

Opinion

Have Ecosystem Services Been Oversold?

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The concept of ecosystem services (ES) neatly encapsulates the ways in which human society depends upon the existence and functioning of nature, but also draws power by chiming with dominant neoliberal ideology. Scientific paradigms such as this have an inherent tendency to stop adherents from recognizing alternative approaches. It is high time to examine whether the concept is being oversold with potentially damaging consequences. Many authors have questioned the monetization of ES, but the origin of the problem lies deeper in anthropocentrism. By illustration with alternatives, I attempt to show how the ES paradigm has constrained thought, particularly towards the monetization and financialization of nature, even when many ecologists and others oppose this trend.

From Metaphor to Tradable Commodity

Since 2005, when **ecosystem services** (ES) were given prominence in the Millennium Ecosystem Assessment (MEA) [1], the concept has become the dominant paradigm framing research and policy making in biodiversity, ecology and conservation biology. At the same time, major nature conservation organizations have refocused their missions towards the needs of humans [2] and 'nature' has now been redefined as 'natural capital' [3]. Scientific concepts change over time, and it is instructive to look back at how 'ES' developed from Arthur Tansley's original idea of the 'ecosystem'. Tansley's 1935 paper [4] provided us with the abstract concept of nature that was necessary to start thinking about function (Table 1). Once **ecosystem functions** (see Glossary) were defined, they could become commodified, valued, and then monetized. The idea that nature has a **use value** has historical roots in philosophy and economics. Classical economists recognized nature as a source of use value, but attributed the **exchange value** belonging, for example, to a stand of trees as deriving from the ownership of the land on which the trees stood or to the labor involved in turning them into merchantable timber, not directly to the trees themselves [5]. In the same the vein, when the term ES was first employed for pedagogical purposes in the ecological literature of the 1980s, it was usually as a metaphor for the use value of nature. Valuing nature does not necessarily mean monetizing it, but it seems that the two are hard to separate. Attempts had already been made in previous decades to place a monetary value on 'nature's services' [6], for example to estimate the **external cost** of damage caused by pollution [7].

The transformation of ES into exchange values, which has now reached industrial proportions, continues to be motivated by the idea that nature will benefit if the external costs of actions that exploit or damage ecosystems are made explicit [8]. Nature will then (i) be preserved on account of its recognized true exchange value, (ii) gain if the higher price in the market caused by including external costs reduces demand for the damaging activity, and/or (iii) be compensated to restore damage. This is the logic variously behind the 'Payment for Ecosystem Services' program of the Global Environment Facility [9], carbon and emissions trading [10], and the REDD+ program (Reducing Emissions from Deforestation and Degradation) [11]. Once markets in a commodity

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Table 1. How the Development of the ES Paradigm Has Constrained Thinking About Nature and Some Alternatives to These Developments

Concept of nature (date of introduction)	Ontology	Transformation of the concept of nature	Constraint introduced by the transformation	Alternative
Ecosystems (1935)	Ecosystem functions including nutrient stocks and cycles, energy flow	Abstraction	Intrinsic value of biodiversity can become secondary to its generic roles in ecosystem function [18]. For example, plants are treated merely as 'biomass'	Explicit recognition and inclusion in ecological models and thinking of processes at the individual, population, and community levels [17]
Ecosystem services (1980s)	Provisioning, regulating, cultural and supporting services [1] (Table 1)	Commodification	A wholly-anthropocentric concept of nature [28]	Conservation for biodiversity's sake [2]
ES values (1990s)	Market prices, hedonic prices, travel costs, replacement costs, contingent valuation, discount rates [21]	Monetization	Reduces the intrinsic worth of nature to that which can be monetized [38]	Broader concepts of the value of nature [41,46]
ES markets (2000s)	Markets in wildlife, emissions trading, payment for ecosystem services, e.g., REDD+	Marketization	Conceptualization of environmental problems and their solution become focused on markets, even when such markets are artificial [11]	Recognize that ES markets are rarely if ever a solution to conservation problems. Protect nature from market forces, not expose it to them
ES-based financial instruments (2000s)	Carbon permits, biodiversity offsets, debt-for-nature swaps, green investment products	Financialization	Environmental objectives become secondary to financial ones [10]; control shifts from people to corporations [47]	Public investment in conservation under democratic rather than market control

exist, it is but a small and seemingly inevitable step to financialization (Table 1), in which derivatives of the underlying ES become tradable assets.

A milestone in the monetization of ES was reached in 1997 when Costanza *et al.* [12] published a dollar estimate of the value of the ES of the entire planet (Table 2). Clearly anticipating that the validity of the exercise would be challenged, the authors contended that 'although ecosystem valuation is certainly difficult and fraught with uncertainties, one choice we do not have is whether or not to do it'. This explicit statement illustrates how the 'monetized ecosystem services' (MES) paradigm seeks to define the legitimate boundaries of thought. Although Costanza *et al.* were heavily criticized and even derided [13], the paper went on to be cited more than 4000 times, the global estimate was updated, and the imperative to monetize was reiterated by Costanza *et al.* in 2014 [14].

Alternatives

Contrary to the claim that there is no choice about how we define nature, there are clear alternatives to each one of the conceptual developments that has taken place – from Tansley's initial abstraction to the current trend of financialization (Table 1). Whether one believes that any of these conceptual developments is right or wrong, it is important to appreciate that all have involved choices that have, often invisibly, shaped our thinking about nature.

Glossary

Contingent valuation (CV): a method used in economics to place a monetary value upon non-market goods and services by asking people the hypothetical question of how much they would be willing to pay for them.

Devaluing by monetization: reducing the intrinsic worth of nature by attaching a monetary value to it.

Ecosystem function: the ecological processes that take place in an ecosystem, including photosynthetic fixation of CO₂, decomposition, nutrient uptake, and population processes at all trophic levels.

Ecosystem services (ES): the goods and services of use to humans that are directly attributable to the ecological functioning of ecosystems.

Exchange value: the price at which an item is bought and sold in the market.

External cost: the cost to the environment of damage or exploitation that is not reflected in the market price of the goods or services produced. For example, the price of aviation fuel does not reflect the environmental costs of burning it.

Make-believe markets: all markets are social constructs, but make-believe markets exist only in the mind of the researcher who invents them to fit reality to their model instead of fitting their model to reality. CV is a tool that depends on make-believe markets.

Monetized ecosystem services

(MES): ES on which a price has been fixed.

Natural capital: 'Earth's lands and waters and their biodiversity' [3].

Neoliberalism: a political and economic philosophy that seeks the de-regulation of markets and the privatization of all possible goods and services [45].

Non-use value: the value of an item attributed to its existence, not to its use. For example, the aesthetic pleasure given by wild birds (*cf.* Use value)

Payment for ecosystem services (PES): a policy instrument that seeks to influence the supply of ES by payments from the beneficiaries to those controlling the supply.

Public goods: goods that are free to all and that can be consumed without reducing their benefit to

Table 2. Summary of Monetized ES for the Entire Earth Calculated by Costanza *et al.* [12]

Ecosystem service	Total global flow, \$year ⁻¹ × 10 ⁹
Gas regulation	\$1341
Climate regulation	\$684
Disturbance regulation	\$1779
Water regulation	\$1115
Water supply	\$1692
Erosion control	\$576
Soil formation	\$53
Nutrient cycling	\$17 075
Waste treatment	\$2277
Pollination	\$117
Biological control	\$417
Refugia	\$124
Food production	\$1386
Raw materials	\$721
Genetic resources	\$79
Recreation	\$815
Cultural	\$3015
Total	\$33 268

others. For example, clean air and public sanitation.

Revealed preference: an indirect method of estimating the monetary value of an ecosystem service (e.g., woodland amenity) based upon how much people spend to access or travel to the site. Note that this method gives higher amenity value to a visitor who travels by car than someone who travels on foot or by bicycle, even though the former involves the least effort and is the most environmentally damaging.

Use value: the qualitative value of an item owing to its usefulness, as distinct from its monetary value in a free market (*cf.* Exchange value).

In his book, *What Money Can't Buy* [15], political scientist and philosopher Michael Sandel argues that society can and does choose not to place a price on certain things, and that it is morally right to reject market valuation in a range of important cases. For example, people are not allowed to sell their organs or their children. These have an intrinsic value that is beyond price. Sandel discusses how the political dominance of **neoliberalism** – the philosophy that seeks the deregulation of markets and the privatization of all possible goods and services – has caused market concepts and practices to enter more and more areas where once they were absent or even anathema. He argues that markets degrade some goods and practices by turning them into commodities. For example, the possibility that nature has an intrinsic, existential value of its own that is independent of its use to humans cannot be accommodated by the market because nature itself is not an actor in that market. Nature is **devalued by monetization**. All non-commercial notions are invisible to 'the one-eyed imperatives' of capital [16].

Ecological economists can go to great, one might even think absurd, lengths to try to make the invisible visible (Box 1). Biodiversity and ecological complexity can easily become casualties of the market's need for a single number that represents value. In 2012, one of the lead authors of the MEA complained in an article in this journal that the role of species in supplying the services that ecosystems provide was being obscured by a confusion between biodiversity and ES. Mace *et al.* [17] wrote that 'In some cases, the two terms (biodiversity and ES) are used almost synonymously, implying that they are effectively the same thing and that if ES are managed well, biodiversity will be retained and vice versa.' Addressing the same issue, Peterson *et al.* [18] argue that obscuring the role of the biota in ecosystems is a direct consequence of replacing the concept of ecosystem function with that of ES.

Sandel [15] demonstrates that the decision to attach a price to something is ultimately a moral choice, not a scientific, logical, or even economic imperative. This is of course at variance with

Box 1. Make-Believe Markets

A fundamental problem with ES monetization is that there are no markets for many of the goods and services that ecosystems provide. The MES paradigm has essentially three solutions to this: (i) invent a market, for example in carbon credits (licenses to pollute), (ii) pretend there is a market and ask people how they would value ES in hypothetical situations (the '**contingent valuation**' method), and (iii) use a surrogate to value ES, for example the total cost to visitors of traveling by car to a natural area as the recreation value of that area (the '**revealed preference**' method). A significant portion of the literature on the valuation of ES is devoted to the technical issues that arise in make-believe markets [48].

Contingent valuation (CV) is a method that has been widely used for decades, but its results are particularly subjective. The response of someone asked a typical survey question such as: 'how much would you be willing to pay towards a project that will increase the number of Red Kites in Scotland from 59 now to 200 in 10 years time', not surprisingly depends upon how much time they are given to think about it [49]. It will also depend upon their disposable income and whether they can suspend disbelief in the fiction that has been presented to them. More than half the people interviewed in an Australian CV study said that they would not be willing to pay anything at all towards the protection of endangered birds, even though over 80% said they would be upset if a bird went extinct [50].

Such differences between people's feelings about extinction when expressed in monetary and non-monetary ways shows exactly how misleading ES monetization can be. Far from protecting species by valuing them as is claimed, MES weakens the case for protection because it ignores the moral feeling people have against extinction unless they are rich and/or compliant enough to place a price upon this. A study that interviewed participants in a CV exercise after the survey had taken place found that respondents had a much more sophisticated and multi-dimensional sense of the value of nature than the 'willingness-to-pay' questions that they were asked allowed them to express [51]. The study authors reported that 'There was a feeling of moral outrage..that a monetary sum was being used as a measure of what individuals saw as their ethical and moral values for nature.' Participants rejected the idea that the CV exercise was a legitimate way in which to decide an environmental issue, and wanted instead a process in which local people, scientists, and policy-makers could all participate through dialogue.

the MES paradigm that insists that we have no such choice [12]. The issue of whether monetization is essential or not defines two different approaches to ES. On the one hand, where monetization is optional it is used mainly as a metaphor, while on the other monetization is the very purpose of redefining ecosystem functions as ES. If we follow Sandel's argument that monetization is an option not an imperative, we can then ask when it is appropriate to monetize and then use the approach pragmatically [19].

Do Markets Actually Protect Biodiversity and Ecosystem Function?

The acid test of the MES paradigm is whether placing a price on biodiversity and ecosystem function actually leads to greater protection and improvement, or merely puts a price on destruction. The literature contains a great many examples of the monetary valuation of ES made to demonstrate ES value [20], but the evidence that this monetization has itself resulted in benefits that would not otherwise accrue is almost always missing. Perhaps the largest number of case studies has been collated by the TEEB project (The Economics of Ecosystems and Biodiversity) which has summaries of 122 MES initiatives from all over the world on its website (<http://www.teebweb.org/resources/case-studies>). Most of the TEEB case studies were compiled in 2010 when the main TEEB report was published [21], and very few contain any evaluation of whether the projects that are described improved biodiversity or ES. The purpose of TEEB was 'to show how economic concepts and tools can help equip society with the means to incorporate the values of nature into decision making at all levels' [21]. Evidence that doing this would actually benefit biodiversity is absent from the report, and a recent update published in 2014 similarly lacks any evidence [22].

A key idea in the MEA and in the promotion of the concept of ES was that, because humans are dependent upon ES, actions that protect ES can also benefit humans. Howe *et al.* [23] conducted a meta-analysis of a sample of the ES literature to test whether win-wins of the type envisaged in the MEA were common compared to trade-offs in which gains in human welfare were made at the expense of ES. They concluded that win-wins are the exception rather than the rule and that trade-offs are more likely in situations where private interests or markets are present.

Many of the TEEB case studies involve monetization for accountancy purposes only and do not involve genuine markets. It ought to be easier to tell whether monetization has benefits in situations where actual markets exist. Two clear examples involve (i) **payment for ecosystem services** (PES), and (ii) wildlife trade. A review of PES published in 2014 found that there was insufficient evidence to decide whether it generally works as intended or not [24]. One reason for this is that PES markets tend to be highly artificial, often being designed, or morphing into, schemes to distribute government subsidies to farmers [25]. A recognized problem with PES as a global strategy is that it rewards property owners and thereby increases wealth inequalities [26,27], which is contrary to the principles of sustainable development.

The wildlife trade is undoubtedly the most absolute form of market for biodiversity and should be the best test of what critics describe as the MES strategy of 'selling species to save them' [28]. The international trade in wildlife is regulated by the Convention on International Trade in Endangered Species (CITES) which restricts or bans trade in more than 30 000 species. In 1989 the 173 parties to CITES decided to protect African elephants by closing the international market for ivory, with the result that numbers rose by an estimated 140 000 in the 8 years following the ban [29]. Unfortunately, domestic markets in ivory continued to operate within four African states, providing poachers in adjacent countries with an outlet under the cover of the legal market. Poaching and illegal trade have now reached devastating levels that are causing a global decline in African elephants [30]. It could be argued that this is not the responsibility of markets *per se*, but of illegal trading. However, the evidence is that markets and illegal activity are bedfellows and that, even when operating within the law, large corporations rig markets for their own benefit [10]. Since 2008 it has become clear that the financial markets are not immune to illegal and risky behavior on a scale that has threatened the stability of the entire global economy. Is it wise to stake the survival of 30 000 species on a bet that they can be saved by the market, legal or otherwise?

Indeed, even within the MES paradigm itself it is recognized that speculators could profit from the increasing rarity of valuable species because this would increase their price in the market [31]. There is a market in extinction. This has already brought bluefin tuna and black rhino to the brink, and is possibly doing so now for African elephants. Ultimately, if there is a market for a species, or if it occupies habitat where the land would be more valuable housing people or corporations, then market efficiency can dictate its extinction [32]. From a MES perspective, the logical answer to this situation would be for those who want to save threatened species to put their money where their mouths are and outbid the threat – effectively paying for the preservation of the desired ecosystem service (PES). This does occur when land for nature conservation is bought on the open market, but it happens out of necessity and it is a tactic, not a sustainable global strategy. If it were to become a strategy, we should have to accept that nature is a private resource and not a **public good** – and that we can only have the nature that we can personally afford. As ever with markets, the poor will be further impoverished [33].

There is another important difference between one-off tactical purchases of habitat to protect ES and strategic MES. Tactical purchases, for example to add land to a national park or protected area, can achieve permanent protection against present and future threats. By contrast, strategic MES can achieve short-term protection, but also exposes biodiversity and ES to the vagaries of the market. Some iconic examples of MES have fallen foul of this hazard. Mexican free-tail bats feed on aerial insects including pests of cotton in the southwestern USA. The value of pest-control by bats was estimated to be \$23.96 million in 1990, but falls in the price of cotton and the introduction by farmers of bt-varieties that are engineered to be resistant to caterpillars combined to reduce the value of this service to only \$4.88 million in 2008 [34].

In Costa Rica, a study found that coffee plantations benefited from lower levels of pests when surrounding bird habitats were preserved. Then, a fall in the market price of coffee caused farmers to switch to growing pineapples instead, and forest habitats as well as coffee plantations were replaced with the more profitable crop [28]. There is a close parallel between MES today and the field of economic ornithology which flourished in the 1880s–1920s. This sought to monetize the value of wild birds in pest control and a wide range of other services, from use as carrier pigeons for the military to supplying the ingredients of birds' nest soup [35]. Unlike MES, economic ornithology explicitly recognized that wild birds could be economically injurious, for example in carrying disease. Economic ornithology had some success in controlling the wanton destruction of wild birds, but its main *raison d'être* was destroyed by the introduction of chemical pesticides. The clear lesson from both the historical and contemporary examples of MES is that relying mainly on monetized values puts biodiversity at the mercy of changeable markets and advancing technology.

These flawed attempts to use MES to justify the protection of biodiversity contrast with a recent success in forest protection in Britain. There, a popular mass-movement rejected the neoliberal policy of a government intent on privatizing the nation's publicly-owned forests, showing that democratic conservation action can obtain results where technocratic valuation fails (Box 2).

ES without Markets

The concepts of ES and **natural capital** define nature in anthropocentric terms. Whether one subscribes to this anthropocentrism or not, it is important to realize that it is an ideologically chosen standpoint and not one dictated by science, even though humans now undoubtedly dominate the planet [36]. As a development of anthropocentrism, monetization of ES was introduced into ecological thinking as a means to connect with policy-making, but it is clear that few outside the field of ecological economics believe that MES can adequately capture the multi-faceted sense in which people value nature [19,28,37–43]. The widely made assumption that monetization and markets benefit biodiversity and ES has not been systematically tested against the evidence. I suggest that this fundamental tenet has remained untested because the MES paradigm holds that there is no alternative to monetizing the value of nature [12,14]. While this

Box 2. Britain's Forests: Public or Private?

Britain is one of the least-wooded countries in Europe, with only 13% of land area under forest [52]. Over a quarter of this is owned or managed by the Forestry Commission – which was set up in 1919 to ensure that the timber shortage that had threatened the war effort in the First World War would not recur. Large areas of land were acquired by the Commission and planted, mainly with non-native conifers. However, when the Second World War began in 1939, even the first of the new plantations were only 20 years old and the trees in them were not usable.

After WWII, planting continued on public and private land, and felling was strictly regulated by license to build up a strategic reserve of standing timber [53]. Ironically, as these plantations began to mature, the economics of forestry changed; the price of timber fell, the cost of labor increased, and the need for a strategic reserve was challenged [54]. The Forestry Commission eventually altered its policy and began to manage forests for public amenity and nature conservation as well as for production. Economists used the indirect revealed preference method to monetize the amenity value of forests, and found that visitors spent an estimated £53m on traveling by car to reach Forestry Commission sites compared to £71m earned by the organization from timber in the same year [55].

In October 2010, the recently elected government in the UK announced that it intended to privatize the forests held by the Forestry Commission. New governments with a fresh mandate expect to have their own way, but by February 2011 a storm of public opposition and half a million signatures on a petition forced the government to abandon the policy [56]. In many ways, the two sides on this issue embody the difference between how the public values nature and how it is valued within the MES paradigm. On the one side, the public value forest for its aesthetic and **non-use values**, and object to attempts at monetization and privatization (Box 1). On the other is a neoliberal government for whom the MES paradigm offers a technocratic rationale for the deployment of its natural capital. Several large nature conservation organizations expressed themselves neutral on the issue of forest privatization, taking the view that it is regulation and not ownership that matters. In fact, neoliberal governments cut regulatory agencies, as the same UK government has done in the realm of nature conservation, preferring to cede control as well as ownership to private enterprise.

situation persists, the MES paradigm will remain immune to refutation and hence open to the charge that it is propaganda and not science.

The strong claim that we are compelled to put a monetary value upon ES [12] can and should be rejected together with the whole apparatus of **make-believe markets** (Box 1). If we choose to take the position, which is shared by many people, that some things in nature are without price, then it is possible to use the concept of ES in a more nuanced way to build upon the moral case for biodiversity conservation and not to displace or devalue it by monetization [41]. Two recent surveys of the opinions of professional conservationists towards ES monetization and the market reported that most of them, including MES skeptics, were pragmatic about its use [42,44]. From this perspective, there will be occasions when it is valid and useful to calculate the monetary value of a particular ecosystem service, but even in these cases it will be important to recognize that such valuation is contingent on market conditions. Such decisions need to be made democratically and should not be obscured by false quantification of value in markets that are at best fickle and at worst corrupt.

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References

1. Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-Being: Synthesis*, Island Press
2. Doak, D.F. *et al.* (2014) What is the future of conservation? *Trends Ecol. Evol.* 29, 77–81
3. Daily, G.C. *et al.* (2011) Mainstreaming natural capital into decisions. In *Natural Capital. Theory and Practice of Mapping Ecosystem Services* (Kareiva, P.M. *et al.*, eds), pp. 3–14, Oxford University Press
4. Tansley, A.G. (1935) The use and abuse of vegetational concepts and terms. *Ecology* 16, 284–307
5. Gómez-Baggethun, E. *et al.* (2010) The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. *Ecol. Econ.* 69, 1209–1218
6. Baveye, P.C. *et al.* (2013) Monetary valuation of ecosystem services: it matters to get the timeline right. *Ecol. Econ.* 95, 231–235
7. Westman, W.E. (1977) How much are nature's services worth? *Science* 197, 960–964
8. Kruger, O. (2005) The role of ecotourism in conservation: panacea or Pandora's box? *Biodivers. Conserv.* 14, 579–600
9. Cavelier, J. and Gray, I.M. (2014) *GEF Investments on Payments for Ecosystem Services*, Global Environment Facility
10. Spash, C.L. (2010) The brave new world of carbon trading. *New Political Econ.* 15, 169–195
11. Corbera, E. (2012) Problematising REDD+ as an experiment in payments for ecosystem services. *Curr. Opin. Environ. Sustain.* 4, 612–619
12. Costanza, R. *et al.* (1997) The value of the world's ecosystem services and natural capital. *Nature* 387, 253–260
13. Editorial (1998) Audacious bid to value the planet whips up a storm. *Nature* 395, 430
14. Costanza, R. *et al.* (2014) Changes in the global value of ecosystem services. *Global Environ. Change Hum. Policy Dimen.* 26, 152–158
15. Sandel, M.J. (2012) *What Money Can't Buy: The Moral Limits of Markets*, Allen Lane
16. Robertson, M.M. (2006) The nature that capital can see: science, state, and market in the commodification of ecosystem services. *Environ. Plann. D: Soc. Space* 24, 367–387
17. Mace, G.M. *et al.* (2012) Biodiversity and ecosystem services: a multilayered relationship. *Trends Ecol. Evol.* 27, 19–26
18. Peterson, M.J. *et al.* (2010) Obscuring ecosystem function with application of the ecosystem services concept. *Conserv. Biol.* 24, 113–119
19. Kallis, G. *et al.* (2013) To value or not to value? That is not the question. *Ecol. Econ.* 94, 97–105
20. Kareiva, P.M. *et al.* (2011) *Natural Capital. Theory and Practice of Mapping Ecosystem Services*, Oxford University Press
21. Sukhdev, P. *et al.* (2010) Mainstreaming the Economics of Nature: A synthesis of the Approach. In *Conclusions and Recommendations of TEEB*. TEEB
22. Sukhdev, P. *et al.* (2014) The economics of ecosystems and biodiversity (TEEB): challenges and responses. In *Nature in the Balance: The Economics of Biodiversity* (Helm, D. and Hepburn, C., eds), pp. 135–152, Oxford University Press
23. Howe, C. *et al.* (2014) Creating win-wins from trade-offs? Ecosystem services for human well-being: A meta-analysis of ecosystem service trade-offs and synergies in the real world. *Global Environ. Change* 28, 263–275
24. Miteva, D.A. *et al.* (2014) Do biodiversity policies work? The case for conservation evaluation. In *Nature in the Balance: The Economics of Biodiversity* (Helm, D. and Hepburn, C., eds), pp. 251–284, Oxford University Press
25. Shapiro-Garza, E. (2013) Contesting the market-based nature of Mexico's national payments for ecosystem services programs: four sites of articulation and hybridization. *Geoforum* 46, 5–15
26. McAfee, K. (2012) The contradictory logic of global ecosystem services markets. *Dev. Change* 43, 105–131
27. Kronenberg, J. and Hubacek, K. (2013) Could payments for ecosystem services create an 'ecosystem service curse'? *Ecol. Soc.* 18, 1–12
28. McCauley, D.J. (2006) Selling out on nature. *Nature* 443, 27–28
29. Lemieux, A.M. and Clarke, R.V. (2009) The international ban on ivory sales and its effects on elephant poaching in Africa. *Br. J. Criminol.* 49, 451–471
30. Wittemyer, G. *et al.* (2014) Illegal killing for ivory drives global decline in African elephants. *Proc. Natl. Acad. Sci. U.S.A.* 111, 13117–13121
31. Burgess, J.C. *et al.* (2014) On the potential for speculation to threaten biodiversity loss. In *Nature in the Balance: The Economics of Biodiversity* (Helm, D. and Hepburn, C., eds), pp. 341–360, Oxford University Press

32. Freeman, M.C. and Groom, B. (2013) Biodiversity valuation and the discount rate problem. *Account. Auditing Account. J.* 26, 715–745
33. Piketty, T. and Saez, E. (2014) Inequality in the long run. *Science* 344, 838–843
34. Lopez-Hoffman, L. *et al.* (2014) Market forces and technological substitutes cause fluctuations in the value of bat pest-control services for cotton. *PLoS ONE* 9, e87912
35. Kronenberg, J. (2014) What can the current debate on ecosystem services learn from the past? Lessons from economic ornithology. *Geoforum* 55, 164–177
36. Lewis, S.L. and Maslin, M.A. (2015) Defining the Anthropocene. *Nature* 519, 171–180
37. Winthrop, R.H. (2014) The strange case of cultural services: limits of the ecosystem services paradigm. *Ecol. Econ.* 108, 208–214
38. Adams, W.M. (2014) The value of valuing nature. *Science* 346, 549–551
39. Schroter, M. *et al.* (2014) Ecosystem services as a contested concept: a synthesis of critique and counter-arguments. *Conserv. Lett.* 7, 514–523
40. Vatn, A. (2000) The environment as a commodity. *Environ. Values* 9, 493–509
41. Norton, B.G. and Noonan, D. (2007) Ecology and valuation: big changes needed. *Ecol. Econ.* 63, 664–675
42. Fisher, J.A. and Brown, K. (2014) Ecosystem services concepts and approaches in conservation: Just a rhetorical tool? *Ecol. Econ.* 108, 257–265
43. Spash, C.L. (2011) Terrible economics, ecosystems and banking. *Environ. Values* 20, 141–145
44. Sandbrook, C.G. *et al.* (2013) What do conservationists think about markets? *Geoforum* 50, 232–240
45. Scales, I.R. (2015) Paying for nature: what every conservationist should know about political economy. *Oryx* 49, 226–231
46. Heal, G. (2000) Valuing ecosystem services. *Ecosystems* 3, 24–30
47. Loftus, A. and March, H. (2015) Financialising nature? *Geoforum* 60, 172–175
48. Spangenberg, J.H. and Settele, J. (2010) Precisely incorrect? Monetising the value of ecosystem services. *Ecol. Complexity* 7, 327–337
49. MacMillan, D. *et al.* (2006) Contingent valuation: environmental polling or preference engine? *Ecol. Econ.* 60, 299–307
50. Zander, K.K. *et al.* (2014) Threatened bird valuation in Australia. *PLoS ONE* 9, e100411
51. Clark, J. *et al.* (2000) 'I struggled with this money business': respondents' perspectives on contingent valuation. *Ecol. Econ.* 33, 45–62
52. Forestry Commission (2011) *Woodland Area, Planting and Restocking – 2011 Edition*, Forestry Commission
53. Edlin, H.L. (1972) *Trees, Woods and Man*, Collins
54. Rackham, O. (2006) *Woodlands*, Collins
55. Willis, K.G. (1991) The recreational value of the forestry commission estate in Great Britain – a Clawson–Knetsch travel cost analysis. *Scottish J. Political Econ.* 38, 58–75
56. Hodge, I.D. and Adams, W.M. (2014) Property institutions for rural land conservation: towards a post-neoliberal agenda. *J. Rural Stud.* 36, 453–462