The Capitalocene

Part II: Abstract Social Nature and the Limits to Capital

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This essay builds out an argument for understanding the past five centuries as the Capitalocene, the "age of capital." The present essay – the second of two parts – reconstructs the limits, opportunities, and crises of the capitalist world-ecology since the long 16th century. This reconstruction is pursued through the world-ecological reading of value-relations introduced in Part I. While Marxist political economy has taken value to be an economic *phenomenon with systemic implications, I suggest value-relations as a* systemic *phenomenon with a pivotal economic moment. The accumulation of abstract social labor is possible only to the degree that unpaid work (human* and *extra-human) can be appropriated. The value-*form *(the commodity) and its substance (abstract social labor) depend upon value-*relations *that configure wage-labor with its necessarily more expansive conditions of reproduction: unpaid work. Elaborating an approach that seeks to translate the appropriation of work/energy into value, I argue for a conception of value-relations as co-produced through relations of exploitation (capital-labor) and appropriation (capital-unpaid work). This latter, accumulation by appropriation, is enabled by* abstract social nature*, the relational counterpoint to abstract social labor. If the substance of abstract social nature is the production of "real abstractions" of time (linear), space (flat), and nature (external), its historical expressions are found in the family of processes through which capitalists and state-machineries map, identify, quantify, measure, and code human and extra-human natures in service to capital accumulation. The historical conditions of "cheap nature" are found not only in the capital-labor relation but also in the production of knowledge-practices necessary to identify and to appropriate unpaid work. A framework that unifies the domains of human and extra-human activity in the making of the modern world may well prove useful in developing effective analytics and emancipatory politics as modernity unravels today.*

This essay builds out an argument for understanding the past five centuries as the Capitalocene, the "age of capital." In what follows – this second of two essays – I understand capitalism, including its limits, opportunities, and crises, as a civilization that is co-produced by humans and the rest of nature. This co-production unfolds through the double internality of historical change: humanity-in-nature/nature-in-humanity. As we saw in Part I, despite a widespread philosophical agreement that humans are a part of nature, a historical method premised on dualism ("society plus nature") has remained strongly entrenched. It is of course now commonplace to assert that humans are part of

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nature; but translating the philosophical position into new conceptual and narrative foundations for historical change has been slow.

Why should it have been so slow? In brief, because the problem of dualism is an onion problem; we are dealing with layers within layers. To critique Nature/Society dualism is to implicate not one but many binaries: the repertoire of "interrelated and mutually reinforcing dualisms" immanent to modernist thought (Plumwood, 1993: 42). The terrain of this critique is vast and I will not reprise it here. What I should like to highlight is the especially tight connection between three sets of dualisms that cannot be ignored: nature/society, base/superstructure, local/global. While it is straightforward to *de*construct the Nature/Society dualism, the *re*construction of a post-Cartesian historical method implies the transcendence of two other dualisms: base/superstructure and local/global. I am well aware that much of critical scholarship since the 1970s has targeted three dualisms for transcendence. And yet, global studies has only weakly digested, much less synthesized, the triple critique: 1) humanity (or capitalism) continues to act upon nature rather than develop through it; 2) the material processes of capitalism are conceptualized as ontologically prior to embodied thought, as if ideas and symbolic praxis do not matter; system-level processes are either asserted empirically or constructed theoretically, but not historically constructed through the interplay of socio-ecological agencies and processes at multiple scales. This is particularly true of the dominant Anthropocene framework, which is representative of global environmental change approaches offered by mainstream and critical scholars alike (e.g. Steffen, et al., 2007, 2011a, 2011b; Foster, et al., 2010).

If nature *does* include humans, if humans *are* a "natural force" (Marx, 1973: 612), if human thought is embodied in an "unbroken circle of being, knowing, and doing" (Maturana and Varela, 1987: 25), if ideas themselves may constitute "material forces" (Marx, 1978: 60), then we are presented with a challenge and opportunity. This is the pursuit of a conceptual-historical vocabulary – and with it, a framework for interpreting historical change – that moves from humanity *and* nature towards humanity-*in*-nature. The world-ecology argument – not for a singular theory but for a framework of historical interpretation that dialectically unifies capital, power, and nature – has developed to meet this challenge (Moore, 2003, 2011a, 2011b, 2011c, 2013a, 2013b; also Deckard, 2012, 2013; Leonardi, 2012; Niblett, 2012, 2013; Mahnkopf, 2012; Marley, 2013; Marley and Fox, *forthcoming*; Oloff, 2012; Ortiz, *forthcoming*; Parenti, 2014; Weis, 2013).

How do we move from the humanity *and* nature towards historical narratives, analytical strategies, and methodological frames that treat humanity and the rest of nature as co-producers of historical change? In this essay (Part II), we explore the possibilities for explaining capitalism as world-ecology – joining the accumulation of capital, the pursuit of power, and the co-production of nature in dialectical unity – through the optic of value-relations. In this reconstruction of value-relations as methodological premise, I shall privilege four vital dialectical propositions: 1) the accumulation of capital is the transformation of earth (and its creatures); 2) the *substance* of value is abstract social labor but the *relations* of value encompass and unify commodity production and socio-ecological reproduction; 3) because value is premised on the appropriation of unpaid work outside the circuit of capital but within reach of capitalist power, the expanded reproduction of value-relations turn on frontiers of uncapitalized natures, the source of the "Four Cheaps" (labor power, food, energy, raw materials); and 4) these frontiers are not "just there" but are actively constituted through symbolic praxis and material transformation, at once unifying and alienating "mental" and "manual" work (base/superstructure).

This reading of value-relations – as a co-production of human and extra-human work – unfolds from Marx's conception of abstract social labor as the substance of value. But I will much further than this. While Marxist political economy has taken value to be an *economic* phenomenon with systemic implications, I argue that value-relations are a *systemic* phenomenon with a pivotal economic moment. The accumulation of abstract social labor is possible only to the degree that unpaid work (human and extra-human) can be appropriated. The value-form (the commodity) and its substance (abstract social labor) depend upon value-relations that configure wage-labor with its necessarily more expansive conditions of reproduction: unpaid work. Crucially, capital's appropriation of unpaid work transcends the Cartesian divide, encompassing both human and extra-human work outside, but necessary to, the circuit of capital and the production of value. There is, crucially, a historical and logical *non-identity* between the value-form and its necessary value-relations. The simplification, rationalization, and homogenization of socio-ecological life that occurs through the disciplines of manifold commodity regimes – from the assembly line to agro-monocultures – works through a simultaneous process of exploitation (of paid labor) and appropriation (of unpaid work). This double (but not dual) process must occur simultaneously because life-activity within the circuit of capital is subject to relentless exhaustion, as Marx points out in his discussion of the working-day. The condition of the historical transformation of work-activity into value is the devaluation of most work.

This observation has been made often and frequently, especially by feminist Marxists in the long-running (and I think still very useful) "domestic labor" debate (Dalla Costa and James, 1972; Seccombe, 1974; Vogel, 1983; Waring, 1988; Federici, 2012). But the most powerful implications of this critique have been contained – so far – within a Cartesian frame of Nature/Society. As a consequence, a value-relational method to historical change has only slowly and unevenly materialized. Adopting a world-ecological frame, I argue for a conception of value-relations as co-produced through relations of exploitation (capital-labor) and appropriation (capital-unpaid work). This latter is accumulation by appropriation; it is enabled by *abstract social nature*, the relational counterpoint to abstract social labor. If the substance of abstract social nature is the production of "real abstractions" of time (linear), space (flat), and nature (external),[2] its historical expressions are found in the family of processes through which capitalists and state-machineries map, identify, quantify, measure, and code human and extra-human natures in service to capital accumulation. The historical conditions of "cheap nature" are found not only in the capital-labor relation but also in the production of knowledge-practices necessary to identify and to appropriate unpaid work. A framework that unifies the domains of human and extra-human activity in the making of the modern world may well prove useful in developing effective analytics and emancipatory politics as modernity unravels today.

VALUE RELATIONS IN THE CAPITALIST WORLD-ECOLOGY: AN OUTLINE

Modernity's law of value is an exceedingly peculiar way of organizing life in a civilization. Born in the midst of the rise of capitalism after 1450, the law of value enabled an unprecedented historical transition: from land productivity to labor productivity as the metric of wealth and power. It was an ingenious civilizational strategy, for it enabled the deployment of capitalist *technics* – crystallizations of tools and ideas, power and nature – to appropriate the wealth of uncommodified nature (human work included!) in service to advance labor productivity within the zone of commodification. The great leap forward in the scale, scope, and speed of landscape and biological transformations in the three centuries after 1450 — stretching from Poland to Brazil, and the North Atlantic's cod fisheries

[2] The "notion of real abstraction… [is] abstraction not as a mere mask, fantasy, or diversion, but as a force operative in the world... [T]hese abstractions are not mental categories that ideally precede the concrete totality; they are real abstractions that are truly caught up in the [socio-ecological] whole" (Toscano, 2008: 274, 275).

to Southeast Asia's spice islands — may be understood in this light (see "The Capitalocene, Part I"; also Moore, 2007; 2010a; 2010b; 2013a; 2013b).

Such transformations were the epoch-making expressions of a new law of value that reconfigured uncommodified human and extra-human natures (slaves, forests, soils) in servitude to labor productivity and the commodity. The new law of value was quite spectacular. Never before had any civilization negotiated this transition from land productivity to labor productivity as the decisive metric of wealth. This strange metric — value — oriented the whole of west-central Europe towards an equally strange conquest of space. This strange conquest was what Marx (1973, 524) calls the "annihilation of space by time," and across the long sixteenth century we can see a new form of time — abstract time — taking shape (Landes, 1983). While all civilizations in some sense are built to expand across varied topographies, none represented these topographies as external and progressively abstracted in the ways that dominated early capitalism's geographical praxis. The genius of capitalism's cheap nature strategy was to represent time as linear, space as flat, and nature as external (Mumford, 1934; Merchant, 1980; Pickles, 2004). It was a civilizational inflection of the "God-trick" (Haraway, 1988), with bourgeois knowledge representing its special brand of quantifying and scientific reason as a mirror of the world — the same world then being reshaped by early modernity's scientific revolutions in alliance with empires and capitals. The God-trick was the work of abstract social nature.

With abstract time, in other words, would come abstract space (Lefebvre, 1991). Together, they were the indispensable corollaries to the weird crystallization of human and extra-human natures in the form of abstract social labor. It was this ascendant law of value — operating as gravitational field rather than mechanism—that underpinned the extraordinary landscape and biological revolutions of early modernity. Notwithstanding the fanciful historical interpretations of the Anthropocene argument and its idealized model of a two-century modernity (Steffen et al., 2011), the origins of capitalism's cheap nature strategy and today's biospheric turbulence are to be found in the long sixteenth century. The issue is not one of anthropogenic-drivers — presuming a fictitious human unity — but of the relations of capital and capitalist power. The issue is not the Anthropocene, but the *Capitalocene*.

The "Age of Capital" has been premised on a relation that enables advancing labor productivity in great bursts with even greater bursts in the production of "cheap natures," above the Four Cheaps of labor-power, food, energy, and raw materials (Moore, 2012). The catch is that capital-labor relations are not well-equipped to map, code, survey, quantify and otherwise identify and facilitate *new* sources of cheap nature. This latter has, crucially, involved all manner of knowledge-practices, closely linked but not reducible to territorial power (Parenti, 2014), in which the expanded reproduction of the capital-unpaid work relation has been central. This is the historical terrain of abstract social nature and accumulation by appropriation.

The idea of nature as external has worked so effectively because the condition for capital's "self"-expansion is the location and production of external natures. (An obviously co-productive process.) Because these natures are historical and therefore finite, the exhaustion of one historical nature quickly prompts the "discovery" of new natures that deliver yet untapped sources of unpaid work. Thus did the Kew Gardens of British hegemony yield to the International Agricultural Research Centers of American hegemony, which in turn were superseded by the bioprospecting, rent-seeking, and genomic mapping practices of the neoliberal era (Brockway, 1978; Kloppenburg, 1988; McAfee, 1999; 2003.) This means that not only is capitalism bound up with a historically-specific nature; so are its specific phases of development. Each long century of accumulation does not "tap" an exter-

nal nature that exists as a warehouse of resources. Rather, each such long wave creates — and is created by — a historical nature that offers a new, specific set of constraints and opportunities. The accumulation strategies that work at the beginning of a cycle — creating particular historical natures through science, technology, and new forms of territoriality and governance (abstract social nature)—progressively exhaust the relations of reproduction that supply "cheap" labor, food, energy, and raw materials. At some point, this exhaustion registers in rising commodity prices.

This view of nature as external object, while demonstrably false in terms of historical method, was an essential moment in the rise of capitalism. Here we can see ideas as "material force" (Marx, 1978, 60). Early capitalism's world-praxis, fusing symbolic coding and material inscription, moved forward an audacious fetishization of nature. This was expressed, dramatically, in the era's cartographic, scientific, and quantifying revolutions. These were the symbolic moments of primitive accumulation, creating a new intellectual system whose presumption, personified by Descartes, was the separation of humans from the rest of nature. For early modern materialism, the point was not only to interpret the world but to control it: "to make ourselves as it were the masters and possessors of nature" (Descartes, 2006, 51). It was a powerful vision, one so powerful that that even today many students of global environmental change have internalized the early modern view of nature as effectively external to human activity (e.g., Steffen et al., 2011).

The origins of cheap nature are, of course, far more than intellectual and symbolic. The transgression of medieval intellectual frontiers was paired with the transgression of medieval territoriality. While civilizational expansion is in some sense fundamental to all, there emerged in early modern Europe a specific geographical thrust. While all civilizations had frontiers of a sort, capitalism was a frontier. The extension of capitalist power to new spaces that were uncommodified became the lifeblood of capitalism. I have elsewhere considered the historical geographies of early capitalism's commodity frontiers (Moore, 2000b, 2003a, 2003b, 2009, 2010a, 2010b, 2010d, 2010e). For the moment, I wish to highlight two relational axes of these frontiers. First, commodity frontier movements were not merely about the extension of commodity relations, although this was indeed central. Commodity frontier movements were also, crucially, about the extension of territorial and symbolic forms that appropriated unpaid work in service to commodity production. This unpaid work could be delivered by humans — women or slaves, for example — or by extra-human natures, such as forests, soils, or rivers. Second, such frontier movements were, from the very beginning of capitalism, essential to creating the forms of cheap nature specific to capitalism, the Four Cheaps.

What are the implications of this line of thought for a post-Cartesian historical method, one that takes the law of value as a co-production of humans bundled with the rest of nature?

An approach to value that joins the appropriation of cheap natures (including humans!) and the exploitation of commodified labor-power allows us to unravel some of the mysteries of early capitalism's dynamism – a civilization with few significant resource or technological advantages and yet endowed with an epoch-making capacity to reshape landscapes worldwide. While *marxisante* ecology tends to ignore value (e.g. Foster, Clark, and York, 2010), it does so by hiding from view Marx's formulation that use- and exchange-value represent "*on the surface*" the "internal opposition of use-value and value" (Marx, 1977: 153, 209). Marx's discussion in these opening pages of *Capital* are pitched at so high a level of abstraction that I think the implications of this "internal opposition" have been insufficiently grasped. These implications are explosive. For to say that value and use-value are *internally related* is to say that the value relation encompasses the relation value/use-value in a way that necessarily extends far beyond the immediate process of production. Here is a connection

that allows us to join definite "modes of production" and definite "modes of life" in concrete historical unities (quotations from Marx and Engels, 1970: 42).

This means that capitalism can be comprehended through the shifting configuration of the exploitation of labor-power and the appropriation of cheap natures – a dialectic of paid and unpaid work that demands a disproportionate expansion of the latter (appropriation) in relation to the former (exploitation). This reality is suggested – even if its implications for accumulation are only partially grasped – by those widely-cited estimates on the contribution of unpaid work performed by humans (UNDP, 1995: 16; Safri and Graham, 2010) and the rest of nature ("ecosystem services") (Costanza, et al., 1997, 2014). The quantitative reckonings for unpaid human work – overwhelmingly delivered by women – vary between 70 and 80 percent of world GDP; for "ecosystem services," between 70 and 250 percent of GDP. The relations between these two moments are rarely grasped (but see Perkins, 2007); their role in long waves of accumulation, rarely discussed (but for unpaid human work, see Caffentzis, 2010/1980; O'Hara, 1995). I would observe that unpaid work comprises not only the active and ongoing contributions to the daily reproduction of labor-power and the production cycles of agriculture and forestry. Unpaid work also encompasses the appropriation of *accumulated* unpaid work in the form of children raised to adulthood largely outside the commodity system (e.g., in peasant agriculture) and subsequently pushed or pulled into wage-work, and also in the form of fossil fuels produced through the earth's biogeological processes.

The appropriation of unpaid work signifies something beyond the important – but nevertheless too partial – notion of environmental costs and externalities as "missing" (e.g. Patel, 2009). I think in this respect that we may take the crucial insight from feminist marxism: the contribution of unpaid work is not "just there," but actively produced through complex (yet patterned) relations of power, (re)production, and accumulation. I risk pedantry here in saying that the "free gifts" of nature are not "low-hanging fruit" that can simply be picked without much time and effort. Quite the contrary! Cheap natures are actively produced by human activity bundled with the rest of nature, and human and extra-human natures are *both* replete with creativity and contingency. Nature is too often regards as a passive substrate – as in the popular ecological footprint metaphor (Wackernagel and Rees, 1996) – but this is a modernist conceit; one that reflects capital's priorities rather more the history of capitalism. But nature is not substrate; it is the field within which all life unfolds. And all of that life is actively, creatively, incessantly engaged in environment-making (Levins and Lewontin, 1985; Moore, 2013a) – such that, in the modern world, human ingenuity (such as it is) and human activity (such as it has been) must *activate* the work of particular natures in order to appropriate particular streams of unpaid work. Such activation is co-produced reality, bundling the life-activities of human and extra-human nature, present and accumulated over time.

What are the implications for a historically grounded theory of value? On the one hand, capitalism lives and dies on the expanded reproduction of capital: value-in-motion. The substance of value is abstract social labor, or socially necessary labor time, implicated in the production of surplus value. On the other hand, this production of value is particular – it does not value everything, only labor power in the service of commodity production – and therefore rests upon a series of devaluations. Plenty of work – indeed the majority of work in the orbit of capitalism – does not register as valuable. Work by humans, especially women; but also "work" performed by extra-human natures. For good reason, Hribal (2003) asks, "Are animals part of the working class"? The question itself illuminates the law of value's combination of absurd and consistent praxis. Although confusion persistent on the matter, it is now clear that Marx understood that extra-human natures perform all sorts of useful (but not valuable) work for capitalist production, and that such useful work was in fact *imma-*

nent to the capital-relation (Burkett, 1999). Marx's reading of value was, in other words, eminently post-Cartesian.

All of these de- and un-valued forms of work are, however, outside the value form (the commodity) – they do not directly produce value (*contra* Dalla Costa and James, 1972). And yet – it is a very big *and yet* – value as abstract labor cannot be produced except through unpaid work. I would therefore suggest that the value *form* and the value *relation* are not coincident; they cut across the paid/unpaid work divide such that generalized commodification cannot be sustained except through the incessant revolutionizing not only of the forces of production but also the relations of *reproduction*. The historical condition for socially necessary labor-time is socially necessary unpaid work. De-valued work, in this model, becomes an "immanent… antithesis" within the generalization of commodity production and exchange (Marx, 1977: 209). In this contradiction between the expanded reproduction of capital and the simple reproduction of life we have "two universes, two ways of life foreign to each other yet whose wholes explain one another" (Braudel, 1977: 6). The crucial geographical implication of this enabling and constraining tension between paid and unpaid work is the necessity of frontier-making. Recurrent waves of socio-ecological exhaustion – understood as the inability of a given bundle of human/extra-human natures to deliver more work to capital – implicate recurrent waves of geographical expansion. The commodity frontier strategy has been so decisive not because of the extension of commodity production and exchange as such – a common misunderstanding of commodity frontier theory (Moore, 2000, 2013c, 2013d). Rather, commodity frontiers were so epoch-making because they extended the zone of appropriation (of natures' unpaid work) *faster* than the zone of commodification. Marx puts his finger on the crucial dialectic when he addresses the contradictions of the working day, the tendency towards manifold "industrial patholog[ies]," and the necessity of incorporating "physically uncorrupted" human natures into the world proletariat (1977). In sum, not only does capitalism *have* frontiers; it *is* a frontier civilization.

It will consequently not suffice to identify the influence of abstract social labor as an "economic" phenomenon, although this remains pivotal. The endless frontier strategy of historical capitalism is premised on a vision of the world as endless: this is the conceit of capital and its theology of endless substitutability.[3] Abstract social labor, in this reading, is the *economic expression* of the law of value, which is unworkable historically without strategies of appropriating cheap nature. Why is this? Because, in short, the creation of socially necessary labor-time is constituted through a shifting balance of human and extra-human work; *the co-production of nature*, in other words, is constitutive of socially necessary labor-time. Socially necessary labor-time forms and re-forms in and through the web of life (Moore, 2013b).[4] Early capitalism's landscape transformations, in their epoch-making totality, were unthinkable without new ways of mapping space, controlling time, and cataloguing external nature – and they are inexplicable solely in terms of world-market or class-structural change. The law of value, far from reducible to abstract social labor, finds its necessary conditions of self-expansion through the creation and subsequent appropriation of cheap human and extra-human natures. These movements of appropriation must, if capital is to forestall the rising costs of production, be secured through extra-economic procedures and processes.

By this I mean something more than the recurrent waves of primitive accumulation that we have come to accept as a cyclical phenomenon of capitalism (Angelis, 2007). These also remain pivotal.

[3] Much of ecological economics can be read as a sustained critique of this theology. A useful introduction is found in Daly and Farley, 2004; also Perelman, 2007.

[4] "[T]he process of reproduction has to be considered from the standpoint of the replacement of the individual components of C' both in value and in material" (Marx, 1978: 469).

But between our now cherished dialectic of "expanded reproduction" and "accumulation by dispossession" (Harvey, 2003) are those knowledges and associated practices committed to the mapping, quantifying, and rationalizing of human and extra-human natures in service to capital accumulation. Thus the trinity: abstract social labor, abstract social nature, primitive accumulation. This is the relational core of capitalist world-praxis. And the work of this unholy trinity? Produce cheap natures.[5] Extend the zone of appropriation. In sum, to deliver labor, food, energy, and raw materials – the "Four Cheaps" (Moore, 2012) – faster than accumulating mass of surplus capital derived from the exploitation of labor-power. Why? Because the rate of exploitation of labor-power (within the commodity system) tends to exhaust the life-making capacities that enter into the immediate production of value. Capital is indifferent to the Cartesian divide:

> Capital asks no questions about the length of life of labor-power. What interests it is purely and simply the maximum of labour-power that can be set in motion in a working day. It attains this objective by shortening the life of labour-power, *in the same way* as a greedy farmer snatches more produce from the soil by robbing it of its fertility (Marx, 1977: 376, emphasis added, also 636-38).

This exhaustion might take the form of an obvious withering of "vital forces" (Marx, 1977: 380). More often, however, exhaustion manifests in the inability of a given production complex to yield a rising stream of unpaid work – performed by human and extra-human natures alike. This latter form of exhaustion typically issues from some combination of class struggle, biophysical change, and the tendentially rising "geographical inertia" of regional built environments (quotation from Harvey, 1982: 428-29). In a world treated as boundless, capital as a whole has evinced a cumulative, but cyclically punctuated, tendency to search out and appropriate new, "physically uncorrupted" (Marx, 1977: 380) zones of cheap labor, food, energy, and raw materials. Exhaustion signals a rising value composition of capital, and the inflection point of decline for a given production complex to supply a growing stream of unpaid work to regional accumulation.[6] To the degree that "foreign preserves" can be identified and dominated, such relative "degeneration of the industrial population" matters little (quotations respectively from Cairnes, 1862: 110-111 quoted in Marx, 1977: 377; and Marx, 1977: 380).[7] Has it been so different for extra-human natures? English agriculture, though not necessarily physically exhausted, was certainly exhausted in terms of its capacity to send a rising stream of

[5] *Produce* does not mean "call forth at will," but rather signifies a dialectic of co-production (Marx, 1977: 283).

[6] This explains something of the recurrent waves of financialization that redounded to the benefit of the declining world hegemon – in their respective *belle époques*, the Dutch, British, and American hegemonies each enjoyed a renewal of accumulation by capitalists in their respective geographical loci by deploying financial means to secure the fruits of agro-industrial expansions, based on new appropriations of cheap nature elsewhere in the world (Arrighi, 1994).

[7] Of course we should take care to appreciate that movements to drive down labor costs are found in technical innovation in core industrial sectors, alongside class politics and imperial initiatives to widen the sphere of appropriation. Thus, English labor-to-capital costs were 60 percent higher than on the Continent in the mid-18th century, which encouraged efforts to mechanize production (Allen, 2011, 31-32 and ch. 3 passim). Nevertheless, the new phase of industrialization gathered steam in those regions of England – such as the northern Midlands – where wages were relatively low compared to the south of England (Hunt, 1986). Yet, such mechanization was possible in great measure, especially after 1780s, by technical innovations that were probably "capital-saving" as much as they were "labor-saving" (von Tunzelmann, 1981), at least until the 1830s (Deane, 1973). In textiles, we are clearly dealing with rising labor productivity. But even here the technical composition of capital (the mass of machinery) could rise much faster than its value composition because of opportunities for appropriating cheap energy and cheap iron through the coal/steampower/iron nexus. We are, then, unavoidably dealing with a cascading series of technical innovations that work simultaneously to reduce the value of labor-power and the rest of the Big Four inputs. These cascades – *necessarily and irreducibly* – extend well beyond any sectoral or national frame, crucially encompassing production/reproduction configurations in the minimally-commodified colonial and frontier zones.

cheap food to metropolitan capital by the early decades of the 19th century (Thomas, 1993). Not surprisingly, British capitalism at its mid-century apex would nourish itself on the basis of cheap calories – grain and sugar – supplied from New World frontier zones in North America and the Caribbean (Cronon, 1991; Mintz, 1985).

We can now connect the dots between the rise of capitalism and the emergence of the law of value. Value relations incorporate a double movement to exploitation and appropriation – within the commodity system, the exploitation of labor-power reigns supreme, but this supremacy is only possible, given its tendency toward self-exhaustion, to the degree that the appropriation of uncommodified natures counteracts this tendency. It is has been a difficult process to discern because value *relations* are necessarily much broader than the immediate production of the value *form* (the commodity). The generalization of commodity production has historically proceeded through an expansionary web of value relations whose scope and scale extends considerably beyond the immediate process of production. McMichael puts the issue very well when he observes the problem of capitalist development as one of the uneven globalization of wage-work *dialectically joined to* the "generalization of its conditions of reproduction" (1991: 343). The difficulty in pursuing such an analysis has been rooted in the dualisms immanent to modern thought; for to construct capitalism in the fashion that I have suggested is to transcend the man/woman, nature/society boundaries upon which the whole edifice of modernist thought depends (see esp. Plumwood, 1993: 41-68; also Waring, 1988). For not only do we need to unify the distinctive but mutually formative dialectics of human work under capitalism through the nexus paid/unpaid work – "productive" and "reproductive" work. We also need to recognize that the dynamism of capitalism has owed everything to appropriating and co-producing ever more creative configurations of human and extra-human work across the *longue durée*.

If we take the nexus paid/unpaid work as our premise – implicitly suggested by ecological and feminist scholars – the implications are significant. Capitalism and value relations cannot be reduced to a relation between the owners of capital and the possessors of labor-power. To repeat: the historical condition of socially necessary labor-time is socially necessary unpaid work. This observation opens a vista on capitalism as a contradictory unity of production and reproduction that crosses the Cartesian boundary. The crucial divide is between the zone of paid work (the exploitation of commodified labor-power) and the zone of unpaid work (the reproduction of life). This contradictory unity works by creating a relatively narrow sphere of commodity production within which labor-power can be said to yield either rising or falling productivity, which can be represented (imperfectly) through input-output calculations. This narrow sphere, premised on the exploitation of labor-power within commodity production, operates in relation to a much more expansive sphere of appropriation, through which the diversity of nature's "free gifts" – including the reproduction of life from the family to the biosphere – may be taken up into commodity production, but not fully capitalized. Why not fully capitalized? Because the capitalization of reproduction is subject to the exhaustive tendencies we have just discussed, which imply a rising value composition of capital and signals a situation in which capital must bear a great share of its own costs.

The upshot is this. This new law of value, turning on socially necessary labor-time within commodity production, required an expansive (*and expanding*) domain of appropriating cheap natures. This was in fact what early capitalism was best at doing: developing technologies and knowledges unusually well-suited to identifying, coding, and rationalizing cheap natures. Here the new way of seeing the world – inaugurated by the emergence of Renaissance perspective – decisively conditioned a new organizing *technics* for the capitalist world-ecology, manifesting in the cartographic-shipbuilding revo-

lution of early modernity, from the Portolan maps and caravels to Mercator globes and galleons, and much beyond.

Appropriating cheap natures was a far more creative act than the *dependencia* language of plunder allows (e.g. Galeano, 1973; Clark and Foster, 2009; see Moore, 2010a). "Appropriation" represents a productive activity every bit as much as "exploitation." The outright seizure of basic wealth – clearly no invention of the sixteenth century – provided no durable basis for the endless accumulation of capital. What did provide a reliable basis for the new civilization was a set of appropriative practices combined with the world market and technological innovations oriented towards global expansion. Crucially, these comprised quite conscious colonial strategies to reorganize indigenous populations into strategic hamlets that functioned as labor reserves: the *reducciones* in the Andes and the *aldeias* in Brazil (Gade and Escobar, 1982; Schwartz, 1978). The practices created rising labor productivity within the only zone that capital cares about: the zone of commodification. It did not matter that horrific levels of mortality accompanied this rising labor productivity so long as the costs of appropriation – through indigenous and African slave trades – were sufficiently low (Schwartz, 1985; Moore, 2007).

This speaks to a problem not only of economic historiography but also of Marxist political economy. We are, in the conventional reading of Marx, offered two categories for the production of surplus value: absolute (more hours worked) and relative (more commodities produced in the same number of hours). For good reason, Marx focused on the basic tendencies at play in the rise of large-scale industry, and this focus has been reproduced ever since. But Marx also points towards a theory of the rate of exploitation that is grounded in the dialectic of human labor with external natures. In this, the fertility of the soil may "act like an increase of fixed capital" (1977: 238, 636-38; quotation from 1973: 748; also 1981: chapter 38). We can take this reference to soil fertility as a shorthand for the life-making capacities of human and extra-human natures. Even where extraordinary soil fertility was in some sense "given," it was equally co-produced: as in the fertility of seventeenth century Bahia or the nineteenth century American Midwest and Great Plains. Absent the cartographic-shipbuilding revolution of the long sixteenth century, or the railroad revolution and the rationalization of American territory in the long nineteenth century, the bounty of these frontiers was no more than *potential*. These "hard" and "soft" technologies of production advanced labor productivity by harnessing the capacities of these natures to work for free. But it took work to gets these natures to work for free, and this was the innovation of early capitalist technical advance. Sugar and wheat frontiers remade the world only through extraordinary movements of capital, knowledge, and humans, each movement a mighty expenditure of energy aimed at transforming nature's *work* into the bourgeoisie's *capital*. Yes, coal and oil are dramatic examples of this process of appropriating unpaid work, understood in such a relational framework. But this observation – namely, that fossil fuels have been central to great leaps forward in labor productivity – is turned into a fetish when the same processes are not applied to early capitalism.

The consequence is a massive blindspot in radical thought: the great labor productivity revolution of early capitalism is almost universally ignored.[8] Why? Because our metrics and narrative frames have been largely unable – or perhaps unwilling? – to bring unpaid work into value-relations. The challenge is to internalize, in our narrative frames and analytical strategies, how configurations of paid

[8] This revolution is largely unacknowledged, although sometimes hinted at (Landes, 1998). Why the blindspot? On the one hand, economic historiography remains overwhelmingly Eurocentric, methodologically nationalist, and quantitatively fetishist. One the other hand, it has been unable to grasp the role of unpaid work secured by extra-economic means, which include but go beyond processes of primitive accumulation.

and unpaid work stabilize, and are cyclically restructured, through successive productivity regimes in historical capitalism. Returning to our early modern frame, we might ask, How do we internalize, analytically, the fertility windfalls of *massapé* soils in 17th century Brazil? Of the contributions of the families of the *mitayos* (forced wage-workers) traveling to the Potosi mines? Of Norwegian and Baltic forests to the shipbuilding centers of the Dutch Republic? Of peasant cultivation to the off-season iron-making work of Swedish peasants, whose labor costs were correspondingly much lower than English competitors? And perhaps most spectacularly – I am again transgressing the Cartesian boundary – of African families whose sons and daughters were impressed into plantation labor?

This early modern labor productivity revolution turned not only on Smithian specialization, technological change, and organizational innovation, but also on the new *technics* of value through which cheap natures were mapped, organized, and appropriated. The "fertility" of cheap natures was the pedestal for productivity advance within the commodity zone. Perhaps inadvertently, Clark offers an illuminating contrast about labor productivity informed by a caloric metric. In a passage that would resonate with any energy-centered critic of industrial agriculture (e.g. Pimentel, et al., 1973), Clark notes that the average "worker-hour" in English agriculture around 1800 would have yield about 2,600 calories, premised on wheat, milk, and wheat staples (2007: 67-68). In contrast, the average "worker-hour" in swidden agriculture in turn-of-the-century Brazil, cultivating manioc, maize, and sweet potatoes, yielded anywhere between 7,000 and 17,600 calories (ibid; also Werner, et al., 1979).

What does this tell us? Most of all, it tells us that one of the key reasons why capitalism was able to consolidate across the early modern era was its ability to appropriate the astounding realities, and realize the extraordinary potentialities, of uncommodified natures worldwide. If sixteenth century Europe was exceptional in any technological sense, it was this. Food works well as an example, because the metrics are easy, but one could multiply the appropriations of worker-hour windfalls to all sectors of early capitalism. How would work-hour productivity in timber vary between, say, coppiced English forests and the relatively unmanaged Norwegian forests of the late sixteenth century? Or between long-exploited Central European silver mines and Potosí's Cerro Rico around 1550? In a narrow sense, these differences were not "produced" in any straightforward, linear, sense. But neither were these bountiful frontiers simply there for the taking. *They were co-produced.*

There was necessarily a mix of serendipity and strategy at play in early capitalism's productivity revolution: serendipity insofar as New World crops such as maize, potatoes, and manioc were high-yielding, and strategy insofar as the new commodity frontiers (sugar and silver above all) actively constructed their production systems around such high-yielding crops. But even where Old World crops were introduced – the Spaniards in colonial Peru loved wheat bread – the initial yields were extraordinarily high (an order of magnitude greater than the Europe average) and remained so for the first long wave of colonial domination (c. 1545-1640) (Super, 1988; Moore, 2010e). The point can scarcely be overstated: the introduction of "cheap" food, as civilizational strategy, "acts like an increase in fixed capital." The declining price (value composition) of food is advancing labor productivity is the rising rate of exploitation.

The catch? The cheapening of food – along with raw materials and energy – cannot be accomplished by economic and territorial means alone. Cheap food, and "cheap nature" as capitalist project, could be realized only through the symbolic regimes of abstract social nature. These encompassed the "primitive accumulation of botanical knowledge" organized by Iberian botanical gardens (Cañizares-Esguerra, 2004, 2006), the emergence of a new "map consciousness" (Pickles, 2004), the

"death of nature" inaugurated by early modern materialism (Merchant, 1980), and much more. We will have both motive and opportunity to return to the question of abstract social nature presently.

The law of value-in-formation during the early capitalism – *and since* – unfolded through two simultaneous movements, corresponding to the dialectic of value/not-value. This latter moment is "produced" through the zone of appropriation that is the condition for *value* as the zone of exploitation; it encompasses the unpaid labor of all humans, but especially "women's work." Historical capitalism has been able to resolve its recurrent crises because territorialist and capitalist agencies have been able to extend the zone of appropriation faster than the zone of exploitation. For this reason, capitalism has been able to overcome seemingly insuperable "natural limits" through coercive-intensive appropriations of global nature, producing the "Four Cheaps": labor power, food, energy, and raw materials (Moore, 2012). The Four Cheaps are produced by extending the zone of "accumulation by appropriation" faster than "accumulation by capitalization" (Moore, 2011a, 2011b). Significant enlargements in the zone of appropriation resolve capitalism's crises by effecting a remarkable – and necessarily short-lived – trick: Appropriation "works" to the degree that it controls and channels, *but does not immediately capitalize,* the reproduction of life-making capacities for the benefit of accumulation. Modernity is in this sense a mighty "code and control" project, effecting the widest range of quantifying and categorizing procedures oriented towards identifying, securing, and regulating human and extra-human natures in the service of accumulation. This latter is the terrain of abstract social nature.

HISTORICAL NATURES: VALUE, WORLD-PRAXIS, AND ABSTRACT SOCIAL NATURE

Abstract social nature names the family of processes through which capitalists and state-machineries map, identify, quantify, measure, and code human and extra-human natures in service to capital accumulation. In my view, this family of processes is *immanent* to capitalism's law of value; it is directly constitutive of those relations that nourish and sustain the long-run self-expansion of capital, whose substance is abstract social labor, value's "economic" expression. This dialectic of abstract nature and abstract labor – crystallizing successive weaves of capital, power, and nature – is at the heart of those *historical natures* that are cause, consequence, and unfolding condition of successive long centuries of accumulation. (About which, I will say more presently.) This approach allows us to kill two birds with one stone. In the first instance, it allows us to transcend a Nature/Society dualism and illuminate the historically-concrete interpenetration of "paid" and "unpaid" work in the accumulation of capital. Secondly, it allows us to transcend a base/superstructure dualism in the history of capitalist environment-making. This will be our focus in this stage of the argument.

This is hardly a minor point. For the literature on global environmental change – in its Anthropocene variant as well as in radical approaches to metabolism (Foster, Clark, and York, 2010) – we have seen a resurgence of a materialism that strikes me as unduly dismissive of science and culture (*inter alia*) in the making of the modern world.[9] I don't, mean to suggest that global environmental scholars are somehow unaware of the importance of science in a broad sense – radical and mainstream arguments both tend to embrace natural science, albeit largely uncritically. But the resulting interpretations of historical change – say of the "Great Acceleration" or the theory of monopoly capitalism (Steffen, et al., 2007; Foster, Clark, and York, 2010) – have little room for the flow of ideas in the history of the modern world (but see Pálsson, et al., 2013). And it is here that the

[9] For the "metabolic rift" critique especially, there is a special irony to this sort of reductionist materialism, insofar the perspective centers on John Bellamy Foster, whose enduring relevance is found in his contribution to the intellectual history of Marxism (e.g., Foster, 1999, 2000; Foster and Holleman, 2012, *forthcoming*).

base/superstructure approach of global environmental analysts meets up with the Nature/Society dualism. The implication is that human thought is not *really* embodied within the web of life – that human thought is somehow exempt. This is the enduring justification for some form of human exemptionalist social science, and it the key stumbling block to the analysis of humanity-in-nature understood as the "the unbroken coincidence of our being, our doing, and our knowing" (Maturana and Varela, 1987: 25).

The historical point? Productive forces *are* tools and technological systems; they are also more than this. For the metabolism of humanity-in-nature is ontologically structured by humanity's species-specific and highly plastic mode of sociality: the "application and development of a certain body of social knowledge" to definite ways of producing and reproducing life (Williams, 1977: 71).[10]

In short, *ideas matter*. The recurrent scientific, botanical, cartographic, agronomic, and chemical revolutions of the past five centuries can hardly be regarded as epiphenomenal to the accumulation of capital. Yes, with Marx and Engels (1970) we can say that the ruling ideas of society are the ideas of the ruling classes. But this hardly clarifies matters. Ruling classes owe their position to the production of surpluses, but this is never a simple economic process independent of social knowledge. In the modern world, science, too, is a "productive force" (Marx, 1967, I: 341; also Rosenberg, 1974).[11] The production of knowledge itself is a constituent force in the trinity of capitalist world-praxis – abstract social labor, abstract social nature, primitive accumulation – without which the "triple helix of commodification" (labor, land, and the commodities produced) could not develop over large-space and long-time.

It is this unity of "science, capital, and power" that has long been suggested by critical agrarian scholars (Brockway, 1979: 461; also Kloppenburg, 1988; Weis, 2013), but insufficiently linked to the theory of capital accumulation, and the value-relations at its core. This is the challenge we will take up in the remainder of this essay.

Grounding science, capital, and power in the web of life requires – as the Anthropocene argument correctly points towards – a periodization of "natural" history in which human activity matters. But the paired dualisms of the global environmental change literature (Nature/Society, base/superstructure) prevents the very synthesis suggested by these analyses. How might we move beyond these dualisms towards a dialectical reconstruction of capitalism-in-nature?

The world-ecological approach to the historical natures and historical limits of capitalism proceeds with a decisive ontological shift. This is a shift from seeing nature as *resource* to seeing nature as *matrix*. Does this mean we no longer need to talk about *resources*? Hardly! It does, however, mean that

[10] "What then is a 'productive force'? It is all and any of means of production and reproduction of real life. It may be seen as particular kind of agricultural or industrial production, but any such kind is already a certain mode of social co-operation and the application and development of a certain body of social knowledge. The production of this specific social co-operation or of this specific social knowledge is itself carried through by productive forces" (Williams, 1977: 91). Neither are productive forces the basic relations upon which power unfolds; to say "power and production in the web of life" is to implicate the interpenetration of these moments in the totality of the biosphere: "There are not first of all relations of production and then, in addition, alongside or on top of these relations, mechanisms of power that modify or disturb them, or make them more consistent, coherent, or stable…. Mechanisms of power are an intrinsic part of all these relations and, in a circular way, are both their effect and cause (Foucault, 2007: 17). Where Foucault writes production, could we not say *capital*? Where he says mechanisms of power, could we not say *relations of nature*?

[11] On this point, the Moore and Aveling translation is perhaps superior to Fowkes' (compare Marx, 1967, I to Marx, 1977: 482).

we recognize the bourgeois representation of nature – of resources as things-in-themselves – as both a fetish and a particular historical project to create a specifically modern historical nature: "cheap nature" (Moore, 2014). To move beyond the fetish, we may view resources as bundles of relations rather than geo-biological properties *as such* – without of course denying these properties. The journey from geology to geohistory necessitates a historical method that grasps the material-symbolic formation of power in human organization, itself already constituted relationally in the web of life. Thus a world-ecological view of, say, coal's "agency" since 1800 allows us to distinguish the geology of coal from coal's geohistory – to discern geological from historical facts. Geohistorically speaking, whomever says capital implicates coal in the era of large-scale industry: those who say fossil fuels make industrial capitalism are not wrong so much as errant in the insertion of a non-relational object (coal) in the relational process of capital accumulation (e.g. Malm, 2013; Altvater, 2006).[12] By itself, coal is only a *potential* actant; bundled with the relations of class, empire, and appropriation in the 19th century, however, coal becomes something quite different. It becomes a way of naming a "mass commodity" whose hand was seen in every strategic relation of nineteenth century capitalism.[13] Resources, then, are actively co-produced; they are markers and creators of the historical natures that help to define the scope of opportunity and constraint in successive eras of capitalist development. If this sensibility has long been registered theoretically (Harvey, 1974), the historiography of resource extraction has seldom taken the relational point seriously (e.g. Bunker and Ciccantell, 2005; Wrigley, 2010).

Just what would it meant to take the relational point seriously? I would begin with a banal observation whose truth is rarely taken to heart: What "counts" as a resource shifts as the terms of the *oikeios* change – as new historical natures emerge. To paraphrase Marx, coal is coal. Only under specific conditions does it become fossil fuel, and come to shape entire historical epochs. My name for these specific conditions is *historical* nature (after Marx and Engels, 1970). Historical nature must not be taken as an output of capitalism or any other kind of system. Capitalism does not produce an external "historical" nature according to its needs (a functionalist position). Nor does capitalism simply respond to external changes in nature (another functionalist position). Rather, successive phases of capitalist development are "at once cause and consequence of fundamental reorganization[s] of world-ecology" (Moore, 2000a: 124). Both "capital" and "nature" *acquire new historical properties* through these reorganizations: hence the couplet historical capitalism/historical nature may be given real *historical* content. (And not given merely lip service that acknowledge time but does not embrace history.) These reorganizations unfold through the interpenetrating patterns of climate change (*inter alia*) – forged over Braudel's "very *longue durée*" of geological time (2009: 195) – and capitalism's configurations power and production forged across the long centuries of accumulation – indeed over the long-run of civilization itself. Historical natures are, in other words, a dance of the dialectic between part (modes of humanity) and whole (the web of life) through which particular limits and opportunities come to the fore.[14] And the question of historical natures is a question of how the layers of historical time shape each other (Braudel, 1972-73). The history of this dance of the dialectic is often told in dualistic terms, but in fact the close relation between climate and the rise

[12] Huber's argument, while surficially similar to Alvater's, gets us moving in the right direction in his emphasis on fossil fuels as articulated through the reproduction of capitalist power and value relations (2008).

[13] "In the long march toward the modern world-system, *mass commodities* – gold, sugar, slaves, cotton, coal, oil – have been its beasts of burden. They have sometimes served as markers for entire historical epochs… They are the motors of production, the ultimate hard currency of exchange" (Retort, 2005: 39).

[14] The dancing metaphor is Ollman's (2003). The view of nature as constraint and opportunity for capital accumulation has been clearly articulated by Henderson (1998) and Schurman, Boyd, and Prudham (2001) – but in regional-historical or systemic-theoretical terms, respectively, rather than across the historical-geography of capitalism as a whole.

and demise of great civilizations – say Rome over the Roman Climatic Optimum or feudal Europe during the Medieval Warm Period (Crumley, 1994; Moore, 2013a; Lieberman, 2011) – suggests a different view of historical natures. In this alternative, cascading movements of the web of life enter into particular historical-geographical configurations of power and production. If human sociality articulates these relations – in its double meaning (to connect and to give expression to) – the biosphere is its integument. In contrast to the widely held view of nature as "nature in general," a more illuminating vantage point is offered by seeing *historical* natures as the co-production of specific part-whole combinations – civilizations-in-nature – in which specific "geological, hydrographical, climatic, and [biogeographical]" conditions enter into the most intimate, and also the most expansive, domains of human history.[15]

These historical natures are the *fields* upon which the conditions and constraints of capital accumulation unfold in any given era. Such constraints and conditions are most effectively situated within the ways that humanity co-produces specifiable bundles of relations – say, agriculture or religion or markets. These enable and express specific configurations of species-environment relations. Put glibly, relations of capital, labor, and power move *through*, not around, nature; they are "specifically harnessed natural force[s]" (Marx, 1973: 612). Capital does not interact with nature as external object but rather is a specifically harnessed natural force. Capital, itself co-produced, in turn co-produces specific historical natures, albeit under conditions that are full of resistances and frictions to capital's desire for a world of fungible, passive, and malleable life. The upshot? World-economies do not interact with world-ecologies; world-economies *are* world-ecologies. It is from this species-environment dialectic that issues humanity's diverse world-ecologies (civilizations) and the historical natures within which they unfold.

In the modern world, successive historical natures have been produced through a dialectic of commodification and appropriation. On the one hand, through the monetized transformation of land and labor, on the other, through the harnessing of unpaid life-activity in service to commodification. This latter moment – appropriation – has long been recognized by the theory of imperialism (Luxemburg, 1913; Wallerstein, 1974), but has been only weakly grounded in the theory of accumulation, which in practice has tended to regard the circuit of capital as a closed-system of sorts. This accounts in part for the surprising nature-blindness of Marxist economic accounts of the post-2008 era (e.g. Foster and McChesney, 2012; McNally, 2011; Panitch and Gindin, 2012).

What makes appropriation possible, and what makes it such a powerful moment in the history of capitalism? Part of the answer can be found in a long history of analysis on culture, ideology, and hegemony in the modern world, representing what Shapiro calls the "cultural fix" (2012), which

> broadly includes Gramscian hegemony and all forms of cultural and social customs, institutions and identity-formation. The cultural fix covers the moments of class compact as well as mechanisms by which the working-class is simultaneously pitted against one another, the moments when capitalism exports its own competition onto the working-class. The spatial fix and the cultural fix also frequently overlap, such as when housing struggles include slum clearance and gentrification in ways that alter working-class identities within the urban ecology… The role of the cultural fix [comprises, moreover, those] social and cultural matters involving the reproduction of class identities and relations *over time-lengths greater than a single*

[15] The phrase is from Marx and Engels (1970).

> *turnover cycle [of capital] are intrinsic, not superficial, to the [accumulation] of capital* (Shapiro, 2012, emphasis added.)

If cultural fixes cement successive hegemonic agreements between capital and the direct producers (Silver and Slater, 1999), they also extend beyond the sphere of *direct* production. Necessarily, cultural fixes transcend the wage-relation's double boundary with unpaid work. Such fixes naturalize not only capital's appropriation of unpaid work by humans – above all the reproduction of labor-power – but also new epoch-making practices of appropriating unpaid work by extra-human natures. Today's meat-industrial complex, for instance, would be unthinkable to those living in an earlier era of capitalism when the human relation to non-human animals was – symbolically and materially – more direct and intimate (e.g. Weis, 2013; Hribal, 2003). Cultural fixes serve to normalize otherwise unacceptable appropriations of global natures, human and extra-human. Thus are revolutions in gender and nature closely bound, materially instituted and symbolically practiced: "ideas" of nature/gender are not simply outputs of the system but implicated in the intergenerational reproduction of life and labor-power that capital cannot fully pay for but must appropriate. (Lest reproduction costs rise and accumulation falter.) This tendency found dramatic expression in early modernity's complementary movements of scientific revolution and "proto-industrial" demographic restructuring (Merchant, 1980; Seccombe, 1992). Cultural fixes, in this light, appear as the necessary symbolic condition for the ongoing reproduction of "long wave" appropriations of the Four Cheaps.

If cultural fixes naturalize capitalism's punctuated transitions in the relations of power, capital, and nature, *abstract social natures* make those transitions possible.

In this perspective, abstract social nature signifies those relations of appropriation – through scientific practice and their institutional forms – that are directly implicated in making the world legible for capital accumulation.[16] Socially necessary labor-time forms through the dialectic of capital-labor relations and the relations of appropriating unpaid work made possible through abstract social nature. The language is clunky. The Cartesian vocabulary of social change dies hard. To be clear, we are working with a double internality: of labor-in-nature and nature-in-labor, *not* with the Cartesian coupling of nature/society. However clunky, the formulation makes a necessary point: Value relations are a dialectic between human and extra-human in the specific historical form of the relations of exploitation and appropriation. These form and re-form through the active relation of life-making – the *oikeios* (Moore, 2013a). Value in motion is *value-in-nature*. The relations of value are co-produced through human and extra-human natures, channeled historically through exploitation and appropriation. Value, then, is not an economic form with systemic consequences but a systemic relation with a pivotal "economic" *expression* in historical capitalism.

This proposition is this. Socially necessary labor-time cannot be determined through the technics of commodification alone. We must take care to make a part-whole distinction here. Labor-time forms *also* through the relations of power and knowledge that identify and enable unpaid part to flow into the determination of paid work; this is the relational translation of work into value. If abstract social nature's leading phenomenal expressions are associated with value-facilitating praxis of mapping,

[16] I am well aware that the Weberian tradition – from Weber to Ritzer (1983) – has long made the argument for the centrality of modernity's forms and logics of rationalization. In my view, the differences with Marx's value-relational approach have been overstated, and unduly framed by economy/culture and economy/polity dualisms. The argument for abstract social nature incorporates certain elements of the Weberian – but also Foucauldian – traditions, but with an eye to those practices that directly enter into the identification and appropriation of sources of unpaid work in service to capital accumulation.

quantifying, and otherwise making legible human and extra-human relations, we must take care not to conflate this collection of practices with its relational core. That relational core turns on the appropriational analogue of the capital-labor relation: the capital-unpaid work dialectic. If abstract social labor names the capital-labor relation through which surplus value is produced, abstract social nature names the relation of capital-unpaid "worker" through which the conditions of rising labor productivity are reproduced on an ever-expanding scale.

With the working conceptualization, two major issues must be addressed from the outset.

First, abstract social labor operates solely within the confines of the commodity system; regimes of abstract social labor therefore nourish, and are in turn sustained, by relational processes of standardization, quantification, mathematization, and so forth. Without these processes value could not exist; but without the long 16th century's movement towards labor productivity as the metric of wealth – marking a rupture with feudalism's emphasis land productivity – there could be no such movement towards the consolidation of a regime of abstract social nature. Clearly, we are looking at a conjuncture of transformations – of knowledge, of production, of markets, of states, of classes – in the early modern era. In dialectical perspective, the emergence of new civilizations is defined by their process of becoming. *Becoming* is not mere precondition, but also the first moment of new modes of production, whose key patterns are, at first, glimpsed in fragmentary and "immature" form.

Our second problem is that all the standardizing, simplifying, mapping, and quantifying practices of abstract social nature – whose focus is the zone of appropriation – also pertain to similar practices within commodity production. How these two moments are similar and how they are distinct – standardization and simplification within commodity production and across the zones of socio-ecological reproduction – is a question that the present argument poses but cannot resolve. Preliminarily, I would say that something like Frederick Winslow Taylor's famous time-and-motion studies (1914) – providing the basis for the "scientific management" revolution of the early 20th century – belong to the zone of abstract social labor, reworking already-commodified relations (Braverman, 1974). On the other hand, something like the imposition of the metric system in Revolutionary France belongs to the zone of abstract social nature, representing a fundamental advance of capitalist power into weakly commodified relations of reproduction (Alder, 1995; Kula, 1986). It is of course a porous distinction, not only between abstract social nature and cultural fixes, but also relative to simplifications within commodity production (e.g. scientific management) and to the bloody violence of bourgeois power, crystallized in Klein's account of neoliberalism's "shock doctrine" (2007). Although one must be wary of a hard-and-fast distinction, the "hard" transformations of material life, represented by abstract social labor in the commodification process, are complemented and enabled by the "soft" process of symbolic practice and knowledge formation in the capitalist world-ecology. (Primitive accumulation is the necessary cyclical mediation between the two moments.)The goal of such "soft" techniques – always with the brute force of states and empires behind it – is to discover new sources of unpaid work; the goal is to secure access to minimally- or non-commodified natures (the Four Cheaps) for as close to free as possible.

The standardizing, simplifying, mapping, and quantifying practices of abstract social nature clearly did not emerge out of the blue in early modern Europe.[17] It is equally clear that such practices

[17] "Calculation, even with decimals, and algebra have been carried on in India, where the decimal system was invented. But it was only made use of by developing capitalism in the West, while in India it led to no modern arithmetic or bookkeeping. Neither was the origin of mathematics and mechanics determined by capitalistic interests. But the technical

reached a qualitative turning point during the 18th and 19th centuries, and that they depended upon state power (Scott, 1998; Kula, 1986) – with the qualification that state power was still, well, *capitalist* power. We are dealing with a dynamic interplay of the science and technologies of "court" and "commerce," going back to the 15th century (Misa, 2004). Perhaps most dramatic was the generalization of the metric system in the long 19th century. But even here, the metrical revolution found its precondition in early capitalism's new planetary consciousness (Pratt, 1992; Grove, 1995). The meter was defined as one 10,000th part of the distance from the pole to the equator," thereby combining a global imagination with "extreme unworldliness," very far removed from realities of everyday life for the vast majority (Porter, 1995: 26).[18] Launched by French revolutionaries towards the end of the 18th century, the metric system "tended to follow the barrel of a gun, only becoming instituted in Germany in 1868, Austria in 1871, Russia in 1981, China in 1947, and of course never in the United States" (Mirowski, 2004: 150). Why was the advance of the metric system so important? For many reasons to be sure. But surely at the top of the list is the "story of how a rational language – the metric system – was deliberately crafted to break the hold of the Old Regime's political economy and serve as the universal idiom of the modern mechanism of exchange" (Alder, 1995: 39).

But such "metrical revolutions" (Kula, 1986), broadly conceived, were not only a weapon of the bourgeoisie in its struggle against *ancien regimes*. They were also implicated in the class struggle in the countryside. For peasant communities across early modern Europe,

> the subjective [and localized] form of measurement… [was perfectly acceptable]. There were disagreements, but they could be negotiated face to face. Informal measurement was inseparable from the fabric of these relatively autonomous communities… [In contrast,] the metric system was not designed for peasants. It did not bring back the true bushel [which varied by locality], but discarded the bushel in favor of a system of wholly unfamiliar quantities and names, most of them drawn from an alien dead language. The institutionalization of the metric system involved special difficulties because of the aspiration to universalism that helped to give it form. This universalism was consistent with the ideology of the revolution, and more particularly with the ideology of empire (Porter, 1995: 223, 26).

Modernity's metrical revolutions are suggestive of broader transformations in the regime of abstract social nature. These imply, as well, state- and capital-led "simplifications… [that imposed upon society and nature a] standard grid whereby [humans and the rest of nature] could be centrally recorded and monitored" (Scott, 1998: 2-3); they include also the "whole system of surveillance, hierarchies, inspections, bookkeeping, and reports… that can be described as the disciplinary technolog[ies] of labor" (Foucault, 2003: 242; 2007: 16-39). If the hallmarks of abstract social labor are control and exploitation, the defining characteristics of abstract social nature are control and *appropriation*. We are looking at the historical process of simplification, measurement, mapping, and so forth, as forms of how capitalism brings ever-wider "domains of experience under systematic" order and control (Wise, 1995: 5). These expansive (and expansionary) processes of ordering, rationalizing, and controlling domains of experience clearly cuts across the Cartesian binary, seeking to identify and en-

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utilization of scientific knowledge, so important for the living conditions of the mass of people, was certainly encouraged by economic considerations, which were extremely favorable to it in the Occident" (Weber, 1992: xxxvii)

[18] "There is something radical in the metric system that is related to its revolutionary origin. The metric system was part of a larger project to introduce a rupture at all levels of collective life, to create a 'new man', to initiate a new era in history, and to rationalize social life as a whole" (Vera, 2008: 140).

close any form of life-activity – including the congealed work of extremely ancient life – that might be useful for capital accumulation.

VALUE AND ABSTRACT SOCIAL NATURE

From these historical sketches, we may derive a working proposition: the law of value is a way of organizing nature. It is a world-historical project and process of reordering capitalism's historical natures, such that one biophysical moment is internalized qua human labor power (reclassified as "social") and another is externalized through the progressive subsumption of the rest of nature as a free gift to capital. Value, in other words, is co-produced by human and extra-human natures, and extra-human natures' relationality is reordered through value as a way of organizing life.

In the English language, value signifies two big things. First, it refers to those objects and relations that are valu*able*. Second, it refers to notions of morality, as in the fact/value binary that has loomed so large in modernist thought. Marx's deployment of the "law of value" was, of course, precisely aimed at identifying the relational core of capitalism, grounded in the expanded reproduction of abstract social labor. And Marxists ever since Marx have defended – or sometimes, elided (Wallerstein, 1974) – the law of value as an economic process that encompasses that first meaning of value, those objects and relations that capitalist civilization deems valu*able*. And so it has been difficult indeed, on this historical experience, to suggest that the operation of the law of value – the expanded reproduction of value-*relations*, enabling the quantitative expansion of abstract labor – may encompass both meanings of value.

Difficult. But not impossible. Historically speaking, it is hard to deny that new knowledges and symbolic practices – say, cartographies and double-entry bookkeeping – were crucial to the formation of a value regime that pursues abstract time and space in the interests of universal commodification. To introduce such symbolic-cultural affairs into value is of course to destabilize the subjective/objective binary presumed by most political economy. The objective world of value has been forged through the subjectivities of "capital's imagination" (Haiven, 2011). The calculative character of value is not a matter of capital using an objective knowledge – premised on dualism and quantification – but a matter of capital deploying its symbolic power to represent the arbitrary character of value relations *as* objective (Bourdieu, 1979; Bourdieu & Wacquant, 1992). This I think is Mitchell's point in his account of the British economy-making in colonial Egypt, centering on calculability as not merely an objective tool of empire but as a calculative project immanent to imperialism's bundling of power, class, and nature in the early 20th century. This line of argument has, alas, centered more on politics than on *political economy*, and thus attention has been lavished on the sphere of power without sufficient attention to the value-relations that determine, in Bourdieu's language, the decisive stakes of the game. It is not of course that capital operates independently of power, but rather that the rules of reproduction are not determined by power in general, or by territorial power, but by the law of value-in-nature. This re-framing may help us to clarify the value-relational configuration of paid and unpaid work. For a long time, the "objective" world of economic process was immunized from the moral critique – notwithstanding a centuries-long countercurrent of moral economy protest and argument (Thompson, 1991). But was not this fact/value antinomy itself a strategic way of making rational the essentially arbitrary boundary between paid and unpaid work? That is two say, are not the two common usages of value – as morality and economy – implied in capitalism's law of value?

The foregoing has suggested that knowledge/culture and value as abstract labor are indeed closely linked. But how? The argument may be stated simply enough. Abstract social nature names a sys-

temic family of processes aimed on rationalizing, simplifying, standardizing, and otherwise mapping and coding the world in service to the quantitative expansion of abstract labor. In this reading, abstract social nature signifies the relation of capital to unpaid work through which spatio-temporal practices identify and facilitate the appropriation of unpaid work necessary to accumulation. These appropriations do more than to supply necessary raw materials; they co-determine "socially" necessary labor-time. In this, abstract social nature can be understood as directly constitutive of value *relations* in creating the conditions for the generalization of commodity production and exchange. This has never been a linear sequence – either with new knowledges in the lead, or as derivative of commodification – but a conjunctural affair, in which cascading processes of commodification, capital accumulation, and symbolic innovation have constituted a virtuous circle of modern world development, beginning in the long sixteenth century. I do not propose a revision of Marx's law of value in a strict sense: the substance of capital is abstract social labor. But the relations that make abstract labor's growth possible cannot be reduced to technology and the economic sphere alone; they must be grounded in the *technics* of capitalist power and the conditions for the expanded reproduction of capital on a world-scale. Neither an adequate history of capitalism, nor a sufficiently dynamic theory of capitalist limits, is possible within the strict confines of a conventional reading of the law of value as a narrowly economic phenomenon.[19] For this reason, I have emphasized value-relations as a methodological premise that finds its nexus in the trinity of capital/power/nature.

We may begin with the law or value's drive to convert the "natural distinctness" of particular commodities into "economic equivalence" (Marx, 1973: 141), and particular labor processes into "general types of work motions" (Braverman, 1974: 125). We know these are value-relations in which "sociology and economics pervade each other" (Schumpeter, 1943: 45): the "economic" relations of value imply the class struggle of bourgeois and proletarian. But what of ecology? Is this beside the point? I do not think so.

The difficulty with global environmental change thinking today is a certain erasure of agency, at least short of calls for socialist revolution. (All fine and good, but one is left wondering how we get from here to there.) In the main, the radical critique gives global nature that power to be depleted, to break down, to usher in a Venusian-style apocalyptic warming, but little agency in the actually unfolding flux and flow of power and production in the 21st century. Let us hold open at least the possibility that the story of world-ecological change implies a sort of ongoing class struggle between capital and the agents of unpaid work, and that these agents include extra-human natures.

From this perspective the tension between "natural distinctness" and "economic equivalence" – holding across the Cartesian divide – may well include more than exhaustion and depletion, encompassing resistance and revolt by extra-human natures alongside humans. To be sure, we may be way of a broad-brushed call for some eco-centric equivalence of all forms of resistance – workers and peasant struggles retain their central place in the story, even as we recognize these struggles as co-produced. But neither should we refrain from identifying a certain common thread: weeds confound the simplified landscapes of agro-factories; workers defy and creatively adapt around the simplification of work tasks. (A stylized point, to be sure.) In these, there is a common resistance to the capitalist project, in which all space is interchangeable, all time rationalized and controlled.

[19] I am indebted to the rich literature on value theory, without which the present argument is unthinkable. A useful recent text is Saad-Filho (2002; see also Grossmann, 1992/1929). The classic text that suggests an open-relational approach to the law of value is, of course, Luxemburg (1913).

Capitalism, as a historical project, seeks to create a world in the image of capital – reflected very well in neo-classical economics – in which all elements of human and extra-human nature are effectively interchangeable. In the fantasy of neoclassical economics, one "factor" (money, land, resources) can be substituted for each other, and the elements of production can be moved easily and effortlessly across global space (Perelman, 2007). This effort to create a world in the image of capital is what I call capitalism's *correspondence project*, through which capital seeks to compel the rest of the world to correspond to the imaginary (but quite real) desire for a universe of "economic equivalence." But of course the world – extra-human natures of all kinds, and of course also the producing classes – does not want a world of economic equivalence. All life rebels against the value/monoculture nexus of modernity, from farm to factory. No one wants to do the same thing, all day, everyday. Hence, the struggle over the relation between humans and the rest of nature in the modern world-system is necessarily a class struggle. The struggle over the grip of commodification is, in the first instance, a contest between contending visions of life and work. Extra-human natures, too, resist the grim compulsions of economic equivalence: superweeds frustrate genetically-modified agriculture; animals resist their assigned roles as objects and forces of production (Moore, 2012; Hribal, 2003, 2012). In this way, capitalism's correspondence *project* meets up with all manner of contending and contentious visions and resistances to create a historical *process* full of contradictions.

Amongst these contradictions, surely at the top of the list we find those countervailing forces that threaten to slow down the turnover time of capital and that defy the radically simplifying disciplines of capital: working class struggle in the heartlands of industrial production is a good examples (Montgomery, 1979; Silver, 2003). So too is the revolt of extra-human nature in modern agriculture, where a distinctive form of struggle manifests: the "battle with weeds" (a plant in the wrong place) and troublesome pests (Clayton, 2003). The pesticide/herbicide treadmill (and its cognates) are bound up with cheap nature strategies that hothouse evolutionary adaptation at the point of production and the scale of world accumulation. On the one hand, as the flurry of news reports on the "superweeds" sweeping across the GMO soy zones of the USA revealed in 2010-11, biological natures now appear to be evolving faster than the capacity of capital to control them — resulting in a "Darwinian evolution in fast-forward" (Neuman & Pollack, 2010). On the other hand, the revolt of extra-human natures is aided by the revolutionary geography of accumulation itself: from the origins of modernity, "the accumulation of capital… is strongly and positively associated with the accumulation of alien invasive species" (Perrings, 2010; e.g. Crosby, 1972). In sum, the temporal speed-up and geographical rationalizations of the capitalist mode of production suggest a tendency towards "geographical inertia" (Harvey, 1982: 428-29) that extends well-beyond the built environment to encompass, well, *all* environments entrained within value's gravitational pull.

How have these spatio-temporal contradictions, of compressed time and simplified space, been resolved? By and large, through geographical expansion and restructuring – two moments which are geographically distinctive and yet common the same time. For both turn on shifting costs and appropriating unpaid work – inwards towards the relations of reproduction (e.g. the shift to the two-income household in the North since the 1970s) and outwards towards minimally-commodified zones of cheap food, labor, energy, and raw materials.

These paired movements of geographical expansion and restructuring are at the core of capitalism's successive spatial fixes, necessary to resolve successive *conjonctures* of overaccumulation. They are constituted, from the standpoint of value relations, through a double movement: 1) widening and deepening the zone of commodification (value production/abstract social labor); and 2) on an even

greater scale, the widening and deepening the zone of appropriation.[20] This latter movement turns on the production of abstract social nature. Abstract social nature is produced through the biopolitical, geographical, and scientific-technical knowledges and practices necessary to secure the conditions for cheap labor, food, energy, and raw materials (Moore, 2012). This means that new "frontiers" of *unpaid work* must be identified, and then pressed into the service of capital accumulation. Crucially, unpaid work comprises life-activity from human and extra-human natures both: "women, nature, and colonies" (Mies, 1986).

This reading of the law of value allow us to see the difference between capitalism as historical *project*, and capitalism as historical *process*. As project, capitalist civilization produces both symbolic forms and material relations that lend Cartesian dualism its kernel of truth; the law of value does indeed reproduce a way of seeing reality that is dualist. Capitalism, as project, creates the idea and even a certain reality of "the" environment as an external object. The idea of the environment as external object – rather than as *oikeios*, the creative relation of species and environment-making – is not false, but rather a historical creation of the capitalist world-ecology. The mistake of environmental studies has been to confuse the real historical creation of the *idea* of environment as external object with the *reality*: the reality is that environments are always inside and outside of us, material and symbolic *at once*. That is why I emphasize capitalism as a dialectic of project (what the law of value wishes to do, in creating a world that corresponds of value's interchangeability), and process. Capitalism, as world-historical process, is a co-production of humans and the rest of nature. This co-produced historical reality compels the capitalist *project* to deal with nature (as *oikeios*) no matter the utopian fantasies of value and its universe of economic equivalents. As a process of capital accumulation, capitalism must relentlessly dissolve the boundaries of life in its voracious internalization and reconfiguration of unpaid work – human and extra-human alike (e.g., women's work, beasts of burden, etc.) – in service to the utopian project of the endless valorization of abstract social labor. Thus are abstract social nature and abstract social labor dialectically joined.

ABSTRACT SOCIAL NATURE AND THE RISE OF CAPITALISM

By the long sixteenth century, we had entered an era when the world would become increasingly enfolded in the symbolic violence of "idealized mathematical abstractions" (Bavington, 2010). Here we find abstract social nature at the core of the emergent law of value – understood as *technics* – mobilizing both material and symbolic machineries of power and production, capitalization and appropriation. Foremost among these symbolic revolutions – they were bound up closely with material processes – were remarkable innovations in ways of seeing and knowing:

> The new approach was simply this: reduce what you are trying to think about to the minimum required by its definition; visualize it on paper, or at least in your mind, be it the fluctuation of wool prices… or the course of Mars through the heavens, and divide it… into equal quanta. Then you can measure, that is, count the quanta (Crosby, 1997: 228).

Early modernity's epoch-making abstractions – constituting a vast but weak regime of abstract social nature – were registered through the era's new cartographies, new temporalities, new forms of sur-

[20] Missed, I think, in Harvey's groundbreaking formulation (1982) – and subsequent elaborations – is the significance of successive waves of producing built environments *across* the urban-rural divide. While the production of urban built environments facilitates the circulation of capital and the exploitation of commodified labor-power, the production of town-country and agrarian built environments *also* facilitates the productive appropriation of unpaid work for capital, enabling flows of cheap labor-power, food, energy, and raw materials to move from country to city.

veying and property-making, schools of painting and music, accounting practices, and scientific revolutions (Capra, 1982; Cosgrove, 1985, 2008; Crosby, 1997; Merchant, 1980; Pickles, 2004; Warf, 2008; Mumford, 1934; P. Harvey, 1993; Blomley, forthcoming; Postone, 1993; Landes, 1983). This vast but weak regime reached an early tipping point towards the end of the sixteenth century. The dynamic center of abstract social nature would be – not surprisingly – the Low Countries and after 1600, the Dutch Republic above all. Here space, time, and money was rationalized and abstracted as never before. In the northern Netherlands after 1585, we find era's leading mapmakers, excelling both in the number of maps produced and in their quality (Unger, 2011; Koeman, et al., 1987). So central was cartographic knowledge to the Dutch East India Company that pilots of VOC vessels were given uniform instructions to map new territories in minute detail. By 1619 the company had created an internal mapmaking office to coordinate the flow of geographical knowledge (Zandvliet, 1987). Nor were these mapping impulses strictly colonial; internal to the northern Netherlands, polderization, water-control, and capitalist agriculture propelled a cadastral revolution whose surveys were so detailed they would not be superseded for two centuries (Kain and Baigent, 1992). Work-time, too, was subjected to a "radical rationalization" after the 1574 synod of the Reformed Church, which "abolished *all* holy days," and extended the work-year by 20 percent by 1650 (de Vries, 1993: 60; de Vries, 2008: 88-89). With space and work, so with money. Here too the VOC loomed large, its 1602 formation giving new form to world money- and credit-creation dramatized with the foundation of the Amsterdam Bourse (stock market) that same year, and the Amsterdam Exchange Bank in 1609. As American silver flowed into Amsterdam – silver wrested from the earth with no small amount of mechanical but also biopolitical ingenuity (Moore, 2010e) – it provided the conditions for the rise of fiat money (Quinn and Roberds, 2007). World money, as Mitchell rightly clarifies, is always *bundled*, "always material as well as calculative" (2009: 111). As for the Bourse, not only were shares of the Dutch East India Company traded, but also, very soon, a growing number of commodities (360 different commodities by 1639!) and even *option-derivatives* (futures). The Bourse's material coordinations and symbolic "rationality provided the basis for a universalisation and intensification of world credit practices which served to set the Dutch[-led world] financial order apart from pre-modern world finance" (quotation from Langley, 2002: 45; also Petram, 2011: 23-24 and passim; Dehing and 't Hart, 1997: 53; also Arrighi, 1994: 138-140; Braudel, 1982: 390–5).

In emphasizing early modern developments once more, I wish to underscore the epochal shift of the long sixteenth century, whose strongest impulses were renewed and amplified in the long 19th century transition to fossil fuels. The rise of large-industry, co-produced through a new phase of appropriation (centered on fossil fuels), was unthinkable in the absence of these symbolic-material revolutions – producing abstract time, space, money, and nature. This family of abstractions was central to revolutionary transformation of the Atlantic-centered capitalist world-ecology, three centuries before the steam engine reached maturity.

This line of thought allows us to read the history of capitalism, in part, as a succession of broadly-conceived scientific revolutions that actively co-produced distinctive historical natures in and through successive phases of capital accumulation. In every significant respect, these scientific revolutions not only produced new conditions of opportunity for capital and states, but transformed our understanding of nature as a whole, and perhaps most significantly, of the boundaries between humans and the rest of nature (Young, 1985). The point has been underscored by neoliberalism's systematic combination of shock doctrines with revolutions in the earth system and life sciences, tightly linked in turn to new property regimes aiming to secure not only land but life for capital accumulation (Klein, 2007; Mansfield, 2008). This has unfolded at the nexus of the global and molecular scales (McAfee, 2003). On the one hand, the new life sciences emerging after 1973 (with the inven-

tion of recombinant DNA) became a powerful lever for producing new conditions of accumulation premised on redistribution and speculation – patenting life forms, starting with the micro-organisms recognized in 1980 by the US Supreme Court (Bowring, 2003). The ambition has been to enclose "the reproduction of life itself within the promissory accumulation of the debt form" (Cooper, 2008: 31). On the other hand, the earth system sciences, aided considerably by the mapping sciences (e.g. remote sensing, GIS, etc.), have sought to reduce

> the Earth… to little more than a vast standing reserve, serving as a ready resource supply center and/or accessible waste reception site… [They] aspire to scan and appraise the most productive use of . . . [the] resourcified flows of energy, information, and matter as well as the sinks, dumps, and wastelands for all the by-products that commercial products leave behind (Luke, 2009: 133; also Pickles, 2004; e.g. Costanza, et al., 1997).

This is what Luke calls "planetarian accountancy" (2009). But planetarian accountancy is not merely biophysical in the ways the earth-system scientists have conceived it. It is also about the production of new financial techniques premised on the same worldview of "scanning and appraising" the most profitable opportunities for capital accumulation, what Lohmann calls *quantism* (2009; also Altvater, 1993).

From this perspective, the combinations of science, capital, and power that have loomed so large in the history of neoliberalism may be fruitfully located within a longer history. Something like "bioprospecting" (e.g. McAfee, 1999) has deep roots in the colonializing thrust of early capitalism (Schiebinger, 2004), an era in which botany was (then as now) not only "big science" but "big business" (Schiebinger and Swan, 2005: 3; also Smith and Findeln, 2002). "From its inception [early modern] botany served the need of transnational merchant capital," (Cañizares-Esguerra, 2004: 99; 2006). Here we find a key originary moment of abstract social nature, in an era when much of the colonial project's profitability turned "on natural historical exploration and the precise identification and effective cultivation of" extra-European plants (Schiebinger and Swan, 2005: 3; also Naro, 1999). Such processes, unifying "science, capital, and power" (Brockway, 1979: 461), were in motion from the earliest moments of the capitalist world-ecology. At the same time as the new sugar plantations were transforming Madeira, the Portuguese were

> developing a system of acclimatisation gardens and, long before the Dutch became dominant in this field, were carrying out a complex, although not highly organised, series of plant transfers, some of which were to have major economic consequences. In performing such transfers, the Portuguese built on much older patterns of distribution and pharmacological trade in the Indian Ocean region. The main contribution made by the Portuguese was to link such existing systems to the West African, Caribbean and Brazilian regions. The first agencies of plant transfers and the first founders of collecting and medicinal gardens under the Portuguese were the religious houses founded in the first years of settlement (Grove, 1995: 73-74; also Cañizares-Esguerra, 2004).

Such early movements represented the audacious global appetites of abstract social nature.[21] They reflected "massive taxonomical exercise[s]" that accompanied the rise of capitalism (Richards, 2003: 19). Here again we see epoch-making transformation – alongside the metrical revolution – in the 18th century, embodied by Linnaeus:

> When Linnaeus returned to Sweden [in 1738], he fulfilled numerous commissions for industrial and pharmaceutical uses of plants…[,] and as superintendent of the botanical garden of the University of Uppsala devoted himself to raising seeds and cultivating plant transfers from colonial satellites. Like other botanists of the period, he explored the possibilities of plant cultivation in area where cheap colonial labor was available, and studied economic plants to determine whether native-grown might substitute for imported (Boime, 1990: 475).

The Linnaean revolution, building on earlier Iberian and Dutch botanical initiatives, set in motion a process that would be elaborated and extended: first by the Kew Gardens of the British Empire in the later 19th century, and then with the International Agricultural Research Centers of the American empire after World War II (Brockway, 1978; Drayton, 2001; Kloppenburg, 1988). Each of these moments implied a new historical nature, emerging from the innovations of capitalist production, science, and power in forging new combinations of paid and unpaid work across the world.

This points to historical method that breaks with the neat and tidy separations of humans and nature, ideas and material flows, offered by Cartesian dualism. Instead of "nature in general," the alternative method helps us navigate a dynamic set of processes that make and remake capitalism-in-nature, understood as succession of "historical capitalisms" and "historical natures." The early modern materialist revolution that dethroned medieval holism and divine teleology was implicated in an epochal shift from the historical nature of feudalism to the historical nature of capitalism. Early capitalism's scientific revolutions replaced a mode of reason favorable to feudal arrangements with a new reasoning of mathematical abstraction and cartographic perspective conducive to the law of value as abstract social labor and abstract social nature (Pickles, 2004: 75-106; Merchant, 1980; Crosby, 1997). The audacity of the project can hardly be overstated, circumscribing nature "in advance, in such a way as to be determinable and accessible to inquiry as a closed system, [conceptualized] so that the entirety of [nature could…] be accessible to calculative knowledge" (Heidegger quoted in Elden, 2006: 121).

The new of value – as a way of organizing nature – manifested earliest, and most spectacularly, in two domains. The first could be found in an extraordinary, cascading series of landscape and bodily

[21] In their important intervention, Pálsson and his colleagues argue that "the most striking feature of the Anthropocene is that it is the first geological epoch in which a defining geological force is actively conscious of its geological role. The *Anthropocene therefore really commences when* humans become aware of their global role in shaping the earth and, consequently, *when this awareness shapes* their relationship with the natural environment. This is thus not just a new geological epoch; it also potentially changes the very nature of the geological by clearly marking it as a domain that includes intentionality and meaning" (Pálsson, et al., 2013: 8). This argument strikes me as unduly idealist. On the one hand, "awareness" was as much product and producer of the "relationship with the natural environment." On the other hand, such awareness – I am not sure this the best word for family of processes I am calling abstract social nature – is dialectically bound to the transition in the relations of power, (re)production, and wealth unfolding in the long sixteenth century. One also notes the difficulty Pálsson and his colleagues confront in trying to forge a ontologically monist argument – that humans and the rest of nature are one – with a conceptually dualist vocabulary: "relationship with the natural environment," which is of course a relation co-produced by humans within the web of life.

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transformations across the Atlantic world and beyond. The second, in an emergent set of perspectives that allowed European states and capitals to see time as linear, space as flat and homogenous, and "nature" as external to human relations (Crosby, 1997; Merchant, 1980; Cosgrove, 1985; Mumford, 1934). The conceit of capital, from its very origins, was to re-present the world through the "God trick" (Haraway, 1988: 581): to treat the specifically capitalist ordering of the world as "natural," claiming to mirror the world it was in fact seeking to re-construct (Warf, 2008: 40-77).

These remarkable innovations in ways of seeing and knowing were, in the first instance, premised on a new quantitativism whose motto was: reduce reality to what can be counted, and then "count the quanta" (Crosby, 1997: 228). Such quantitative reductionism was paired closely with a transforming space into something that could viewed from outside. Here the emergence of perspective in Renaissance painting – linked tightly with the renaissance of Euclidean geometry in northern Italy[22] – was important far beyond the aesthetic realm (Cosgrove, 1985). Renaissance perspective "turned the symbolic relation of objects into a visual relation: the visual in turn became a quantitative relation. In the new picture of the world, size meant not human or divine importance, but distance" (Mumford, 1934: 20). In this quantitative reductionism, "space was robbed of its substantive meaningfulness to become an ordered, uniform system of abstract linear coordinates" (Jay, 1993: 52). This was crucial to a new mapping of the world, without which a modern world-market, modern state-formation, and modern property-making, was impossible. The early modern transition in

> mapping practices… can be seen in terms of a series of concrete concerns about property and identity emerging from political economic [and world-ecological] transformations of the period. First, there was a need for maps to envision and consolidate new communities, increasingly imagined as territorially bounded states and discrete unities of people (articulated in terms of a common history, ethnicity or language and culture). Second, there was a need for plots and plans for estate planning as private property claims on land and capitalist practices of land alienation and sale increasingly became the norm (Pickles, 2004: 99).

Here we see abstract social nature in its earliest formation. Especially in relation to bourgeois property – as in 17th century England – it is impossible to overstate this new of seeing and mapping, where the new survey practices help to "reformat property" by reimagining such spaces as "geometric" and "calculable" (Blomley, forthcoming; also P. Harvey, 1993). Landownership was, increasingly and especially (but not only) in England, was reduced to "facts and figures, a conception which inevitably undermines the matrix of duties and responsibilities which had previously been seen to define the manorial community" (McRae, 1993: 341). Not for nothing, the modern map "was effectively an invention of the sixteenth century" (P. Harvey, 1993: 8; also Brotton, 1997). Far from derivative of political economy and empire – but unthinkable except in relation to capital and power – these new ways of seeing were in fact co-constitutive of the historical natures that simultaneously limited and enabled successive bursts of commodification and appropriation inside and outside Europe (Moore, 2007). Mapping space was constitutive of global conquest, not merely representative of it. Both global commodification and the global appropriation of unpaid work turned on *representing* the "practical activities" of astronomical observation in a manner that was abstract and yet useful for capital and empires (Cosgrove, 2008: 21). The great breakthrough of Mercator, who was as much capitalist as cartographer, was to construct

[22] "The critical advance came from the re-evaluation of Euclid and the elevation of geometry to the keystone of human knowledge, specifically its application to three-dimensional space representation through single-point perspective theory and technique" (Cosgrove, 1985: 47).

> a plane representation which depicted the meridians as parallel to each other rather than, as is the case with the true representation of the globe, converging on the north and south poles. If this could be achieved, then it would be possible to chart across its surface a line of constant bearing that was straight, rather than a spiral as would be the case when trying to trace it on a globe. The importance of Mercator's innovation in terms of accurate navigational practice and commercial profit was quite clear. Instead of taking awkward and imprecise bearings on board ship across the surface of a globe or a portolan chart, his new projection allowed for a line of bearing to be drawn accurately across the surface of a plane map, explicitly foregrounding… its usefulness to the art of navigation… With pilots and navigators in mind, Mercator went on to outline the mathematical procedure which allowed him to employ an accurate grid of straight lines across his map, whilst also retaining the relative geographical accuracy of the topography of the globe (Brotton, 1997: 166)

Nor was this early modern revolution – marking the origins of abstract social nature – confined to space and extra-human nature. We can also see abstract social nature at work in slave trade. Much as a meatpacker today demands a "standard hog" from suppliers (Ufkes, 1995), so the slave market of the seventeenth century Caribbean was measured in terms of the standard slave: male, 30-35 years old, between five and six foot tall. This standard slave was a *pieza de India* ("piece of the Indies"). Individuals who did not measure up were reduced to some fraction, reduced to "pieces of Indies" (Williams, 1970: 139). It was a small step to move from considering extra-human natures, local property, or global space, in terms of equivalents and interchangeability, to considering human beings in the same fashion. While the *pieza de India* is often considered as merely a measurement for taxation (King, 1942) – important in its own right – it was in fact widely used in the 17th century as a unit of measuring labor-power, from Angola to the Caribbean (Emmer, 1972: 736; Ferreira, 2012: 27). The *pieza de India*

> was a measure of potential labor [labor-power], *not of individuals*. For a slave to qualify as a *pieza*, he had to be a young adult male meeting certain specifications as to size, physical condition, and health. The very young, the old, and females were defined for commercial purposes *as fractional parts of a* pieza de India. *The measure was convenient for Spanish imperial economic planning, where the need was a given amount of labor power, not a given number of individuals* (1972: 22, emphases added).

These early modern developments reveal something much different from the facile representations of early capitalism as mercantile or "pre-industrial" – euphemisms for saying early capitalism was not *real* capitalism (e.g. Fox-Genovese and Genovese, 1983; Wolf, 1982). The shift from land productivity to labor productivity revealed a new law of value. But this new law was more than a valuation premised on abstract social labor. It implied a second dialectical moment, one of abstract social nature. For humans are unevenly exploited by, and appropriated for, capital. The valuation of labor power inside commodity production implied and necessitated the *de*valuation of labor power outside commodity production. This dialectic of value/not-value has given rise to multiple misrecognitions in marxist political economy because labor power is exploited (e.g. in wage-work) and appropriated (e.g. in unpaid household labor).[23] Thus humans, alone amongst species, have found themselves unevenly exploited *and* appropriated by capital. All manner of racialized and gendered mediations –

[23] This was most conspicuous in the groundbreaking "domestic labour" debate, well-surveyed by Vogel (1983).

suggestive of Shapiro's cultural fixes – have served to normalize the appropriation of human nature's free gifts over the past five centuries. It turns out that capitalism itself practiced a form of what sociologists call "human exemptionalism" (Catton and Dunlap, 1979) – one internalized even by many radical political economists – that restricted our attention to labor-power within the circuit of capital. This is a pillar of any analysis of capital accumulation. But taken too far, the framing of capitalist development in these terms alone produces an unduly narrow basis for understanding the combined and uneven geographies of accumulation. Every act of exploitation implies an even greater act of appropriation.

What we see, from the earliest moments of the capitalist world-ecology, is a law of value emerging through a double dialectic. The first is premised on exploitation: abstract social labor/capital and wage-labor. The second, premised on appropriation: abstract social nature/capital and unpaid work).[24] This allowed for the historical combination of accumulation strategies – accumulation by capitalization and accumulation by appropriation. Through capitalization, labor productivity is advanced through the rising value composition of production; through appropriation, labor productivity is advanced by seizing upon cheap human and extra-human natures, and thereby reducing the value composition of production.

Crucially, the zone of appropriation is *always, necessarily* much more expansive – geographically and demographically – than the zone of exploitation. I say *necessarily* in a specific sense. Given capital's productive dynamism, the capacity to transform raw materials into saleable commodities grows faster than the capacity to produce those raw materials (Marx, 1967, III: 119-121). This is Marx's oft-forgotten, but today absolutely salient, "general law" of underproduction (also Moore, 2011a, 2011b; Bukharin, 1929: 89-95). The mirage of cornucopia – of endless free gifts produced through capital's limitless capacity to substitute human ingenuity for this or that biospheric product (see Perelman, 2007) – was in part the creation of the founders of neoclassical economics, who confused the era's specific global conditions of railroad- and steamship-created resource abundance with an eternal condition of abundance.[25]

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[24] Every moment of a dialectic is premised on its own set of distinctive, but interpenetrating, relations.

[25] Nadeau (2008) ably summarizes this absurdity of neoclassical economic theory: the "19th-century creators of the economic theory now used by mainstream economists (Stanley Jevons, Leon Walras, Maria Edgeworth and Vilfredo Pareto) are credited with transforming the study of economics into a rigorously mathematical scientific discipline… The progenitors of neoclassical economics, all of whom were trained as engineers, developed their theories by substituting economic variables derived from classical economics for physical variables in the equations of a soon-to-be outmoded mid–19th century theory in physics… The strategy used by the creators of neoclassical economics was as simple as it was absurd — the economists copied the physics equations and changed the names of the variables. In the resulting mathematical formalism, utility becomes synonymous with the amorphous field of energy described in the equations taken from the physics, and the sum of utility and expenditure, like the sum of potential and kinetic energy in the physical equations, is conserved… Because the physical system described in the equations of the theory in physics is closed, the economists were obliged to assume that the market system described in their theory is also closed. And because the sum of energy in the equations that describe the physical system is conserved, the economists were also obliged to assume that the sum of utility in a market system is also conserved… Because utility-energy in this mathematical formalism is conserved, the creators of neoclassical economic theory *concluded that production and consumption are physically neutral processes* that do not alter the sum of utility… This misalliance between economic thought and a 19th-century physical theory explains why the neoclassical economic paradigm is predicated on the following unscientific assumptions: [1] Market systems exist in a domain of reality separate and distinct from other domains[; 2] Capital circulates in these systems in a closed circular flow between production and consumption with no inlets or outlets…[; 3]Market forces will resolve environmental problems via price mechanisms…[; 4] The resources of nature are largely inexhaustible, and those that are not can be replaced by other resources or by technologies that minimize the use of the exhaustible resources...[; 5] The environmental costs of economic activities can only be determined by pricing mechanisms that operate within closed market sys-

My argument proceeds from a certain destabilization of value as an "economic" category. What I am suggesting is twofold. On the one hand, the systemic formation of value relations occurred through a cascading series of small and large shifts in the Atlantic world after 1450. These shifts transcended the convenient boundaries of economy, culture, politics, and so forth; they favored a view of reality and a practice of material transformation that encouraged a mathematized and mechanical world-praxis. On the other hand, the emergence of a capitalist world-praxis depended upon the explosive growth of commodity production and exchange after 1450, an expansion which was, nevertheless, quantitatively modest in the overall weight of the Atlantic world-ecology for some time, and insufficient *on its own* to effect the rise of capitalism. The genius of early modern commodification – in contrast to medieval Europe – was its articulation with the appropriation of cheap natures, such that the scale and speed of landscape transformations outpaced the quantitative growth of commodification as such. For it was on early capitalism's frontiers that the greatest combinations of mechanization and appropriation occurred. Was it so different later, with the arrival of the steam engine and coal's "vertical" frontier? What we are looking at, after 1450, is a process of transition through which new rules of reproduction emerge, and new stakes of the game are established that create new synergies and logics of power and production. That is the magic of great historical transitions. These new rules and stakes of the game turned on commodification, whose radical expansions after 1450 turned on the symbolic and material abstractions of concrete labors into money-capital. This was necessary for the transition from the appropriation of surplus-product to the accumulation of surplus-value.

Necessary, but not sufficient. That this transition involved more than abstract social labor has long been recognized. There is a considerable literature – much of it written over the past decade – on primitive accumulation and the role of state power to secure the necessary conditions of the accumulation of capital (valorized abstract social labor) (e.g. Perelman, 2000; Harvey, 2003; Angelis, 2007). But no combination of state violence and capitalist innovation in commodity production could produce the knowledges necessary to map, navigate, survey, and calculate the world. By calling this family of processes abstract social nature, we should not exaggerate. The Iberian pioneers excelled at cartography, natural history, and navigation in ways clearly different from the mathematizing and mechanizing procedures of seventeenth century science in northern Europe (Cañizares-Esguerra, 2006). We should be under no illusions that this initial phase of producing new knowledges resembles the ideo-typical models of subsequent eras. But we might also take care not to *under*-state the efficacy of Iberian empire-building overseas, made possible through the new technics of "long-distance control" (Law, 1986). These technics made possible durable seaborne empires heretofore unknown in world history. None of which suggests the autonomy of the intellectual sphere – whatever that might mean – but rather its constitutive role in forming a weak, *but vast*, law of value that took the globe as its theater.[26]

And for the value-added of calling these processes abstract social nature? Three reasons stand out. In the first instance, any conception of value as economically-reductionist seriously undermines our capacity to explain the rise of capitalism as a unity of power, production, and wealth in the web of life. Second, historically speaking, it is difficult to sustain, on any consistent empirical basis, the *a priori* assertion of economic processes propelling the transition to capitalism. It seems to me that this is the inverse of Weberian approaches that insist on various incarnations of the capitalist spirit and its fondness for rationalization. Instead, I think what we are seeing in the long sixteenth century is a

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tems… [; 6] There are no biological or physical limits to the growth and expansion of market systems" (emphasis added; see also Mirowski, 1989; Nadeau, 2003).

[26] To borrow a phrase from Marx.

family of processes – quasi-dependent on, and quasi-independent from, each other – that enabled a revolutionary configuration of commodification and appropriation. It is difficult for me to see the new "measures of reality" – in accounting, timekeeping, mapping space, and externalizing nature – as any more definitive in the process of transition than the new mechanizations implied in the key commodity sectors of early capitalism. Rather, the cascading processes that facilitated – but did not ensure – the triumph of capitalism emerged sometimes from commodification, sometimes from the imperial- and state-machineries, sometimes from new modes of knowledge production (abstract social nature). As so we are back to the world-historical trinity of the rise of capitalism: abstract social labor, primitive accumulation, abstract social nature. Of course, each was implied in the others, but the world-historical weight of each varied as this new world-praxis formed in the long sixteenth century.

Finally, with abstract social nature we find a way out of the state-centric rendering of this process, brilliantly crystallized in Scott's (1998) arguments on "state simplifications" and Foucault's wide-ranging discussions on governmentality and biopower (e.g., 2003, 2007). If the production of abstract social natures has often been bound closely to imperial and state power, such political structures have hardly been independent of the vortex of world accumulation. The state- and market-led simplifications charted, in distinct but complementary ways by Scott (1998) and Worster (1990), reveal a process of remaking life-activity – entraining a range of processes aimed at simplifying, standardizing, and geometrically encoding and mapping human and extra-human natures in the interests of facilitating capital accumulation. "Nature, colonies, and women," in this perspective, are not merely plundered but *actively created* through symbolic praxis, political power, and capital accumulation. It is this process of active creation that is signaled by the nexus: historical nature/abstract social nature/abstract social labor. In this sense, the law of value establishes an interpretive basis for what we have seen in modern world history – worlds of landscapes, cultures, markets, states, production systems (and so much more than these) that resemble and reproduce (even as they contest or condition) the radical simplifications immanent in the value relation and commodity form.

What the law of value allows us to explain is precisely what has been hidden in plain sight: the epoch-making transition in humanity's environment-making relations and patterns that began in the sixteenth century and have reached a limit today. The limits to capital are real enough, and it includes the "great forces of nature" but is not reducible to these. A world-ecological reading of value-relations illuminates these limits as relationally constituted through capitalism, itself producer/product in the web of life. The law of value, in this approach, becomes a methodological premise that permits the excavation of capitalism's foundational logic. This logic encodes labor productivity as the decisive metric of wealth – inverting the longstanding primacy of land productivity in premodern civilizations – and mobilizes the rest of nature in the service of labor productivity. The argument here is that value relations, understood solely in terms of abstract social labor, cannot explain this long-run mobilization of human and extra-human work outside the circuit of capital. Nor do the state and science work as external factors, ontologically independent of capital accumulation. State, science, and capital form an organic whole, shaped by a double imperative: to simplify natures and to extend the domain of appropriation faster than the zone of exploitation. Marx's insight that soil fertility could "act like an increase of fixed capital" (1973: 748) was no throwaway comment; it is an observation that speaks to capitalism's voracious appetite for non-capitalized natures, without which the labor productivity revolutions of the capitalist era are unthinkable. For every Amsterdam there is a Vistula Basin. For every Manchester, a Mississippi Delta.

FROM ANTHROPOCENE TO CAPITALOCENE

The alternative presented here does not deny that the Industrial Revolution was *a* turning point. Far from it! It does, however, question the utility of a model that sees modernity beginning in England during the latter half of the eighteenth century. In sum, the so-called Industrial Revolution was a turning point in a historical process already in motion. It was *not* the termination of a premodern developmental pattern (*contra*, e.g., Pomeranz, 2000; Wolf, 1982).

How do we know this? For one, there was no fundamental rupture in the relations of environment-making between early capitalism and so-called industrial capitalism. These relations were governed by a specifically modern law of value that gave primacy to labor productivity in the commodity sector. This new value relation found its clearest expression in the great commodity frontiers of early capitalism – in sugar, silver, copper, iron, forest products, fishing, and even cereal agriculture (Moore, 2000, 2007, 2010a, 2010b). In the new frontier zones, cutting-edge technology combined with the free of appropriation of non- or minimally-commodified natures: by 1600, we find sugar mills in the canefields of Brazil, sawmills in thickly-forested Norway, and a huge hydraulic-silver-mercury production complex in the Andes. In these regions we see on display capitalism's marriage of accumulation by capitalization (lots of machines) and accumulation by appropriation (lots of "free gifts"): the marriage of productivity and plunder that has formed the historical condition for every great wave of accumulation.

From the perspective of exploitation and appropriation – the production of abstract social labor and abstract social nature – we can better identify the continuities of capitalist history. The Industrial Revolution marked not a rupture with, but *an amplification of*, early capitalism's frontier logic, premised on value's weird configuration of exploitation and appropriation. It was a major amplification, to be sure. But the historical geography of the commodity frontier – appropriating cheap natures in the service of advancing labor productivity – had governed the accumulation process in early capitalism, and would continue to govern world accumulation after the Industrial Revolution. Before Industrial Revolution, appropriate nature and advance labor productivity. After Industrial Revolution, appropriate nature and advance labor productivity.

Can we deny the epochal significant of fossil fuels, starting with coal? Of course not. Who would want to?

But if our concern is the modern fossil fuel boom, then its origins can be found in the sixteenth, not the eighteenth, century (see also Fischer-Kowalski, et al., *forthcoming*).[27] English coal production rose from 50,000 tons (1530), to 210,000 tons (1560) to 1.5 million tons by 1630, at which point nearly "all of England's major coalfields had… been opened" (quotation from Weissenbacher, 2009: 198; Nef, 1932: 19-20, 36, 208). Production continued to surge forward, doubling to 2.9 million tons by the 1680s (Nef, *op. cit.*). Output increased another 300 percent by 1780 (J. Davis, 2006: 122). European coal output, including England and Scotland, stood at four million tons per annum by 1700 (Malanima, 2006: 119).

That a new phase of capitalism was taking shape around cheap coal around the year 1800 is not in question. But we ought to be careful about exaggerating its importance. France produced maybe 10

[27] The issue is easily dismissed by Anthropocene analysts, who recognize widespread coal use in medieval China and early modern England, but reject a change in periodization according to their consequentialist logic: "The Chinese and English combustion of coal had no appreciable impact on the atmospheric concentration of CO2." (Steffen, et al., 2011a: 846).

percent as much coal as England, but realized the same economic growth in the first three-quarters of the eighteenth century (Davis, 1973: 301; also O'Brien and Keyder, 1978). The United States industrialized with some coal, but water and charcoal remained dominant until 1870 (Hobhouse, 2005: 3-66).

What "work" did all this coal perform for an emergent industrial capitalist order? Yes, rising labor productivity at the point of production – in English textiles, as our textbooks teach us – was crucial (Clark, 2009). But this is only part of the story. Accumulation by capitalization, as in the Manchester textile mills, was accompanied by a truly earth-shaking revolution in accumulation by appropriation. This latter reached a definitive turning point after 1830. For the commodity frontier strategy that enabled the rise of capitalism in the long sixteenth century was, by the middle of the nineteenth century, propelled to new heights by the coal/steam power nexus. This nexus came into its own – for capitalism as a whole – with the first major wave of railroad and steamship expansion in 1831-61, by which date 107,000 kilometers of railroad track had been laid and 803,000 tons of steamship were afloat (Hobsbawm, 1975: 310).

For the first time in human history, civilization on a planetary-scale was possible through the production of a globe-encircling railroad and steamship network. Thus were new conditions laid for two tightly connected developments: 1) the *global* hegemony of value relations, previously contained within the Atlantic world; and 2) the significant reduction in the value composition of systemwide commodity production, aided by the massive enlargement of the arena for accumulation by appropriation. These conditions, in concert with the productivity-advancing innovations of large-scale industry, did indeed set the stage for a new era of capital accumulation: one characterized by chronic overproduction crises rather than underproduction crises. Too easily we forget that the primary contradiction of early capitalism was not too few customers, but too few inputs. Not overproduction, but underproduction. One of the consequences of the Two Century Model for our thinking about capitalism has been the undertheorization of capitalism's tendency towards underproduction crises in Marx's sense of the term (1967, III: 119-121; but see Moore, 2011a, O'Connor, 1998). But this is one-sided, as Marx would say. Here the Two Century Model occludes one of the defining features of our times: the shift from the primacy of overproduction to the primacy of underproduction, a return to conditions of early capitalism (Moore, 2007, 2011a). Only this time around, there are very few frontiers. The mass of capital is now greater than ever; the frontiers capable of delivering huge new streams of unpaid work, fewer than ever.

Unfortunately, both Anthropocene and critical approaches to global environmental change have hewed closely to an argument that discourages research into the relations – and rules of systemic reproduction – that have produced climate change, along with the crossing of manifold "planetary boundaries" (e.g. Rockström, et al., 2009). The foundational terms of the Anthropocene argument therefore obscures the very line of investigation necessary to illuminate the historical and relational specificity of overaccumulation crises, which have derived, historically, from *both* underproduction and underproduction crises.

We might be better served by *un*thinking received notions of "preindustrial society" – the implicit benchmark even of most radical critiques of "fossil capitalism" (e.g. Altvater, 2006; Huber, 2008). In the first place, we may ask if the "preindustrial" world really conforms so nicely to neo-Malthusian assumptions? Energy and food production and constraints in early capitalism were nowhere as inelastic as neo-Malthusian theory would have it, and nowhere close to their techno-biological limits (de

Vries, 2001).[28] There *were* barriers, and these did emerge, in part, from real landscape transformations. Soil fertility *does* run down, forests *are* cleared. To limit the story to such consequences, however, is to create a mirage of history that is not only neo-Malthusian, but reflects the explanatory limits of neo-Cartesian vistas. For to admit environmental change into the analysis of capitalism as an arithmetic procedure – society plus nature – is to oscillate between social reductionism and environmental determinism. This is unavoidable in the Cartesian scheme. A dialectical method moves us from environment as object to environment-*making*, a process of creating and transcending historical limits co-produced by humans and the rest of nature. Did coal come to the rescue because of a scarcity of power, or because of the balance of class power? Steam did not decisively vanquish water power in English textiles until the 1830s, largely because coal facilitated the concentration of production in cities with relatively tractable labor-power (Malm, 2013). Did coal resolve England's agro-ecological crisis of the late eighteenth century? As English agriculture stagnated after 1760, grain was imported in growing volumes, at first from Ireland and then from North America, but steamships did not displace sails for most commodities – save cotton – until the 1850s, and then rapidly, after 1870 (Headrick, 1988: 18-48; Sharp, 2008; Jacks and Pendakur, 2010; Harley, 1988). If the 1830s marked a decisive turning point in textiles, even as late as 1850, "preindustrial" innovations and practices often held sway in transport.

The extraordinary material transformations and scientific-cultural revolutions of early capitalism do not fit well with the neo-Malthusian vista on the "preindustrial." Are such transformations, material and symbolic, really mere footnotes to the "real" story that begins in 1800? And is the story of humanity as "geological agent"[29] best narrated through the specter of neo-Malthusian resource scarcity and overpopulation (e.g., Steffen, et al., 2011b)? Or best told through the alleged subjectivity of humanity as unified agent in an era of the unprecedented global polarization of rich and poor? Better, in my view, is to re-focus our attention on the relations of power and wealth that govern environment-making in the modern world-system.

To focus on the relations of power, (re)production, and nature in the modern world-system is necessarily to direct our attention to the turning point of the long sixteenth century – rarely acknowledged in accounts of capitalism's crisis today. This is no academic hair-splitting. Lacking a historical-relational perspective on how modernity develops *through* the web of life, the Anthropocene argument is relatively powerless to explain the early modern origins of the relations that enabled the era of humanity as geological agent sometime after 1800. The relations of power, wealth, and nature that emerged after 1450 were the relations that made possible the long fossil boom of the past two centuries. The Anthropocene registers an important reality. But *which* reality? The bias of green materialism tells us that "coal transformed the world" (McNeill, 2008: 3). But is not the inverse formulation more plausible?: *New commodity-relations transformed coal*. (In the process, activating coal's epoch-making powers.) Yes, the fossil boom transformed the *conditions* of capitalist civilization. But did these new conditions imply a fundamental rupture with the value relations – and historical-geographical patterns – of early modernity? This is the very line of questioning that has been ruled out by the dominant Anthropocene argument.

[28] "Much of what [English farmers] learned about how best to maintain soil fertility while increasing yields was not actually applied in England, because it involved highly labor-intensive methods and English capitalist farmers… were intent on labor-cost minimization and profit maximization. The methods they adopted instead, which raised labor productivity, represented a fundamental break with much of the literature on best farming practices and actually interfered with preserving soil fertility" (Pomeranz, 2000: 216).

[29] The term is Chakrabarty's (2009) and Vernadsky's (1997: 31).

When the Anthropocene argument begins with the *consequences* issuing from a stylized and uncritical version of the Industrial Revolution, it implicates a problem inherent in green materialism since the 1970s. Given human exemptionalism's hegemony across the historical social sciences, the main thrust of environmental history and social science was to make explicit the environmental dimension *of* social processes. As a result, when explanatory models in environmental history challenged the Cartesian dualism – seeking to move ecohistorical research beyond the environmental consequences of social relations, and towards the pivotal relations of production and reproduction (e.g., respectively, Worster, 1990; Merchant, 1989) – they seldom gained traction. More recently, green scholars have sought to remedy this consequentialist bias with calls for nature's agency. Beinart and Hughes (2007), for example, talk about "environmental causation," with the Columbian exchange of flora and fauna as a prime example (e.g. Crosby, 1986); similarly, Campbell speaks of climate as "historical protagonist" in the late medieval crisis (2010). Such calls, as with the Anthropocene argument, have the virtue of saying – quite correctly – that nature matters. But they have reproduced the underlying problem of a dualistic conception: "nature" remains an ontologically independent realm of agency that acts upon "society." (And vice-versa.) The immediate consequence is to reproduce competing models of historical change characterized by a tug-of-war between social reductionism and environmental determinism. These dualistic arguments for nature's agency reinforce the very thought-structures they aim to critique; they get us scarcely closer than before to explanations of the *causes* of historical change premised on the dialectic of human and extra-human natures – always already bundled in specific forms.

TOWARDS SYNTHESIS: CAPITAL AS WORLD-ECOLOGICAL LIMIT

The consequentialist bias of green materialism has not given the Anthropocene argument much to work with. Common to the stylized version of the Industrial Revolution embraced by the Anthropocene argument is the reluctance to explain modernity as constituted *through* nature. Instead, modern world history is reduced to the outputs of industrialization and the its impacts upon nature. Left to its own devices, green materialism tends to succumb to a global empiricism of cobbled together meta-forces, endowing some descriptive categories – industrialization, urbanization, transport systems, and so forth (e.g. Steffen, et al., 2011a) – with the power to "overwhelm the great forces of nature" (Steffen, Crutzen, and McNeill, 2007). (As if industrialization was not itself, in Marx's nicely-turned phrase, a "specifically harnessed natural force.") But correlation is not causation. The accumulation of descriptive categories illuminating important trends in the modern world-system does not – *cannot* – "add up" to an explanation of humanity-in-nature since the sixteenth century.

If *adding up* doesn't suffice, what would? The Anthropocene argument belongs to the green materialism forged in an era when nature still did count for much. From its first stirrings in the 1970s, the dominant approach – of both radical and centrist green thought – was not dialectical but arithmetic. The society-plus-nature perspective has been very successful, and has generated an extraordinary wealth of empirical studies and theoretical explorations. And yet, the outpouring of empirical assessments by environmental change scholars has been slow to move from capitalism *and* nature towards capitalism-*in*-nature: capitalism as co-produced by and through humans with the rest of nature. Nowhere is this slow movement more apparent than on the terrain of global socio-ecological change, where the great crises of our times – finance, climate, energy, food, and much beyond – defy the conventional ordering of environmental and social crises.

It is on this same terrain that the emergent world-ecology synthesis offers a framework for theorizing that *enfolds* consequences into new constitutive terrain for new human/extra-human relations.

Climate change – and climate is always changing – is a good example. Instead of a "factor" that gets in the way of civilizations once the weather gets too cold, too wet, too hot, too unpredictable, climate change is a constitutive factor the emergence and development of civilizations, not only in their crises (Moore, 2013a). The difference between the Anthropocene and world-ecology perspectives is a difference over how one frames the history of geological and biospheric changes. Above all, it is a difference over how one sees the geobiosphere as constitutive of historical change itself, and not merely as a repository of exogenous natural limits. There *are* limits, to be sure; but how one frames the relations that form and re-form those limits is crucial. It is of no small consequence whether we begin with the origins of modernity – as a capitalist world-ecology – in the long sixteenth century, or with the fossil boom that commenced around 1800. One approach tells us to consider the relations of capitalism first; the other tells us to look at machines and resources first.

If Anthropocene and allied arguments tend to suggest crisis – of humanity? of capitalism? of industrial civilization? – they too often *assert* limits without historically-constructing those limits. I have said elsewhere that the "ecological" limit of capital is capital itself (Moore, 2011b) – a claim that only makes sense if we take capital to be a relation *simultaneously* of class, wealth, and nature. Such a conception of capital was called for, in distinct and complementary ways, by Foster (2000) and Burkett (1999) more than a decade ago. But it has found few takers. Until now.

Taking a relational view of capital and its limits within the web of life directs out attention to capital as the gravitational center of modernity's environment-making as an ongoing effort to reproduce the conditions for capital accumulation. From this standpoint, one seeks the limits of capital not in social or environmental domains, but in the co-produced limits of empire and capital, class and nation, commodity production and socio-ecological reproduction within the web of life. There *are* limits – even if green radicals too often point to abstract scarcity rather than the capitalist relations that induce and produce scarcity as forms of class-discipline.

The key question is this. What is the best way to identify, to narrate, and to explain these limits historically – in their emergence, development, and transcendence – and in so doing, to see what is genuinely novel about the present conjuncture?

Today's manifold tipping points (e.g. Rockström, et al., 2009) are more effectively comprehended by framing the great movements of capitalist history as bundles of human and extra-human natures, guided by endless commodification. Here, the commodification of everything is irreducibly a relation of humans with the rest of nature. Some great measure of today's global turbulence unfolds through the inability of these commodity-centered relations to do what they have done for the past five centuries: issue a great leap forward in labor productivity *and* restore the "Four Cheaps" of labor-power, food, energy, and raw materials (Moore, 2012, 2013b). A considerable measure of this problem turns on the declining willingness of extra-human natures to surrender their work for free; food becomes more costly to produce, oil more costly to extract, and much more beyond these. Needless to say, climate change only amplifies the systemic problem, which would still be a problem without runaway global warming.

If we take "limits talk" as a methodological proposition rather than empirical claim, we can view limits and crises as historical and relational. Substances *do* matter. Far from denying geological and biospheric realities, the limits suggested by resource depletion and exhaustion of capitalism's cheap nature strategy can be more effectively understood within its long-run patterns of capital, power, and nature. The limits of capitalist civilization include biophysical realities, but are not reducible to them.

The kernels of truth offered up in widely circulated notions of peak everything are better grasped and elaborated in terms of capitalism's peculiar civilizational project – one premised on labor productivity as the decisive metric of wealth. Recoding human activity as social and the objects of that activity as natural was the symbolic register of a civilization whose emergence was revealed most dramatically in an epochal shift in the scale, scope, and speed of landscape transformation, centuries before the steam engine.

The problem today is not one of humanity "overwhelming the great forces of nature" in a binaristic opposition (Steffen, McNeil and Crutzen, 2007), but rather one of capitalism exhausting the capacity of uncommodified natures to perform unpaid work for capital accumulation. (This, the small kernel of truth in the otherwise absurd discourse on ecosystem services.) That process of getting extra-human natures – and humans too – to work for free is the history of capitalism's great commodity frontiers. The appropriation of frontier land and labor has been the indispensable condition for great waves of capital accumulation, from the age of the Dutch in the 17th century to the rise of neoliberalism in the 1970s and '80s (Moore, 2010b, 2012). The crucial "work" of these commodity frontiers has been to re-establish the conditions for the renewal of the Four Cheaps – labor, food, energy, and raw materials. In successive great waves of capitalist development, frontier appropriations – largely but not wholly analyzed in the historiography of colonial expansion – sent vast reservoirs of labor, food, energy, and raw materials into the global vortex of capital accumulation (Moore, 2014).

Historically, frontier zones of low or minimal-commodification have represented capital's greatest opportunities to reduce the "Big Four" input prices: labor, food, energy, and raw materials. Depeasantization, the reorientation of peasant agriculture towards the world market, the extraction of abundant energy and other mineral wealth – these great movements of modern world history have been frontier movements, some more obvious than others. These movements of appropriation have enlarged the reserve army of labor; expanded food supplies to the world market; directed abundant energy flows to, and in the process boosted labor productivity within, commodity production; and channeled gigantic volumes of raw materials into industrial production. All of which drove down the value composition of both fixed and circulating capital even as the technical composition of capital rose mightily (esp. Moore, 2011a, 2011b). Astoundingly, commodity prices declined 1.2 percent annually for the *entire* 20th century (Grantham, 2011)! Put simply, the Great Frontier that opened the capitalist epoch did so by making nature's free gifts more-or-less cheaply available to those with capital and power. The end of the frontier today is the end of nature's free gifts, and with it, the end of capitalism's free ride. This means, today, that capital must start paying its own way, exactly what the frontier obviated: frontiers were the decisive way of making others – outside the circuit of capital but within reach of capitalist power – foot the bill for the endless accumulation of capital. The great secret and great accomplishment of the capitalist mode of production has been to *not* pay its bills: to get something for nothing – or if not for nothing, for as close to nothing as possible.

Marx once remarked that the accumulation of capital is the proletarianization of labor (1977: 764). To this we might add: the accumulation of capital is the proletarianization of labor is the appropriation of global natures. The endless accumulation of capital and the endless appropriation of the earth are two sides of the same coin. The one is unthinkable without the other. This dialectic is comprised of the tendency towards *accumulation by appropriation* – through which the Big Four inputs (labor, food, energy, and raw materials) are appropriated with minimal outlays of capital and territorial power – and the tendency towards *accumulation by capitalization*, whereby these Four Cheaps are put to work by capital-intensive, productivity-advancing, innovations (Moore, 2011a, 2011b, 2012).

The plunder of the frontier zones and the labor productivity advances of the metropoles form an organic whole.

Why should this be? In a word, value. Value relations illuminate the foundational logic of capitalism as world-ecology – as a civilization that joins the production of nature, the accumulation of capital, and the pursuit of power in dialectical unity. The value relation mediates the unstable relation between the accumulation of capital and the reproduction of life by creating something entirely unprecedented in human history: "cheap" nature. Understood as the web of life, Nature is of course never cheap. "Cheap nature" is the epochal conceit of the capitalist project; it is a civilizational strategy; it is the God-trick of capital. At the core of this project is the mobilization of all natures – human natures included – to accomplish a triple objective: 1) reduce the value composition of food, labor, energy, and raw materials through appropriating unpaid work; 2) expand the material volume of production; and 3) achieve significant advances in labor productivity. (These are but three angles of vision on the same process.) The first moment – the cyclical creation of the Four Cheaps – is the precondition for the modern world's great industrial revolutions, which have registered the achievements of expanding global commodity production and rapidly advancing labor productivity. In the absence of this first moment, the value composition of production tends to rise, profitability falters, and the tempo of accumulation slows.

Rather than an external crisis of nature-imposed necessity, today's global turbulence – including climate change and the multiform transgression of planetary thresholds (Rockström, et al., 2009) – is rooted in the exhaustion of the very relations that initially propelled modernity's epoch-making transformations. The origins of modernity's valuation of nature – humans included – are found in the long sixteenth century. This was the transition from land productivity to labor productivity as the civilizational metric of wealth. Through the passages of this world-ecological revolution, European states and capitals came to see time as linear, space as flat and homogenous, and "nature" as external to human relations. "Cheap nature" did not just appear; it had to be created, and to be created Nature had to be invented, biospheric reality subjected to the rationalizing and disciplining logic of successive scientific, botanical, cartographic, metrical, and other revolutions. It was these revolutions that identified and facilitated the appropriation of those cheap natures necessary to sustain rising labor productivity and rise volumes of material production. Without a widening sphere of appropriation, production costs would have risen and profitability faltered, as Marx warns in his general law of underproduction and his account of the working day (1967, III and I, respectively). For this reason, until the 1970s all great eras of world capitalism were premised on new production complexes that greatly enhanced labor productivity in concert with the restoration of the "Four Cheaps" – cheap labor, food, energy, and raw materials. Capital-intensive production and accumulation by appropriation go hand in hand in the history of capitalism.

Today, that dialectic of capitalization and appropriation has reached a breaking point. Across the neoliberal era, labor productivity growth sagged rather than surged, notwithstanding the productivity of uptick of 1996-2004 (Gordon, 2012). The trend line would have been even lower if not for historically-low food and metal prices – the fruits of accumulation by appropriation – which reinforced the cheap nature strategy in two major ways: 1) by cheapening labor-power through the cheap food/dispossession nexus; and 2) by significantly cheapening fixed capital between 1980 and 2005 (Araghi, 2000; Moore, 2010c, 2012; Grantham, 2011; Bank for International Settlements, 2006). Indeed, post-recovery productivity growth in the US since 2008 – a similar story could be told of Europe (Roberts, 2013) – has been "unusually weak," and since 2004 has sagged below the 1972-96 trend (Madigan, 2012; Sivy, 2013; Gordon, 2012). Concern over the "end of growth" – at least in the

Global North – is now widespread even amongst mainstream economists (e.g. Summers, 2013; Krugman, 2013; Cowen, 2011). This might be welcomed, were it not for capital's effort to reverse the productivity slowdown through a series of last-ditch scrambles for the last crumbs of cheap nature remaining. The top 200 oil and gas companies, for example, spent $674 billion in 2012 to "find and develop" new energy resources (Leaton, et al., 2013: 4; also Klare, 2012; Moore, 2014) – a movement that reflects a frightening inversion of the 20th century's trend for economic crises to reduce carbon emissions. Not so any longer (Peters, et al., 2012)!

The situation today would be highly unfavorable for a new "golden age" even if climate were not a factor. But climate *is*, and this is what Anthropocene arguments have highlighted with great narrative force. Having identified the "What?" – climate change and biospheric tipping points – we can now move to the "How?": *How* has capitalism transformed the biosphere over the past five centuries? There are those who might prefer a different signifier – modernity perhaps, or industrial civilization – but let us not quibble too much over naming, so long as we do name, identify, and explain the non-arbitrary, quasi-reproducible, and incessantly globalizing patterns of power, wealth, and re/production over the *longue durée*. In this effort to name, identify, and explain the long history of modernity we may take special care to see power, wealth, and re/production as *already* signifying humanity as "natural force," as already bundled (and bundl*ing*) with other forces and conditions of nature. To begin to grasp the history of capitalism in these terms – and the present argument is offered as opening rather than closure – is to recast the binaries of Nature/Society, base/superstructure, production/reproduction into fresh dialectical categories whose distinctions form through the relational movements of the parts. We have considered this through a recasting of value, too often considered independently of its historical conditions of expanded reproduction.

What I am proposing, then, is a dialectical extension of value-relational thinking that takes seriously the notion that historical processes actively contain their own negation. Thus value works only to the extent that most work is not valued. Labor productivity works only to the extent that land productivity is not. The epoch-making efficiencies of capitalist production are premised on the exponential accumulation of waste. All imply frontiers of one sort or another, but it is arguably this last moment this is now moving to center stage. For we have reached the point in capitalism's development when the geometric expansion of waste production threatens the biospheric stability inaugurated with the onset of the Holocene. Every commodity frontier is also a waste frontier.

What the great historian Walter Prescott Webb (1964) once called the "Great Frontier" opened by the audacious conquests of the New World was not merely a consequence of the colonial-commodity nexus, but constitutive of the rise of capitalism itself. And the nature of frontier space is to knit together, while simultaneously constructing, the local and the global: "place" *and* "process" in the language of the historians (Cronon, et al., 1993). These frontiers are not merely "out there," but actively produced by bourgeois knowledge, from Linnaean taxonomy to genomic mapping. It is the frontier *strategy* that bears ever less fruit – low-hanging or not – and this speaks directly to the problem of surplus capital in the 21st century. "Golden ages" and "great frontiers" are two sides of the same coin. As cheap nature frontiers have receded, the ballooning mass of surplus capital has surged – finding temporary lodging a bloated financial sector (Chang, 2014). This is no ordinary financial expansion that we've seen for the past decade (Arrighi, 1994). Rather, we are witness today to an epochal transition within historical capitalism.

That transition is suggested not only by the peculiar character of 21st century financialization but by the exhaustion of capitalism's labor productivity model (Gordon, 2012; Balakrishnan, 2009). They

are, in fact, two sides of the same coin. On the one hand, financialization has transited from a process that redirects surplus capital towards the new centers of industrialization – as during the Genoese-, Dutch-, and British-led financial expansion – and towards a process of robbing Peter to pay Paul. This means, simply, that financialization has become *primarily* a mechanism of redistributing shares of surplus value from productive to finance capital (Moore, 2012).[30] The major systemic expression of this redistributive shift is the sea-change in world commodity markets – the "financialization of commodities" – transformed over the course of the seemingly endless commodity boom that began in 2003, and as of this writing shows few signs of collapse (Tang and Xiong, 2011; Moore, 2014). (Barring a 1930s-like collapse, which is of course entirely possible [Chang, 2014].) But even such a collapse would not somehow usher in a new era of cheap nature, since "market-clearing" is only one moment, entwined with the centuries-long exhaustion of easily-extracted and –harvested cheap natures.

But neither is depletion a self-evident ecological phenomenon; it involves "mixing our labor with the earth" (Williams, 1980). Here we move to the flip side of financialization. The cyclical – and possibly secular – reversal of capitalism's cheap nature fortunes around 2003 has reinforced the slowdown in labor productivity growth that commenced in the 1970s. The significance of this slowdown has been seldom been attended to in global political economy – although it is often implied (e.g. McMichael, 2012). Just as the transition in financialization implies a shift from productive to redistributive accumulation strategies, so the transition in the labor productivity model implies another momentous shift: from relative to absolute surplus value. Perhaps counter-intuitively, the neoliberal era favored not a renewed revolution in labor productivity and automated production but its opposite: a grand seizing upon of those life-reproducing frontiers – including those of an emergent "surplus humanity" (Davis, 2006) – in order to squeeze out the last remaining drops of absolute surplus value, and the last remaining frontiers of unpaid work. Not for nothing the neoliberal era has been defined by *taking* first, and *making* second – a magisterial final act of redistribution without productivity revolution.

All of which suggests the reality of our times as the waning days not of the Anthropocene, the "Age of Man" *and* nature, but of the Capitalocene, the "Age of Capital"-*in*-nature. The common sense green objection to this line of thought is that one may needn't explain everything in order to explain the enormity of the challenges of global environmental change. And of course this is true. But common sense is good sense only up to point. For the explanatory challenge posed by the extraordinary biospheric changes charted by the dominant Anthropocene argument must engage, centrally, the relations of power and re/production that have made these environmental changes. These relations cannot be reduced to technical- and resource-determinism, nor to the price-determinism of the Jevon's Paradox – all of which have been embraced, too often, by critical green scholars. Rather, these relations turn on value and the conditions and mechanisms necessary to turn work, paid and unpaid, into surplus value. The pivotal systemic implication of value-relations in the web of life were articulated by Marx, and expressed in socio-ecological terms with special clarity by Altvater (1993): the law of value, as it develops historically, implies a rising extra-human energy/material throughput per unit of socially necessary labor-time. But of course this is not the end of the story. This development of the law of value – compelling a falling abstract labor-to-rising energy ratio – can occur only through the mapping, coding, and quantifying of new sources of Cheap Nature: labor-power, food, energy, and raw materials. Hence the centrality of abstract space, abstract time, and abstract

[30] I am aware that the line between a "productive" and "financial" capitalist has become blurred over the past four decades. Auto manufacturers, for instance, often make more money through financing auto sales than on the sales themselves.

extra-human nature immanent in the law of value – as abstract social nature – but non-identical with the value-form (the commodity) and the substance of value (abstract labor).

In all this, value-relations constitute not merely a theoretical claim about how capital works in the web of life, but historical method for excavating the history of the capitalist world-ecology, unifying the relations of accumulation, power, and nature across the great arc of modernity. To understand the nature of the problem today, we must root our diagnosis in the rigorous historical investigation of the origins of that problem – starting at the mid-point of the Industrial Revolution is not only empirically problematic, it reinforces the dualist predispositions that have trained us to understand historical change as social change. But historical change is a not a long chain of social events with environmental consequences; it is a long history of co-produced ensembles of human and extra-human nature, understood as an unbroken circle of being, knowing, and doing. This connection between "knowing" and "doing" has been highlighted in Part II of this essay, for two closely related reasons. First, the global environmental change literature has been characterized by a kind of vulgar materialism. Ideas seldom matter in global environmental history; when they do matter (e.g. Grove, 1995; Drayton, 2001), they are typically connected to territorial power and de-linked from the accumulation of capital. The Anthropocene argument has little patience for the role of knowledge-praxis in modernity; neither does the Marxist metabolism school (e.g. Foster, et al., 2010). Second, the transition from the philosophy of humanity-in-nature to a historical framework entails not only a critique of nature/society dualism, but also the dualism of base/superstructure. The trinity of science, capital, and power (Brockway, 1979: 461) implies a far more radical re-thinking of modern world history than is normally supposed. Thus we are dealing with more than historical interpretation in considering the Anthropocene and the Capitalocene; we are confronted with the challenge of re-evaluating the thought-structures of modernity that continue to shape the intellectual, and therefore political, habitus of even radical critics. Many of us are fond of putting forward some version of Einstein's point: "We can't solve problems by using the same kind of thinking we used when we created them." Most radicals – and I think most centrist Anthropocene analysts – are now keenly aware of this. How to ford the Cartesian Divide, in practical ways, is the great question. The bad news is that we find ourselves at the tipping point of multiple thresholds in the modern world-system, including the destabilization of biospheric conditions that have sustained humanity since the dawn of the Holocene some 12,000 years ago. The good news is that our ways of knowing are also in a mighty period of transition and radical change.

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