The political ecology of ecosystem services

Christian A. KULL, Xavier ARNAULD DE SARTRE, and Monica CASTRO-LARRAÑAGA

Highlights

- 'Ecosystem services' appears neutral or technical but implies consequential choices.
- We investigate the social construction and application of the concept.
- The framing, ontology, and use of the concept have political outcomes.
- 'Ecosystem services' is not only a tool in the neoliberalization of nature.
- It is also a discourse used in complex ways to serve multiple agendas.

Abstract

The dominance of "ecosystem services" as a guiding concept for environmental management – where it appears as a neutral, obvious, taken-for-granted concept – hides the fact that there are choices implicit in its framing and in its application. In other words, it is a highly political concept, and its utility depends on the arena in which it is used and what it is used for. Following a political ecology framework, and based on a literature review, bibliometric analyses, and brief examples from two tropical rainforest countries, this review investigates four moments in the construction and application of the ecosystem services idea: socio-historical (the emergence of the discourse), ontological (what knowledge does the concept allow?), scientific (difficulties in its practical application), and political (who wins, who loses?). We show how the concept is a boundary object with widespread appeal, trace the discursive and institutional context within which it gained traction, and argue that choices of scale, definition, and method in measuring ecosystem services frustrate its straightforward application. As a result, it is used in diverse ways by different interests to justify different kinds of interventions that at times might be totally opposed. In Madagascar, the ecosystem services idea is mainly used to justify forest conservation in ways open to critique for its neoliberalization of nature or disempowerment of communities. In contrast, in the Brazilian Amazon, the discourse of ecosystem services has served the agendas of traditional populations and family farm lobbies. Ecosystem services, as an idea and tool, are mobilized by diverse actors in real-life situations that lead to complex, regionally particular and fundamentally political outcomes.

Keywords

Ecosystem services, environmental services, market-based instruments, Brazil, Madagascar, tropical forests, payments for ecosystem services

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1. Introduction

'Ecosystem services' (ES) is one of the buzzwords of environmental management at the beginning of the 21st century. This concept directs our attention to humanity's dependence on ecosystems and ecosystem processes for food production, for regulation of climate and water resources, for aesthetic and spiritual values, and for basic, underlying life-supporting processes like photosynthesis and soil formation. Scientists, policymakers, and practitioners have used the concept to justify a wide array of environmental initiatives (Costanza et al., 1997a; Daily et al., 1997; MEA, 2005; Kumar, 2012). The crowning moment of ES was its high-profile use in framing the 2005 *Millennium Ecosystem Assessment*, a report sponsored by a who's who of international environmental agencies (MEA, 2005).

Current use of the ES idea demonstrates a relatively tight conformity of definition. It is centered on four main elements:

- **something out there** (ecosystems, nature, forests, watersheds…)
- **provides things** (resources, goods, products, services…)
- **useful to people and/or nature** (health, livelihoods, fundamental life-support systems, species…)
- **and this should be valued** (often in monetary terms).

As the third and fourth elements indicate, some fundamental differences arise, however, between those who emphasize ecosystem functioning and attributes, versus those who focus more specifically on the benefits – or calculable value – for humans (Boyd and Banzhaf 2007; Fisher et al. 2009; Nahlik et al. 2012; Lele et al. 2013). ES tend to be divided into four main categories. *Regulating* services are the benefits gained from ecosystem processes such as air quality, climate, water, erosion, waste, diseases, pests, pollination, and hazards. *Provisioning* services are the direct products we obtain from ecosystems, like food, fiber, fuel, and water. *Cultural* services are non-material, such as education, spiritual values, and recreation. *Supporting* services are the indirect or long-term processes that are necessary for the production of the previous three categories of service, like soil formation, photosynthesis, and nutrient cycling (MEA, 2005, p. 40).

The ES concept has gained impressive rhetorical and scientific power in the last two decades. On the scientific side, over two thousand journal articles contain ES as a keyword, with top outlets including *PNAS*, *Environmental Management, Biological Conservation*, *Ecological Economics* and *Ecology and Society* (Schaich et al. 2010). On the policy side, major international environmental NGOs like the World Wide Fund for Nature (WWF), the Wildlife Conservation Society (WCS), and the International Union for the Conservation of Nature (IUCN) have incorporated ES into their programs. The Convention on Biological Diversity (CBD) makes an explicit link between biodiversity and ES within its Strategic Plan for Biodiversity 2011-2020. ES has been central to the construction of new, high profile multi-institutional international environmental programs such as TEEB (The Economics of Ecosystems and Biodiversity) and IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services). At a national level, numerous funding councils have made calls for research linked to ES, often with explicit links to policy. As just one illustration, the British government finances a £40m research program linking its development agency (DFID) and its national science agencies (NERC and ESRC), titled *Ecosystem services for poverty alleviation*.

Both an applied and critical literature has accumulated quickly. On the one hand, many practitioners and scholars seek ways to operationalize the concept, apply it in particular case studies, or frame their arguments with it. Some attempt to circumscribe definitions and tools to be able to use the concept in economic models (e.g. Fischer et al., 2009; Johnston and Russell, 2011). Others analyze the loss or degradation of ES (e.g. Lant et al. 2008), or seek to work out the mechanisms by which payments for ES can be implemented (like TEEB). On the other hand, a variety of scholars, including both users of the concept and external observers, critique the ES idea (Schröter et al. 2014). From an ecological perspective, the concept is criticized for obscuring ecological functions (Peterson, 2009) or leading to unjustified simplifications (Norgaard, 2010; Swift et al., 2004). From a strategic perspective, some see the concept as too broad, easily confused with others such as environmental services or landscape multifunctionality (Lamarque et al., 2011), while others critique its political efficacy (Van Hecken, 2010). Finally, from a social perspective, scholars critique the way in which the concept avoids consideration of crucial social, political and contextual factors (Corbera et al., 2007; Daw et al., 2011; Fairhead et al., 2012; Barnaud and Antona, 2014). Furthermore, scholars critique the way in which the concept, despite its merits, reflects and reinforces certain market-based models of society and underlying ideologies (Gomez-Baggethum et al., 2010). Critical scholars see ES as a neoliberal approach to the environment that commodifies nature and creates new sites for capital accumulation largely in the hands of a global elite (Heynen and Robbins, 2005; McAfee, 1999, 2012a, b; McCarthy and Prudham, 2004).

Concern over environmental transformations and environmental protection long precedes ‘ecosystem services’. And ES is only one out of many possible ways of framing environment-society relationships. This begs a number of questions. What explains its meteoric rise as a dominant tool to think about environment-society relations? What does it reflect about today’s society? What are its advantages and disadvantages? Who gains from it, who loses? Is it an indispensable tool to save nature in the modern world, a further appropriation of nature by capital, or something else altogether?

In this article, we seek to build a bridge between social science critiques and the ways in which practitioners have used the concept. We seek to understand more specifically how the notion works, how it is used, what the notion allows and does not allow, and what its impacts are. As these objectives specifically engage with winners and losers in terms of environmental management, the power structures and discursive frameworks that facilitate such outcomes, and the specific regional ecological and social contexts in which the concept is used, we have labeled our approach a “political ecology” of ES. We argue that the utility of the ES concept depends on the arena where it is used and what it is used for. ES is not simply a tool in neoliberalization of nature, but a rhetorical concept that is used as such, and must be understood as such, with sometimes divergent outcomes. ES as a concept and tool is more complex than it has been argued in many neoliberal nature theorizations. This is not only due to the nature of nature or to the nature of capitalism, but to the very notion itself, which has been marked, since its creation, by many debates among ecologists, economists, and policy makers

2. Approach: theory and method

What do we mean by ‘doing a political ecology of ecosystem services’? We do so in the sense that political ecology is a research approach or posture that addresses nature-society phenomena – whether concrete local cases of environmental change or abstract global concepts like ES – using historically and geographically contextual approaches. More specifically, political ecology guides researchers to pay attention not only to the ‘ecology’ or science of the topic at hand, but also to the agency of ideas and the actions of social, economic, and discursive power across scales. The approach pays particular attention to who wins, who loses, and what the impacts are for different parts of society and different components of the environment (Robbins, 2012; Gautier and Benjaminsen, 2012). In the words of Tim Forsyth (2005, p. 165), who uses political ecology to investigate the ‘ecosystem approach’ idea, political ecology “does not suggest that environmental problems do not exist, or that ecological science cannot help, but acknowledges the greater political controversies about the nature of ecological risk, and the influence of different political actors upon what is seen to be authoritative knowledge.” It differs from apolitical approaches to understanding environment-society concepts, like Timothy Farnham’s history of ‘biological diversity’. Farnham (2007, p. 5-6) ascribes the success of that concept to its encompassing breadth and its ability to strike a chord with different interest groups, but dwells less on the underlying politics. .

Political ecologists have already produced a number of critical analyses touching on the ES concept. The main critics investigate ES as a tool of a neoliberal conservation, of market-based environmental policy, or as a project of 'green grabbing' that creates new markets and empowers new actors (Arsel and Büscher, 2012; Fairhead et al. 2012; Bumpus and Liverman, 2012; MacDonald and Corson, 2012). ES can reinforce unequal power relationships (Corbera et al., 2007) or lead to social injustice (Daw et al., 2001; MacAfee, 2012a; Sikor, 2013). While the ES concept did not imply such outcomes, its use in the particular political and economic situations of recent decades conditioned these outcomes (Gómez-Baggethun et al., 2010; Gómez-Baggethun and Ruiz-Perez, 2011). In addition, political ecologists, among others, have shown that the metrics used for such services lay on instable values and uncertainties that compromise the possibility of the commodification of nature on stable metrics (Robertson, 2006; Barnaud et al., 2010; Ernston and Sörling, 2012).

Nevertheless, some authors suggest that these are not default characteristics of ES, and that the use of ES does not necessarily signal adherence to an ideology of 'neoliberalisation of nature' (Dempsey and Robertson, 2012). First of all, green neoliberalism as conceptual framework has numerous fragilities: it is not a single project (Bailey and Caprotti, 2014), and the multi-dimensional fungibility of 'nature' means that ES cannot enroll it so easily (Bakker, 2012). ES policies are very heterogeneous. In many cases, they are used by States to reinforce their environmental agendas without allowing new directions in such policies (Roth and Dressler, 2012; McElwee, 2012), so that policies and practices around the ES concept deviate considerably from neoliberal doctrine (Dempsey and Roberston, 2012).

In the present piece, we present a broad-scale, conceptual review of ES as a particular idea, social phenomena, and management tool, drawing on a mix of approaches including literature review, conceptual deconstruction, bibliometric analysis, and examples from tropical forests in Brazil and Madagascar. We call our review a 'political ecology' because it seeks to triangulate between science, power, and knowledge in order to better understand a particular nature-society phenomenon (in this case, ES), both in general and in particular contexts, and in doing so to contribute to more socially just and environmentally sustainable outcomes. It traces, like Forsyth's (2005) review of the 'ecosystem approach', how the concept is defined, by whom, and how it is modified through the influence of political concerns at multiple scales. In addition, we address the concept's ideological and ecological underpinnings and its practical implications. We structure our analysis into four discrete sections that together could be argued to constitute a full political ecological enquiry, crossing between ecology and politics, discourse and power, local and global (Peet and Watts, 1996; Demeritt 2001; Walker 2005, 2006, 2007; Robbins 2012). The four sections are:

2.1. The emergence of a discourse

First, we ask how the discourse of ES emerged and rose to prominence – what social-political-environmental climate created the concept. This inquiry into the social, scientific, and institutional roots of the concept sets the stage for later considerations of how it is enrolled in the exercise of power, what it does, and whom it serves (Forsyth, 2003). We build on political ecology's tradition of placing diverse ideas like 'degradation' or 'the suburban lawn' into their geographical and historical context (Leach and Mearns, 1996; Robbins, 2007) by situating ES in contemporary discourses of environmental degradation, neoliberalism, and ecological modernization. In order to more specifically trace the co-production of science and politics that resulted in ES, we investigate specific networks of power and knowledge through bibliometric approaches applied to ES scientists and practitioners (Castro and Ollivier, 2012; Xu and Marinova, 2013; Abson et al. 2014).

2.2. Ontology of the concept

A political ecology of a concept like ES must address the notion itself. What does the concept itself consists of, what does the idea allow and does not allow? This part of our review investigates how the ES notion reflects – or even shapes – our social world. What does the concept suggest can be known about the world? How does it frame the world and the possibilities of action? Here we build on a rich tradition of dissection of concepts as basic as 'nature' (Castree and Braun, 2001) by analyzing ES as a type of metaphor that communicates certain ideas about human-environment relationships (Larson 2011).

2.3. Applying the concept on the ground: science and practice

Third, we ask how ES 'works' in specific contexts. This section builds on political ecology's tradition of robust attention to the ecology and science of a topic, as well as to the co-production of that science by multiple actors with different interests (e.g., Robbins 2001). In this portion of our review, we build on a literature review and examples from Madagascar and Brazil, in particular on our experiences contributing to a project identifying and quantifying ES from 51 farms in six localities in two Amazonian frontiers (Grimaldi et al., 2013). These cases illustrate the many choices implicit in the application of ES as a tool – in terms of categorization, weighting, scale, and quantifiability. These choices leave gaping holes for politics to enter (Rangan and Kull 2009).

2.4. Politics: impacts and opportunities filtered through institutions and actors across scales

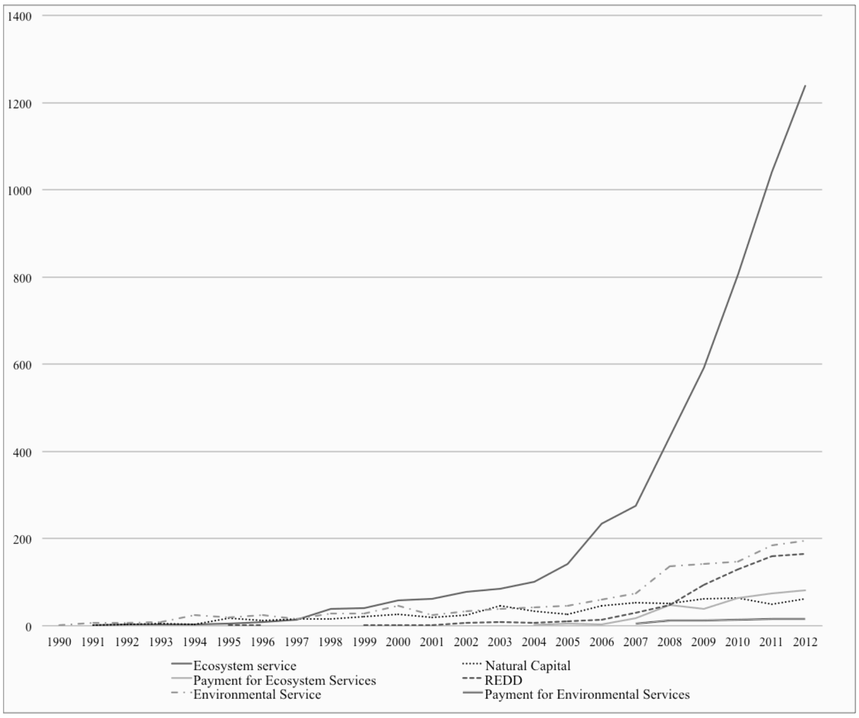
Finally, we ask about the effects of the ES idea. Who are the winners, who are the losers, who uses the idea and for what purposes? A variety of political ecologists have traced the political lives of ideas, including 'forest' in Southeast Asia (Peluso and Vandergeest, 2001) and 'sustainable development' in the Brazilian Amazon (Arnauld de Sartre and Berdoulay, 2011). They often adopt a 'governmentality' approach that investigates how societies are rendered governable through discourses and other techniques (Agrawal, 2005; Dressler, 2013). This approach problematizes straightforward conceptions of governance and the tools it uses (like ES). It articulates local practices of power to those of high-level institutions. The approach does not allow simply being 'for' or 'against' certain ideologies or technologies of power (like ES), but instead promotes the investigation of how they produce effects that have meaning and consequences. The result is that we are able to grasp the rules of the discourse, to observe the power relations of policy making, and to highlight gaps between the rhetoric and practice of policy (Barry et al., 1996). In this section, we build on the literature and on the Madagascar and Brazil examples to investigate who gains and who does not and highlight the impacts and opportunities created by the concept in a complex, multi-scalar world of social interactions.

In sum, what we intend to do in this review is to present a political ecology of the concept of ES as an idea and governance tool. Human-environment relationships are highly diverse across and within societies. As a result, when a metaphor such as ES takes on global importance, it is necessary to deconstruct it and demonstrate the relativity of its point of view. In addition, it is necessary to understand the conflicting ideological and political realms shaping the notion, the pragmatic situations where the notion is mobilized and implemented by different actors, and their outcomes (Arnauld de Sartre et al. 2014). Below, we present our review following the four categories described above.

3. Emergence of a discourse

The idea of ES took wings in the late 1990s with emblematic publications by high-profile ecologists and economists. Costanza et al. (1997b, p. 254) wrote in *Nature* that "Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions", while Vitousek et al. (1997, p. 499) argued in *Science* that "Our activities are causing rapid, novel, and substantial changes to Earth's ecosystems. Maintaining populations, species, and ecosystems in the face of those changes, and maintaining the flow of goods and services they provide humanity, will require active management for the foreseeable future." In the same year, Gretchen Daily (1997) edited a book titled *Nature's Services: Societal Dependence on Natural Ecosystems*, with of contributions from the above scientists and more. Within a few years of these seminal publications, ES was prominently enshrined in the *Millennium Ecosystem Assessment* (MEA, 2005). The assessment, which took place under the auspices of UNEP and was funded by the UN Foundation, the Packard Foundation, and the World Bank, was conducted to gather knowledge and data to render an actionable package to policy makers – in a fashion similar to the IPCC climate reports (Mitchell et al., 2006). In this section, we explain the emergence of ES, exploring why it became a ‘buzzword’ (Callicott et al. 1999). We first investigate the historical intellectual and discursive space of the concept’s emergence, and then look more specifically at networks of individuals and institutions behind the concept’s meteoric rise. Citation analyses dramatically illustrate the trends (Figure 1).

Figure 1. The meteoric rise of ‘ecosystem services’. Number of publications with the term ‘ecosystem services’ in title, keyword, or abstract in Web of Science, 1990-2012, compared to other related keywords.



The ideas that constitute ES have a deep history in a variety of intellectual trends linking environment and economy (Gómez-Baggethun et al., 2010; Gómez-Baggethun and Ruiz, 2011), particularly in the fields of environmental and ecological economics (Pearce, 1993; Costanza et al., 1997a). The concept responds to environmental crises of degradation, pollution, deforestation, and habitat loss that have been occurring for decades (MEA 2005, p. 1), pushed largely by an economic system of unsustainable exploitation that did not “internalize its externalities” (Pigou, 1920).

The emergence of ES in the late 1990s is neither a direct response to the environmental crisis nor a profoundly new idea. Instead, its emergence reflects two broader social and political trends. The first is the growing dominance of (neo)liberal ideas that critiqued the ineffectiveness and inefficiency of state regulation and supported markets as the most efficient management and regulatory tool (Brenner et al. 2010). The second trend is ‘ecological modernization’, which sees the solutions to the modern environmental crisis not in fighting against the industry and consumption causing it, but in undertaking *more* and *better* modernization. This set of ideas comes with a faith in technology and a commitment that states and society should ensure that market mechanisms incorporate the value of nature to economy and society (Buttel, 2000; Mol et al., 2009). Together, these trends suggested to environmentalists – who were disappointed with how the state had failed to protect nature – that although capitalist markets had done much of the damage, the solution for better environmental management was not more state control but rather in states working with society to transform the workings of the market to create greener industries and resource exploitation practices.

As mutually reinforcing dominant discourses of the 1990s, neoliberalism and ecological modernization made it possible to conceive of society-environment relationships in a particular way. While there are several ways in which ES markets are not strictly neoliberal[1], these two discourses prepared the way for it to appear quite natural that we should value, and perhaps pay for, 'services' rendered by ecosystems. A pioneering application of these ideas was in Costa Rica, a country marked by a strong uptake of neoliberal policies and environmental action: its innovative 'payments for environmental services' program was launched in 1997 (Zbinden and Lee, 2005).

But why did ES rise to such prominence? The emergence of the concept is strongly rooted in the work of influential academics with prominent institutional linkages and networks. We traced these networks through citation and author analysis (Castro-Larrañaga and Arnauld de Sartre, 2014). Our initial analysis began with early champions of the concept like Gretchen Daily and Robert Costanza. By tracing citation chains and collaborations, we identified particular networks of researchers in subfields including ecological economics, systems ecology, and conservation biology. Environmental scientists concerned with the loss of intact and functioning ecosystems allied with heterodox economists to promote a concept that could transform capitalism by internalizing the externalities. Several institutions emerge as key nodes: Stanford University (home to Paul Ehrlich, Gretchen Daily, Peter Vitousek, Harold Mooney, and Stephen Schneider), University of Florida (historically: this is where H. T. Odum and C. S. Holling pioneered systems ecology; Robert Constanza was a student of Odum), and the Beijer Institute of Ecological Economics and the Resilience Alliance (both key networking sites, based in Stockholm: Parker and Hackett, 2012). While other institutions play a role, many of the key actors in the history of ES are linked to one of the above. Networks between these and other actors were built through meetings and workshops facilitated by the Stockholm-based institutes mentioned above as well as by the Pew Charitable Trust and the National Center for Environmental Synthesis and Analysis.

To further uncover some of the social processes behind the rise of the ES concept, we analyzed the authors, institutional affiliations, and citations referenced in the broader literature up to the 2005 publication of *Millennium Ecosystem Assessment*, as well as the participants in the MEA itself (Table 1).[2] The MEA involved more than 1360 authors, and resulted in a theoretical framework, five volumes about the state of world's ecosystems, and several other reports. The process behind the MEA was highly structured and thus of interest in understanding how particular forms of knowledge are created and promoted (Mitchell et al., 2006).

[1] At a narrower level ES are not 'free market' but created by states and other actors in order to have a particular desired effect. They rely on centralized authorities to set them up, contradicting neoliberalism's push toward decentralization.

[2] We created a cross-referenced database of ES authors and their institutional affiliations from two sources: Web of Science (for most prolific and most cited publications on ES), and the 13 reports of the MEA (for most cited and role). For each individual, we also noted their institutional affiliations (historical and current) and discipline (determined by the individual's website or CV, giving priority to field they self-identify rather than PhD field). The frequency of citations were calculated using CiteSpace©, a freely available Java application for analyzing and visualizing scientific literature: http://cluster.cis.drexel.edu/~cchen/citespace.

Table 1. Top ecosystem services actors 1990-2005 (up to and including the Millennium Ecosystem Assessment, MEA). Includes individuals with 'top-20' positions in any one of four categories as well as 'top-50' position in at least one additional category. Blank entries indicate position outside of 'top-50'. **'Prolific'** refers to number of Web of Science publications authored with the topic 'ecosystem services' 1990-2005 (as reflected by title, keywords, or abstract). **'Cit. lit.'** refers to the frequency that an author is cited within articles with the topic 'ecosystem services', 1990-2005. **'Cit. MEA'** refers to the frequency that an author is cited within any of the 13 MEA reports (theoretical framework, assessment reports, synthesis reports, summary, and bridging scales report). **'Role MEA'** refers to participation by individuals in the MEA. This is coded as follows. A number followed by 'A' indicates number of chapters or reports in which the person had a major authorship role (i.e., a position as lead author, core writing team, or synthesis team). 'E' is membership in the Exploratory Committee, 'B' is member of the Board, 'P' is participation in the Assessment Panel, and 'V' is volume editor. **Discipline** based on individual websites; **Institution** includes significant recent and historic affiliations as well as membership of the Resilience Alliance (RA) or Fellows of the Beijer Institute (from those institutions' websites).

Name	Prol-ific	Cit. lit.	Cit. MEA	Role MEA	Discipline(s)	Institution
tops four categories						
CARPENTER, Stephen	8	40	26	5A P V	Biology	Wisconsin; Beijer Fellow, RA member
DAILY, Gretchen	5	26	12	2A	Biology	Stanford, Beijer Fellow
tops three categories						
COSTANZA, Robert	19	220	20		Ecological economics, Systems ecology	PhD Florida, Maryland, Vermont, Portland State, ANU; Beijer visiting scientist
FOLKE, Carl	17	48	16		Systems Ecology	Stockholm, Beijer Institute (Director), RA member
PETERSON, Garry	5		19	6A	Systems Ecology	PhD Florida, Wisconsin, McGill, Stockholm, RA member
NAEEM, Shahid	5	40		3A	Ecology	Columbia
BALMFORD, Andrew	5	21	15		Conservation Biology	Cambridge
TILMAN, G. David	4	75	21		Ecology	Minnesota
PAULY, Daniel		35	18	2A	Marine Biology, Fisheries	UBC
POSTEL, Sandra	3	31	18		Conservation	Worldwatch Institute, Global Water Policy Project; Pew Scholar
BERKES, Fikret		27	49	2A V	Applied Ecology; Common Property	Manitoba; Beijer; Resilience author
DASGUPTA, Partha		17	11	2A B P	Economy	Cambridge; Beijer Fellow
MAY, Robert M.		18	12	2Ch P	Theoretical Ecology	Princeton, Oxford, Royal Society (President), Chief Scientific Advisor (UK)
tops two categories						
CAIRNS, John Jr.	18	25			Environmental Biology	Virginia Tech, USA science policy circles
EHRLICH, Paul	8	39			Biology, Ecology	Stanford, Beijer Fellow

WALL, Diana	7			3A	Soil Biology, Environmental Science	Colorado State
VAN WILGEN, Brian	7	24			Ecology	CSIR (South Africa)
KREMEN, Claire	6	17			Conservation Biology	Berkeley
WILSON, Mark	5	17			Ecological Economics	Maryland, Vermont, World Resources Institute
TURNER, R. Kerry	5	22			Environmental/Ecological Economics	Univ. East Anglia
LEEMANS, Rik	5			3A P V	Ecology, Environmental Systems	Waageningen U.
WALKER, Brian	4	22			Ecology	CSIRO (Australia); Beijer Fellow (and former chair of board), RA member and author
VITOUSEK, Peter		81	20		Biology, Ecology	Stanford
HOLLING, C. S. 'Buzz'		53	32		Systems Ecology	Florida, Beijer Fellow, RA member and author
MYERS, Norman		51	14		Environmental Science	Independent Advisor and Consulant associated with Oxford
LOREAU, Michel		40	13		Ecology	CNRS (France), McGill
PEARCE, David		38	15		Environmental Economics	University College London
SCHEFFER, Marten		35	14		Ecology	Waageningen U.; Beijer Fellow, RA member
CHAPIN, F. "Terry" Stuart		32	14		Ecosystem Ecology	U. Alaska-Fairbanks; Beijer Fellow, RA member
OSTROM, Elinor		22	33		Political Economy, Common Property	Indiana U.
ALCAMO, Joseph			27	5A	Environmental Engineer	U. Kassel, now Chief Scientist UNEP
GUNDERSON, Lance		19	22		Ecology	PhD Florida, Emory, Beijer Fellow, RA exec director and author
DIETZ, Thomas			21	3A	Environmental Sociology, Ecology	Michigan State
RASKIN, Paul	3		20		Environmentalist	Tellus Institute, Stockholm Environmental Institute, IPCC and other assessments
HOWARTH, Richard	3		18		Environmental/Ecological Economics	Dartmouth
REID, Walter			13	10A E P B V	Environmental Science	Stanford, World Fish Centre, MEA (Director)
SCHOLES, Robert			12	8A P V	Systems Ecology	CSIR (South Africa)
BENNETT, Elena	3			12A V	Ecology	PhD Wisconsin, McGill, RA member

The principal authors (n=534)[3] of the MEA represent a wide variety of disciplines, with 45 percent from the life sciences, as would be expected given the topic matter. Social and political sciences represent 19 percent, earth sciences 8 percent, resource sciences (fisheries, forestry, agriculture) 9 percent, and economics 13 percent. It is notable that ecological economics, the subfield that was central in developing the concept of ES (through the work of Costanza and the journal *Ecological Economics*), constitutes only 12 percent of the economics category. None of the economists among the 69 authors serving in core leadership roles[4] in the MEA, or in its governing bodies, self identify as ecological economists. They are either agricultural economists (e.g. Kanchan Chopra, Rachid Hassan, Monika Zurek) or environmental economists (e.g. Prabhu Pingali, Partha Dasgupta and Pushpam Kumar). Many of the above economists are, for instance, named as fellows of the Beijer Institute of Ecological Economics and collaborate with the Resilience Alliance. This may be due to a blurring of distinctions, with ecological economics appearing less radical as some of its ideas were taken up by multilateral institutions like UNEP, the World Bank, or TEEB.

Despite the broad disciplinary spread, the affiliations of the 69 authors serving in core leadership roles, as well as of the authors cited in the report's bibliography, demonstrate a striking concentration of people linked to the networks cited earlier, including Stanford University, the Beijer Institute, and the Resilience Alliance. The membership of the MEA's Board and its core writing team included a strong representation from Stanford (e.g. Mooney and Daily, both pioneers of ES, and Walter Reid, a specialist in managing and undertaking global assessments) as well as Partha Dasgupta of Cambridge, a strong proponent of 'payments for ecosystem services' (PES) and fellow of the Beijer Institute. The importance of these networks is demonstrated further by comparing important publications and citations in the scientific literature with the authors and cited publications in the MEA (highlights in Table 1). Aside from citations of the classic pieces by Costanza (1997) and Daily (1997), co-occurrence between the top 30 authors in the scientific literature and the MEA is largely restricted to authors working within the framework of resilience thinking and/or systems ecology (C. Folke, S. Carpenter, G. Peterson, H. Mooney) and economists linked to the Beijer Institute (P. Dasgupta, S. Polasky).

At the risk of simplification, what we have seen in this section is how a strong network of influential and ecologically-oriented scientists and economists, with a long tradition of seeking to make a difference in the management of this planet, and working within the contemporary dominance of neoliberalism in ideological and policy circles, came together to propose and promote ES as a key concept for environmental management. The concept served as a 'boundary object' (Star and Griesemer 1989), repackaging environmental concerns in a way that aligned with the anthropocentric and neoliberal tendencies of policy makers, and quickly gained wings. In the next section, we further investigate the ES as a boundary object, asking what it actually means.

[3] For 'principal authors' we included lead authors, coordinating lead authors, core writing team, and synthesis team members. These results apply to the full MEA (13 documents). For just the 'Theoretical framework' document, the numbers are similar with the exception of a larger economics presence (45% life sciences, 26% economics, 16% social sciences, 6% resource sciences, and 5% earth sciences).

[4] The number 69 represents those people who were either member of the exploratory committee, the board or the assessment panel and the authors of the theoretical framework and that were involved in a minimum of three chapters or documents. Pesche (2011), using the criteria of being member of one of the management bodies, arrives at a smaller number: 23.

4. Ontology: what does the concept consist of and do?

The ES concept frames the world in a particular way. It implies a particular ontology and epistomology about what can be known and how. ES is at its root a metaphor that helps humans communicate about the complex world (Larson, 2011, Norgaard, 2010, Tassin and Kull, 2013). In applying a term or phrase to something to which it is not literally applicable in order to suggest a resemblance, a metaphor brings together different orders of reality. It carries certain values, and provides a frame that can structure thought and action (Goffman, 1974).

In this section, we analyze the ontology of ES (what it is; the nature of its existence) through its two component metaphors, ecosystems and services. We point out how this double metaphor, in the neoliberal context of the 1990s and 2000s, served as a boundary object that could accommodate multiple interests. Successful concepts take root because they semantically and discursively create, reflect, or even co-produce points of consensus. Debates about the environment tend to be highly conflictual (Forsyth, 2003). In the face of such conflict, a successful concept must, at a minimum, allow a discussion between opposed interests and facilitate arbitration. Such 'boundary objects' are entities that carry widespread appeal, help translate between different interest groups, but can be used for different purposes by different actors. They are both, in the words of Star and Griesemer (1989, 393) "plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites". This lies behind the strength and endurance of buzzwords like 'sustainable development' (Kates et al. 2005; Lele, 1991), 'watershed management' (Cohen, 2012), and 'biological diversity' (Farnham, 2007).

4.1. The 'ecosystem' metaphor

The term 'ecosystem' tends to be used, in both scientific and public discourse, as an abstraction to refer to assemblages of species and their environment and the processes by which they interact. A forest may be called an ecosystem; so too a stream or a pile of cow dung. An ecosystem is a concept for analysis, not a tangible thing. Arising together with broader systems thinking, the idea is freighted with a historical analogy to an interacting, self-contained, self-perpetuating organism. Some have criticized it for being an inappropriate term for metastable adaptive systems (O'Neill, 2001), though, arguably, the term has evolved along with conceptions of it (Golley 1996; Pickett 2013).

A fundamental tension in the 'ecosystem' metaphor is the conceptual baggage associating it with 'nature' and other contexts where humans play a minor role at best. The images given in scientific discourse (textbooks, presentations, articles) tend to associate 'ecosystems' with forests, lakes, deserts, and other 'natural' areas, and we feel the need to add the qualifier 'urban' or 'agro-' when specifying those places with an obvious human imprint. In popular use, the concept evokes the agency and processes of a non-human nature, permitting for instance the comment "whoa, there is a whole ecosystem in there" when staring into the refrigerator at a container of long-forgotten, moldy leftovers.

There is a tension, then, between ecosystems representing 'external' nature separated from human influence, and 'universal' nature, the all-encompassing nature of which humans are a part (Williams, 1983; Ginn and Demeritt, 2009). This is ironic, for one of the reasons conservation biologists adopted ES as a term was due to the long-standing critiques of the ideas of pure nature.

According to Callicott et al. (1999), ES represents a functionalist conservation philosophy where humans are part of nature, as opposed to a compositionalist conservation philosophy where humans are separate from it.

A consequence of this tension is that the concept 'ecosystem' tends to be uncomfortably applied to anthropogenic assemblages of species and their environment, such as agricultural landscapes. This is because contrary to the idea of ecosystems as self-regulating natural assemblages, agricultural landscapes have particular histories and their components and processes are actively managed (or "piloted") by farmers for particular emergent properties (Tassin, 2012, p. 61). So while official definitions and schematic descriptions of ES are at pains to include anthropogenic nature – food crops from agricultural fields feature prominently among provisioning services, for example[5] – the value of ES to biologists is more frequently seen as justifying conservation of natural areas; the value of food crops is self-evident, after all.

4.2. The 'services' metaphor

The second half of ES is another metaphor. 'Service' can be understood in several ways – as the condition of serving a master, as an altruistic action, or, in an economic sense as an activity one pays for. The latter is the meaning evoked in ES, though there are echoes of the other senses. In the meeting of economics and ecology that created the concept, the motivational idea was the internalization of the externalities of economic production and consumption (Daily, 1997). Costanza et al. (1997b, p. 253) explicitly referred to "goods and services" and only dropped the word *goods* from *ecosystem services* "for simplicity."

The translation of human interactions with ecosystems to a transaction (usually paid for) occludes other types of interactions. These could be experiential, spiritual, or based on other metaphors like 'stewardship' or 'living with' (Turnhout et al., 2013). It is utilitarian and anthropocentric, which is only one way of looking at the world, and which has social consequences. Political ecologists have built strong critiques of how economic conceptions of nature abstract it from its spatial and social contexts, enroll it into capitalist relationships, and conceal or legitimate the social relations involved in its production (Castree, 2008; Ginn and Demeritt, 2009; McAfee, 1999, 2012a, b).

4.3. Common notions and boundary discourses

ES is a boundary object as well as a successful buzzword (Abson et al. 2014). Its strength comes from quickly making sense to those who hear it, even though their interpretations may be varied. It combines conservation concerns over forests, wetlands, and other components of 'nature', the economic logic of a capitalism that aspires to be greener, and development interests in human well-being. So, while the term is really an embedded contradiction ('ecosystems' evoke the non-human world, or at least non-human agency, and 'services' is purely an artefact of the human world), it rose to prominence as a concept of shared interests. Environmentalists see ES as a means to fund conservation; economists see ES as a way to incorporate externalities; policy makers see ES as a convenient tool.

[5] See e.g. the World Resources Institute's definition at http://pdf.wri.org/esrdefinitionsofecosystemservices.pdf (accessed 7 June 2012). Likewise, the MEA sees the scope of biodiversity extending to "all ecosystems managed and unmanaged: wildlands, nature preserves or national parks…; plantations, farms, croplands, aquaculture sites, rangelands or even urban parks and urban ecosystems" (MEA, 2005b, p. 18)

ES even serves as a 'boundary object' between different schools of thought within economics. For environmental economists, it is assumed that environmental degradation is due to the externalization of the costs of the damages caused by the use of nature as a tool of production. From this point of view, if these 'externalities' are internalized by giving them value – if the destroyers pay for destruction of nature while conservationist receive payments – then the environment can be protected. The value of any particular ES, can, then, be estimated through its marginal contribution to richness. In contrast, ecological economists begin by assuming that the economy is part of nature and subject to its fundamental limits. Ecosystems are unique and are not substitutable. Nature provides ES for humanity, but these services can only be furnished by ecosystems as a whole, and are not necessarily calculable through individual components. Despite the different assumptions of environmental and ecological economic, they seem to have both found common cause in the ES concept (Gómez-Baggethun et al., 2010).

In conclusion, we have seen in this section that the 'ecosystem' metaphor hides tensions between external and universal visions of nature, and that the 'services' metaphor implies a certain framing of society-environment relationship. Together they have succeeded in building bridges between conservationists, policy makers, and different economic schools of thought. Environmentally-minded biologists have sought to use the ES concept as a way of raising concern over ecosystem functions and ecosystem health, whereas more policy-oriented practitioners from economics, environmental policy, and conservation see ES (often framed as PES) instead as a crucial management tool (Castro-Larrañaga and Arnauld de Sartre, 2014). Even people who may be skeptical of the term use it to access policy audiences. The usefulness of ES as a boundary object is that it brings diverse audiences together; its challenges are that it hides unresolved conflicts. For instance much writing on ES uncritically conflates non-material values with calculable benefits (Chan et al. 2012). Furthermore, even if the concept represents undercurrents of diverse discourses, it has finished by taking on its own life, its own autonomy, its own agency. It participates in the social construction of nature in both senses – as an ontological construction of nature and as a materialization of this construction. The concept travels, doing its work – which as we will see in the next two sections is often quite political work. We will demonstrate this with examples of the application of ES to forest conservation in Brazil and Madagascar. In each case, we will analyze both the difficulties in measuring ES (section 5) and the politics of implementing ES policies (section 6).

5. From concept to practice: the devil in the details

While ES appears as a 'natural' notion to the many interest coalitions and epistemic communities that adopt it, the way it actually works and gets applied in practice belies a variety of scientific or ecological complexities. As Robertson (2012) notes, the abstractions of ES to which humans assign value pass through several moments: classification, categorization, unbundling, and stacking. These complexities lead to choices that are implicitly or explicitly political. They impact outcomes and benefit certain groups or views more than others. In this section, we identify four different types of choices that bedevil the application of ES.

5.1. Categorical consequences

The four commonly used ES meta-categories promoted in the MEA (2005a) – provisioning, cultural, regulating, and supporting services – are awkward, for they crisscross ontological and epistemological barriers. Some include single-variable items that are easily measurable under a capitalist logic (e.g. timber production), others are more difficult, multivariate, complex 'services' informed by climatological or ecological theory (e.g. climate regulation). Yet others are non-quantifiable conceptions rooted in human experience (e.g. landscapes of ritual significance). This diversity poses problems for aggregation and comparison across categories. Obviously, any classification scheme for ecosystem services reflects its purposes and uses, and these can be debated (Wallace, 2007; Costanza, 2008), but such transparency is often lacking.

The MEA categories hide a number of important distinctions that matter when the concepts are used for policy. **First**, they conflate indicators that are specifically services to humans with others that are better seen as indicators of ecosystem processes. The latter, including soil formation or photosynthesis, provide resources to different functional groups, including humans (Jax, 2005), but are not directly appropriable. **Second**, no distinction is made between what is actually used by humans (i.e., the products of a crop field) or what can *potentially* be used, such as the capacity of an ecosystem for providing a defined service like water cleaning. **Third**, the categories hide the fact that humans play a role in creating or facilitating many services. Soils may be formed by earthworms and other soil engineers, bees may do pollination work, but humans also shape ecosystems, most obviously in agriculture. Some aspects of ES are inherent, others are managed by humans. In the Amazon, for instance, Grimaldi et al. (2014) estimate that around 30% of the variation of soil ES are dependent on soil properties, 30% on farming practices and 40% on the interaction between farming practices and soil structure. Focusing analyses only on the services produced in a 'natural' area – or on a farm – can lead to not 'seeing' the effects of, respectively, humans or natural processes on the services provided.

5.2. Which service?

Any ecosystem provides multitudes of services, yet the need for specific evidence and quantifiability (see below) typically constrains researchers and policymakers to address only a small selection of them. Fifty percent of studies on ES study one sole service, without considering other services or the interactions between them (Seppelt, 2011). Focusing on one service like this can hide other services, functions and characteristics of ecosystems, and can push policy and management recommendations towards maximizing only this service, with diverse consequences. As such, the *choice* of service is highly political.

At its most obvious level, this can be illustrated by the preponderant focus on carbon sequestration. Pushed by important policy objectives related to climate change, and facilitated by the relative ease of quantification, global attention focuses on particular ecosystems, like rainforests, that stock large amounts of carbon. Yet as the debate over REDD+ and similar policies has shown, this downplays other services that are important to local livelihoods, focuses attention only on certain types of ecosystems, with the effect of reinforcing certain forms of poverty, inequality, and power relations (McAfee, 2012a).

Many authors have recognized the risk of focusing on single services. In particular, it has been recognized that there are 'trade-offs' between different services (Chisholm, 2012; de Groot et al., 2010; Martin-Lopez et al., 2012). Some services are contradictory to one another, particularly if they are maximized. These antagonisms are obvious in the case of biodiversity versus intensive food production, or forest carbon storage versus beef production. Yet contradictions can also be observed within a single category. For instance, in the Amazon again, Grimaldi et al. (2014) compared the supporting services of soil chemical quality and soil plant-available water, both essential for food production. They showed that these services do not co-vary in the landscape, and that one could be fulfilled while another was critically low.

This means that when studies choose to measure one particular variable as representative of a broader service, it may not reflect the full picture. For instance, let us look at Wendland et al. (2010), a study that investigates whether carbon offset payments in Madagascar could be justified as a means to fund biodiversity conservation or linked to additional water quality benefits. This study reduces 'water services' to water quality (as opposed to regulation or supply), and in turn reduces this to a predictive model of sediment-free water availability for drinking water, rice cultivation, and downstream mangroves. Clearly, analyzing one ecosystem service instead of another can fundamentally change the resulting assessment. Grimaldi et al. (2014) show that in the Amazon, it is possible to justify in the name of ES, either deforestation or conservation policies. It just depends on choices made in including and weighting different services.

5.3. Scale

The scale of analysis affects conclusions about ES (Swift et al., 2004). What is the unit of analysis? The planet? Or is it a country, an ecosystem, a farm, a landscape, a satellite image, transect, a specific forest plot, a particular species, or a category like invasive aliens (Pejchar and Mooney, 2009)? Certain aspects of each service are more prominent at different scales of measurement. Climate regulation services are measured globally (the amount of carbon sequestered) and typically broken down by country or biome. In contrast, productive services like food production are typically assessed locally – at the crop field or farm level – and aggregated upwards. ES benefits may differ across scales: for instance soil carbon capture contributes to global climate mitigation but also to local soil-based 'supporting services' for farmer. Services may best be managed at scales that differ from the scale at which benefits are measured or accrued. The farm scale makes sense for producers, but not for a community based management, for wildlife or for soil formation. Each scale frames the processes and potential human management actions differently.

The up-scaling of ES estimations made at lower scales generates many uncertainties. In an analysis based on the same Amazon data as Grimaldi et al. (2014), Le Clec'h et al. (2014) demonstrated that up-scaling the model-based estimations of various ES from a local scale (5 km^2) to a regional scale (50 km^2) led to differences of 30 to 60% per ES with the values measured in field-based verifications. Such issues make it impossible to correctly estimate ES tradeoffs at higher scales.

The study of ES in Madagascar (Wendland et al., 2010) cited earlier also highlights a number of scale issues. ***First***, this study illustrates some technical issues. The study models carbon storage services (based on a global database), water quality services (reduced to supply of sediment-free water, as noted earlier), and biodiversity services (based on range and threat data for mammals, birds, and amphibians, including hand-drawn maps). Quantitative indicators of these services were created for the entire island in pixels measuring roughly 1km on a side. Data were re-sampled down from lower resolution data, or combined from higher resolution data, to fit this grid. Global services (mitigation of atmospheric carbon) are mixed in each pixel with very localized services (clean drinking water for a particular village). The assumptions, multi-scale data sources, and data handling procedures involved in this process led to a hefty number of limitations and caveats described by the study's authors themselves that may affect the validity of the outcomes.

Second, Wendland et al. (2010) make a telling decision about the scalar bounds of their study. They limit their analysis to those pixels containing Madagascar's remaining wetlands and forests. This is internally consistent with their interest in terrestrial biodiversity, but given that the study is at a national scale this decision results in the somewhat circular finding that services exist in *these* areas as opposed to any others ("Sixty percent of the areas identified for PES in this analysis overlap with existing or proposed protected areas. This is not too surprising given the high biodiversity values and amount of forest cover found in these areas"; Wendland et al. 2010, p. 2103)

This is particularly so when (and this is the ***third*** point) the results are *represented* through particular scales (Rangan and Kull, 2009). The national scale maps presented by Wendland et al., which purport to show the distribution of 'multiple ES', give the impression that ES just come from natural, biodiverse forests and wetlands because these are the only areas that appear in shades of gray (the non-forest and non-wetland areas appear in white). The map captions do not remind readers that non-forest or wetland areas were not included in the analysis, resulting in a map that denying any potential role of other lands in ES provision. Services other than carbon, biodiversity, and water are downplayed as they are not shown. The result justifies the utility of a carbon offset payment for ES program for conservation. This is unsurprising, given the affiliation of the authors with the NGO Conservation International. The study's methodological, analytical, and representational choices frame the findings in ways that support a particular set of conservation politics that have been shown to be at odds with the interests and aspirations of local people (Corson, 2012; Keller, 2008; Pollini, 2011).

5.4. Quantification

There is an enormous pressure to quantify ES. Indeed, Costanza et al.'s (1997b, p. 253) seminal publication bluntly begins with the following: "Because ecosystem services are not fully 'captured' in commercial markets or adequately quantified in terms comparable with economic services and manufactured capital, they are often given too little weight in policy decisions." Yet the quantitative measurement of most ES is far from straightforward (Schroth and McNeely, 2011), even for more readily quantifiable services like carbon sequestration (Canadell and Raupach, 2008).

One consequence of the pressure for quantification is that it invites cherry picking of the most accessible and measurable variables. The Madagascar study we described above, Wendland et al. (2010, p. 2096) chose their variables because they are "the services where spatial data is easily attainable at the national scale". Likewise, when Pejchar and Mooney (2009, p. 502) review the cultural (dis)services provided by invasive species, they emphasize recreation and tourism (quantified in terms of revenue) and aesthetics (quantified using the impact of frog decibels on property values). They do not go into detail on other cultural services, such as impacts on "inspiration, spirituality, religion, ceremony and tradition", because they "remain poorly studied, complex and difficult to quantify". The result is a lop-sided, incomplete view of ES, privileging what can be counted and ignoring what cannot.

A second consequence is pressure to create aggregate measures to facilitate comparison or use in markets. Creating a combined unit of measurement for services as different as water cleaning, carbon storage or grain production contains many difficulties, both practical and ethical. As Robertson (2006, p. 382) notes, "The difference between selling ecosystem services and selling loaves of bread is that legal and capital logics require information about ecosystem services that scientists cannot provide in an uncontroversial way." Any combined indicator reflects social choices. Even if each individual variable is measured using recognized methods, and the method of combining the variables is based on statistical techniques, it reflects highly contingent and insufficiently explored choices.

Quantification can obscure scientific uncertainty and the political implications of how certain things are counted (or not) and calculated. Pressures to find quantifiable measures – which are by their nature more appropriate to some kinds of services than others – lead to increasingly technocratic approaches that hide the politics. It leads to rule by bean-counters, as opposed to by leaders. We may have better and better numbers, but leaders are needed to debate which numbers matter and which things are innumerable. Making complexity legible – in this case through selective numbers – invites forms of political control and economic commodification that can have pernicious side effects (MacDonald and Corson, 2012; Robertson, 2012).

6. Politics: impacts and opportunities

ES are highly political. Who (or what) benefits from the concept, and who loses? What kinds of avenues are opened, which ones are closed? In this section, we investigate the impacts and opportunities created by the concept in the complex, multi-scalar world of social and governance interactions. We first trace, based on the literature, the 'in principle' and somewhat black-and-white readings of 'winners' and 'losers' in what can be a very polarized debate. Then we draw on examples in Madagascar and particularly Brazil to look at the complex gray areas that may be opened by the application of ES, specifically through Reducing Emissions from Deforestation and Degradation (REDD) policies.

6.1. In principle

The confluence of interest between ecology and economics that is embodied in ES is meant to create a number of 'winners'. First, **ecosystems** are protected because they are properly valued. Second, **environmental governance**, under a neoliberal regime, becomes more efficient. Third, **people** win, for they benefit from the ES provided. And finally, the **service owners** benefit from the application of ES, for they can charge for the delivery of these services – and given the geography of ES, these could often be otherwise marginalized rural and/or indigenous people.

REDD is often touted as a good example of such a policy. In brief, this policy sought to compensate rainforest countries and residents for reducing deforestation, in order to reduce carbon emissions. This provides a global service: cost effective mitigation of climate change. In addition, it is argued, REDD benefits other, more local ES – watershed protection, biodiversity – and can be a source of sustainable financing for rural communities in developing countries.

Yet many critiques have been laid at ES in general, or REDD in particular – about winners not winning, about losers that are not mentioned, about collateral damage, or about missed alternatives and ideological consequences. Three themes stand out. *First*, critiques from a political economic angle see ES as creating new spaces of capitalist accumulation out of formerly common and/or public goods. They point out the irony of capitalism being harnessed to rectify the very problems it creates, and critique the way in which the process reifies dominant power relations and creates exclusions (Bumpus and Liverman, 2011; Corson and MacDonald, 2012; McAfee, 2012b). *Second*, the urgency of implementation, its top-down inspiration, and the size and strength of the finances involved are criticized for reversing some of the gains in decentralizing natural resource management. Instead of empowering rural managers, programs like REDD have led to a loss of local or community control (Phelps et al., 2010). *Third*, the use of ES sidelines other approaches to environmental management, whether regulatory, stewardship, or spiritual (Turnhout et al., 2013).

6.2. In practice

A jaded view might argue that the real winners of ES are the experts hired to produce reports, evaluations, and projects. More prosaically, it behooves us to note the complexity of impacts and uses of ES by multiple actors at diverse scales and in varied social contexts. There is, as Pirard and Broughton (2011, p. 1) note, a remarkable heterogeneity in the mechanisms lumped under ‘market-based instruments’, and they only have ‘loose links to markets as defined by economic theory’ but instead close ties to legal frameworks and public policy. ES are being used, together with other market-based instruments, for agendas not easily glossed as neoliberalization, indeed, they “significantly exceed conventional versions of neoliberalism both in the diversity of their empirical forms and in the polyphony of theoretical justifications and foundational principles” (Dempsey and Robertson, 2012, p. 773). In other words, the application of ES messily reflects the specific political, ecological, and historical context: which actors, which country, at what scale.

This becomes evident when investigating the implementation of REDD and other payment for ES programs in tropical rainforest countries. At a global level, rainforests are mainly seen as carbon traps (Bidaud, 2011; Moolna, 2012; Desvallées, 2014). Locally and regionally, of course, rainforests (and cleared rainforest lands) provide diverse other services, from food production to nutrient cycling. At a national level, there is strong interest in forests as an income source, and many governments lobbied strongly for REDD and other programs in order to bring these income streams to their country (to augment or replace logging income, or to finance sustainable development; Angelsen et al., 2009). But the way they do so is extremely diverse – here we contrast Madagascar with multiple administrative scales in Brazil.

In Madagascar, ES are mobilized mainly to justify and finance the conservation or preservation of biodiversity in more ‘natural’ landscapes. The policies are largely initiated and implemented by international actors from development agencies and conservation organizations in what has been called a ‘governance state’ (Duffy, 2006). One result has been five pilot REDD projects promoting forest conservation in zones varying from 2000 to 372,000 hectares through carbon offset funds from overseas (Ferguson, 2009; Rakotoarijaona, 2012). Unfortunately, however, incentive-based conservation mechanisms in Madagascar have been demonstrated to struggle with a national context of poor governance and instability. They face serious problems with the distribution of costs and benefits, creating winners and losers within local communities (Kari and Korhonen-Kurki

2013; Brimont and Bidaud, 2014).

Brazil, home to the lion's share of the Amazonian rainforest, provides a starkly different example. The dramatic decrease in deforestation rates since 2006 is attributed to increased productivity in the Cerrado region (Brown, 2013) and to command and control policies (Dalla Nora, 2013). This result obviates a need for REDD funds. Furthermore, Brazil is jealous of its sovereignty (Arnauld de Sartre and Taravella, 2008) and thus is sensitive to the loss of policy control in REDD and other payment for ecosystem services projects (Aubertin et al., 2014). Yet the federal government still uses ES to justify policies, but not directly for conservation, instead in the agricultural and social sectors.

One program, *ProAmbiente*, aimed to pay small-scale farmers on the Amazonian frontier to adopt less aggressive deforestation practices not involving fire. This program grew out of local relationships and national politics, particularly the lobbying of trade unions and others in defense of small-scale family farming (Arnauld de Sartre and Berdoulay, 2011). *ProAmbiente* was criticized for three reasons. First, it focused only on certain practices, such as slash-and-burn cultivation, to the detriment of others such as incentives for perennial crops. It did not support activities which favored landscape heterogeneity (Eloy, 2012). Second, even if the farmers received the payments (which rarely occurred), they would have lost money adopting the prescribed practices due to increased labor demands (Börner et al., 2007). Finally, the program, if adopted at a broad scale, could have had a negative impact on the regional economy (Costa, 2009). Family farmers were the main losers, as well as democracy since the program led to the reinforcement of clientelistic practices.

ProAmbiente was one of the few program developed by the federal Brazilian government. State governments are more interested in ES based policies to finance infrastructure projects. In Amazonas, for instance, a large program of payment for environmental services is dedicated to protected areas. It is composed of four different subprograms that fund social infrastructure, associations, productive activities or families. Families living in protected areas (who typically fall into categories known in Brazil as 'traditional populations', such as 'ribeirinhos', riverine descendants of indigenous people) can receive income supplements of up to 25$ a month for engaging themselves in practices favorable to nature conservation. This mechanism is not a real compensation payment since farmers cannot choose whether or not to implement the practices. As they are in the protected area, they have to follow its rules, and the payment can be seen as a tool to facilitate the acceptance of these rules. The program is funded through a partnership between the federal government (through the *Fundo Amazonia*), the state, and various corporations. Many programs like this exist, but they have little to do with the idealized theoretical frameworks for payments for ES (e.g. Engel et al., 2008) as they encompass a mix of social transfers, compensation systems, price supports, contracts, stipends for environmental actors, and hopes about carbon markets. They are institutional arrangements bringing together diverse public institutions, sometimes with civil society, but rarely with the private sector (Aubertin et al., 2014)

To conclude, ES create winners and losers, but one cannot be categorical about how this concept plays out across the two different contexts. Even if the concept of ES has largely served to give rhetorical weight and new tools to those who seek to conserve biodiversity (as in Madagascar), it has also been harnessed (as in Brazil) to justify public policies focused on social welfare or farm support. It has not found a major place in formal markets (c.f. Dempsey and Roberston, 2012).

7. Conclusion

Following a political ecology framework, we have investigated the origins, assumptions, and networks of knowledge and power behind the 'ecosystem services' idea, the practical on-the-ground difficulties of applying the idea, and its impacts on and uses by different parts of society in different contexts. The concept is simultaneously a technical, pedagogic, heuristic, policy, and political notion. When it serves to reinforce the idea that humans are dependent on ecosystems, it is pedagogical. When scientists use it to have a different gaze on the environment, it has a heuristic function. When it is used to justify conservation, social or agricultural policies, it is a policy-framing notion. And when it helps to solve conflicts or to engage different actors with one another, it is a political notion. The ES concept is a boundary object with widespread appeal, used in diverse ways by different interests to justify different kinds of interventions that at times might be totally opposed. As a powerful concept, it must be engaged with.[6] Yet, it is important to remember that many choices are made in selecting and applying the ES concept. They make ES political (Rangan and Kull 2009).

ES is fundamentally political in how it frames society-environment relationships. It creates new market, property, and power relations out of what were often common or public goods, and in doing so, it can exclude or disempower some people to the benefit of others, as the Madagascar studies cited show. But it does not necessarily do so. The standard, more simplistic critique of neoliberalism does not always apply; ES can have variable impacts. While ES has often been harnessed to justify and finance a biodiversity conservation agenda as in Madagascar, we have seen that it has also been appropriated by other actors – notably activists representing traditional people (ribeirinhos) and family farming lobbies in Brazil – to further other agendas. The apparent consensuses around biodiversity and neoliberal policies that stand behind ES are not shared by all, nor understood in the same way, so it is important to trace the overlaps and contradictions of different epistemic communities and how they become expressed through political processes in particular countries and regional contexts (cf. Bailey and Caprotti, 2014).

Political ecologists have long asserted that environmental change is not just a scientific or technical phenomenon, but fundamentally social. ES as a concept is a perfect illustration of this. Couched in the language of scientific certainty, the concept facilitates certain types of interventions and discussions that reflect particular discourses, power relations, and political-economic structures, even if, at times, it is somewhat subverted as we saw in Brazil. Yet ES's utility is not in formulating the questions that societies must ask when debating resource management policies and actions. ES does not resolve questions of winners and losers, trade-offs, and who has the right to decide and the might to enforce. It is, however, well placed to provide evidence that informs these social and political

[6] The crowning moment ES in the MEA perhaps also marked its apogee. Citation analyses show that citations to 'ecosystem services' were lower in the decade after the MEA compared to the decade before the MEA for the founding disciplines of ecology and economy, but that the concept lives on strongly in applied disciplines like conservation biology and environmental management (authors, unpublished material). It is prominent, for instance, in the IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services) launched by the United Nations in 2012.

decisions – this plot of trees sequesters X tons of carbon; this valley is habitat for Y families of mammals; this forest supports the livelihood needs of Z families. In the end, human societies are the arena where such decisions are negotiated. Legislators, agencies, and private actors make proposals and counterproposals; activists and scientists and the media shape the discourses used; institutions appropriate ideas, implement them in their own way, learning and adjusting along the way; and throughout people lobby, contest, and protest. The initial idea evolves. This has been the story of ES – an idea with political ambitions takes wings, crosses boundaries, and gets harnessed or applied in hundreds of contexts.

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