Environmental financialization: what could go wrong?[1]

Eric Kemp-Benedict and Sivan Kartha [Stockholm Environment Institute, Somerville, MA, USA]

Abstract
The desire to mitigate pressure on ecosystems has led to the development of ecosystem valuation. Valuation demonstrates how ecosystems contribute to human well-being, but has arguably also encouraged the creation of environmentally-based commodities and tradable financial assets, a process that has been called the "financialization of nature". This paper addresses the claim that trading such instruments can effectively protect ecosystems. We argue that the abstractions needed to make financial assets usable makes them unsuitable for that purpose. We identify some partial exceptions, including tradeable permits to place non-specific pressure on ecosystems and socially responsible investment (SRI). However, those exceptions hold only under highly restrictive circumstances. We further acknowledge that valuation can demonstrate the importance of ecosystems in contexts where monetary values carry substantial weight, but the streams of value are diffuse and in nearly all cases cannot be appropriated. Moreover, appropriation creates an incentive to maximize income-generating services over broader ecosystem function.

Keywords natural capital; ecosystem services; ecosystem valuation; financialization

JEL codes D6; G0; Q2; Q5

1. Introduction

In 2012, Food and Water Watch (2012) introduced a new term of art, "the financialization of nature". It was quickly taken up (e.g., Silvertown, 2015; Kill, 2015). Studies that use the term warn against a range of related policy proposals: monetization of ecosystem services and natural capital; pursuit of "green" growth; and creation of financial markets for environmental assets. Defenders of natural capital accounts and ecosystem service valuation respond that they are simply providing information (e.g., Potschin et al., 2016; Schröter and van Oudenhoven, 2016) and that the information is critical if ecosystems are to be protected (Daily et al., 2009; Costanza et al., 2014). In this paper we address one particular aspect of the financialization of nature: the claim that tradable financial instruments and their exchange on financial markets can be effectively enlisted to protect nature. We argue that the abstractions needed to make financial assets usable also makes them unsuitable for protecting ecosystems.

The environmental motivation for financializing nature is clear. When natural capital is not explicitly integrated into economic decision-making, services derived from nature are uncounted benefits (positive externalities), and the harms done to it uncounted costs (negative externalities), in financial and economic transactions. As natural environments are being degraded and destroyed at an alarming rate, whatever value people might place on nature is clearly not translating into conservation and care. A range of voices, from influential

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environmental economists (e.g., Chichilnisky and Heal, 1996; 2000) to environmental activists (e.g., Krupp 2008) to corporate leaders (Carbon Pricing Leadership Coalition, 2016; e.g., The B Team 2016), advocate the creation and market exchange of financial “environmental assets”.

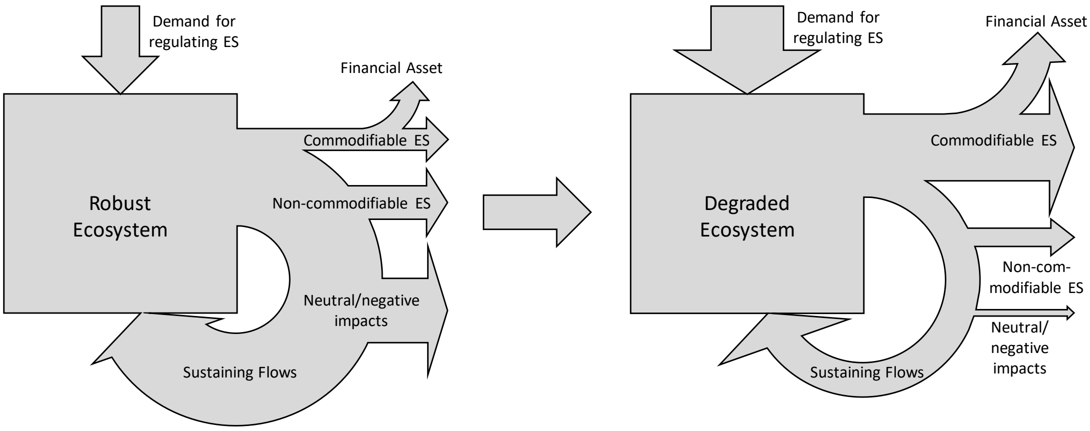
We question the conclusion that financial markets – specifically, trading in ecosystem-backed securities – is an effective strategy for preserving natural capital. For a financial asset to be usable, it must be fungible; that is, it must be comparable to, and exchangeable with, other assets. From the investor’s point of view, different financial assets (or portfolios of assets) are distinguished along a narrow set of relevant dimensions – price, expected rate of return, and risk – that abstract from the underlying real assets. In contrast, ecosystems are not exchangeable and differ along manifold and complex dimensions. We argue that this complexity, and the challenges inherent in abstracting beyond it, pose a threat to natural capital and ecosystem services when they are “securitized” to back tradeable financial assets.

A financial asset is a right to a stream of income payments. It therefore has a value that is only weakly tied to the particularities of the underlying physical asset. While the fundamental value of the financial asset – the income stream – depends ultimately on the viability of the underlying physical asset, its market value is determined in trades of the financial asset, and can diverge from the fundamental value. An extreme example of the consequences of such divergence is the financial crisis precipitated by the collapse of the sub-prime mortgage market.

Our claim is that securitizing ecosystem services will lead to simplification and degradation of ecosystems. They are examples of Karl Polanyi’s (2001, chapter 6) “fictitious commodities”. Like land, labor and money, treating ecosystem services as commodities, contrary to fact, leads to perverse outcomes. Securitization creates strong incentives to maximize output of commodifiable services at the expense of broader ecosystem function and non-commodifiable services – as well as the provision of local ecosystem-based livelihoods. We will argue that ecosystems have suffered from this dynamic in the past, and will continue to do so, despite the somewhat expanded list of ecosystem services that we recognize today, and despite good-faith efforts to protect the ecosystems behind environmental financial assets.

For natural capital, the question is how well the characteristics of financial assets reflect the value of the underlying natural asset. If preserving natural capital is the goal, as proponents of ecosystem services valuation claim, then the paramount interest is to maintain ecosystem function. When instead the investor’s desire for high and reliable returns is given priority – as financial markets do, by design – it creates incentives to maximize the provision of the ecosystem services that yield the largest and most stable payments. This will typically come at the expense of other ecosystem flows, both those that are valued by people (but not commodified) and those that are not valued by people. In parallel, growing economies tend to place increasing pressures on ecosystems for their regulating services, such as waste management and carbon dioxide absorption. This process is sketched in Figure 1.

Figure 1 Enhancing commodified ecosystem services (ES) and their associated financial assets tends to degrade ecosystem function



We will identify three partial exceptions to this broad claim. First, when a permit to place a non-specific pressure on ecosystems is traded, in principle it can help protect ecosystem function. For example, trading a restricted supply of permits to emit SO_x or CO_2 from industrial plants reduces demand for gas regulation across a broad range of ecosystems. Whether permits are effective in practice is open to debate; regardless, the same partial exception does not apply to ecosystem-based carbon sequestration, where pressure is being placed upon the gas regulating services of a specific ecosystem. Second, payment for ecosystem services (PES) schemes could, in principle, function like mortgages in PES-backed securities. However, it is unclear how well such an approach would work in practice. Third, we argue that socially-responsible investing (SRI) can be effective in mitigating harm to ecosystems that are already under production. However, SRI should not be seen as a way to protect ecosystem function more broadly.

2. The process of environmental financialization

In environmental financialization, the financial asset represents a stream of payments that is associated with commodified ecosystem services that have had some monetary value placed on them, and that are ultimately tied to some underlying natural capital. Ecosystems – the natural capital – produce flows of goods and services of value to people – the ecosystem services (see Costanza and Daly, 1992). They also produce flows of no or negative value to people while contributing to ecosystem function (such as floods, predators and fire). Although the idea goes back centuries, if not millennia (Gómez-Baggethun et al., 2010), the term "natural capital" was introduced in the 1970s by Schumacher (1973) as a metaphor to frame conservation in business terms. The concept of ecosystem services – that is, the flow of various benefits arising from natural capital – also appeared in the 1970s (Westman, 1977), and was later popularized by the Millennium Ecosystem Assessment (MA, 2005). Only after the 1970s were these concepts taken literally: natural capital becoming a stock that can be assigned a monetary value so that nature can be properly reflected in commercial transactions (e.g., Pearce et al., 1989), with the monetary value based on valuations of the ecosystem services provided. The twin concepts of natural capital and ecosystem services are motivated by a desire to account for the benefits that humans derive from nature, while markets for ecosystem services aim to bring those values explicitly into economic decision-making.

In a foundational paper, Costanza et al. (1997) provided a list of ecosystem services: 1) gas regulation (such as CO_2, SO_x, O_3); 2) climate regulation; 3) disturbance regulation (e.g., storm protection); 4) water regulation; 5) water supply; 6) erosion control and sediment retention; 7) soil formation; 8) nutrient cycling; 9) waste treatment; 10) pollination; 11) biological control (e.g., pest or weed control); 12) refugia (such as habitats for migratory species); 13) food production; 14) raw materials; 15) genetic resources; 16) recreation; 17) cultural. Any given ecosystem might provide some or all of these services, which people value directly, while carrying out many other functions, which they value only to the extent that a healthy ecosystem continues to provide the preceding list of services. But not all of the items in the list can be commodified to provide a stream of payments.

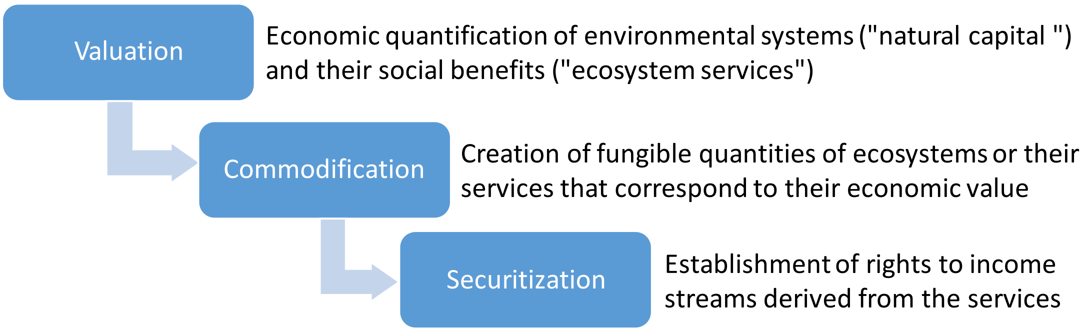
Much of the work on ecosystem services focuses on valuation, or assigning monetary values to those services (Farber et al., 2002). The values do not have to correspond to actual exchanges of money, and they often do not – we discuss this at length in the next section. The purpose of valuation is to compare the normally invisible ecosystem services to other goods and services using a well-recognized unit of value. In this way, for example, Costanza et al. (1997) found the total value of their list of ecosystem services to exceed global gross national product. Valuation thus serves a communicative role. Defenders of the ecosystem services concept emphasize this aspect of valuation, arguing that it should not be equated to monetization and market exchange (e.g., Schröter and van Oudenhoven, 2016).

Nonetheless, to underpin a financial asset, an ecosystem service must produce a flow of actual payments. And to create a market in that financial asset, different instances of the flow of payments must be comparable. Thus, the payment streams underlying a security must, to some degree, act as commodities – that is, one payment stream should be effectively indistinguishable from another. If that is not the case, then the process of securitization will hide potentially crucial information about their differences.

The difficulty of commodifying ecosystem services can be seen in a list of "proxy commodities" proposed by Landell-Mills and Porras (2002) for forest-based ecological services. Of the twelve instruments for biodiversity conservation in their review, only three have the potential to provide a steady stream of payments that could back a broadly exchangeable financial instrument: biodiversity credits/offsets, bioprospecting rights, and equity shares in businesses that market themselves as "biodiversity-friendly" (although others would question this claim; see Apostolopoulou and Adams, 2017). The others relate to ecosystem services that are not broadly interchangeable: locally-specific contractual arrangements (easements, conservation concessions, development rights, managerial contracts, and research permits), non-commodity goods and services (from biodiversity-friendly companies), one-time transactions (debt-for-nature swaps and land acquisition), or policy measures (protected areas) distinct from financial markets.

Finally, the commodified payment stream must be securitized. This process establishes a tradable right to an income derived from that stream of payments. The whole process is shown in Figure 2: first, assigning an economic value for the ecosystem service (valuation); second, establishing a fungible proxy for the ecosystem service, in that quantities of equal economic value are also physically equivalent (commodification); third, creating tradable rights to an income stream associated with the ecosystem or service (securitization).

Figure 2 Levels of abstraction and simplification involved in financializing environmental goods.



We now examine these three successive steps – valuation, commodification, and securitization – involved in environmental financialization. In particular, we look at them as a progressive process of simplification and abstraction.

2.1 Valuation: defining an economic value

Farber et al. (2002) distinguish between value systems, value, and valuation in the introductory paper to a special issue on ecosystem services. *Value systems* are normative and moral frameworks that guide action. Within their value systems, people assign *value* to actions or objects in the degree to which they meet user-specified goals, objectives or conditions. *Valuation* is then the process by which values are assigned to actions and objects. As Farber et al. point out, because valuation ultimately rests on the particular value system, whether the economic value of an ecosystem service can be defined in a meaningful manner has not been settled. Until it is, we are blocked at the first step in Figure 2. However, in case economic notions of value prevail, Farber et al. considered the concept of "value" in economic history: the ancient distinction between "use value" and "exchange value"; the classical labor theory of value; and marginalism, which is the basis of nearly all economic policy analysis today.[2]

The argument for valuing natural capital and ecosystem services is that nature has a very high use value, a proposition to which the classical economists would likely have agreed (Gómez-Baggethun et al., 2010). In contrast, they believed that the exchange value of goods and services derives from the cost of labor used to produce them; natural capital and ecosystem services are provided by nature at no cost, so their exchange value is zero. When the services provided by nature can be appropriated, the one holding title can extract a rent, but the services are prior to the economy proper.

In marginalist theory, people reach an optimal allocation of resources when the marginal utility they derive from application of the resource is equal across different ends. The great theoretical advantage is that value in exchange derives from value in use (Farber et al.,

[2] The literature on ecosystem services contrasts "use value" with "option value" and "non-use value" (de Groot et al., 2010). The sum is Total Economic Value (TEV). Option value is the value of deferring use to an uncertain future. Non-use value is the value of leaving something alone. We recognize the validity of the concepts, and note that they are inherently friendly to the notion of sustainability. We question, however, the identification of option value or non-use value as uniquely "economic" notions. After all, they can be enforced through exclusion, *e.g.* through the expansion or establishment of a protected area, without any recourse to a market or market prices.

2002): marginal utility dictates the price. In an economy with multiple agents all seeking to maximize their utility by exchange with one another, the end result is (in theory) a set of prices that ensures demand is equal to supply. According to the welfare theorems of neoclassical economics, the final result is "optimal", in the special sense that it is Pareto efficient. The second welfare theorem says that any Pareto efficient outcome is the result of a competitive equilibrium, thus justifying the construction of markets in order to achieve social goals.

The equivalence of classical use value and exchange value in marginalist theory means that one of the two can be dropped from the lexicon. However, we note some well documented flaws in the marginalist story. The requirements for a market to actually lead to efficient outcomes (even in the narrowly defined sense of Pareto efficiency) are very stringent, and not seen in reality (Gowdy and Erickson, 2005). Markets are generally not competitive, there are substantial barriers to entering and leaving markets, and information is far from perfect. It might be thought that it is enough that the Paretian conditions hold approximately, but that expectation is dashed by the general theorem of the second best (Lipsey and Lancaster, 1956). If conditions depart from the ideals of perfect competition, free entry and exit, and perfect information, then adding or subtracting a constraint may raise welfare, lower it, or leave it the same, and the new optimum need not look anything like the one calculated without the constraints.

In the case of ecosystems, the relevant constraints required to preserve the ecosystem may be unknowable. Ecosystems are complex systems in constant flux. The concept of ecosystem services is a useful idealization that provides heuristic guides to manage the complexity, but those idealizations do not translate well into concrete policy (Evans 2018). Attempts to apply ecosystem services assessment in practice reveals its deficiencies, leading practitioners to extend and "patch" the framework in an attempt to better reflect reality. Each extension and patch corresponds to a new constraint in a welfare analysis, so each is likely to change the optimum solution. If any constraints are left out – as they almost certainly will be from the standpoint of preserving ecosystem function – then a constructed market cannot be expected to yield an optimal outcome.

2.2 Commodification: ecosystem services as fungible assets

The source of exchange value for ecosystem services in marginalist theory is the same as in classical economics: the service must be appropriated before anyone will pay for it. Marginalist theory introduces the useful concept of a "shadow price", which is the value derived from a marginal change in the availability of some unpriced good or service, but unrealized shadow prices cannot underlie a financial asset. Neither can other forms of indirect valuation, such as contingent valuation, in which people are asked how much they would pay to accept or give up a good. Enforceable property rights are central to the design of markets for ecosystem services in either classical or marginalist theory.

Even in cases where an economic value may be sensibly assigned to a given ecosystem service in a given locale, it may not be sensible to then construct a corresponding financial asset with enforceable property rights that can be widely traded on a market. This would require those ecosystem services to be fungible across the domain of that market, *i.e.*, for there to be a common currency that allows for faithful comparison of their value across the full range of contexts that the market is intended to encompass. Without this fungibility, a common market through which they are exchanged at a common market price cannot be constructed.

By way of example, Driesen (2005) writes “suppose that the Army Corps of Engineers allows a developer to fill in a 100 acre wetland, but requires it to purchase 100 acres of restored wetlands in order to make up for it. This sounds like an environmentally responsible trade. But is it? We cannot tell without a lot more information. Some wetlands play a critical role in preventing floods. Others are less important in that regard. Some wetlands provide critical habitat for endangered species; others do not. Wetlands also vary in their value in providing water filtration.” The non-fungibility of a given acreage of wetlands, and indeed the absence of any simple valuation metric that can handle the diversity of wetlands makes a tradeable financial security in wetlands preservations of questionable usefulness.

Even if specific ecosystem services lend themselves to commodification as a fungible financial asset, it does not follow that it holds for the ecosystem as a whole. For example, a mangrove may provide climate regulation (by storing carbon), disturbance regulation, water regulation, nutrient cycling, waste treatment, pollination, refugia, genetic resources, and cultural services. Moreover, as Redford and Adams (2009) point out, some ecosystem services are not benign; mangroves are home to carnivores and disease vectors. Thus, even if one service may be treatable as a commodity, the ecosystem itself – the natural capital – cannot be reliably valued through market mechanisms. Aside from heavily managed landscapes, such as forest plantations or cropland, these non-commodity flows will predominate. Indeed, the dynamic illustrated in Figure 1 can be seen in the global transformation of natural forests and grasslands into forest plantations and monoculture croplands.

In Costanza et al.’s (1997) list of 17 ecosystem services, each of the items can be valued more or less reliably – that was the point of their paper – although refugia and cultural amenities are particularly challenging. But only four are suitable candidates for creating fungible financial securities that represent the underlying ecosystem services: gas regulation; climate regulation; food production; raw materials; and genetic resources. The output of two of these items – food production and raw materials – are already traded on commodity markets, albeit without the explicit goal of ecosystem protection. Genetic resources also have become economic assets. While one genetic resource is not substitutable for another, the patenting of genome sequences and entire genomes (Jensen and Murray, 2005) shows that exclusive rights can be established, even if it is not entirely clear what the object of those rights actually is (Calvert, 2007). The rights are sought in order to secure a future stream of income, which can then provide the basis for a financial asset.

Gas regulation itself – the ecosystem service – has not been put on markets, but pollution permits have; the same can be said for climate regulation. In both cases, markets for pollutant emissions permits have been implemented. The commodity here is not the ecosystem service itself, which cannot be appropriated, but rather the permit to place a burden on the shared natural system that provides that ecosystem service. Markets have been established for gases that disperse over global (ozone-depleting compounds and greenhouse gases including CO_2) or large regional (SO_x) scales.

Climate regulation poses unique problems. The global climate is shared, and measures that mitigate drivers of climate change are welcome. However, ecosystem-based measures for climate regulation are problematic for the reason alluded to above: it is only one of many services provided by any particular ecosystem. Thus, the Amazon may be a vast store of carbon, but it is also a home to many indigenous and non-indigenous people, a watershed, a biodiversity reserve, a source of non-timber forest products, a potential source of land for commercial agriculture or forestry, and the site of underground mineral resources, as well as a climate regulator through means other than serving as a carbon sink, such as albedo control and effects on the global hydrological cycle.

One might argue that any failure to identify commodities among ecosystem services is a failure of imagination. After all, the gas regulating services of nature are not themselves amenable to commodification; pollution permits are an indirect but effective "proxy" commodity for pricing the pressure on ecosystems. However, as illustrated by the list compiled by Landell-Mills and Porras (2002) that was introduced earlier, it is not easy to identify proxies that are truly commodities. Moreover, even when ecosystem services can plausibly be treated as commodities (individual agricultural and forest products and mineral resources), they are invariably coupled with others that cannot, which means the ecosystem itself cannot be properly valued by markets.

2.3 Securitization, financialization and the environment

The final step in the financialization process is to generate tradable rights to an income stream derived from a commodifiable unit of natural capital or ecosystem service.

In some cases, rights to natural capital or ecosystem services permit firms to produce goods. For example, operating a paper mill requires rights to timber, which the mill's owners ensure either by owning forest land or by buying timber futures contracts for later delivery. To take another example, an emissions permit allows a firm to operate its marginally higher-emitting equipment in order to produce goods and services, while it rewards the seller of the permit for low-emissions operations. Once goods and services are sold, firms receive income from the sale, so holding the rights to the ecosystem service is valuable.

The connection between the ecosystem service and the financial asset need not be so direct. For example, a publicly-traded firm may seek to expand its market and boost its stock price by appealing to green consumers and investors. By establishing a reputation for good stewardship, a firm can secure a segment of the market in which it operates. That can reassure conventional investors of a reliable, if narrow, profit stream, and convince green investors to purchase stock. Another indirect instrument is certified emissions reductions (in contrast to tradable emissions permits). In this case, a firm pays someone else to reduce emissions so the firm can operate its marginally higher-emitting equipment. As we discuss below, in each of these cases the abstraction inherent in commodification and securitization makes these approaches particularly problematic.

In this paper we have used "securitization" to mean any process for creating a security – that is, a tradeable financial asset. In a narrow sense, securitization is used to mean the bundling together of illiquid financial assets (ones that are hard to buy and sell, such as a mortgage) as collateral on liquid securities (ones that are easy to buy and sell, such as a mortgage-backed security or collateralized debt obligation). To the extent that the values of the bundled assets move independently of one another, the risk of a loss from the diversified bundle is lower than the risk of a loss from any one of the underlying assets. The expectation of acceptable risk, combined with greater liquidity, invites a broad range of investors to finance the underlying assets (Schwarcz, 1994).

It is theoretically possible for a payment for ecosystem services (PES) scheme to back a securitized instrument, because it includes a flow of monetary payments.[3] Such schemes are entirely location-specific (Jack et al., 2008), and so do not naturally lend themselves to commodification. However, the community providing the ecosystem services could sell rights to a portion of the payments received under the scheme. If the community has access to credit – not at all certain in many countries – it could use the payment stream as security on a loan, either to get the scheme itself started or for some other purpose. The promise of payment from the downstream users would be collateral on the loan. The risks to the bank issuing the loan would be that community providing the service failed to uphold its conservation responsibilities or the downstream users refused to pay. The bank could assess the severity of the risk if it was familiar with the parties involved. The resulting loan would be illiquid, but the bank could securitize it by bundling it with similar loans.

We could not find any examples of this practice. Securitization presumes that the loans are offered, which already presents a substantial barrier. Access to credit is often limited for the communities where PES is practiced, and there is very limited evidence that PES schemes improve access. In a study of farmers in Kenya, participation in extension and ecosystem services (EES) was associated with only a small and statistically insignificant reduction in interest rates (Benjamin et al., 2016). The large bulk of the extensive literature on PES does not address this question at all. Given the rarity and potential difficulties of securitizing PES schemes, we note its possibility but do not consider it further.

3. Forms of environmental financialization and their problems

From the preceding discussion, we can identify four characteristic ways in which ecosystems and other forms of natural capital, or ecosystem services, can back securities traded in financial markets:

1. The ecosystem service lends itself to commodification (e.g., agricultural, mineral or forest products);
2. A publicly traded firm establishes a reputation for treating ecosystems well;
3. A tradable permit to a share of the pressure placed on an ecosystem is established (e.g., a pollution permit);
4. A certified credit is issued for reducing pressure on ecosystems (e.g., through the Clean Development Mechanism or biodiversity credits)

Our central claim is that each of these mechanisms suffers to a greater or lesser degree from the cascade of abstractions in the production of natural financial assets, particularly in the process of commodification and securitization. A financial asset that is backed by natural capital necessarily reduces the multifaceted processes of viable ecosystems to a few of their services. In this way, ecosystem services obscure ecosystem function (Peterson et al., 2010).

[3] A classic example of PES is when a comparatively wealthy city is downstream from a relatively poor rural area. The economic incentives for the upstream rural communities may be to conserve their vegetation and topsoil, but it may also be to deforest and grow crops, resulting in larger variation in river flow and greater pollutant run-off and silt loads. To maintain the quality and reliability of their water supply, the city can contract to pay the upstream communities to maintain vegetation cover. It is not straightforward to implement and sustain such schemes, and it is not always clear what counts as PES (Schomers and Matzdorf, 2013). Nevertheless, under some conditions they can be a useful tool in the local policy toolkit (Salzman, 2005).

3.1 Traditional natural resource commodities and ecosystems

For about 10,000 years, people have transformed plants and ecosystems to produce specific crops in abundance (Evans, 1996), and for thousands of years people have substantially deforested and altered temperate woodlands (Ellis, 2011). Markets for commodities are also ancient, established in some form several thousand years ago in China and Mesopotamia.

Production and exchange of agricultural commodities was not intended to protect ecosystem function, but it was certainly in the interest of agricultural societies to do so. And, to some degree, the value placed on agricultural commodities did encourage conservation. While managed forests and cropland are very different from the natural ecosystems they replace, they can persist (with significant human intervention) as ecosystems producing a stream of income that is worth protecting. Nevertheless, that protection is not absolute. Deforestation and erosion arguably contributed to the collapse of classical Mediterranean civilization (Hughes and Thirgood, 1982). More generally, agricultural expansion and deforestation both supported civilization and made it vulnerable to collapse when the climate changed (Tainter 1988; Wilkinson, 1997; Weiss and Bradley, 2001). When ancient civilizations modified natural environments for the optimal production of commodities, it compromised other ecosystem function.

These ancient patterns persist, and land-use pressures are growing in scale and scope (Foley et al. 2005). Highly altered and potentially vulnerable managed ecosystems are protected because they provide a stream of value; but as ecosystems are reoriented towards optimal production of specific commodities, they become vulnerable to stresses that they might have survived in the past. In the short run, this may not be evident. Intensively managed tree plantations are less susceptible than natural forest to pests, diseases and physical disturbance. Exotic species perform best, because they are less vulnerable than native plants to pests and diseases (Gadgil and Bain, 1999). The same could be said of intensively managed croplands planted to non-native monocultures. Indeed, reliable and high yields are the main reason to grow intensively-managed single-species crops. However, in the longer run and on larger scales, ecosystems populated by native species and with high functional diversity (Walker 1995) are more resilient and adaptive (Folke et al., 2004; Fischer et al., 2006; Thompson et al., 2009).

Moreover, even the relatively compromised function of agricultural ecosystems is not ensured by agricultural markets. As urban areas expand, agricultural land is displaced (Azadi et al., 2011), despite the existence of markets for agricultural products. This is also true of environmental markets. If carbon can be sequestered at lower cost on plantations than in natural forest, a carbon market may compete with plans to increase biodiversity (Hunt, 2008). Demand for bioethanol in the US displaces land for crops, which are then likely to be produced elsewhere, resulting in further land conversion and indirect carbon emissions (Chakravorty et al., 2014).

While these problems do not arise from financial transactions *per se* (in this case, in commodity exchanges), they arise from commodification, which is a necessary precursor to creating a financial security. Thus, in the case of agricultural commodities, it is not the way trading is done that is creating incentives to maximize short- and medium-term productivity, but rather the incentives to maximize productivity that shape the way trading is done.

3.2 Buying shares in ecologically-friendly firms

It is difficult to imagine a future in which commerce does not play a major role. Indeed, it is likely impossible to support the current global population without a connected and technologically advanced global economy, although it could conceivably differ significantly from our present one. If there is to be commerce, then it is better that it be ecosystem-friendly, and if we value nature, then let us show it through our investments. That, in a nutshell, is the argument behind buying shares in ecosystem-friendly firms as a way to place a value on ecosystem services.

Equity shares in companies are commodities distinguished by their historical and anticipated yield, as well as their risk profile. Socially-responsible investing (SRI) is no different in principle, but SRI funds restrict their equity shares to firms that meet certain social and environmental standards. They may passively monitor firm performance, aiming to stay alert to "greenwashing" or changes in firm culture. Alternatively, they may actively use their influence as shareholders to encourage firms in their portfolio to maintain or improve adherence to standards. The extent to which they succeed relies on their motivation and capacity to faithfully monitor the firm's impacts across a potentially broad array of domains, and make financial decisions depending on the results.

The record to date on SRI is mixed. There is evidence that SRI has grown to the point that it is influencing corporate decision-making (Sparkes and Cowton, 2004), although early enthusiasm for "triple win" investment strategies has faded. Recognizing that there really are tradeoffs between protecting the environment and firm profits in today's markets, SRI is increasingly dependent on the prospect of future regulation to make a business case to firms (Richardson, 2009; Harmes, 2011). Moreover, SRI is more attractive to private and institutional investors than it is to fund managers, who have a fiduciary duty to the effective management of the funds entrusted to them. Fund managers are more focused on delivering an acceptable return at minimal risk than they are to social and environmental goals (Jansson and Biel, 2011).

As a commodification strategy, SRI works to the extent that a large number of assets passes through the investor's filter. Finer and more specialized filters are costlier to monitor, so investors usually rely on third-party organizations, such as the Global Reporting Initiative and Carbon Disclosure Project, which collect information from firms and present the results in a standard format for investors, civil society actors, and other interested parties.

Porter (1996) uses the phrase "mechanical objectivity" to describe the practice of impersonal comparison through rules-based assessment, particularly using standardized quantitative indicators or checklists. When applied to the multiple and complex social benefits of environmental systems, mechanical objectivity is problematic, because local and context-specific information, including unarticulated tacit knowledge, is essential for making value judgements. Establishing incentives on the basis of a particular set of indicators, however large that set may be, tends to shape the underlying system in the image of the indicators (Scott 1998). Hence, the business adage, "You get what you measure." When applied to ecosystems, rule-based systems do not fully capture the underlying ecosystem services, given the complexity of socio-ecological systems and the institutions tasked with managing them (Robertson, 2006).

One could counter that what is important in the process of financialization is that it creates a sufficient incentive for effective protection of the ecosystem service. We offer two objections to this position. First, valuing a particular ecosystem service means treating it as a commodity, which returns us to the first type of environmental financialization. It is possible that a system can be created that sustainably maximizes the production of a commodified ecosystem service. But that is not what an ecologically-friendly firm is promising. Rather, they promise to protect additional, non-commodifiable functions of a socio-ecological system. That brings us to the second point. Without knowing what might compromise the system, it is not possible, even in theory (Lipsey and Lancaster, 1956), to construct a "second-best" solution that accurately captures the value of protecting ecosystem function.

The commodity corresponding to an equity share in an ecologically-friendly firm is thus a share in a firm that has passed a filter for ecological friendliness. While superficially identical, these are different things. The filter is an abstraction that pools firms with quite different corporate cultures and approaches to ecosystem management operating in substantially different environments. While SRI represents a broader conception of nature and society than investment in traditional natural resource commodities, and is therefore worth pursuing, its effectiveness is limited. It cannot ensure that firms take account of the specificity, richness, and function of any particular ecosystem. Rather, it encourages better conservation practice in already-managed ecosystems.

3.3 Constraining pressure through tradable permits

Emissions permits are proxies for ecosystem services. They aim to preserve a range of ecosystem services by constraining the ability to impose pressure on ecosystems under an overall cap. Constraining pressure values leaving the ecosystem alone, without regard to the details of how the ecosystem functions. In contrast to the concept of "non-use value", this might be thought of as "restrained use value". Unlike non-use value, restrained use has a well-defined interpretation in marginal pricing theory: the price of a permit to place a pressure should equal the shadow price associated with loosening or tightening the limit on that pressure by a small amount. While shadow prices are theoretical constructs with no direct bearing on economic decision-making, they are made manifest when the permit to loosen the constraint becomes a tradeable asset.

Perhaps surprisingly, the theory of emissions permit pricing follows a different argument, while applying marginalist principles (Tol, 2011). In that theory, cost-benefit analysis reveals the social value of the viability of the ecosystem, and the social cost of an additional amount of pressure. We should therefore, as a society, be willing to pay for a reduction in the pressure in an amount equal to the marginal social cost. However, quite aside from the daunting and perhaps prohibitive conceptual and practical difficulties of calculating marginal social cost (Ackerman and Stanton, 2015, p. 29), society as a whole does not pay for the reduction; business do, and they typically pass on the cost through their markup. While welfare economics says that the marginal social cost should equal the shadow price encountered by firms, as we discussed earlier, the theoretical basis for that belief is weak.

The motivation for using cost-benefit analysis and social cost is that it purports to answer the question "How much is enough?" But there are other bases for that answer. Global negotiations on climate mitigation under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC) have adopted a number of trading mechanisms (Schneider et al., 2016), and have also adopted an agreed goal of keeping warming below either 1.5°C or 2.0°C above pre-industrial levels. A global temperature rise can be interpreted as an emissions constraint, and converted into global emissions trajectories, which can then be apportioned between emitters. If emissions permit trading is efficient, then different firms' emissions should reach the point that they all face the same marginal cost of reducing emissions. This principle can be generalized: a limit is set through a biophysical determination of the level of ecosystem pressure consistent with social goals, and then a market in permits to apply pressure within the limit is implemented.

Permits to apply pressure can be converted into financial assets if the source of pressure can be commodified. That is, one firm's or household's pressure on the environment must be directly exchangeable with any other's. That is the case for emissions of any given greenhouse and ozone-depleting gases. These are globally dispersed gases linked to ecosystem damage through reasonably well-understood causal chains. However, value-laden questions arise when considering gases that have differential impact over time (e.g., relating to intergenerational justice), or distance (distributional fairness). Further problems arise with efforts to aggregate across different gases that act across different timescales (Shine, 2009; Neubauer and Megonigal, 2015). Perhaps most problematic is the fact that different measures for reducing pollution, even when they are equivalent in terms of the commodified unit of pressure reduction (e.g., tonnes of carbon dioxide), may have very different ecosystem impacts. For example, switching from a more carbon-intensive fuel to a less carbon intensive one (e.g., from coal to gas) based on an existing, widely disseminated conventional energy technology may directly provide the same quantity of pressure reduction as deploying a certain amount of a new, emerging, zero-carbon, renewable energy technology, but the latter may also provide learning-by-doing benefits, help achieve greater economies of scale, shift perceptions of technological riskiness, weaken socio-institutional carbon lock-in, and otherwise help induce further innovation, deployment, and thus emission reductions.

In addition to these challenges, permit trading schemes have been notoriously vulnerable to political interference on the part of vested interests, manifested in the form of set-asides, free allocations, exceptions, and other consequences of rent-seeking behavior (Markussen and Svendsen, 2005; Spash, 2010).

3.4 Reducing pressure with credits and offsets

In practice, one way in which firms and other entities are allowed to meet their obligations with regard to imposing environmental pressure is to pay someone else to do it on their behalf. In contrast to markets in permits, which convey a permit to apply a pressure by an entity that is under an overall cap, markets in credits enable an entity not under the cap that has achieved a reduction in pressure to sell that reduction to an entity under the cap. As with permit trading, the economic principle is that, through trade, mitigation targets can be met through the least cost means.

On its face, this seems like a modest extension of the idea of trading permits, and indeed it faces the same challenges outlined above. Yet, it also faces additional constraints. To take a highly relevant and concrete example, the Clean Development Mechanism (CDM) allowed countries under the cap (the Annex I countries) to meet their obligations in part by purchasing credits from parties outside the cap (the non-Annex I countries). Under the Paris agreements, a similar mechanism may evolve for trading "internationally transferred mitigation outcomes" (ITMOs). Recognizing the danger of generating mitigation credits at the expense of local development, both CDM projects and ITMOs are required to achieve goals other than mitigation, such as promoting sustainable development. However, it is only the mitigation outcome that is valued and commodified, and experience with the CDM has shown the hoped-for sustainable development benefits do not materialize (Olsen, 2007; Schneider, 2007; Sutter and Parreño, 2007).

The situation is similar to that of an SRI fund. If the actual mitigation outcome can be verified and quantified, then it can be made into a tradable commodity. However, to meet additional goals, such as contributing to sustainable development, achieving transparency, or ensuring environmental integrity, then it must also pass a filter. Applying the filter raises the problems of rule-based "mechanical objectivity" that plague SRI funds; the situations on the ground are too disparate to be effectively protected by creating tradable credits that have passed through a filter.

These challenges are exacerbated when the credits are derived from ecosystem-based projects, which entails a complex and location-specific ecosystem being reduced to a single ecosystem service. When firms trade pollution permits, they are exchanging reasonably fungible commodities, but that does not hold for ecosystem-based credits. This can be seen in the case of biodiversity offset banking, in which biodiversity credits are bought and sold (McKenney and Kiesecker, 2010; Bull et al., 2013), but implementation is problematic because conditions are location-specific and "biodiversity" does not have a uniform measure (Burgin 2008). The same can be said of the wetlands example given by (Driesen, 2005) and discussed above.

A prominent example of ecosystem-based climate mitigation is actions for reducing emissions from deforestation and forest degradation (REDD), combined with sustainable management of forests, conservation of forest carbon stocks and enhancement of forest carbon stocks (REDD+). The REDD+ mechanism was explicitly included at the Cancún climate conference and has been widely promoted as a way to achieve emissions reductions while contributing to sustainable development in low-income countries. However, early enthusiasm gave way to more modest expectations as experience accumulated. Economic analysis has focused on capturing opportunity costs that might hinder adoption (Lubowski and Rose, 2013; Irawan et al., 2013), but even at the time of the Cancún conference, there were known problems of political economy in reforestation projects. For the Asia-Pacific region, Barr and Sayer (2012) noted that previous reforestation projects had displaced local communities, exacerbated inequalities, and accelerated biodiversity loss, among other perverse outcomes. As anticipated, issues of political economy (among others) have emerged in REDD+ projects (Corbera and Schroeder, 2017).

Credit mechanisms raise further difficulties. Credits are meant to measure reductions additional to any that would have taken place otherwise. However, it has long been recognized that ascertaining this "additionality" is epistemically fraught (Grubb et al., 1997). Certifying that reductions as measurable, reportable, and verifiable (MRV) is impossible if the world against which those reductions are measured is an unknowable counterfactual. If the uncertainty were minor and the errors random, the difficulties would be manageable. However, this is not the case, and there is large scope for overestimating reductions (Bernow et al., 2001). This expectation appears to be borne out (Schneider, 2009; Schiermeier, 2011).

The market in credits is structurally biased, as both the buyer and seller have an economic incentive to define their credits relative to as generous a counterfactual as possible, while certifying entities have an incentive to retain project developers as satisfied clients. Such a transaction is thus quite different from the normal market dynamic. In the most perverse cases, where revenues from credits significantly exceed mitigation costs, sellers have an incentive to *increase* emissions to reap the rewards of partial abatement, and this has been observed in practice (Schneider and Kollmuss, 2015).

In effect, the generation of credits results in the loosening of the cap, since entities under the cap that purchase the credits are free to emit more than the cap would otherwise allow. If all credits were indeed additional, the effect of the credit mechanism on environmental outcomes would be neutral. To the extent that non-additional credits are certified, environmental outcomes are worsened by the existence of the credit mechanism.

4. Discussion: the non-magical market

There are, broadly, two arguments for financializing nature. The first is a widely-held belief, inspired by neoclassical theory, that markets are the most efficient way to allocate scarce resources. However, the conditions needed for the neoclassical argument to hold are never met in practice and the information requirements for achieving a “second-best” outcome are highly unlikely to be met in the case of natural capital. The second is that because public finance is on the wane, we must turn to private finance to meet social and environmental goals (e.g., Rubino, 2000; Jenkins et al., 2004).

These arguments are connected. Aggressive promotion of market mechanisms as an all-purpose tool led ultimately to political acceptance (Burgin, 2012). Ronald Reagan memorably captured the spirit of this belief as the “magic of the market”. This political reorientation has contributed, over time, to the erosion of non-market policy instruments and declining public funding for the environment. These trends powerfully motivate a search for ways to protect the environment through financial markets. Yet, while we support the sentiment, we believe the conclusion to be misguided.

We have argued that trading ecosystem-backed securities on financial markets will very likely undermine ecosystem function. The most important exception may be those few cases in which a tradable permit to broadly apply a pressure to multiple ecosystems can be established, for which a biophysical assessment can determine the total allowable pressure consistent with social and environmental goals, for which neglected pressures on ecosystem services and other socio-economic impacts are not, in fact, dominant, and where political economic factors do not allow rent-seeking behavior to undermine environmental integrity. This is an extremely narrow set of criteria that may leave only tradable emissions permits for widely-dispersed gases, though this has yet to be demonstrated. Two partial exceptions also apply. First, it is conceivable, although likely difficult, to create locally traded securities backed by payments for ecosystem services (PES). Second, if an ecosystem is already being used for production, then socially-responsible investing (SRI) might help by favoring firms that exhibit greater social and environmental responsibility.

This critique is relevant to climate finance, as well as development aid generally, where there is significant interest in garnering private sector investment to produce ecosystem benefits. The bulk of private adaptation financing hopes to produce ecosystem “goods”. In contrast, our arguments suggest that the focus should rather be on avoided harm. For most conservation, mitigation, and adaptation challenges, local analysis and local solutions are needed, in which a broad array of policy approaches is put on the table. Some policy options might involve locally specific financial arrangements, such as PES, but many, such as establishing a protected area, will not. This is not to say that protected areas are always and everywhere preferable to PES. Indeed, the point is that given the complex reality of ecosystems and societies a solution that works in one place may very well fail in another. Nor do we mean to imply that problems of political economy vanish when decisions are made locally. In fact, they are present in any case. The difference is that there is not also a global market attracting relatively powerful actors to the detriment of less powerful ones.

Our critique is specific to financial markets. Valuation is, in itself, neutral. In principle it can be used to convey important insights, such as that the value of ecosystem services exceeds global GNP (Costanza et al., 1997) or to demonstrate the extent to which we are losing ecosystem services by degrading natural capital (Costanza et al., 2014). Yet, once nature is put in monetary terms, and the values are shown to be very large, there is an understandable tendency on the part of financial actors to try to capture some part of that stream of value. Even though the underlying natural assets are not commodities, financial actors can propose financial instruments that put an explicit monetary value on a subset of ecosystem services and treat them as commodities. The predictable result is that those services are amplified, while broader ecosystem function is impaired.

This leads us to the following recommendations. First, reserve valuation for high-level numbers, not for explicit policy guidance – at fine resolution, valuation can hide more than it reveals. Second, apply filters and mechanical objectivity (as in SRI) to influence economic activity only in cases where ecosystems are already under pressure due to the specific activities of firms, governments, or other entities. Third, restrict any new instruments of environmental financialization to the narrow case where it is possible to trade a permit to place non-specific pressure on ecosystems, unrelated to the specific activities of a particular entity.

5. Conclusion

Ecosystems are under pressure from economic activity. This has led to efforts to place a monetary value on nature (valuation) in order to highlight what is being lost when ecosystems are degraded. Valuation, in turn, arguably encourages the creation of environmentally-based commodities and tradable financial assets that reflect the value of ecosystem services. Yet, this is rarely appropriate. Nearly all ecosystem services are locally-specific and so non-fungible. Creating a tradable financial asset encourages the amplification of a narrow set of ecosystem services at the expense of broader ecosystem function.

We identify one case in which a new financial instrument might help protect ecosystems. That is when a tradable permit to place non-specific pressure on ecosystems can be established, where the pressure is not due to the direct operations of the firm, government, or other entity. The only examples we could identify are tradable permits in emissions of widely-dispersed gases, such as sulfur oxides (SO_x) and carbon dioxide (CO_2). Tradable biodiversity or climate mitigation credits do not fit under this heading. Socially responsible investment (SRI) can help to reduce harm in cases where ecosystems are already being exploited.

Valuation has a useful role to play in highlighting the importance of ecosystems in contexts where monetary values carry substantial weight. However, those presentations must emphasize that the streams of value are diffuse and in nearly all cases cannot be appropriated. When they are appropriated and sold, as with natural resource extraction, there is an incentive to maximize the provision of income-generating services at the expense of broader ecosystem function.

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Author contact: eric.kemp-benedict@sei.org (corresponding author), and sivan.kartha@sei.org

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