

Measurement and alienation: making a world of ecosystem services

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The development of markets in water quality, biodiversity and carbon sequestration signals a new intensification and financialisation in the encounter between nature and late capitalism. Following Neil Smith's observations on this transformation, I argue that the commodification of such 'ecosystem services' is not merely an expansion of capital toward the acquisition or industrialisation of new resources, but the making of a new social world comparable to the transformation by which individual human labours became social labour under capitalism. Technologies of measurement developed by ecosystem scientists describe nature as exchange values, as something always already encountered in the commodity form. Examining these developments through specific cases in US water policy, I propose that examining this transformation can provide political ecology and the study of 'neoliberal natures' with a thematic unity that has been absent. I understand capital's encounter with nature as a process of creating socially-necessary abstractions that are adequate to bear value in capitalist circulation. Such an argument supersedes the issue of nature's materiality and points toward a common language for the analysis of both humans and nature as two participants in the labour process. Political ecologists struggling with the commodification of nature have tended to overlook the social constitution of nature's value in favour of explicit or implicit physical theories of value, often as more-or-less latent realisms. I suggest that critical approaches to nature must retain and elaborate a critical value theory, to understand both the imperatives and the silences in the current campaign to define the world as an immense collection of service commodities.

key words political ecology value ecosystem services commodification
carbon trading nature

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revised manuscript received 13 May 2011

Money thereby directly and simultaneously becomes the *real community*, since it is the general substance for the survival of all, and at the same time the social product of all. (Marx 1973, 225–6)

[Carbon trading] is going to be bigger than the credit derivatives market. (Louis Redshaw, head of environmental markets, Barclays Capital, cited in Horwood 2007)

Ecosystem services and measurement

In the Rivas province of southern Nicaragua, 813 acres of pasture planted with teak and native hardwoods support the exchange of futures contracts

for the delivery of carbon credits in December 2013 (Arreaga and Hayward 2008). At PopOffsets.com, where you can offset your impact on climate 'by funding the unmet need for family planning', the avoided-emissions value of an unborn African child circulates through a credit-card transaction on your screen.¹ In a central Oregon wetland, an interlocking set of material relations are defined as 'salmonid habitat credits' and 'temperature credits'. From the same site, one is sold to a Portland developer far to the north, and the other to a power plant operator to the southeast, to compensate for their environmental impacts.²

Capital circulates successfully in these situations because the futures contract is an adequate

abstraction of the ecology of the Nicaraguan forest, because your receipt from PopOffsets is an adequate abstraction of the ghostly impacts of the avoided African child on atmospheric chemistry, and because the aquatic ecosystem in Oregon becomes an adequate abstract equivalent of the impacts created by the developer and the power plant. In each case, the social process of measuring and abstracting from nature to facilitate exchange has succeeded. We are often focused so intently on the bizarre diversity of forms in this new economy that we forget that they are united in this process of abstraction: at least in capitalism, what is circulating is not wetlands, not trees, not salmon, but *value*. These transactions are made possible by our belief in, and consent to, the adequacy of these abstractions, and they create a world in which value is found, defined and circulated in almost any physical process imaginable.

The rise of ecosystem services

These are only a few of the paths along which the environment is now being transformed into commodities as a set of marketable ecosystem services. As service commodities, the environment achieves a new legibility in the minds of environmental regulators (USDA 2008), market designers (Richmond *et al.* 2007), development planners (Liemona and Lee 2008), derivatives traders (Cogan 2008) and venture capitalists (Spethmann 2008). They are responding to the possibility of profiting from the nonconsumptive trade in functions of the environment such as carbon sequestration and water purification. It is undeniably intoxicating to propose that the Earth is worth \$33 trillion (Costanza *et al.* 1997), and that gene frequencies can generate a coherent price signal (Bruggeman *et al.* 2005; for cases and critical summaries see Corbera *et al.* 2007; Dempsey and Robertson; McAfee and Shapiro 2010).

But how did we come to live in a world that is now widely seen, by policymakers at least, to be composed of ecosystem services? The above transactions deal in objects, such as 'foregone emissions' and 'water quality', that are challenging to even define, much less recognise as an object of utility. The successful ecosystem entrepreneur must be so lucky as to operate in a world where such things are understood to exist in a stable and widely-acknowledged form. This is a remarkable achievement. Through policies that address fungible ecosystem services – such as the UN's Millennium

Development Goals, Australia's habitat banking programmes, Mexico's PROARBOL and the generation of Certified Emissions Reductions under the Kyoto Accords – we now confront an environment that can be defined as potential commodities in nearly every aspect of its material existence, and at every scale from the atmospheric to the biochemical.

This world emerges as we address nature to define new coherent abstractions as bearers of value. This (capitalist) calculus of measurement and abstraction underlies much of the sprawling diversity of forms gestured at in the literature on 'the neoliberalisation of nature'. This paper is meant to document – in one small corner of a large canvas – that although nature's neoliberalisation has been contingent and halting (as many authors have documented³), it is made possible by a constant and long-term concern with the calculus of value. In responding to the call (Bakker 2010; Castree 2008a 2008b) to find thematic unity in this field, I turn to dusty debates over defining human beings as bearers of value – hardly a novel feature of modern society, but quite vexing to political theorists of earlier generations. The rise of ecosystem service markets allows us to observe – in much the same way that the rise of labour markets did – a transformation of the social world through creation of value-bearing abstractions from physical processes. It is thus a new and unique manifestation of a very old mechanism. Inspired by Henderson's (2004a) example, I am led to paraphrase the opening line of *Capital* (Marx 1976): the ecology of societies in which the capitalist mode of production prevails appears as an immense collection of services. The task is then to discover how such a world comes to be.

Critical approaches

How should we think about ecosystem services? As just the expansion of capital into new green fields of accumulation – or at most, 'accumulation by dispossession' as David Harvey would put it? It is tempting to think so, but there is a significant way in which ecosystem services did not have an existence as such prior to their capitalisation. The 'red-legged frog habitat' service is not out there waiting; rather, it is fundamentally defined as a service in the process of its marketing and sale.

Boyd *et al.* (2001) argue that concepts like ecosystem services are part of a massive transition from an extensive and extractive relationship between

capitalism and nature (i.e. the extraction of raw materials) to an intensive focus on industrialising biological processes themselves and treating them as a form of manufacture. Market enthusiasts concur, and view this transformation as a belated and urgent recognition that the natural world is 'a highly efficient and valuable machine' (Daily and Ellison 2002, 2), a 'precious piece of infrastructure' (2002, 4) and that '[t]he degradation of ecosystem services represents loss of a capital asset' (MEA 2005, 9). In capitalists' use of natural processes to increase productivity, Boyd *et al.* find the defining feature of these new industries in that 'they *confront nature directly* in the process of commodity production' (2001, 556; emphasis in original).

Neil Smith (2007) argues (specifically against Boyd *et al.*) that the establishment of ecosystem service markets involves more than a nudging of the boundaries of the productive process deeper into material biological processes. Instead, Smith claims this intensification of capitalism takes place through the apprehension of ecosystem processes and metabolisms through a new calculus of *value*. Biological systems have always been and will always be implicated in industrial production, but Smith notices a profound change in our conditions of life. He argues:

[A] new frontier in the production of nature has rapidly opened up, namely a vertical integration of nature into capital. This involves not just the production of nature 'all the way down', but its simultaneous financialization 'all the way up'. Capital is no longer content simply to plunder an available nature but rather increasingly moves to produce an inherently social nature as the basis for new sectors of production and accumulation. (Smith 2007, 33)

That is, Smith's 'second nature' (1990) is more than just the industrial rationalisation of ecosystems. It is the creation of a set of general abstractions adequate to allow nature to circulate – not just as commodified bits of material, but as financial and service commodities. We are moving from a point where nature can merely be represented by money, to a point where money becomes the more perfect abstract reality of the community of nature, something whose survival is tied to discount rates and futures contracts (see Costanza *et al.* 1989, 357). Our bodily respiration and metabolism can now be the underlyings for leveraged financial commodities – indeed, they already are, in limited cases (BusinessGreen 2011; Patterson and Stripple 2010).⁴

Harvey (1996) anticipated the rise of ecosystem service markets when he connected the alienation of people from their own labour to the processes that result in the full alienation of nature from its products *qua* services.⁵ Sian Sullivan's work (2010 2011) has pioneered empirical attention to the financialisation of ecosystem services. To the extent that the carbon cycle becomes an arena for capital accumulation in carbon markets, we are participants simply by taking a breath, and without the felling of a single tree.

The construction of abstract spaces, the definition of boundaries between types of things that allow nature to be segregated out in a typology, are matters of *measure*, and have uses far beyond capital. Under capitalism, however, these technologies of measurement and abstraction are used specifically to define adequate bearers of value. Geographers have been attentive to 'the politics of measure' (Mann 2007) across a broad array of topics (particularly in state theory, e.g. Asher and Ojeda 2009; Braun 2000; Budds 2009; Mitchell 2002; Scott 1998). In recent years, the cross-fertilisation of critical state theory with critical resource studies has suggested that a Derridean concern with the ordering of appearances could speak constructively to a Marxian concern with the constitution of abstractions, and together clarify the authored contingency of achievements that come to stand as authorless, such as the claim that 33 616 metric tonnes of carbon were removed from the atmosphere by a Nicaraguan forest in 2010 (Arreaga and Hayward 2008).

Such a world of ecosystem services is not born without trouble. Instabilities and misdirections in the encounter between neoliberalism and the environment have been well-documented in a number of settings (for surveys see Bakker 2010; Castree 2008a). Many of these instabilities are perceived and experienced through the practices of measuring the value of the function, and one could conceive of a crisis tendency defined by the increasing resistance to creating social abstractions that rely on less and less secure spatial and ecological measurements. This would be a version of O'Connor's (1994a 1994b) proposed 'second contradiction of capitalism', but it is the *inability* of capital to apprehend nature in commodifiable ways, not just capital's *inattention* to nature, which interferes with the conditions of production.

This resistance must *not* be understood as a conflict between material nature and capitalist

ideology. The crisis comes not at some 'natural limit', but – as with the abstraction of labour from human effort – the point when the socially necessary abstractions that bear value are also socially untenable. The empirical material below is an attempt to illustrate the applicability of this notion in the decades-long historical process of defining ecosystem services for sale.

Following a brief review of value theory below, I begin at a historical moment before the rise of ecosystem services talk – the early 1980s. I trace the history of measuring, valuing and marketing wetlands services through the stages and steps necessary to arrive at a point – more or less the present – in which it is possible to purchase a single, well-defined ecosystem service from a wetland site comprised of them. The titles of the later sections refer to the ways – in the jargon of environmental bureaucrats in the US – that regulators and capitalists alike have tried to wrangle nature into a form that can be sold, governed and bear value. 'Classification' and 'categorisation' have been used in the contexts of creating marketable ecosystem services (in the form of stream and wetland credits) as ways of invoking an underlying order and typology with which to understand ecosystems. The language of 'unbundling' and 'stacking' is then used to manipulate these containers of value within established categories of classes in a typology. Through these processes we can observe the definition of an abstract social nature that can enter the calculus of capitalist production as values.⁶

Value and nature

Value is a topic that has long been avoided in green critical theory and political ecology,⁷ largely on the assertion that Marxian value theory excludes consideration of nature and treats only with human actions. In fact, there is no need to 'bring nature in' to a Marxian analysis, because material nature is already an essential part of the labour process described in *Capital*, and in the creation of value in all commodities. Indeed, the idea that the social labour process consists of a unified metabolism between humans and material nature is one of the few transhistorical and universal claims in Marx's work. Marx calls the earth itself an 'instrument of labour' (1973, 286),⁸ one of the three elements (alongside activity and instruments) of an overall labour process which involves roiling and ecological elements that Marx does not deny: he even

refers to nature as engaged in 'its own production' (1973, 288). He only denies that it can *directly* produce *value of the specifically capitalist kind* – to do so it must enter the capitalist labour process, coupled with human exertion, as a social abstraction. In this critical tradition, labour should be understood as a process that occurs *between* nature and the individual, who 'confronts the materials of nature as a force of nature' (1973, 283). 'Confront', here, as elsewhere in Marx, is a keyword indicating an appearance that must be broken down.⁹

The search for surplus value drives the work of measuring and codifying nature, which creates the conditions of visibility for nature as a socially necessary abstraction confronted 'as a force of nature'. If we are not attentive to this work of world-making, we may see the simpler process of capital reaching into new physical processes and spaces as simply the search for profit in a fixed and existing world. But this would be to miss a crucial distinction: buying a carbon credit is one thing; the creation of a world in which our metabolism already is legible as commodity production is another. In Marxian language, it is the difference between the employment of a worker for wages, and the creation of a society in which the worker always already understands her/his labour as a commodity.

The idea that understanding neoliberal nature requires close attention to the techniques by which measures and abstractions are stabilised in capitalist contexts should not be a surprise: on the first page of *Capital*, Marx alerts us to the importance of 'the invention of socially recognized standards of measurement' (Marx 1973, 125). However, we have strongly inherited the idea that some vital and effective 'natural' (i.e. non-social) source of value survives abstraction and comes to directly constitute value in capital relations. This is exemplified powerfully in Cronon's (1991) foundational work on the Chicago grain market, in which nature is a separate source of value from labour. Thus, in trying to analyse the specifically *environmental* aspects of capitalist production, geography – in particular political ecology – grinds upon the shore of the very old problem of nature's metaphysics.

There is a large and diverse group of scholars in geography, anthropology, environmental studies, environmental sociology and rural studies that has been interested in the privatisation, marketisation, sale and consumption of environmental goods and services. While many or most in this group substantively draw upon the political economy of

Marx, few have followed Marx's analysis of ecology and metabolism, and even fewer his theory of value (some very notable exceptions include Castree 1995; Foster 2000; Harvey 1996; Henderson 2004b; Smith 1990). Most of us whistle past the problems of value and exploitation and hurry on to explore the uses of abstraction to organise the natural resources necessary for capitalist accumulation (e.g. Robertson 2000 2004). We profitably focus on the contradictions that are evident between, say, water-the-commodity and water-the-Newtonian-fluid. But because we skip over the part in Marx where these social abstractions must begin to bear value for capitalism to function, we have cheated ourselves of the language required to describe why these contradictions cause a crisis of accumulation, as opposed to just causing category errors and logic problems, degraded wetlands and flustered bureaucrats (which can be among the symptoms of such a crisis). It is fascinating to play with the differences between wood and timber, or between fish and ITQs,¹⁰ but underlying these many examples is the tension of the process of creating social abstractions adequate to bear value – and, as Mansfield (2008) argues, defining property, which may be close to the same concern.

I am not alone in this pivot. George Henderson also suggests that this process of finding measures adequate to bear value is a crucial hidden moment of politics:

Like everything else in *Capital*, then, the 'unit' is a process. ... The 'unit', insofar as it necessarily directs us to and represents labor power, is the source of the political in the opening paragraph [of *Capital*]. ... We must ask how and whether the 'unit' coheres. (2004a, 507)

Michael Pryke's striking work on weather futures is a valuable empirical case of just such 'world making' (2007, 586) through a new calculus of value. Melinda Cooper, in observing markets in climate derivatives, goes even further to suggest that they represent a novel development in capitalism in which there is no longer any measure of value adequate to creating universal equivalences, in which there is 'no final determination to the value of value' (2010, 179). For McAfee and Shapiro, contestations over Mexico's massive architecture of federal ecosystem service programs centre on 'whether these programs could generate a new category of value ... and, if so, who would measure and capture these values' (2010, 595). And in what must be considered an ur-text of political ecology, Richard

Walker (1973 1974) grounds his stand against the 'mystification' of nature by science and economics in the definition and demonstration of the *value* of wetlands. Indeed, Walker argues that the 'ambiguity' over competing measures of value 'is a recurrent theme in the literature of political ecology' (1974, 229). If political ecology brings a critical heritage to the study of nature under capitalism, it cannot escape a reckoning with the calculus of value by which capital lays its hands on nature.

It is important to note that this focus on value, measurement and science is not merely the concern of esoteric critical theory and pamphleteers from the 1800s, but arises natively as well from the burgeoning literature on ecosystem services within mainstream economics. To environmental economists, the inability of ecologists to offer up stable commodity measures for, say, woodpecker habitat or carbon sequestration remains a fundamental disciplinary anxiety, and economists across the utilitarian spectrum have urged the incorporation of sophisticated ecological knowledge into economic and policy models. Tellingly, the National Research Council (NRC) has asked ecologists to ensure that 'the output from ecological modeling is in a form that can be used as an input into economic analysis' (NRC 2005, 257). The world cannot be remade into a collection of ecosystem services without a group of committed thinkers dedicated to the problem of defining and debating new technologies for quantifying value. The political ecology of nature under neoliberalism should be, in part, the observation of the theorists of capital attempting to sketch the lineaments of a socially abstract nature – and sometimes failing.¹²

In the following sections, I examine in detail several historical moments in the creation of social abstractions that can bear value. This is often a contested and indirect process, and elements may lead in many directions orthogonal to, or directly oppositional to, capital. But by the end, in some cases, commodities have been defined that are traded on markets for ecosystem services.

Classification

[C]ommunications sciences and modern biologies are constructed by a common move – *the translation of the world into a problem of coding* ... (Haraway 1991, 164; emphasis in original)

Water resources are prominently featured in the ecosystem services literature: there are now active

markets for credits in aquatic environments that represent endangered species habitat, water quality, wetland condition and carbon sequestration. Water resources have been subject to regulatory oversight in many jurisdictions worldwide, and so they may serve as an illustration of the creation of nature as a social abstraction from a set of particular material phenomena. Below, I focus on four observable moments in the definition of value-bearing abstractions. The first is the creation of an ordered and hierarchical taxonomy with which to describe nature, a project referred to as 'classification' in the water resource policy literature of the 1980s. Typologies of nature are not something unique to late capitalist logic or the legal strategies of neoliberal states: wetland scientists, for example, have since 1953 used various typologies to classify wetlands for management and scholarly purposes. The 'Circular 39' system (Shaw and Fredine 1956) divided US wetlands into 20 types based on their suitability for duck habitat, a major driver of wetland conservation in that era. The 'Cowardin' system (Cowardin *et al.* 1976) divided US wetlands into 261 types based primarily on their hydrologic and substrate characteristics. Since then, many other classification systems have been developed by ecologists, but increasingly at the behest of bureaucrats and market planners who require classifications that work for purposes of governance and commodification.

Rebecca Lave's (2009) work on the stream classification system developed by hydrologist David Rosgen presents an excellent case in which a classification system provides the basic metrical technology that separates one kind of commodity – a stream of one type – from a related but distinct kind of commodity – a stream of another type. Rosgen, with the authoritative voice of hydrologic science and an essentially Davisian understanding of hydrogeomorphology, developed a classification that has become wildly popular with environmental regulators and entrepreneurs. It presents them with a static, governable, non-mutable landscape that does not require them to, say, understand the inherent dynamism of stream channels when planning a road through a floodplain. This is an easily recognisable feature of political rationality *à la* Scott (1998). Academic hydrologists have fought Rosgen himself, mainly in the pages of the *Journal of the American Water Resources Association* (Rosgen 2008; Simon *et al.* 2007), but also engaged in vigorous efforts to influence policymakers away from reli-

ance on Rosgen classification (Meyer *et al.* 2006). Regulators have reacted very negatively to these efforts by the academic hydrology community to critique Rosgen. And why not? Rosgen offers a classification that describes a landscape of well-behaved streams arranged in types, and can be used in the development of compensation criteria – including the purchase of compensatory environmental credits that are also designed and certified using Rosgen's system. Although vigorous dispute continues, Rosgen's system is very widely accepted as a basis for classifying the world of streams into units.

Categorisation

Red: pessimistic; will do best; heart not in it – nervous about categorization. Afraid Corps will force us to 'eat those lower ones'. (Comments of EPA staffer Edward 'Red' Heinen in notes from an EPA Wetlands Division conference call 5 March 1985)

A form-based classification is a fundamental step in abstraction. But entrepreneurs and regulators need to measure the value of the service provided by nature, not just name the commodity. The use of categories to talk about the value represented by the functions and processes contained within ecosystems has arisen several times over the past 30 years in the wetland regulatory programme at the US Environmental Protection Agency (EPA). Should the EPA object to a permit applicant who proposed to fill a wetland? Knowing, for example, that a permittee desires to fill 2 acres of PEMA wetland (a Cowardin classification) is a valuable first step in deciding. But although the wetland may be present (which we know from classification), how valuable is it? Here we encounter 'categorisation'. Knowing that a man is a steelworker is one thing; but having a measure by which one can assess the flow of steel from his labour is another, and enables a pervasive calculus of profit and management.

In the case of wetlands, the urge to create simple categories of value to express the complex flow of wetland functions from regulated sites arose in 1985 and again in 1991. In the first iteration, the adoption of a 'red, yellow, green' system¹³ (Baldwin 1985) of evaluating the quality of wetlands was premised on the EPA's inability to object to every permit being issued by the Corps¹⁴. In pursuing their bureaucratic mandate to reduce

	Low	Medium	High
Wetland Value	<p>"Unlikely"</p> <ul style="list-style-type: none"> o Sequencing required o 8:1 compensation ratio <p><u>and</u> large acquisition of existing wetlands</p>	<p>"Unlikely"</p> <ul style="list-style-type: none"> o Sequencing Required o 8:1 compensation ratio <p><u>and</u> large acquisition of existing wetlands</p>	<p>"Maybe"</p> <ul style="list-style-type: none"> o Skip "avoid" w/ double mitigation o 5:1 compensation ratio <p><u>and</u> moderate acquisition of existing wetlands</p>
High	<p>"Unlikely"</p> <ul style="list-style-type: none"> o Sequencing required o 8:1 compensation ratio <p><u>and</u> large acquisition of existing wetlands</p>	<p>"Maybe"</p> <ul style="list-style-type: none"> o Skip "avoid" with double mitigation o 5:1 compensation ratio <p><u>and</u> moderate acquisition of existing wetlands</p>	<p>"Likely"</p> <ul style="list-style-type: none"> o Skip "avoid" and "minimize" o 3:1 compensation ratio <p><u>and</u> possible acquisition of existing wetlands</p>
Medium	<p>"Unlikely"</p> <ul style="list-style-type: none"> o Sequencing required o 8:1 compensation ratio <p><u>and</u> large acquisition of existing wetlands</p>	<p>"Maybe"</p> <ul style="list-style-type: none"> o Skip "avoid" with double mitigation o 5:1 compensation ratio <p><u>and</u> moderate acquisition of existing wetlands</p>	<p>"Likely"</p> <ul style="list-style-type: none"> o Skip "avoid" and "minimize" o 3:1 compensation ratio <p><u>and</u> possible acquisition of existing wetlands</p>
Low	<p>"Maybe"</p> <ul style="list-style-type: none"> o Skip "avoid" with double mtgtn o 3:1 compensation ratio <u>and</u> <p>acquisition of existing wetlands</p>	<p>"Likely"</p> <ul style="list-style-type: none"> o Skip "avoid" and "minimize" o 2:1 compensation ratio <p>o Acquisition may also be required</p>	<p>"Likely"</p> <ul style="list-style-type: none"> o Skip "avoid" and "minimize" o 2:1 compensation ratio

¹ Compensation ratios provided for illustrative purposes only. Guidelines for ratios to be written by EPA, COE, and FWS committee.

Figure 1 Categories of wetland value related to their potential for development and the potential stimulation of a market in compensation wetlands. This chart appeared on a policy brief photocopy circulated at EPA headquarters entitled 'Market-based approach for wetland regulation'
 Source: EPA OPPE [Office of Program and Policy Evaluation] (1991)

wetland impacts, the EPA needed some form of triage to decide which wetland fill proposals were truly worth opposing with concerted energy, and which were not. The technology of categorisation was useful in solving a problem of state coordination through the calculation of value, but the issue of commodification never arose and the value calculated, although abstract, was not of the capitalist kind.

In 1991, however, categorisation arose in the context of market environmentalism. Once again, the technique was to identify 'low, medium and

high' categories based on functional value (Figures 1 and 2), a dramatic simplification from the 261 classes offered by Cowardin. The triage had the goal of defining a category of wetlands that was particularly suited to support the emergence of a market in compensation (Wilcher 1991).

Since March 1990, EPA regulators at the headquarters level had worked toward the development of a private entrepreneurial sector providing wetland compensation credits, and the first permit for such a 'wetland bank' was issued in 1991 (Robertson 2008). In an anonymous 1991 memo from the Office of Planning and Policy Evaluation (EPA's public-relations shop), entitled 'Market-based approach for wetland regulation', the author connects the two goals:

wetlands would be categorized as 'Unlikely,' 'Maybe' and 'Likely' for conversion. Where wetland conversions are allowed, mitigation requirements would include restoration or creation of new wetlands ... [this] would create a market for high value wetlands... (EPA OPPE 1991, 2)

Here, a specifically capitalist value is made visible and calculable through the categorisation of classes in a landscape of governed wetlands.

Wetland scientists, however, were having none of this. The suggestion that the complexity of the wetlands landscape clove neatly into such categories prompted strong resistance among

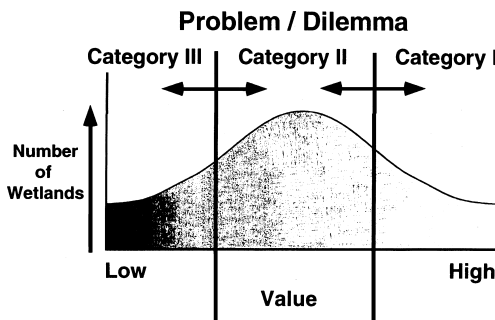


Figure 2 A chart from a photocopied handout used in internal EPA meetings, circa 1991, showing the breaking up of the continuum of value with categorisation
 Source: US EPA (nd)

hydrologists and ecologists, who reasserted the primacy of technologies of classification in response. Lyndon Lee, an elder statesman of wetland policy and ecology, fought back by advocating a system of wetland classification even more complicated than the Cowardin system, with which he hoped to demonstrate the irrationality of assessing all wetlands according to a single scale of value. In a document entitled 'The high, medium and low blues,' Lee posed and answered the question:

Question #1: Can wetlands be classified in a linear fashion according to their value?

Answer: Not with enough credibility to withstand legal challenges focused by competent scientists and regulatory experts operating with the benefit of data. ... No person or existing statute has ever satisfactorily defined 'wetland value.' There are no mandatory technical criteria for definition or identification of wetland 'value' *per se*. (Lee and Fetherston 1991, 3)

Note that Lee made his stand against abstraction specifically on the ground of measuring value, by claiming that the state's arguments about value were not scientifically credible. And, in the end, it was a successful stand, demonstrating the contingency of the social process that creates the value-bearing objects that inhabit capital circulation. Even in the wetland credit market of today, categories are not generally used by the Army Corps or the EPA in assessing the appropriate regulatory response to a wetland fill permit application. Rather, the assessment of each wetland's value remains an idiosyncratic and complicated affair: wetland credit commodities circulate, but the process of asserting and testifying to their equivalence and comparability with other wetland credits is terribly complicated, and almost bespoke. Ecosystem service entrepreneurs continue to offer proposals for categorisation and impatient investors push for more abstract definitions of their assets, but the case of 'categorisation' in wetlands suggests that the building of value-bearing abstractions can be contested and redirected.¹⁴

Unbundling

We presume to value the fish, for example, independently of the water in which they swim. (Harvey 1996, 153)

Categories and classifications provide the containers of value and a notion of the amount of value

involved. At this point we turn to how those semantic containers and the values therein are brought to market as particular produced, financialisable, social abstractions that describe the whole world.

In creating ecosystem credit commodities, economists and policymakers often seek to reframe ecosystems as 'bundles of functions' or 'bundles of values' (e.g. Bennett *et al.* 2009; Raudsepp-Hearne *et al.* 2010). Economists are accustomed to dealing with the multifaceted nature of commodities, and are adept at expressing the value of, say, a house as the sum of the values of the component elements, or the value of a single financial product as tranches of related securities that have different risks. From such equations, it is a trivial task to discover the value of each component. These 'Lancastrian bundle' commodities are analysed in a disaggregated way to find in which component the most value lies:

To say that 'housing' is only a name of convenience for a diverse collection of items will evoke little surprise. ... What is actually bought are copper pipes, brass doorknobs, hardwood parquet flooring, basements, and brick siding. (King 1976, 1078)

In hedonic evaluation, economists apply this model to the environment in a reverse manoeuvre. To find the complete value of the wetland, they aggregate the value of various measurable services provided, describing the wetland commodity as 'a Lancastrian, multi-attribute bundle' (Hoehn *et al.* 2003, 265).

This is what Castree (2003) identified as 'individuation' in the commodification of nature, and Altwater identified as 'the splitting of complex ecosystems which simplifies them into legally definable and economically tradeable property rights' (1993, 185). But it is not a *fait accompli*: even a house is more than the sum of its parts, and more importantly there is no guarantee that the consumer sees the same 'parts' that the economist does. Has the economist drawn the correct boundaries around the elements of the house?

Quite obviously the characteristics defined are arbitrary in several respects. First, there is no certainty that households do perceive the housing bundle as consisting of exactly these four characteristics put together in exactly this way... (King 1976, 1081)

And, to ask the parallel question of wetlands, has the economist drawn the correct boundaries to segregate individual valuable elements within an

ecosystem of a given type or class or category? Perhaps not: 'the list of relevant [wetland] services identified by the researcher and specified in the model may be mis-specified ...' (Hoehn *et al.* 2003, 267).

Other researchers in the ecosystem services literature express similar anxiety over the difficulty of marshalling ecological data to specify the model (Kenny 2009). The NRC, summarising valuation attempts, is forced to conclude that, 'The state of the science is such that there is no broad consensus on a comprehensive list of potential goods and services derived from aquatic ecosystems' (2005, 79). Or, as ecologist Paul Goldstein put it with somewhat more poetry: 'Only the imaginations of ecologists and the shortcomings of language place a ceiling on the alleged number of ecosystem properties' (1999, 253). That is, there is no single authoritative account of how many sticks are in the bundle.

Moreover, the sticks in the ecosystem bundle may be attached to one another. Much like the question of categorising and classification, unbundling an ecosystem into component commodities calls on the work of ecosystem scientists in a very intense way. Ecologists such as Claire Kremen try to sort an ecosystem into explicit 'Ecosystem Service Providers' (ESPs) that retain discrete identities while bundled into aggregates that respond collectively to different management regimes:

[T]he functional importance, f_{ik} , of each ESP_i in environment k will depend on both on its effectiveness at performing the service, here termed 'efficiency' (e_{ik}), and its abundance (n_{ik}). ... In each environment, k , the aggregate ecosystem function (F_k) is simply the sum of the contributions of each ESP_{ik} . (Kremen 2005, 469)

Regression techniques can be used to sort out the level of relatedness between each stick in the bundle, but the foundational conceit of the bundle that can be decomposed into components remains. Parameterising such models remains undone: 'Ecologists have yet to determine how much N[itrogen] and P[hosphorus] can be removed by wetlands without compromising plant and animal diversity' (Zedler 2003, 68).

All of the problems of classification, categorisation and unbundling manifest in the conventional example of housing as well, but in a far less controversial way. How do you segment the housing market? What constitutes a house? What material items are found in a house? These are questions that have relatively noncontroversial answers to economists who point to settled measures: occu-

pancy statistics, design traditions and construction materials. If it is 'nature' that makes the commodification of ecosystems different and more difficult than houses, this difficulty resides not in metaphysics, but in the fact that, in calling on ecosystem sciences to provide answers to similar questions about ecosystems, economists are sometimes met with information, sometimes cacophony and sometimes with silence. Value, if and when it comes to rest in the social abstraction that stands in for the complicated ecosystem, comes from the success of rendering the ecosystem measurable and comparable with other ecosystems, not from nature itself.

Stacking

The power of this bundling of nature into tradable bits of capital should not be underestimated, but nor should it be exaggerated. (Smith 2007, 21)

Once ecosystems have been subjected to a classification system, categorised by value and parsed into individual discrete elements, we are tantalisingly close to their social constitution as abstract values. Kremen's f_{ik} is analogous to the hour of labour in that it is an aggregate measure that can circulate as a bearer of value. But at this point the difficulties inherent in abstraction also begin to become evident as measurement problems and problems of model specification. In the final step, when the unbundled ecosystem is marketed as a 'stack' of credits, these problems may threaten the accumulation process itself.

The correct packaging of ecosystem credit deliverables is a project tackled with enthusiasm by the ecosystem services literature:

Not only are the services provided by biodiversity numerous, but most are hard to measure, which makes them difficult to package for sale. ... The growth and diversification in market participation has produced significant innovation in the design of commodities used to sell biodiversity. (Landell-Mills 2002, 4)

The marketing of separate sticks in the bundle is known as 'stacking' (Bio-Business Support Services 2004; McElwaine 2005; Willamette Partnership 2009), and 2009 witnessed its first few tentative steps as an accumulation strategy in real markets. In North Carolina, the sale of both water quality and wetland habitat credits from the same restoration sites has already engendered resistance from the scientific and environmental policy

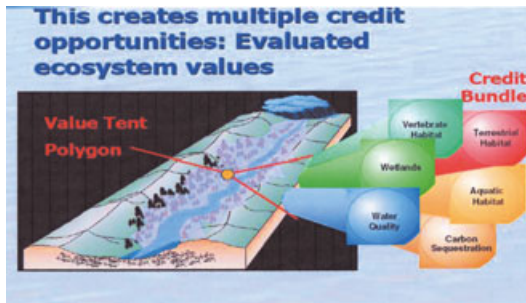


Figure 3 A slide from a Pennsylvania Environmental Council presentation on the use of credit stacking to achieve compensation for multiple environmental impacts at a single site
 Source: McElwaine (2005)

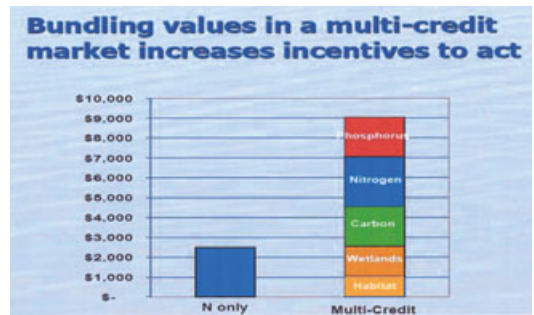


Figure 4 A slide from a Pennsylvania Environmental Council presentation demonstrating how discrete functions can be considered 'stacked' commodities
 Source: McElwaine (2005)

community (Kenny 2009). In Pennsylvania wetlands, a non-profit environmental policy advocacy group is pursuing the wider adoption of a pilot programme already operating in the Conestoga River watershed in which the state resource agency defines a bundle of functions that provide a number of services (Figure 3), each provided to a different degree (McElwaine 2005). A Pennsylvania citizen who receives a permit to, say, emit a ton of CO₂ can purchase the 'carbon' stick in the bundle of this site as compensation. Another citizen who receives a permit to dump pollutants in a stream can purchase the 'water quality' stick. Or the two sticks can be strategically bundled into a single marketed commodity if Pennsylvania regulators desire to achieve water quality improvements by hitching a ride on a thriving carbon market. All permutations are possible.

Ecologists are less than certain about this manoeuvre. In allowing permit-holders to 'consume' individual functions at the site in a credit transaction (in this example, to provide nitrogen reduction credit in the Chesapeake Bay trading programme), the designers of the pilot assume that the other functions of the site *still bear their full value*. But they may not, as ecologists have begun to warn (Bennett *et al.* 2009; Kremen 2005) – the interrelatedness of ecosystem functions means that the full value of one may depend on others (e.g. water quality and carbon sequestration); likewise, the performance of one service may actually reduce the provision of other services (e.g. seasonal wetland habitat and carbon sequestration). When a credit representing one service is transacted, they argue,

its value must include an account of the interrelatedness with other services. In the Pennsylvania case, nitrogen-reduction values are only a part of the stack, and the pilot project encourages site managers to see the rest of these functions as fully-available potential capital. But ecologists struggle to articulate exactly *what* is overlapping between the stacked credit commodities; it is not actual trees or water molecules, and certainly not price. I suggest that it is value: the ecologists wish to articulate that the stacked credit is not an adequate bearer of value because it does not express the functional interdependence of ecosystems. The pilot designers are untroubled by this: as Figure 4 indicates, the axis of the dependent variable in this ecosystem is in dollars, which are of course fully independent of each other as bearers of value. The stacked ecosystem is the finally-full abstraction, in which money has become 'the real community', constituted and contestable through acts of measurement.

Even writers who are generally enthusiastic about ecosystem services (e.g. Fox 2008) are cautious – even frankly pessimistic – about stacking. Advocates recognise that evidence of ecological integration between the sticks in the bundle would be a threat to successful commodification (Daily 1997). There is literally no end to the process of finding new things to stack, and new functions to be defined: 'The more market types emerge,' Fox says, 'the further the unbundling will go' (2008, 173). Why six functions under the value tent? Why not 20 or 50? While housing economists or wetlands policymakers might articulate four or five primary functions, the concept could endorse thousands of stacked functions and lead to a kind of instability in

which the geographical unevenness that drives capital accumulation reaches a point at which actual exchange of commodities is threatened by the surfeit of representations of ecological distinctiveness.

Consider the specific form that instability might take in this case. The availability of multiple ecosystem functions from a site creates an entrepreneurial interest in defining more such functions – that is, in measuring nature in more and more precise ways. And attempts to sell more and more ecosystem services from a single site must invoke less and less secure metrical technology, and more and more spatial and ecological arguments against fungibility. This situation will become more severe with the addition of each new service. This may result in an increasingly unstable foundation in value: realisation crises and overleveraging are possible, but the shape of such events is hard to imagine.

This is a specific case of the general crisis tendency that Smith refers to as capital's 'contradictory tendencies between differentiation and equalization' (1990, 97): the creation of equalisable value-bearing abstractions requires, and produces, a differentiated landscape that may recursively threaten accumulation.¹⁵ The instability does not arise from the point at which intransigent nature expresses its material character, but rather at the point at which we (scientists, stakeholders, etc.) retract our consent to the adequacy of social abstractions as bearers of value. This will happen at different points in each specific conjuncture, or may not happen at all. This is not a novel idea when applied to more conventional markets, or even to markets in novel financial products such as credit derivatives. However, in the case of ecosystem services instability takes a specifically geographic form of scientific polyphony over adequate terms of measuring the containers of value, the amounts they contain and the connections between them.

Conclusion

Simplification is complicated. (Blomley 2008, 1825)

Ecosystem services, like all resources, can be defined as fungible commodities only through a process of assessment, measurement and negotiation between capitalists, scientists and regulators concerning value. If we do not attend to the particular constitution of each resource commodity, we are left to think that capital grapples directly with material nature. And yet such a resistant, intransi-

gent nature is just one end of the dyad *produced* by this work of assessment and measurement, and so such arguments become fully circular. Moving past the antinomy between a commodity's materiality and its meaning is what value theory is *for*, today as in the 1800s.

So this transformation of the world is, in one sense, the latest iteration of a venerable process; and yet Smith is insistent that something new is at play as well. I have argued that the achievement of its commodification has come with a redefinition of the natural world in which capitalism moves – and, to the extent that we exist within a capitalist episteme (which is no guaranteed thing, as the invaluable Gibson-Graham (1995) will always remind us), the world that we live in. The rise of ecosystem service commodities moves us towards the monetisation and financialisation of the conditions of life in a way not seen since the commodification of labour, but is perhaps an even *more* ambitious task, even larger in scope. In ecosystem services, capital has found a way of defining *all of life* – not just human life – as bearers of value nimble enough to circulate through the myriad overlapping circuits of finance and credit, allowing money to represent nature, and 'become the general substance for the survival of all', at last. The resemblance between carbon credits and the consolidated debt obligations is not casual, and this should give even the most dedicated market economist pause – what would the collapse of a bubble or a realisation crisis look like in the carbon market?¹⁶ Perhaps a rush to assure ourselves that there is a real connection to underlying ecological processes – processes from which, because they are *successful* social abstractions, ecosystem services are necessarily distant.

Yes, one can say that ecosystem services differ mainly in the declaration that they are non-consumptive or non-material commodities, but this is an effect rather than a cause: it is not that coal does not circulate like carbon credits because coal is more material; rather, the fact of coal's materiality emerges from its failure to overcome various barriers to circulation. Creating and attesting to value *is* the process of creating social abstractions that circulate in capitalist accumulation; but the work must be done to convince observers that these simplifications are adequate to the task of representation. When we attribute these difficulties to 'nature itself', or to individual preference, we risk losing track of the levers of potential political

change, and losing sight of (as Harvey has it) nature's alienation from itself.

I offer three conclusions.

- 1 In presenting a particular staged process here, I do not mean to supersede or override other sequences suggested by Castree (2003) or Bakker (2005), or even myself (Robertson 2000) in the context of neoliberal capitalism. I do mean to couch all such formulations in the process by which elements of nature become bearers of value, and to suggest the moral horizon that Castree notes is lacking in work on neoliberal natures. Observing a certain difficulty in defining credits in, for example, carbon sequestration, we have a choice. We can place our analysis in a bifurcated world of 'nature exceptionalism' in which abstractions from nature are technically absurd but morally rather neutral: at least in developed countries (where the ecosystem services in question almost always are vested in sites already privatised and involved in capitalist production), we may struggle to define the actual *problem* with ecosystem credit stacking. Sure, it is interesting and contingent, but without dispossession in the traditional sense, who is harmed? Instead, I urge that we understand the recent movements in the struggle over adequate abstraction from nature as part of the larger process of rendering surplus value from our bodies and lives.
- 2 Three significant achievements of the modern era seem to be related. Two of them were analysed by Marx in *Capital*: establishing the social necessity of labour time as a measure of value, and creating a world in which we see ourselves as utility-maximising and self-interested. The third is that of rendering the biophysical world as composed of neatly nested classifications and neatly stacked functions, which takes the appearance of an act of reduction and simplification.¹⁷ Nature is now encountered as ecosystems that consist only of services that already take the commodity form. The commodity form is not something imposed on it after it is extracted from a forest or a mine – it is now a precondition for an encounter with material nature. This is emphasised by no less than the flagship organisation of scientific ecology in the United States, the Ecological Society of America (ESA). In an educational poster advocating the ecosystem services concept (ESA and USUCS

2006), they do not simply recognise the 'value' of ecological features, they subject the viewer to a profound moment of epistemic uncertainty and reorientation. Regardless of what you thought you were looking at when you view the biophysical world, the ESA says, you are actually already looking at ecosystem services, which 'are as familiar as fish and fresh water or as subtle as the stabilization of the climate'. As in the opening epigram, the abstraction becomes 'the real community'.

- 3 These achievements, for all their absurdities and clear logical barriers to completion, continue every day all around us (see Blomley 2008). Achievements as ambitious and unthinkable as establishing the social necessity of labour time as a measure of value, or of creating a world in which we see ourselves as utility-maximising and self-interested, or of rendering the entirety of the biophysical world as classifications and functions, occur through rather mundane and incomplete acts of reduction and simplification. The impossibility of complete abstraction is often less problematic than the real violence executed by attempted abstractions – many of which, as documented above, fail at least in part. It is one thing to point out the abundant absurdities in reducing ecosystems to commodities. But to note this is only the first step, says Blomley: 'to stop here is to risk ignoring the ways in which such absurdities organize the world for us in often brutally efficient and powerful ways' (2008, 1840).

As we become consumers of ecosystem services, and are pulled further and further from a world in which we simply respire and metabolise in primitive accumulation, we will need to keep a firm grasp on the complexities, injuries and silences that may result. Bracketing nature as 'material' or as an unmediated force in capitalist accumulation prevents us from discerning the struggle over the creation of value-bearing abstractions from its materiality. The manifold other phenomena of the natural and human world that must remain unthought within successful abstractions are resources for critical scholarship and political action. In dealing with nature, we are always attended by the invitation to mistake the ordering of appearances for order itself (Mitchell 1988, 60), to mistake the difficulties of classifying and categorising nature for the intransigence of nature itself. Let us continue to refuse the invitation.

Acknowledgements

I am deeply indebted to the participants in the University of California – Berkeley Environmental Politics Colloquium for spending a great deal of time and thought with me on this paper, suggesting new directions and curtailing unproductive ones. I am also very grateful for the input of Joel Wainwright and Nick Blomley to various drafts of this paper, and for the very incisive comments of four anonymous reviewers. All errors are my own responsibility.

Notes

- 1 This site was highlighted in Sullivan (2010).
- 2 See the website at http://www.ecosystemmarketplace.com/pages/dynamic/organization.page.php?page_id=7553§ion=library&eod=1
- 3 The broadening literature on nature under neoliberal capitalism has touched on this point repeatedly: capital does not simply expand into nature as if pushing beyond a frontier, it engages scientists and bureaucrats in redefining what counts as nature and how it is known, in ways that make it more amenable to fiscalisation, governance, commodification and the disciplining of subjects (see especially Guthman 2007; Mansfield 2007; McAfee 2003; Parry 2004).
- 4 One could argue that our 'bodily respiration and metabolism' have been supporting financial commodities for decades in the form of insurance and insurance derivatives. However, insurance commodities do not deal directly with metabolism and respiration, but rather the activities and risks emergent from them. Labour itself is, of course, made possible by metabolism and respiration – my argument is that financial commodities are now grounded in the processes themselves rather than the activities supported by them.
- 5 I am particularly indebted to Julie Guthman and Joel Wainwright for insisting on this point.
- 6 These findings are also informed by my own experience as a bureaucrat working in environmental regulation at the headquarters of the United States Environmental Protection Agency from 2004 to 2007.
- 7 Three misconceptions stand in the way of understanding the neoliberalisation of nature through a lens of value. First, we must not see the commodification of nature as the simple exchange of money for material resources or processes. This is no more the case than it is that the commodification of labour consists simply of the exchange of money for caloric expenditures. Second, value is not price. Conceding to this tenet of neoclassical economics amounts to ignoring one of the foundational elements of critical political economy. Finally, belief in a distinction between material and

discourse has made us think that inquiring deeply into the social constitution of natural objects prevents us from assigning them materially effective roles in the labour process in which value is created under capitalism. The segregationist habit of thinking that our job involves a 'sorting out' of the material from the discursive does us no good when the very distinction itself is a product of the process we wish to observe (cf. Wainwright and Barnes 2009).

- 8 Compare with Costanza *et al.*: the Earth 'is a very efficient, least-cost provider of human life-support services' (1997, 255).
- 9 Compare with 'only the products of mutually independent acts of labour ... can confront each other as commodities' (Marx 1976, 132).
- 10 Individual Transferrable Quotas in fisheries management.
- 11 Tracing the connection between ecosystem function toward the constitution of a consumable service that enters a household production function is a massive theoretical and practical endeavour that some enthusiasts conceive of as a kind of moonshot that 'may require an investment akin to that devoted to agriculture, medicine, space exploration, or defense' (Kremen and Ostfeld 2005). The USDA's Office of Environmental Markets was established in 2009, and the US National Science Foundation has augmented research funding with the statement that 'It might be possible to factor valuation of ecosystem services into economic activities in such a way as to inform decisions about land and water use' (Killeen and Lightfoot 2009).
- 12 Based on the prospect of objecting to the permit issuance ('red'), allowing it with alterations and conditions ('yellow') or not objecting to the permit issuance ('green').
- 13 The US Army Corps of Engineers administers the permit system that regulates impacts to protected aquatic resources in the US; the EPA oversees the Corps' application of environmental criteria in issuing permits.
- 14 However, categories have been adopted by other regulatory programmes that drive ecosystem service markets, such as the habitat credit market under the Endangered Species Act, and the wetland credits purchased under the US Department of Agriculture's 'Swampbuster' provisions.
- 15 'The production of nature is the basic condition for ... equalization, but equalization is continually frustrated by the differentiation of geographic space' (Smith 1990, 152).
- 16 I am indebted to Patrick Bigger for bringing this comparison to my attention several years ago.
- 17 I have focused entirely on the process of constructing appropriate boundaries and categorisations around natural phenomena that allow them to be brought to market. But an equally weighty task is to entrain

entrepreneurial actors in the process of mobilising and marketing these commodities. In short, getting the logic right is not sufficient, and the world beyond the policy whitepaper will take some convincing that their environment consists of stacked services that may present the savvy land-manager with comparative advantage in rent or profit. As the EU-sponsored report 'The economics of ecosystems and biodiversity' declares: 'The goal is to identify or evolve standard metrics for consumer footprint (in terms of land, water and energy use) which are based on sound ecology and economics simple enough to understand and to be implemented by retailers' (Dimas and Gabriel 2008, 55). That the world 'should turn a mart' (Cronon 1983, 159) – and not just a mart, but a Walrastian grocery store – requires a willing population of producers and retailers who see with the proper eyes. Ecosystem services must be created, but so must the people who will *make* and *sell* ecosystem services.

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