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Short communication

How to be a more effective environmental scientist in management and policy contexts

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ABSTRACT

This paper is intended for young researchers with an environmental conscience, alerting them that a self-centred ecology can work against conservation and other desirable goals. I propose that there is confusion in the biophysical ecologists' community about the role of knowledge, stemming from several already surpassed beliefs that have been strongly criticized by scholars in the field of science and technology studies. In particular, environmental scientists still often seem trapped in the information deficit model, assuming a linear and unidirectional flow of knowledge from experts to users. This leads to an incomplete understanding and unrealistic expectations of ongoing processes of citizen participation (co-production of knowledge), impatience regarding the speed at which issues can be dealt with by politics, and a fuzzy notion of the role of our convictions regarding the value of nature conservation when we are consulted as experts. I analyse the consequences of disregarding tacit knowledge, i.e. the one knowledge beyond that codified in academic papers and books. I emphasize that preferences and values have a large influence on how we perceive, process, and act (or postpone to act) on information on our non-exclusive roles as scientists, decision makers or citizens. I argue that this is why political and ideological preferences have a large influence not only on which teams are appointed to solve problems, but also on which situations are perceived as problematic and given higher priorities. I include a cheat-sheet to enhance communication with decision-makers and other non-scientists that could prevent environmental zeal to be transformed into society's annoyance and our eventual irrelevance. I plea for a more realistic attitude towards ecological research, highlighting that in environmental debates we are also long-term stakeholders, and not only casual, external and aseptic observers.

1. Introduction

> *The notion that science . . . can and should settle disputes and guide political action remains a core operating principle [and a flawed one at that!] . . . on both sides of . . . environmental controversies*—Sarewitz (2004)

Despite a long tradition in the social sciences to the contrary, there is still confusion in the biophysical research community (to which I feel honoured to belong) about the role of ecological knowledge in decision making. I propose that this derives from four flawed and unstated assumptions, so widespread that they amount to generalized beliefs: (1) that better information is all it takes for individuals and societies to change behaviour in favour of the environment; (2) that such information mostly involves "hard data" (meaning peer-reviewed), properly communicated; (3) that scientific consensus – even certainty – is indispensable for managerial and political action; and (4) that as scientists we are in a privileged position to provide an unbiased view and to propose 'the best solutions' on issues close to our field of expertise.

I analyse these beliefs and their consequences, the most visible of which seems to be the tendency to accuse politicians and managers of being ignorant and insensitive, while the accuser remains ignorant of their knowledge and unaware of the functioning and constraints of the decision-making processes. We would not respect someone trying to manage ecosystems without a notion of how they operate—but it seems that we are acting in a similar way when we move into the world of environmental management and policy. Moreover, I argue that this attitude is not just wrong but also detrimental, because it makes many researchers with a biological, physical and chemical background (hereafter, "ecologists" for short) act in a provincial and sometimes defensive way, isolating the ecological community

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Table 1
Caricature version of twelve common complaints stemming from oversimplification of (and obstructing feasible solutions to) environmental and other complex context-dependent and value-laden problems. This list can be used as an *aide-mémoire* or as a questionnaire: e.g., Candidly answering 'yes' to most questions from the first column shows a lack of environmental literacy, and is a recipe for irrelevant and even counterproductive advocacy. The answers on the second column are meant for debate and study. Based on Fernández (2014, 2015).

#	Do you often . . . ?	. . . this could be a mistake—so common as to have its own name! *Italicised* terms are search suggestions.
1	. . . wonder why available scientific knowledge does not translate into sounder environmental policies?	You risk being accused of *scientism* and *technocratic* thinking. The environment encompasses complex human-nature systems. Context and values matter to define policies; moreover, they determine what constitutes a problem and (like it or not) it influences research. Look at *constructivist epistemology*.
2	. . . think that most politicians are either ignorant, or corrupt, or lack political will?	The focus should not be on specialized information (Greek *logos*) only. Besides "hard data", required knowledge includes its *co-production* by mutual learning and sharing of tacit assumptions, preferences and beliefs. *Ethos* and *pathos* also matter.
3	. . . demand or expect scientific consensus and certainty as a requirement for action? ...conclude after each project that more research is needed in order to provide more reliable advice?	Science is an endless search, and every answer yields a number of new questions. Thus, incomplete knowledge and uncertainty are inevitable. We have to learn how to live with them, and avoid and detect their *tactical*[a] use as an excuse for inaction.
4	. . . become impatient because even when there seem to be broad scientific and political consensus, action does not occur immediately?	All new knowledge takes a while to permeate through previous notions and competing values in all actors (researchers included). Mutual trust over time *(social capital)* is needed to cooperatively develop viable solutions (but see *rationalized trust* [Berardo, 2009]).
5	. . . accuse adversaries of selective and ideological use of information? ("Notice the speck in your brother's eye . . . ?")	You are acting as a *stealth advocate*[b] in the name of scientific objectivity. As for "ideology", check the dictionary: we all have one. Discuss issues and options, not big words.
6	. . . are tempted to overstate data for the sake of nature's future? (" . . . but do not see the log in your own eye?")	Environmental commitment should not compromise intellectual honesty; it is wrong, and sooner or later it backfires.
7	. . . dismiss information that contradicts your views as "bad science", and refuse to debate with their authors and even to read them?	These are the *ad consequentiam* and *ad hominem* time-tested fallacies routinely used from each side of every dispute. Isolation, in biology and politics, develops incompatibility and lack of dialogue.
8	. . . believe there are intrigues and conspiracies by powerful people?	You have a common case of the *devil shift*[c], i.e. view opponents as more corrupt and powerful than they probably are. Even if this turns out to be true (e.g. Jacques et al., 2008) we can denounce them, but should not use them as excuses (see next point).
9	. . . spread pessimistic and apocalyptic messages regarding the future?	People are sympathetic with short-term catastrophes, but tend to become bored and to screen out repetitive gloomy forecasts. Even if we are right, still need to work around several denial barriers (e.g. Stafford Smith et al., 2011).
10	. . . wonder why societies' behaviour does not conform to what would be expected from conscientious citizens?	Appeal to individual responsibility has been mostly ineffectual. Besides, it is unfair in a planet with huge imbalances in wealth. Shove (2010) argues that this is not an innocent claim, but one that takes responsibility away from governments.
11	. . . think that long-term cultural changes are needed before a more responsible behaviour can take place?	You may have fallen into the *progressist dilemma*[d]: rejecting shorter-term regulatory or technical fixes to tackle problems that have ethical roots.
12	. . . wish there were everlasting solutions to environmental problems?	New circumstances and context, including past solutions, require ongoing work because we are dealing with co-evolving systems.

Terms borrowed from: (a) Shafer (2008); (b) Pielke (2007); (c) Sabatier (2007); (d) Sarewitz (2010).

from many fora and sources of crucial information, and limiting our potential contributions.

This article analyses the four beliefs listed above, summarizing background information from relevant social science studies in the hope of making young ecologists sufficiently curious and motivated to grasp some useful language and explore the literature on their own. My goal is to stimulate a more realistic attitude towards ecological research, more modest regarding its role in decision making, but at the same time bolder in its overall ambitions. Table 1 is meant to serve as a practical synopsis, and to provide a heuristic basis for debate and further study. Since it may appear overly harsh, I point out that the left-hand side column contains mostly prejudices that I have heard myself voicing, and that the answers on the right-hand one have to be taken as tentative, as they are just some out of many possible ones and could be contentious. Thus, the table should not be taken as a do's and don'ts list. On the contrary, my overall point is that there is no recipe for an easy role of scientists in public contexts. In order to be heard, we need to listen and study more, working harder to develop technical options in the understanding that these will then need to be explored through social and political debate until the most appropriate pathway for a given context emerges.

2. The linear model and its progeny

Most of the misguided beliefs listed above are related to what is known as the "linear model" (LM) of research and information flow between scientific and technical producers and lay users formalized during the post-WWII years (e.g. McNie, 2007). Decades of scholarship in the social and behavioural sciences, particularly in Science and Technology Studies (STS), have incontestably shown that the production of knowledge always involves social and cultural factors (Wesselink et al., 2013), and that the relationship between evidence and decision-making is highly politicised, complex and recursive (Ludwig, 2001; Sarewitz, 2004; Juntti et al., 2009). In other words, it is the opposite of the seamless one-directional flow described by the LM.

What we do as researchers, how, and why, is the focus of STS scholars, and is a pity how little we have apparently learnt from what they have to say (Table 1, rows 1–4, 8, 10).What is remarkable is that the field of STS was conceived by some of its founders as "science for public understanding" (Aikenhead, 2003); then, as most academic territories, turned into a specialized field hard to follow for scholars from other disciplines (Becher and Trowler, 1989). What worsens the gap is the generalized attitude of

ecologists considering our work policy neutral, a point to which I will return in Section 5.

The LM is not only mistaken in assuming that information flows in just one direction, from experts to the public, but also in considering that information production and supply is always the limiting factor for decisions. Thus, a more fitting name used for it is Information Deficit Model (IDM). This LM-IDM evolved over the decades into a family of Civic Models, taking more into account deliberative and inclusion processes and with increasing central roles for non-state actors (Bulkeley and Mol, 2003). Concepts akin to adaptive governance of common resources, including stakeholder participation ("co-production of knowledge"), have been familiar to ecologists since C.S. Holling's proposals during the 1970s (e.g. Chaffin et al., 2014). However, this seems to have occurred without a realisation that the IDM had been superseded, and thus some of its powerful corollaries (e.g. Table 1, rows 1–4) remained unchallenged.

As a recent example of the pervasive influence of the LM-IDM in ecology, Courchamp et al. (2015) have pleaded for more emphasis on information supply from the extreme of basic science, while others keep assigning a central role for science popularization and outreach (e.g. Groffman et al., 2010; Lubchenco et al., 2015). A perhaps more subtle descendant of the older model is the notion of a supply-demand mismatch in terms of environmental information (McNie, 2007; Sarewitz and Pielke, 2007). Here again, in accordance with LM-IDM, knowledge production and use are separated with scientists in the role of suppliers and policy makers in the more passive role of users (Wesselink et al., 2013).

3. Like it or not, coproduction is already under way

Ecologists have long insisted on the need to consult and communicate with stakeholders. Both actions, however, could be understood as unidirectional: the first just listening, and the second just talking (McNie, 2007). Respectful and extended dialogue, instead, is the desirable, two-way approach towards full participation, and has two justifications—and reasons for success (Morán, 2010; Bulkeley and Mol, 2003). The first one is that, in democratic societies, it confers legitimacy. The second is that stakeholders are also knowledge-holders, and thus their full participation allows not only to build social capital and trust (Table 1, row 4) but also helps different types of knowledge to emerge (Table 1, row 2; Turnhout et al., 2013). The importance of local, traditional environmental knowledge has been appreciated in ecology for some time now (e.g. Raymond et al., 2010); however, here I am referring to all forms of tacit knowledge (*sensu* Roux et al., 2006), i.e. our perceptions and experiences beyond the "codified" information in technical papers and books. Tacit knowledge is encompassed by a view of expertise that includes not only technical information, but also the experience and proficiency needed to apply it under specific contexts, being aware of uncertainties, risks, and knowledge gaps (Wesselink et al., 2013; Table 1, row 3). There has been some semantic discussion on whether this is trans-science, post-normal science or no science at all, but I agree with Carolan (2006) in that a more fruitful discussion is what type of skills are needed to attain the required expertise.

For many of us, the idea that some non-peer reviewed information might be at times as valuable as our cherished peer-reviewed papers sounds heretic, which it is–as long as we continue to see a sharp line between scientific and non-scientific information (e.g. Lövbrand and Öberg, 2005 Turnhout et al., 2013).[1] Fair solutions need not only scientists' but also citizens' involvement, and leadership from trustworthy individuals (Folke et al., 2005) and bridging organizations (Kowalski and Jenkins, 2015), particularly those which facilitate the emergence of a variety of knowledges. Some social scientists have called this "participatory action research", and at its core there is strategic negotiation (Giller et al., 2008)—more likely to last longer, and thus also to be fruitful, when it starts from a shared conceptualization and prioritisation of problems (agenda setting, see Section 5, below) and basic agreement on procedures (e.g. Gorddard et al., 2016).

It is often said that the desideratum is taking better-informed decisions, for which we need to frame problems in ways that make action more likely (e.g. Scheffer et al., 2003). Such apparently sensible statement, however, leaves the two probably most important issues unresolved: What are the most desirable actions? And what is the information needed to find them? A common expression that I have intentionally avoided is "evidence-based" decisions, because it begs the question of evidence for whom.[2] None of these questions is easy to answer, in part because of the existence of many potential sources of misunderstanding between "cultures", not only the most obvious ones of scientists vs. managers vs. lay citizens (Roux et al., 2006), but also between biophysical scientists and scholars from more socially- and human-oriented fields (Snow, 1998), and even within each academic discipline (Becher and Trowler, 1989).

Moreover, all of this is multiplied by a more or less identifiable variety of political preferences and/or commitments (Sabatier's, 2007 "advocacy coalitions"), which in no way ensures that the outcome of our choice will be the frontrunner. Tacit knowledge, again, seems the key concept to make some sense out of this complexity, together with the realisation that we are also stakeholders (Giller et al., 2008; Fabinyi et al., 2014). I believe that not acknowledging this is part of why scientists are often perceived as arrogant and self-serving (Roux et al., 2006). Boldness in convictions should not exclude humble manners.

4. Communication is difficult and slow, but predictably so

As much as one would wish for information to swiftly flow between its eventual producers, whoever they are, and prospective users, things are somewhat different. Scheffer et al. (2003) highlight the prevalence of long periods of stasis after problem detection, followed by sudden shifts, often motorized by changes in public opinion. This may occur because, on the one hand, knowledge may lay dormant and only turn into 'evidence' when the political climate is ripe for a problem to be identified (Juntti et al., 2009). On the other hand, when an emotionally charged event gets the attention of mass media and is perceived as a catastrophe, triggering a self-sustaining cascade that moves the public from worry to panic (Kahneman, 2011), it tends to prompt fast government action. Under such a climate, the required integrative solutions are not easily reached because those in charge are more likely to resort to the first workable option (Scheffer et al., 2003), often within their zone of comfort, both politically (Sabatier, 2007) and academically (Ludwig, 2001). This will probably not yield the best possible solutions—even assuming noble intentions and behaviour all along, because while trying to optimize specific variables one is overlooking possibly important variables, or more or less consciously bypassing them (Dicks et al., 2014), thus hindering potentially better solutions. Another damaging force stemming from such urgency is the tendency of political pressure to push attention from plural, conditional

[1] We need to get used to the notion that " . . . all knowledge should be treated with caution, seeking to understand the conditions under which it is produced" (Juntti et al., 2009).

[2] See discussion of *ethos* in Conclusions.

approaches toward simplistic, 'definitive' ones (Stirling 2010; Table 1, row 12).

Regarding the speed of change, is interesting to look at Paul Sabatier's advocacy coalition framework, because it is one of the policy theories which most strongly emphasizes the role of specialized knowledge (e.g. as compared with other six theories; Sabatier, 2007). Still, it assigns it an indirect role, through gradually modifying the beliefs of policy participants, and thus it explains why change usually takes so long, i.e. of the order of decades–in a process not so different from what was traditionally known as enlightenment (Shafer, 2008). However, as said, there is an enormous variation in the speed of response (or lack thereof) to environmental problems, and although they understandably differ according to the lifetime of decisions (Stafford Smith et al., 2011) and to the scale and type of problem (Brooks et al., 2014), we can make several useful generalizations.

Some problems are more amenable for technological solutions ("tech fixes"), but others are so strongly context-dependent that such a solution could not exist, simply because knowledge about them will be non-cumulative (Sarewitz and Nelson, 2008). These have been sometimes called "wicked problems" (Ludwig, 2001). Perhaps more important is the distinction drawn by Pielke (2007) between societal problems with widespread shared values (his "tornado politics"), for which specialized technical information is the most important input to make a decision, which then can be rapid, and those with the opposite features (his "abortion politics"). For the most extreme examples of this latter class (as abortion itself), it is often hard to imagine what type of factual knowledge may cause people to change their minds. In a related vein, Sabatier (2007) discussed conditions that lead to the maintenance of the status quo (stalemate or gridlock), which boil down to the asymmetric distribution of benefits and costs in favour of the coalition in power, both materially and ideologically. The barriers for applying known solutions, then, are not only logical, but also psychological and social, and thus suggestions need to be translated for each and every new institutional context (Stafford Smith et al., 2011).

5. Tinted glasses—personal and professional perception filters

I have briefly mentioned at the beginning that most ecologists consider their work as policy neutral; moreover, we tend to see ourselves as apolitical and non-ideological (Table 1, row 5; Wesselink et al., 2013). This fits with the seemingly still prevalent positivist view of natural sciences as the only truly objective source of facts and theories about reality, that makes us remain 'stubbornly innocent' in this respect (Sarewitz, 2004). Constructivism, in the sense of considering science as a social and value-laden activity, risks being understood among us as an accusation of bad work and even of misconduct (Lövbrand and Öberg, 2005).

Since complex problems usually face difficult trade-offs, they often have different possible solutions, choosing among which often rests strongly on preferences and values and not so much on purely specialized knowledge (without implying that there is always a strict distinction between these last two). For environmental issues, this frequently becomes entangled with a not-always-clear consideration of our stance as academics vs. nature advocates. What we all perceive as hard data or "facts" are embedded in a network of tacit prior information and experiences that form a coherent, although not necessarily correct, body of knowledge (e.g. Roling and Jiggins, 1998). This construct has been described as our mental model of the world (Jones et al., 2011), which together with our preferences act as very strong perceptual filters (Kahneman, 2011; Table 1, row 4). Thus, the perception of what constitutes a problem, its framing and wording, i.e. its representation as needed for good governance, is not neutral (Bulkeley and Mol, 2003; Sabatier, 2007; Table 1, row 1), and even identifying the relevant academic disciplines involved might not be trivial. Not only do politicians and decision makers belong to advocacy coalitions and have agendas—whether we realise it or not, we all do (Table 1, rows 5–7).

6. Conclusion: what (not) to do

In sum, the four beliefs listed at the beginning of this paper are misleading because: (1) the interactions between science, policy and practice are complex and non-linear; (2) multiple types of knowledge are needed while trying to understand and deal with complex problems; (3) policy makers must consider multiple perspectives when making decisions; and (4) there are personal and professional filters, many of them unconscious, that shape how people engage with research and policy. An overarching assumption behind those beliefs as phrased in the Introduction is that we are mostly rational beings, which is not true (Kahneman, 2011). Or you could say that we are, but only within the realm of our mental model of the world (cf. Section 5). If we were truly and only rational, a purely logical appeal would be enough to convince everybody, as in the *logos* of classical rhetoric (focusing on the message, its coherence and clarity). However, since all of us are a mixture of intellect, emotions and character, if we are to be effective in changing other people's convictions and behaviour we need to appeal also to their emotions (*pathos*, including values and core beliefs), and do so from a believable authority position (*ethos*, reputation, trustworthiness and experience). Is important to note that these three appeals are not independent: for example, what for one ecologist is a solid scientific truth, backed by peer review in a highly-cited journal (his/her *logos*), is likely to be seen by another one as biased evidence precisely because of its publication in a source run by the establishment (different *ethos*).[3]

I add two further clarifications, just in case anything so far sounds like "everything is relative" or that am saying that it is just a question of finding the right political spin (positions which I do not endorse). First, there is a sharp philosophical distinction between what 'is' (factual, positive, descriptive statements) and what 'ought' to be (normative, prescriptive statements)—a distinction of which we need to be aware before getting into supposedly more sophisticated, constructivist arguments (cf. Table 1, row 1). Second, the coproduction of knowledge and negotiations conducive to effective environmental management and policies is not just a political hurdle to be overcome or sidestepped by smart lobbying. Such behaviour would mirror a politician's request for a technical report backing an already taken decision to make it appear as scientifically legitimate. On the contrary, I see open consultation and exchange as an essential process aimed to improve everybody's environmental literacy in the broadest sense.

Environmental problems are not isolated from the rest of societies' problems. Fischer et al. (2015) have recently reviewed advances in collaboration across disciplines, and found more pluralism in both methods and concepts, but insist on the need for a stronger science-society interface. I would argue that this interface is a multifaceted arena, in which we as scientists could contribute in several capacities according to our skills and preferences, never underestimating the power of being a good example to change discourses and practices. Senior scientists with a standard academic career can start regarding invitations to take part in advisory panels, to review proposals, or to give talks for organizations somewhat outside our zone of expertise and comfort as opportunities to listen, learn and share perspectives at some of

[3] In the South, it is not uncommon to consider suspicious anything written in English. Footnote (1) also applies.

the science-policy interfaces. This is a never-ending task (Table 1, row 12), yet readiness for such engagement might be more widespread than what we used to believe (Singh et al., 2014), which is good because otherwise ecology is bound to be a chronicle of our ecosystems' decline, and advocate-ecologists mere heralds of their demise (Table 1, row 9).

I think we should encourage the young, when sufficiently mature, to interact with people from others fields of knowledge to become aware not only of other sources of expertise but also to appreciate their methods. Such exposure may also be useful to clarify the frequently blurred realisation of their own position along the axis that goes from reasonably objective expert advising to advocacy and activism. At the very least, we should refrain from boycotting "too" applied or social interests on their part and instead point out, without cynicism, how all forms of research involve choices and values. Besides, we should emphasise the importance of being open and reflexive about these choices and values so as to avoid two risks: of politics influencing the selection of both work teams and problems, and of us acting as stealth advocates (Table 1, row 5) instead of honest brokers of alternatives and bridging agents (Pielke, 2007; Turnhout et al., 2013). Of course such a "keep it complex" attitude (in the sense of Stirling, 2010) takes more work than being a self-righteous, distant critic but, to me, seems the only way of dealing with our pressing problems.

Although there are some encouraging trends, ours is still a very unfair planet with unacceptable differences in material equity both between and within countries[4] that have to be taken into account to avoid useless generalizations (cf. Table 1, row 10). Many of the most serious environmental and social problems we face are related to our societies' material and power disparities (Scheffer et al., 2003; Wilkinson and Pickett, 2009). Sure enough, there is a myriad of cultural and other factors involved. But if understanding or changing their ultimate causes takes too long, it is our responsibility to help prevent and avoid the practical consequences for our societies and their future (cf. Table 1, row 11). To be more effective at this, it is imperative that we as scientists have a clear view of our professional role. As Molière's character who has been speaking prose his whole life without knowing it until he discovered verse, we need to be aware of the existence of other visions of reality to unveil our own beliefs behind scientific practices before we can improve them.

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[4] Updated statistics with outstanding graphical display: *http://www.gapminder.org/worldhttp://www.gapminder.org/world*.

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