Haugaard, M., 2003. Reflections on seven ways of creating power. Eur. J. Social Theory 6 (1), 87–113.
Hooper, D.U., Chapin III, F.S., Ewel, J.J., Hector, A., Inchausti, P., Lavorel, S., Lawton, J. H., Lodge, D.M., Loreau, M., Naeem, S., Schmid, B., Setälä, H., Symstad, A.J., Vandermeer, J., Wardle, D.A., 2005. Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. Ecol. Monogr. 75, 3–35.
Hoppe, R., 2005. Rethinking the science-policy nexus: from knowledge utilization and science technology studies to types of boundary arrangements. Poiesis & Praxis 3 (3), 199–215.
Hulme, M., 2015. Changing what exactly, and from where? A response to Castree. Dialogues Human Geogr. 5 (3), 322–326.
IPCC, 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (Eds.)]. IPCC, Geneva, Switzerland, 151 pp.
Ish-Shalom, P., 2015. Away from the heart of darkness: transparency and regulating the relationship between security experts and security sectors. In: Berling, T.V., Bueger, C. (Eds.), Security Expertise: Practice, Power, Responsibility. Routledge.
Jasanoff, S., 2005. Judgment under siege: the three-body problem of expert legitimacy. In: Maasen, S., Weingart, P. (Eds.), Democratization of Expertise? Exploring Novel Forms of Scientific Advice in Political Decision-Making. Springer, Dortrecht, pp. 209–224.
Jasanoff, S., 2010. A new climate for society. Theory Cult. Soc. 27 (2–3), 233–253.
Juniper, T., 2014. Framing natural capital: economy and ecology are not in competition. The Guardian Sustainability Blog, <http://www.theguardian.com/sustainable-business/blog/framing-natural-capital-economy-ecology-not-competition>.
Kauppi, N., 2014. Knowledge warfare: social scientists as operators of global governance. Int. Political Sociol. 8 (3), 330–332.
Kauppi, N., Madsen, M.R., 2014. Fields of global governance: how transnational power elites can make global governance intelligible. Int. Political Sociol. 8 (3), 324–330.
Kolinjivadi, V., Van Hecken, G., Rodríguez de Francisco, J.C., Pelenc, J., Kosoy, N., in press. As a lock to a key? Why science is more than just an instrument to pay for nature's services. Curr. Opin. Environ. Sustain. http://dx.doi.org/10.1016/j.cosust.2016.12.004.
Kremen, C., 2005. Managing ecosystem services: what do we need to know about their ecology? Ecol. Lett. 8, 468–479.

Kurowska, X., Tallis, B.C., 2013. Chiasmatic crossings: a reflexive revisit of a research encounter in European security. Security Dialogue 44 (1), 73–89.
Latour, B., 1987. Science in Action. Harvard University Press, Cambridge, MA.
Latour, B., 2011. Politics of nature: East and West perspectives. Ethics Global Politics 4 (1), 71–80.
Leach, M., Scoones, I., Stirling, A., 2010. Dynamic Sustainabilities. Technology, Environment, Social Justice. Earthscan, London and Washington D.C..
Lele, S., Springate-Baginski, O., Lakerveld, R., Deb, D., Dash, P., 2013. Ecosystem services: origins, contributions, pitfalls, and alternatives. Conserv. Soc. 11, 343–358.
Lewis, D., 2011. Tidy Concepts, Messy Lives: Defining Tensions in the Domestic and Overseas Careers of UK Non-governmental Professionals. In: Mosse, D. (Ed.), Adventures in Aidland: The Anthropology of Professionals in International Development Berghahn Books.
Li, T.M., 2007a. Practices of assemblage and community forest management. Econ. Soc. 36 (2), 263–293.
Li, T.M., 2007b. The Will to Improve. Governmentality, Development, and the Practice of Politics. Duke University Press, Durham & London.
Lund, J.F., 2015. Paradoxes of participation: the logic of professionalization in participatory forestry. For. Policy Econ. 60, 1–6.
Lunstrum, E., 2014. Green militarization: anti-poaching efforts and the spatial contours of Kruger National Park. Ann. Assoc. Am. Geogr. 104 (4), 816–832.
Massé, F., Lunstrum, E., 2016. Accumulation by securitization: commercial poaching, neoliberal conservation, and the creation of new wildlife frontiers. Geoforum 69, 227–237.
McAfee, K., 1999. Selling nature to save it? Biodiversity and green developmentalism. Environ. Plan. D: Soc. Space 17, 133–154.
McElwee, P.D., 2012. Payments for environmental services as neoliberal market-based forest conservation in Vietnam: panacea or problem? Geoforum 43, 412–426.
MEA, 2005. Ecosystems and Human Well-being: Biodiversity Synthesis. MilleniumEcosystemAssessment (MEA). World Resources Institute, Washington, DC.
Méral, P., 2012. Le concept de service écosystémique en économie: origine et tendances récentes. Natures Sciences Sociétés 20, 3–15.
Milkoreit, M., Moore, M.-L., Schoon, M., Meek, C.L., 2015. Resilience scientists as change-makers—growing the middle ground between science and advocacy? Environ. Sci. Policy 53 (Part B), 87–95.
Milne, S., Adams, W.M., 2012. Market masquerades: uncovering the politics of community-level payments for environmental services in Cambodia (vol 43, pg 133, 2012). Develop. Change 43 (2), 133–158.
Mitchell, T., 2002. Rule of Experts: Egypt, Techno-Politics. University of California Press, Modernity.
Montana, J., Borie, M., 2015. IPBES and biodiversity expertise: regional, gender, and disciplinary balance in the composition of the interim and 2015 multidisciplinary expert panel. Conserv. Lett. 9, 138–142.
Mosse, D., 2011. Adventures in Aidland: The Anthropology of Professionals in International Development. Berghahn Books.
Muradian, R., Corbera, E., Pascual, U., Kosoy, N., May, P., 2010. Reconciling theory and practice: an alternative conceptual framework for understanding payments for environmental services. Ecol. Econ. 69, 1202–1208.
Muradian, R., Arsel, M., Pellegrini, L., Adaman, F., Aguilar, B., Agarwal, B., Corbera, E., Ezzine de Blas, D., Farley, J., Froger, G., Garcia-Frapolli, E., Gómez-Baggethun, E., Gowdy, J., Kosoy, N., Le Coq, J.F., Leroy, P., May, P., Méral, P., Mibielli, P., Norgaard, R., Ozkaynak, B., Pascual, U., Pengue, W., Perez, M., Pesche, D., Pirard, R., Ramos-Martin, J., Rival, L., Saenz, F., Van Hecken, G., Vatn, A., Vira, B., Urama, K., 2013. Payments for ecosystem services and the fatal attraction of win-win solutions. Conserv. Lett. 6, 274–279.
Naeem, S., Ingram, J.C., Varga, A., Agardy, T., Barten, P., Bennett, G., Bloomgarden, E., Bremer, L.L., Burkill, P., Cattau, M., Ching, C., Colby, M., Cook, D.C., Costanza, R., DeClerck, F., Freund, C., Gartner, T., Goldman-Benner, R., Gunderson, J., Jarrett, D., Kinzig, A.P., Kiss, A., Koontz, A., Kumar, P., Lasky, J.R., Masozera, M., Meyers, D., Milano, F., Naughton-Treves, L., Nichols, E., Olander, L., Olmsted, P., Perge, E., Perrings, C., Polasky, S., Potent, J., Prager, C., Quétier, F., Redford, K., Saterson, K., Thoumi, G., Vargas, M.T., Vickerman, S., Weisser, W., Wilkie, D., Wunder, S., 2015. Get the science right when paying for nature's services. Science 347 (6227), 1206–1207.
Nel, A., 2015. The choreography of sacrifice: market environmentalism, biopolitics and environmental damage. Geoforum 65, 246–254.
Neumann, R.P., 2004. Moral and discursive geographies in the war for biodiversity in Africa. Political Geogr. 23 (7), 813–837.
Norgaard, R.B., 2010. Ecosystem services: from eye-opening metaphor to complexity blinder. Ecol. Econ. 69 (6), 1219–1227.
Owen, T., 2010. Human Security. A Contested Contempt. Chapter 5 in The Routledge Handbook of New Security Studies.
Pagiola, S., Platais, G., 2002. Payments for Environmental Services. Environment Strategy No. 3, May 2002.
Pagiola, S., Ramirez, E., Gobbi, J., De Haan, C., Ibrahim, M., Murgueitio, E., Ruiz, J.P., 2007. Paying for the environmental services of silvopastoral practices in Nicaragua. Ecol. Econ. 64, 374–385.
Pasgaard, M., 2013. The challenge of assessing social dimensions of avoided deforestation: examples from Cambodia. Environ. Impact Assess. Rev. 38, 64–72.
Pasgaard, M., 2015. Lost in translation? How project actors shape REDD plus policy and outcomes in Cambodia. Asia Pacific Viewpoint 56 (1), 111–127.
Pasgaard, M., Dawson, N., Rasmussen, L.V., Enghoff, M., Jensen, A., 2017. The research and practice of integrating conservation and development: self-reflections by researchers on methodologies, objectives and influence. Global Ecol. Conserv. 9, 50–60.
Peet, R., Watts, M., 1996. Liberation Ecologies: Environment, Development, Social Movements. Routledge, London.
Peluso, N.L., Vandergeest, P., 2011. Political ecologies of war and forests: counterinsurgencies and the making of national natures. Ann. Assoc. Am. Geogr. 101 (3), 587–608.
Prowse, M., 2010. Integrating reflexivity into livelihoods research. Progr. Develop. Stud. 10 (3), 211–231.
Raymond, C.M., Singh, G.G., Benessaiah, K., Bernhardt, J.R., Levine, J., Nelson, H., Turner, N.J., Norton, B., Tam, J., Chan, K.M.A., 2013. Ecosystem services and beyond: using multiple metaphors to understand human-environment relationships. BioScience 63 (7), 536–546.
Robertson, M., 2012. Measurement and alienation: making a world of ecosystem services. Trans. Inst. British Geogr. 37 (3), 386–401. http://dx.doi.org/10.1111/j.1475-5661.2011.00476.x.
Rockstrom, J., Steffen, W., Noone, K., Persson, A., Chapin, F.S., Lambin, E., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sorlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., Foley, J., 2009. Planetary boundaries: exploring the safe operating space for humanity. Ecol. Soc. 14 (2).
Roth, R.J., Dressler, W., 2012. Market-oriented conservation governance: the particularities of place. Geoforum 43 (3), 363–366.
Saito-Jensen, M., Jensen, C., 2010. Rearranging Social Space: Boundary-Making and Boundary-Work in a Joint Forest Management Project. Andhra Pradesh, India.
Sandbrook, C.G., Fisher, J.A., Vira, B., 2013. What do conservationists think about markets? Geoforum 50, 232–240.
Scott, J.C., 1998. Seeing like a State. How Certain Schemes to Improve the Human Condition have Failed. Yale University Press, New Haven, CT.
Sikor, T., Lund, C., 2009. Access and property: a question of power and authority. Develop. Change 40 (1), 1–22.
Spash, C.L., 2015. Bulldozing biodiversity: the economics of offsets and trading-in nature. Biol. Conserv.
Steffen, W., Richardson, K., Rockstrom, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B., Sorlin, S., 2015. Planetary boundaries: guiding human development on a changing planet. Science 347 (6223).
Strange, N., Thorsen, B.J., Bladt, J., Wilson, K.A., Rahbek, C., 2011. Conservation policies and planning under climate change. Biol. Conserv. 144 (12), 2968–2977.
Sullivan, S., 2013. Banking nature? The spectacular financialisation of environmental conservation. Antipode 45 (1), 198–217.
Thiel, A., Mukhtarov, F., Zikos, D., 2015. Crafting or designing? Science and politics for purposeful institutional change in social-ecological systems. Environ. Sci. Policy 53 (Part B), 81–86.
Trombetta, M.J., 2008. Environmental security and climate change: analysing the discourse. Cambridge Rev. Int. Affairs 21 (4), 585–602.
Vadrot, A.B.M., 2014. The epistemic and strategic dimension of the establishment of the IPBES: "epistemic selectivities" at work. Innov.-Eur. J. Social Sci. Res. 27 (4), 361–378.
Van Hecken, G., Bastiaensen, J., 2010a. Payments for Ecosystem Services in Nicaragua: do market-based approaches work? Develop. Change 41 (3), 421–444.
Van Hecken, G., Bastiaensen, J., 2010b. Payments for ecosystem services: justified or not? A political view. Environ. Sci. Policy 13 (8), 785–792.
Van Hecken, G., Bastiaensen, J., Windey, C., 2015a. Towards a power-sensitive and socially-informed analysis of payments for ecosystem services (PES): addressing the gaps in the current debate. Ecol. Econ. 120, 117–125.
Van Hecken, G., Bastiaensen, J., Huybrechs, F., 2015b. What's in a name? Epistemic perspectives and payments for ecosystem services policies in Nicaragua. Geoforum 63, 55–66.
Verweijen, J., Marijnen, E., 2016. The counterinsurgency/conservation nexus: guerrilla livelihoods and the dynamics of conflict and violence in the Virunga National Park, Democratic Republic of the Congo. J. Peasant Stud. 1–21. http://dx.doi.org/10.1080/03066150.2016.1203307.
Vohland, K., Nadim, T., 2015. Ensuring the success of IPBES: between interface, market place and parliament. Philos. Trans. R. Soc. B-Biol. Sci. 370.
Waever, O., 2011. Politics, security, theory. Security Dialogue 42 (4–5), 465–480.
Wunder, S., 2005. Payments for Environmental Services: Some Nuts and Bolts. CIFOR Occasional Paper 42. Center for International Forest Research (CIFOR), Jakarta.
Wunder, S., 2015. Revisiting the concept of payments for environmental services. Ecol. Econ. 117, 234–243.
Wunder, S., Engel, S., Pagiola, S., 2008. Taking stock: a comparative analysis of payments for environmental services programs in developed and developing countries. Ecol. Econ. 65, 834–852.
Ybarra, M., 2012. Taming the jungle, saving the maya forest: sedimented counterinsurgency practices in contemporary guatemalan conservation. J. Peasant Stud. 39 (2), 479–502.