As a lock to a key? Why science is more than just an instrument to pay for nature's services

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Abstract: Scholars have argued that the success of conservation instruments such as Payments for Ecosystem Services (PES) depends on improved scientific knowledge in linking ecosystem functioning with value-reflecting prices to optimize the production and delivery of ecosystem services (ES). While enhanced knowledge on the functioning of ecosystems is welcome, these scholars assume that greater sophistication of scientific inquiry rests on uncontroversial ES thinking, without critical recognition that the ES framework represents (and imposes) only one particular social rationality in articulating human-nature relationships. In this paper, we discuss why a singular focus on 'getting the science right' for environmental policy makes a naive abstraction of the many socio-political consequences underlying the use of ES as an 'objective' science. We argue that the *process* of doing science through reflection on social diversity and power dimensions can better reveal the extent to which PES interventions are perceived, debated, negotiated and strategically adapted on the ground.

Introduction:

Environmental policies have become increasingly inspired by market-based instruments, especially Payments for Ecosystem Services (PES) which are often claimed to be more efficient and effective in achieving nature conservation objectives than alternative approaches [*1,2*]. The ecosystem service (ES) narrative is based upon a specific way of conceptualizing the relationship between society and nature in which ES are produced by nature for people, reproducing the logic that ecosystems are external to human beings [*3*]. PES, underpinned by the ES narrative, involves the negotiation of ES providers and beneficiaries through incentive-based arrangements aligning ecological processes with a single subset of human values according to a calculus of opportunity costs [*2*]. From this lens, nature and society are portrayed as separate entities much like a lock and a key, under the premise that the door of sustainability only opens with the right combination. The logic of human-nature relationships framed in terms of ES is increasingly adopted as stabilized knowledge, void of ongoing controversy, to produce numbers for policy

while underlying assumptions and the context of knowledge production surrounding the ES narrative are often undisclosed [*3-6*].

In this article, we critically discuss the trend of 'getting the science right to pay for nature's services' [e.g. *7*] as a naive abstraction of the many social and political underpinnings and consequences associated with treating human-nature relationships under the guise of 'neutral' and 'objective' scientific inquiry. Despite over a decade of empirically-informed contributions from scholars on the socio-political challenges of paying for ES [*8-17*], renewed calls for tightening the science to deliver more efficient PES initiatives [*7*] suggest that critical misunderstandings on the socio-political foundations of scientific knowledge and how it is produced continue to influence ES scholarship. Ecological functions depend on diverse and continuously evolving interactions with embedded socio-cultural factors across spatial and temporal scales, making it highly problematic to fully predict the evolution of complex socio-ecological systems [*18,19*]. Dismissing the complex, non-linear and intertwining reality of both human society and biophysical nature by advancing convenient "lock and key" formulas for sustainability effectively privileges one epistemic version of sustainability over others through the legitimizing effect of an objective 'science' [*20,21*]. We argue that sustainability science is a simultaneous process of transdisciplinary perspectives revealing a complex reality constantly in the process of 'becoming', rather than a pre-given piecemeal and technical aggregation of the natural and social sciences [*22-25*]. Furthermore, different ontological approaches to ES ask different research questions and their answers describe different/partial realities [*26*]. We argue for an approach in which natural science questions are a priori put in perspective with respect to diversity of social positions and power relations among them. The insights of such scientific query can provide more complete understandings of intertwined social and ecological systems.

An ES Science divorced from context

Naeem et al. [*7*] develop a set of natural science principles and guidelines for strengthening the contribution of PES policies, while assuming the underlying epistemic rationality of ES is valid by default since they claim that more sophisticated scientific knowledge will permit paying for ES (p. 1207). While we see value in proposing a stronger scientific basis for environmental policy interventions, we believe that future research in understanding sustainability should more explicitly acknowledge that scientific 'knowledge' cannot be separated from the context in which it was produced [*23,27*]. For example, the development of theoretically-defined PES projects usually rests on three sets of assumptions. The first draws from a narrow definition of human rationality and insists that human beings, if provided with complete information, will choose the most economically efficient solution in maximizing individual well-being [*1,2, 28-29*]. While PES is often viewed as more efficient than other alternatives due to the provisioning of economic incentives to influence behavior [*6,10*], far from being value-neutral, the concept of economic efficiency refers to the maximization of value in monetary terms according to existing purchasing power, and hence privileges certain conceptions of value and pre-existing patterns of wealth distribution in society [*30*].

The second is the resource economics assumption of equivalence whereby safeguarding clean air, water, nutrient cycling and other biophysical processes (i.e. life-supporting systems) *must* produce economic value in order to ensure that its protection is as competitive as say, palm oil plantations used for the manufacture of hydrogenated biscuits [*31-33*]. Thus, the notion that

economic incentive-based policies are more efficient than other environmental policies carries the assumption that economic values for ES would instantly shift as rapidly as other economic pressures in order to remain efficient. Such a perspective ignores the relative sensitivity of multi-dimensional human well-being from changes in ecosystems [*34*], which is likely to be context-dependent, individually variable over space and time, and characterized by non-linear dynamics [*35*]. Indeed, this in part explains why the majority of PES initiatives do not result in functioning markets [*14, 36-38*]. Thirdly, in parallel to establishing 'correct' prices, it is assumed that the scientific method is superior in: a) obtaining complete information of interacting social and natural systems and b) identifying all potential trade-offs in aligning utility maximization of the individual with predicted changes in ecological conditions [*39,40*]. Such a position presumes that the immense diversity of ontological and epistemological frames through which human-nature relations can be imagined is somehow knowable or predictable enough to align with a standardized ES framing [*41,42*].

Since these assumptions hardly hold true, it is clear that PES (and the underlying ES framework), rests on precarious epistemological foundations. Instead, a closer examination of the politics of narrative development, reveals powerful social processes, which often harness the production of knowledge through oversimplified and 'easy to swallow' framings aligned to prevailing cultural worldviews in order to make complexity legible to policy makers [*3,5,14,20, 43-46*]. A body of research known as 'boundary work' has attempted to retain the "value neutral" aspects of action and research-based knowledge from either over-politicizing presumably validated facts or masking political strategies as "technical" concerns to be resolved by experts [*47-49*]. Ultimately however, 'boundary work' reflects less upon the political interests and worldviews of the epistemic communities doing the science (i.e. NGOs, academic research institutions, and their donors), and more upon seeking consensus across diverse forms of knowledge to better justify the adoption of a particular kind of science for decision-making [*50*].

A 'right' kind of science for nature's services?

Naeem et al. [*7*] claim that PES policy requires a process that is simple, rigorous, and abides by *scientific principles* in order to foster evaluations of effectiveness. But what are scientific principles? A common understanding of the production of scientific knowledge rests upon a neutral analyst observing and attempting to understand complex reality, including historical and political processes which manifest in particular social and ecological phenomena [*27*]. The foundations of scientific inquiry are then not limited to generating evidence to validate a particular ordering of nature and human relations. In other words, scientific practice is *not* an analyst telling a story of a particular ordering of the world and developing indicators and measurements to fit the explanation of phenomena into the narrative told by the 'storyteller' [*21*]. Instead, scientific inquiry aims to understand the complexity of observed phenomena as they interrelate to both social and biophysical dimensions [*51*]. Bromley [*39*, p. 18] contends that an honest description of the scientific endeavor is "a structured process that gives voice to reasons for holding particular beliefs about complex events and observations". Since humans inevitably hold different and often conflicting ideas about what nature is and what it is for [*52*], the contributions that scientific knowledge can bring for policy are only relevant to the extent that they reflect and are embedded in socio-political deliberation, implying that politics and science are intrinsically interwoven [*11,34*].

Perhaps most importantly, given that millions of dollars are being invested in PES approaches [*53-57*], there is a highly vested interest in ensuring that projects are seen to be scientifically 'credible', even if they are based on arbitrary theoretical foundations and tenuous empirical evidence. In the presence of a particular epistemic selectivity characterized as a "financial-scientific-policy nexus" [*58*, p. 246], in which funding for scientific research is imprinted within culturally-engrained economic logics of 'value for money', it is hardly any surprise that we have come to a point where scientific evidence is only seen as "right" if it constructs economic value for nature [*50,58-59*]. The imperative of harnessing science to 'prove' a particular narrative then becomes key to attracting greater financial resources, generating more followers and maintaining employment for an epistemic community rallying behind a self-reinforcing conservation buzzword [*11,50,59-64*]. Consequently, the socio-political roots of many environmental conflicts, often steeped in racialized and/or colonialized histories, becomes sidelined or even reproduced in order to avoid deviating from the simplicity of ES 'science', seen as completely divorced from contextual social dynamics [*65*].

As an example, Tadaki et al. [*20*] identified how the *bounding* of ES elevates certain categories of value for which nature matters to humans, while unconsciously marginalizing other rationalities that do not fit within the ES framing or whose voices were missing from the assessment. The authors go on to argue that the process of *measuring* ecological functions and representing them in salient ways for policy-making is equally value-laden when the ES narrative is employed. This is because ES assessments contain value judgments as to how complex ecological processes contribute or translate to a service or a disservice and by doing so institutionalize the analytical power and credibility of measurement of certain perspectives over others [*6,20*]. Together the concepts of bounding and measuring of ES highlight that 'getting the science right' for ES identification and delivery is essentially the consolidation of a single cultural worldview emerging victorious in a political struggle of plural understandings of human-nature meanings.

Reinserting social diversity and power relations for improving science for PES

The epistemic promotion of optimizing ES delivery through science remains fixated on a deductive approach of confirming the theoretical model and conforming local conditions to the parameters of the theory. In contrast, we recognize that the complex and multifaceted realities we experience are in disequilibrium, where power asymmetries, non-linear ecological dynamics, and substantial uncertainty will forever characterize the quest for stable institutional arrangements, watertight policy narratives or privileged methods of bounding and measuring cultural constructs such as ecosystem services. Political ecologists have identified how "bundles of powers" which marginalize, privilege, and are both visible and unconscious play out between and among actors in shaping human-nature relations [*41,58, 66-70*]. Nevertheless, the deconstruction of whose voices are privileged or silenced (and why) need not descend into post-structural relativism in order to be a salient corrective force to technocratic approaches to conducting science [*26,71-74*]. For instance, rather than privileging "the special value of research-based knowledge" [*49*, p. 4615] as exemplified in the earlier example on 'boundary work', we might envision a wider, more transdisciplinary boundary in which knowledge generation (of any kind) is viewed as inherently political, thus requiring robust and systematic inquiry which informs and is itself informed by the *social* [*65,70*]. The rich scholarship on critical institutionalism can help us navigate these turbid waters by recognizing the messiness of the socio-political and cultural

processes which continuously animate how policy narratives and institutions are perceived, adapted, debated, negotiated, and re-crafted into locally contingent and workable solutions [*75-77*]. Instead of conceptualizing the extent or boundary by which science can or should engage with social diversity, a valiant research avenue lies in understanding how power dimensions shape PES interventions in practice, in which "emergent political processes reflect both the agency of current actors and the influence of historically embedded structures, practices and legacies." [*69*, p. 73].

Indeed PES interventions can result in very different outcomes in practice according to how actors deconstruct and strategically adapt ES narratives to fit contingent social realities, worldviews, aspirations, and diverse forms of knowledge [*25*]. For instance, Shapiro-Garza [*78*] demonstrates how efficiency-oriented "market-based" approaches to PES have been contested and reworked by a range of actors to more closely fit national and rural interests as well as values for nature. Kolinjivadi et al. [*79*] identifies how a PES intervention in the Kyrgyz Republic was locally adapted as collective action through the provision of in-kind labour rather than as "payment" in order to better fit with preexisting social institutions. McElwee [*80*] illustrate how PES policies in Vietnam have been reworked by local actors to better reflect notions of justice according to place-specific cultural norms. In an opposite case, Rodríguez-de-Francisco and Budds [*81*] have showed how existing social inequities associated with unequal distribution of land between farmers within communities were reinforced as a result of PES introduction. Finally, Leimona et al. [*82*] illustrates how 'boundary work' attempts to strategically renegotiate the scientific credibility of PES for watershed management in cases where PES donors strongly influence the selection of pilot projects based upon the likelihood of a business-model style transaction between ES buyers and sellers, rather than on scientific knowledge. In all of these cases, power relations are clearly imbricated in the mobilization of knowledge diversity for ES policies and projects. These cases also suggest considerable research potential for reinserting the *social* into the way science is done for PES, notably by linking the variegated ways PES projects are perceived, contested, designed and experienced in the field to the multitude of social and ecological outcomes that continuously derive from their implementation.

Conclusion

Divergent ontological and epistemological positions among scholars have resulted in fundamental misunderstandings on the relevance of scientific knowledge and how it is produced [*26,83*]. From the perspective of a positivist tradition, the goal of ES science is largely to generate objective ES knowledge in order to better insert cumulative and ideally consensus-based information into an overarching narrative or modeled system [*26*]. From this perspective, the environment or 'nature' exists *externally* from the diversity of ways people actually perceive or interact with it, to become an arena ripe for maximizing objective and quantifiable ES. As Veland and Lynch [*84*] have recently suggested, "…a single authoritative and linear scientific timeline that ignores the social construction of knowledge constitutes research within a 'hall of mirrors' which arguably underlies ongoing global environmental crises" (p.4). Conversely, an interpretive tradition of scientific inquiry would view ES narratives and models as messy and dynamic arenas of contesting values and differential relations of power between actors seeking to articulate and negotiate the ways in which environmental problems and solutions are perceived [*65*]. Rather than getting science "right" to align to an unquestioned ordering of the way the world ought to be, science can inform us on the social processes underlying how knowledge

about the environment is produced, for whom, and for what ends. In doing so, interdisciplinary science remains humanity's great hope, since it allows for a systematic, accountable and robust examination of the link between dynamic socio-cultural institutions and ecological processes which have come to shape how value for nature is socially and politically embedded.

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