

The End of Cheap Nature. Or How I Learned to Stop Worrying about "The" Environment and Love the Crisis of Capitalism

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Does capitalism today face the "end of cheap nature"? If so, what could this mean, and what are the implications for the future? We are indeed witnessing the end of cheap nature in a historically specific sense. Rather than view the end of cheap nature as the reassertion of external "limits to growth," I argue that capitalism has today exhausted the historical relation that produced cheap nature. The end of cheap nature is best comprehended as the exhaustion of the value-relations that have periodically restored the "Four Cheaps": labor-power, food, energy, and raw materials. Crucially, these value-relations are co-produced by and through humans with the rest of nature. The decisive issue therefore turns on the relations that enfold and unfold successive configurations of human and extra-human nature, symbolically enabled and materially enacted, over the longue durée of the modern world-system. Significantly, the appropriation of unpaid work—including "free gifts" of nature—and the exploitation wage-labor form a dialectical unity. The limits to growth faced by capital today are real enough, and are "limits" co-produced through capitalism as world-ecology, joining the accumulation of capital, the pursuit of power, and the co-production of nature as an organic whole. The worldecological limit of capital is capital itself.

Introduction

What can it mean to speak of "the end of cheap nature"? It is a deceptively simple question, for it begs a series of clarifications. Is "the end" a cyclical phenomenon? (The end of neoliberalism's cheap nature?) Or is the "end" secular? (The end of historical capitalism's cheap nature?) Capitalism, we know, enjoys a long history of overcoming seemingly insuperable barriers to revive accumulation. This is especially true of barriers concerning the Big Four inputs: labor-power, food, energy, and raw materials. Does "cheap nature" refer to the bounty—and eventual exhaustion—of extra-human biological systems and geological distributions? Or does cheap nature signify a historical circumstance created—and later unraveled—by the relations of power, accumulation, and nature specific to the modern world-system? Does cheap nature, and its possible demise, include *human* nature? Perhaps most significantly, are these questions about the end of cheap nature questions about nature as an easy source of resources—either because the "taps" have been tapped out

or because the "sinks" have been filled up? Or are they about the end of *a way* of organizing nature premised on endless commodification?

Theoretical frame: Value relations in the capitalist worldecology

What we are seeing today is the "end of cheap nature" as a civilizational strategy, one born during the rise of capitalism in the "long" sixteenth century (c. 1450–1648). An ingenious civilizational project has been at the core of this strategy, to construct nature as external to human activity, and thence to mobilize the work of uncommodified human and extra-human natures in service to advancing labor productivity within commodity production. 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 to Southeast Asia's spice islands—may be understood in this light (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 peculiar. 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 (Postone, 1993). While all civilizations in some sense are built to expand across varied topographies-they "pulse" (Chase-Dunn and Hall, 1997)-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. 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*.

This early modern transition from land productivity in manifold "tributary" relations to labor productivity in manifold "commodity" relations emerged through a powerful bundle of processes co-produced by human and extra-human natures. In this view, capitalism unfolds in and through the *oikeios*, the creative, generative, and multi-layered relation of species and environment (Moore, 2011a). Humans, like all species, are at once producers and products of our environments (Levins and Lewontin, 1985). Humans, and also the civilizations we co-produce with the rest of nature. We find the spirit the *oikeios* when Wallerstein (1980, 162, 132–133; also 1974, 44, 89) speaks of "ecological exhaustion" as a world-historical movement encompassing *human* natures alongside soils and forests. The health of bodies and environments are indeed dialectically bound (Marx, 1977, 238, 636–638).

To be sure, humans are distinctive in forming historically-specific notions of our place in the web of life. This is the history of ideas of nature (Williams, 1980), which are in fact ideas of everything that humans do. We are amongst the planet's more effective "ecosystem engineers" (Wright and Jones, 2006); and even so, we too—our civilizations also—are made and unmade by the environment-making activities of life. (Does anyone today doubt that disease and climate make history every bit as much as any empire or class or market?) To take this position is to immediately abandon the notion of civilization (or world-system or capitalism) and environment, and instead re-focus on the idea of civilizations-in-nature, capitalism as environment-making process. These environments include factories no less than forests, homes no less than mines, financial centers no less than farms, the city no less than the country. Taking "ecology" as the signifier of the whole in its manifold species-environment relations, I have taken to calling capitalism a "world-ecology," joining the accumulation of capital, the pursuit of power, and the co-production of nature in dialectical unity (Moore, 2011a, 2011b; also Oloff, 2012; Deckard, 2012; Leonardi, 2012; Mahnkopf, 2013; Niblett, 2013; Ortiz, 2013).

In what follows, "nature" is matrix, rather than resource zone and rubbish bin. But such an assertion is insufficient in itself, for two reasons. The first is that the philosophical recognition—humanity-in-nature—must be accompanied by workable analytics that allow us to interpret historical change as actively co-produced by humans and the rest of nature. This transition from holistic philosophy to relational history is the core of the world-ecology argument. Secondly, the argument for nature as matrix must include and explain the idea and *praxis* of external nature, created by modernity's successive knowledge revolutions. For nature could not be rendered "cheap" until it was rendered external. Yes, the distinction between human and extra-human natures has a long history that stretches back, at the latest,

to Greco-Roman antiquity (Glacken, 1967). But never before had nature as external object become an organizing principle for a civilization.

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, in which space is flat, time is linear, and nature ontologically 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, 2000; 2003; 2007; 2010a; 2010b). 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" of labor-power, food, energy, and raw materials (Moore, 2012).

Capitalism's basic problem is that capital's demand for cheap natures rises faster than its capacity to secure them. The costs of production rise, and accumulation falters. This was recognized by Marx long ago, not only in his "general law" of the "overproduction" of machinery and the "underproduction" of raw materials (Marx, 1967, III, 119–121), but also in his perceptive observations that the bourgeois tends to accumulate capital by exhausting "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). The solution? Move to the frontier, so much the better if such frontiers

were colonies: thus the salience of Irish workers, Caribbean sugar, Mississippi cotton. For this reason, capital finds itself continually dependent on capitalist power and bourgeois knowledge to locate "external" natures whose wealth can be mapped, reshaped, and appropriated cheaply.

In creating these external and "cheap" natures, capital turned weakness to strength. Through its alliance with state-machineries, imperialist power, and bourgeois knowledge, capital has proven adept at overcoming real, or impending, "bottlenecks" to renewed accumulation. The frontier has therefore been capitalism's way of paying the bills that run up across successive long centuries of accumulation. Is the exhaustion of the cheap natures created through neoliberal capitalism a cyclical phenomenon—such as we saw at the end of the late eighteenth century, or the during the long 1970s—or is it the end of the capitalist road to cheap nature? Is the present *conjoncture*, in other words, a developmental crisis, one open to resolution through renewed rounds of capitalization? Or is it, rather, an epochal crisis, one that will compel fundamentally new relations of wealth, power, and nature in the century ahead?

This line of questioning has been marginal in today's proliferating literature on economic and ecological crisis. Prominent scholars who engage both moments—such as David Harvey and John Bellamy Foster—write as if nature and capitalism are separate, rather than unified, phenomena. Their philosophical insistence that humans are part of nature (e.g., Harvey, 1996; Foster, 2013b) rarely translates to historical analysis. Harvey's powerful argument for the relationality of humanity-innature falls by the wayside in his narratives of neoliberalism (Harvey 2003; 2005; 2010); Foster (2009) insists on no necessary connection between accumulation and biospheric crises. Foster and Harvey stand in here for a broader intellectual problem. Even when our philosophical position regards humans as part of nature, the narrative rules, methodological premises, and theoretical frames of world-historical scholars often remain within the confines of a modernist view of nature as external. This may explain some measure of the profound undertheorization of "ecological crisis," and the widespread weakness of critical scholars to explain how nature matters to capitalism, not merely as output, but as constitutive relation.

What would such an explanation—one premised on the co-production of capitalism by humans and the rest of nature—look like?

Nature, limits, and capital: Value and the world-ecological surplus

My answer proceeds from two big issues swirling about nature, capital, and limits today. One is historical. The other is conceptual. In the first instance, we must ask whether the peculiar train of events since 2003, when the present commodity boom began, represents a cyclical or cumulative "end" of the Four Cheaps: food, labor, energy, and raw materials (Moore, 2012). Capitalism since the early nineteenth

century has been remarkably adept at overcoming the actual (but temporary)—and averting potential (but quite threatening)—bottlenecks relating to the rising price of the Big Four inputs (Rostow, 1978). This capacity to overcome and avert such bottlenecks can be seen in successive epoch-making agricultural revolutions, expansively reproducing the cheap food/cheap labor nexus (Moore, 2010c). England's late eighteenth century agricultural stagnation and food price woes were resolved through the American farmer's marriage of mechanization and fertile frontiers after 1840. The productivity stagnation of early twentieth century capitalist agriculture in western Europe and North America was resolved through successive "green" revolutions, manifested in the postwar globalization of the hybridized, chemicalized, and mechanized American farm model (Kloppenburg, 1988; Federico, 2004). From this perspective, there is good reason for seeing the post-2008 global conjuncture as a developmental crisis of the capitalist world-ecology, one that can be resolved through renewed rounds of commodification, especially but not only in agriculture. But the latest wave of capitalist agricultural revolution—in agro-biotechnology has yet to arrest the productivity slowdown (Gurian-Sherman, 2009). It is therefore also possible that capitalism has entered into an *epochal crisis*.

Developmental and epochal crises do not represent a "convergence" of ontologically independent environmental and economic crises (e.g., Foster, 2013a). Rather, such crises give expression to the maturing contradictions inscribed in those regimes of value, power, and nature that govern capitalism over the *longue durée*, and through successive long centuries of accumulation (Arrighi, 1994; Moore, 2011b). In place of the converging crises model, we may instead view our era's turbulence as a singular crisis—of capitalism as a way of organizing nature—with manifold expressions. Food and climate, finance and energy represent not multiple, *but manifold*, forms of crisis emanating from a singular civilizational project: the capitalist world-ecology.

We might begin with how capitalism goes about forming and re-forming its specific configurations of wealth, power, and nature: not as three independent boxes but as mutually relational moments in the cumulative and cyclical development of the modern world-system. To pursue this line of inquiry brings us squarely onto the terrain of capitalism's law of value. For it is the emergence, development, and cyclical restructuring of capital, power, and nature that are conditioned decisively by capitalism's value relations.

We might think value relations in two major ways. The first is *value as method* (Moore, 2011a; 2011b). This approach reconstructs historical capitalism through "the production and reproduction of real life" as "distinctions within . . . the organic whole" (Engels, 1934; Marx, 1973, 99–100). This permits a world-ecological recasting of "nature" and "society" in favor of the contradictory unity of "the production and reproduction of real life." It is a unity that cuts across and destabilizes any meaningful historical boundary between human activity and the rest of nature; the "reproduction of real life" includes the extra-human intertwined with the human at

every step. Taking the production and reproduction of life as our guiding thread allows us to dissolve the ontological and historical divide between the economic and the ecological, in favor of definite historical configurations of human and extrahuman natures. Once freed from the fetish of "the economy," we can focus on the relations of power and (re)production that make possible the endless reproduction of value in its double existence: *as abstract social labor and abstract social nature*. (About the latter, more presently.) Value as method therefore posits historical capitalism not as the zone of commodification but as the contradictory unity of endless commodification and its appropriation of the conditions of reproduction—from the reproduction of human beings to to the reproduction of biospheric stability.

This brings us to a second deployment of value relations. This is *value as historical proposition*. In this, we can think value as a historical project that engages reality as something to be reduced to an interchangeable part. These reductions are at once symbolic and material, and they comprise both "economic" and "non-economic" simplifications (e.g., Braverman, 1974; Worster, 1990; Scott, 1998). Crucially, the generalization of value relations works through a dialectic of capitalizing production and appropriating reproduction. Value is encoded simultaneously through the *exploitation* of labor-power in commodity production, and through the *appropriation* of nature's life-making capacities as unpaid work. This double coding of value is therefore a dialectic of *value/not-value*. This latter, *not-value*, is "produced" through the zone of appropriation: the condition for *value* as the zone of exploitation. It includes, pivotally, the unpaid work of all humans, but especially so-called "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 overcomes seemingly insuperable "natural limits" through coercive-intensive and symbolically-enabled appropriations of cheap natures, cyclically renewing the Four Cheaps. Dramatic 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 capitalize*, the reproduction of lifemaking as unpaid work. Value only works when most work is not valued. Modernity in this sense is a mighty control project, effecting all manner 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*.

From this standpoint, the development of value relations may be discerned through its chief material expression, the Four Cheaps of labor-power, food, energy, and raw materials. These are the indispensable (but not exclusive) conditions for the long-run revival of accumulation, as we saw in 1846–1873, 1947–1973, and mostly recently, 1983–2007.

The cyclical rise and decline of the Four Cheaps therefore offers a promising point of entry into a deeper, world-ecological, understanding of historical capitalism. "Cheap" signifies the value composition of the Big Four inputs. A low value composition represents a relatively low quantum of average human labor (abstract social labor) in the average commodity—and a relatively higher contribution of unpaid work. "Value," understood as abstract social labor, is measured by average labor-time. The *law* of value, in this reading, is a world-historical tendency that—"modified in its working by many circumstances" (Marx, 1977, 798)—transforms the wealth of nature into *value*, as interchangeable and quantifiable units of wealth, defined by interchangeable and quantifiable units of human labor-time *in commodity production*.

This latter is socially necessary labor-time. While all species "work" in some fashion, only humans create and labor under socially necessary labor-time. *Only* humans, and only *some* humans at that. The law of value—not the *theory* of value but its actual historical operation—is anthropocentric in a very specific sense. Only human labor-power *directly* produces value. A tree, or a horse, or a geological vent cannot be paid. And yet, commodified labor-power cannot produce anything without the unpaid work of the horse or the three. Socially necessary *unpaid* work is the pedestal of socially necessary labor time.

"But wait!" says the environmentalist. "Doesn't that show that value is partial, and doesn't work?" The first part of the objection is entirely correct: value *is* partial. *Necessarily* partial. And, unlike the horse or the tree, unpaid human work *could* be paid. But capitalists do not like to pay their bills, and for good reason. To fully commodify the reproduction of labor-power would do away with the unpaid work that allows accumulation to proceed at acceptable rates of profit. Marxists will sometimes characterize capitalism as a system in which "the bulk of society's work is done by propertyless labourers who are obliged to sell their labour-power" (Wood, 2002, 3). But this is precisely what *cannot* occur under capitalism! If the bulk of the work carried out within capitalism were ever to be monetized, the costs of labor-power would soar, and cheap labor-power would not exist. Only the barest rate of capital accumulation would be possible.

None of this suggests that wage-labor is epiphenomenal. Quite the contrary! Rather, proletarianization may be more adequately understood as a "connective historical process" fundamental to the capitalist world-ecology (McMichael, 1991, 343). In this light, the rise of the law of value is not centered on the rise of the modern proletariat *as such*, but on the uneven globalization of wage-work *dialectically joined to* the "generalization of its conditions of reproduction" (McMichael, 1991, 343). Value, as abstract social labor, works *through*, not in spite of, its partiality.

Life-activity outside commodity production, but articulated with it, is *socially necessary unpaid work*. Strictly speaking, it cannot be quantified in the same fashion as commodified labor-power because the condition of quantifiable abstract social labor is a mass of *un*quantifiable work. What capital strives to achieve is the reduc-

tion of necessary labor-time. This reduction is intrinsic to capital's existence: hence capitalism's emphasis on labor productivity over land productivity, and capital's mobilization of cheap natures in order to make this emphasis possible. The acceleration of landscape change and the emergence of a tentative but tenacious regime of abstract social labor were two sides of the rise of capitalism in the sixteenth century; abstract social labor could only take shape on the basis of a new, sharply accelerated, relation to the unpaid work of cheap natures.

In the conventional narrative (Landes, 1969), rising labor productivity is a story of technological advance and organizational innovation in industrial production. This is true enough. But is it the whole story? New machinery and energy sources at the point of production can only advance labor productivity—reducing necessary labor-time over the long-run—through new technologies of power that reduce the value-composition of the Big Four inputs. The Four Cheaps could be restored only partly through innovations within established zones of commodity production; historically, they also depended on new strategies of appropriation, on new frontiers. Here we find a systemic connection between the accumulation of capital and the rise of capitalist power in making possible a civilization cohered by the law of value. In order to reduce necessary labor-time, capital sets in motion—and struggles to create through varied combinations of coercion, consent, and rationalization—a civilization that aims to maximize the unpaid "work" of life outside circuit of capital, but within reach of capitalist *power*.

The reduction of socially-necessary labor time through commodification is what I have been calling *capitalization*; the maximization of unpaid work in service to capitalization, is *appropriation*. There is some overlap, to be sure. Where the Cartesian frame presumes separation of humanity *and* nature, the world-ecology argument presumes a dialectical unity that proceeds from the distinctiveness of humans (amongst many other species) within the web of life. So my focus is directed towards the ways that capitalization and appropriation work together as patterns and rules of reproducing value and power in the web of life. This gives us a way to identify and to explain patterns of environment-making across the *longue durée* of historical capitalism. It is a simplified model, a "first cut" if you will. We are excavating the fundamental historical dynamics of capital accumulation as a pattern that operates through the *specifically* bundled relations of human and extra-human nature governed by the law of value.

We can begin with capitalization and appropriation as relations of reproduction. From there, we may consider the relations between the two moments. First, while the capitalization of reproduction assumes many forms, it has occurred most conspicuously through proletarianization. This was historically prior to the large-scale capitalization of extra-human natures, and indeed historically prior to large-scale industrialization in the nineteenth century (Seccombe, 1995). "Proletarianization" is another way of saying that the reproduction of labor-power flows through cap-

ital, largely in the form of paid work.¹ Of course, even proletarian households in the Global North continue to rely upon the significant expenditure of unpaid work (laundry, cooking meals, raising children, etc.). Humans transform the rest of nature only through the labor process, and the commodification of work—directly and indirectly—is therefore historically pivotal to the capitalization of extra-human natures.

But it is not just the reproduction of labor-power that has become capitalized; it is also the reproduction of extra-human natures. Over the past five centuries, capitalist agriculture reveals the dependence of agro-ecosystems on global capital flows (especially through credit) every bit as much as nutrient and hydrological cycles. The extraordinary shift that occurred in the twentieth century—through successive hybridization, chemical, and biotechnological "revolutions"—has been the capitalization of agro-ecological relations (unpaid work) that were previously outside the commodity system (Kloppenburg, 1988). The twenty-first century capitalist farmer must buy new seeds every year rather than save seeds; she must buy more pesticides and herbicides every year to protect the yield; the farming family must strive to produce more and more to satisfy the debt obligations of an agro-ecological model that is increasingly "reproduced within the circuits of capital accumulation" (Boyd et al., 2001, 560). Flows of nutrients, flows of humans, and flows of capital make a historical totality, in which each flow implies the other—a point frequently missed by green critics of capitalism (e.g., Foster et al., 2010).

Accumulation by appropriation also transcends and disrupts the Cartesian binary. The really meaningful distinction is not between humanity and the rest of nature, but between two spheres: life-activity within the commodity system and life-activity outside the zone of commodification, but still ensnared within capitalist power. The movements of both spheres contribute, decisively, to the determination of socially necessary labor time. The first movement occurs within the "organic whole" of commodity production, comprising distribution, exchange, and distribution, alongside immediate production (Marx, 1973, 100). The other is the "organic whole" of appropriating unpaid work in the service of advancing labor productivity. In other words, the rate of exploitation under the law of value is determined not only by the class struggle within commodity production (between capitalists and the direct producers), and not only by the tools, organization, and value composition of commodity production. *It is also determined by the contribution of unpaid work*, performed by human and extra-human natures alike. (There is a class struggle here, too.)

Successive regimes of abstract social labor therefore turn on the active reconfiguration of worlds of production and reproduction. In this view, value relations

¹ I say "largely in the form of paid work," because the relation of bourgeois and proletarian assumes many concrete forms, including master and slave in the early modern sugar plantation (Mintz, 1978); for the late twentieth century, Lewontin (1998) suggests (with some exaggeration) that the farmer has become a proletarian.

unfold through the dialectic of value/not-value, in which "not-value" is directly productive of the conditions necessary for a regime of abstract social labor. This means that capitalism's *technics*—understood as specific crystallizations of tools, nature, and power (Mumford, 1934)—do more than pick the "low-hanging fruit" (Cowen, 2011). Capitalist *technics* seek to mobilize and to appropriate the (unpaid) "forces of nature" so as to make the (paid) "forces of labor" productive in their modern form (the production of surplus value). This is the significance of the *production* of nature; nature is not a pre-formed object for capital, but a web of relations that capital reshapes so as to advance the contributions of unpaid biospheric "work" for capital accumulation. Capital, in so doing, is reshaped by nature as a whole.

The appropriation of unpaid work—represented historically through the cyclical rise and decline of the Four Cheaps—is therefore a central issue for anyone who wants to take seriously the question of limits. This is because the *real* historical limits of capitalism derive from capital as a relation of capitalization and appropriation. The "limits to growth" (Meadows et al., 1972) are not external, but derive from relations internal to capitalist civilization. Why internal? Clearly, we are not speaking of internal as a fixed boundary—much less in a Cartesian sense of "social" limits and "natural" limits—but rather capitalism as an *internalizing* civilization. Here, *internal* is methodological premise, not historical statement. Economists often speak of how capitalism "externalizes" costs. The conversion of the atmosphere to a dumping ground for greenhouse gases is a good example. What bears emphasizing is that the externalization of costs is also the internalization of spaces necessary for capital accumulation: waste frontiers matter, too.

When capitalists can set in motion *small* amounts of capital and appropriate *large* volumes of unpaid work, the costs of production fall and the rate of profit rises.² In these situations, there is a *high world-ecological surplus* (or simply, "ecological surplus"). The ecological surplus is the ratio of the systemwide mass of capital to the systemwide contribution of unpaid work. A growing relative contribution of unpaid work tends to reduce the systemwide organic composition of capital, especially within the new centers of accumulation. Over the course of an accumulation cycle, the contribution of unpaid work tends to fall, relative to the mass of capital seeking investment. Every great wave of accumulation therefore begins with a high ecological surplus, which is created through combinations of *capital* (value-in-motion) and *capitalist power* (territorial but also cultural). Together, these movements of capital and capitalist power secure new and greatly expanded sources of unpaid work in service to accumulation. This is the dialectical counterpoint to the traditional rendering of primitive accumulation as a process of class formation in production (bourgeois and proletarian). Primitive accumulation is *equally* about the restructur-

² This is a simplified model of capital and nature. One would naturally wish to elaborate the simple model into a series of world-historical specifications and revisions based on richer totalities of many determinations.

ing of the relations of reproduction—human and extra-human alike—so as to allow the renewed and expanded flow of "cheap" labor, food, energy, and raw materials into the commodity system.

The problem for capital is that the strategies that create the Four Cheaps are "one-off" affairs. You cannot discover something twice. The idea of nature as external has worked so effectively because capital must constantly locate natures external to it. 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 external nature that exists as a pre-given 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.

From peak appropriation to the tendency of the ecological surplus to fall

Exhaustion encompasses the physical deterioration of human and extra-human natures (e.g., health problems, soil erosion), but cannot be reduced to such depletion. Deterioration is an empirical reality that speaks to a relational dynamic: the relation between the shares of unpaid work (appropriation) and paid work (capitalization) in world accumulation. Exhaustion is the flipside of "boom." Both turn on the capacity of particular species, ecosystems (including humans), and even geological formations, to deliver unpaid work. That capacity is not, however, "just there." It is actively co-produced through the relations of capital, capitalist power, and class struggle. Exhaustion in this sense signifies the erosion of those historically-specific accumulation strategies that remake the specific forms of capital, power, and nature in successive long centuries of accumulation. The error of much critical discourse on "natural limits" is to confuse the depletion of substances for the exhaustion of accumulation strategies (e.g., Foster et al., 2010). They are related. And substances do matter. But, as any student of resource economics will tell you, the issue for capital is not energy returned on energy invested, but energy returned on *capital* invested: EROCI, not EROEI. What matters, in capitalist history, is the ratio between the mass of unpaid work and the mass of surplus capital. Stated formally, the *mass* of unpaid work may rise even as its *share* declines relative to accumulation by capitalization. This is probably what has occurred over the past decade since the onset of the 2003 commodity boom.

Several examples illustrate this counter-intuitive theoretical picture. Labor productivity growth may continue, but at a much slower rate than previously. This has been the case with world agriculture since the 1980s (Moore, 2010c). Productivity growth has continued, but at a pace that is too slow to meet capital's need for cheap food. A slowing rate of growth indicates exhaustion, if the need for unpaid work rises, and the agro-food regime fails to restore cheap food. At the same time, rising food prices cannot be reduced to productivity in an era characterized by an unprecedented financialization of commodities (Moore, 2012; Tang and Xiong, 2012).

A second mirage appears in contemporary discussions of global energy. Advocates of "peak everything" point to an impending decline in oil—and eventually, coal—production (Heinberg, 2003). Such declines will occur, although it is far from clear that they will be geologically-driven. The geological dimensions are crucial, but a too-narrow focus easily misses the historical reality. This reality turns on the law of value. The "peak" that capitalism cares about is peak appropriation: the moment when the contribution of unpaid work is highest, relative to the abstract social labor (capital) deployed. Peak appropriation can be identified both cyclically, in successive accumulation cycles, and cumulatively, since the sixteenth century. Cumulative peak appropriation for coal was reached sometime in the early twentieth century; peak appropriation for oil, sometime around 2000. Output may rise as the ecological surplus falls, as seems to be the case with coal production today. Rising output will restore cheap energy only if the share of unpaid work (here, geological "work") increases relative to the capital necessary to produce it. In this light, post-peak appropriation registers capital's declining capacity to appropriate nature cheaply (with less and less labor-power). The problem is not whether more oil—for example—can be extracted on an abstract supply curve, but whether more oil (or its equivalents) can be extracted with less labor.

And what of human natures? Labor-power is exhausted too. The American working class today, for instance, is not exhausted in the sense of imminent physical breakdown; it is exhausted in its capacity to deliver a rising volume of unpaid work to capital. Its potential for delivering unpaid work is maxed out. The proliferation of "shifts"—a second and third shift in paid and unpaid work—and the neoliberal extension of the workweek provide good reason to think that American workers cannot work much more or much harder (e.g., Hochshild, 1989; Schor, 1991; 2003). (On the margins, perhaps, but not more than this.) Sociophysical "breakdown" *is* implicated in exhaustion. This can be seen in the dramatic rise of mental health problems in the Global North since the 1980s (HHS, 2010), along with rising cancer rates (Davis, 2007). Beyond mounting health problems, one could also look at the "baby strike" of declining fertility, carried out by proletarian women across the North Atlantic in

recent decades, now extending to industrialized East Asia (Livingston and Cohn, 2010; The Economist, 2013). Over the course of an accumulation cycle, relations of reproduction once outside the cash nexus become progressively monetized. This capitalization of reproduction delivers a middle-run boost to accumulation through multiple shifts. But the middle-run boom is achieved at a price. As reproduction becomes channeled through commodity relations, the share of *un*paid work stagnates or declines. When this occurs, the expanded accumulation of capital becomes increasingly dependent on the *commodified*, rather than the uncommodified, reproduction of life, and the costs of accumulating capital rise.

This dynamic is the tendency of the ecological surplus to fall.

The most obvious indicator of a declining ecological surplus is the rising price of the Big Four inputs. Labor, food, energy, and raw materials become more and more expensive. The Four Cheaps stop being cheap. This usually doesn't happen all at once, although this is in fact what we have seen since the start of the 2003 commodity boom. The point at which the Four Cheaps stop becoming cheaper and cheaper and start to become more and more expensive is the *signal* crisis of a phase of capitalism. Such crises signal the exhaustion of an accumulation regime (Moore, 2012). For the neoliberal phase of capitalism, this signal crisis—far more important than the near-meltdown of the financial system in 2008—began around 2003. Since that time, the ecological surplus has been falling, and there are few signs that the decline will be reversed soon, if ever. Why? Largely because the greatest frontiers have been exhausted, and because, at the same time, the mass of surplus capital continues to rise. What seems to be occurring is a vicious circle. Finding frontiers few and far between, a growing mass of surplus capital has sought refuge in commodity markets, pushing *up* the very prices of food, energy, and raw materials at the moment when capitalism (as a system) needs those prices to go down. This in turn exacerbates the surplus capital absorption problem, which finds partial and temporary resolution in renewed financialization. This in turn further "short-circuit[s] flows of production and trade ... at the expense of what might have been long-term social surplus" (Blackburn 2006, 67).

This points towards a decisive lacuna in the Marxist theory of capital accumulation. The resolution of cyclical overaccumulation crises—crises defined by a rising mass of "surplus" capital that cannot be reinvested profitably—has depended upon the cyclical restoration of the Four Cheaps. The falling ecological surplus, representing a contraction of capital's opportunities for appropriating unpaid work, is closely linked to the contraction of profitable opportunities for investment in the real economy (M-C-M'). Cheap oil, or cheap labor, or cheap metals, *make possible* new products—such as, in their respective eras, the railroad and steam engine, or

³ Here I lean of Arrighi's simplified model of Marx's general formula of capital. In "M-C-M'... [m] oney capital (M) means liquidity, flexibility, freedom of choice. Commodity capital (C) means capital invested in a particular input-output combination in view of a profit. Hence, it means

the automobile. The production systems, urban spaces, and infrastructures implied by these new products absorbed giant volumes of surplus capital. Indeed, the successive industrializations in the North Atlantic between 1790 and 1960—spanning the first, second, and Fordist industrial revolutions—can be told through the ways these epochal inventions (steam/coal, auto/oil) reworked the capitalist *oikeios* and its rising relative contribution of unpaid work over this period. Intriguingly, the information technology "revolution" of the past forty years has been manifestly inadequate in absorbing surplus capital (Foster and McChesney, 2012, 38).

The Four Cheaps, in making possible those great waves of industrialization, are central to the resolution of recurrent overaccumulation crises in historical capitalism—crises characterized by rising volumes of capital that cannot be invested profitably. Consequently, the cyclical "end" of the Four Cheaps, in successive accumulation cycles, corresponds to a growing mass of surplus capital with no place to go. As accumulation in the real economy falters, a growing mass of capital becomes involved in financial rather than productive activities (M-M' rather than M-C-M') (Arrighi, 1994; Leyshon and Thrift, 2007). The exhaustion of commodity frontiers—and the systemwide stagnation of unpaid work that such exhaustion implies—appears to be closely linked to the peculiar forms of financialization that have emerged since the 1970s.

The rise and demise of cheap nature: The neoliberal moment

Can the tendency of the ecological surplus to fall be seen during the neoliberal era? We may recall that a high world-ecological surplus represents a ratio of low capitalization to high appropriation. This is a necessary condition for the revival of accumulation. For good reason, the neoliberal "boom" that commenced after 1983 was accompanied—or preceded—by a significant cyclical decline in food, energy, and resources prices. Commodity prices for metals fell by nearly half between 1975 and 1989; for food by 39 percent; while oil stabilized by 1983, for the next twenty years, at a price per barrel about twice that of the postwar era (McMichael, 2005; Radetzki, 2006; van der Mensbrugghe et al., 2011).

concreteness, rigidity, and a narrowing down or closing of options. M' means expanded liquidity, exibility, and freedom of choice" (Arrighi, 1994, 5).

⁴ M-M' comes into play during what Arrighi calls financial expansions, such as the one that has characterized the capitalist world-ecology since the 1970s. Such financial expansions are "symptomatic of a situation in which the investment of money in the expansion of trade and production [M-C-M'] no longer serves the purpose of increasing the cash flow to the capitalist stratum as effectively as pure financial deals can. In such a situation, capital invested in trade and production tends to revert to its money form and accumulate more directly, as in Marx's abridged formula MM" (Arrighi, 1994, 8–9).

But it was not only extra-human natures that became cheap.

The 1980s revival of accumulation also turned on a cheap *labor* regime. This entailed producing a regime of cheap human nature that could supply both paid and unpaid work in sufficient volumes to restore accumulation. In formal terms, establishing a new cheap labor regime meant reducing the value of labor-power. This was not easy to accomplish. There were five key dimensions of the neoliberal project to restore cheap labor after 1973. The first was "wage repression" (Harvey, 2010, 12). Bourgeoisies across the Global North began to "organize as a class" (Moody, 1988), and moved aggressively against trade unions following the 1974-1975 recession. Wage repression was especially important as labor productivity growth sagged in the 1970s, a deceleration that increasingly looks permanent (Gordon, 2010). Second, the falling rate of profit in American industry—induced both by labor's class power and the rising organic composition of capital—led American and other capitalists to move rapidly towards the "global factory" in the 1970s (Barnet, 1980; Gordon et al., 1982). This was a tectonic shift in world history that entailed the simultaneous de-industrialization of core zones and the rapid industrialization of the Global South (Arrighi et al., 2003). Third, the global factory depended upon the "great global enclosure" (Araghi, 2000) that commenced in the early 1980s. These global enclosures, realized through structural adjustment programs and market liberalization, restructured agrarian class relations worldwide, dispossessing hundreds of millions of peasants worldwide. In China alone, some 200-300 million migrants moved from countryside to city (Webber, 2012). The new global proletariat dwarfed any that came before it. In concert with the opening of Russia, China, and India to the world market, the world proletariat doubled after 1989 (Freeman, 2010). Fourth, this great doubling represented an even greater expansion of the female proletariat, adding paid work on top of unpaid work on an unprecedented scale. Neoliberal proletarianization was, in this reckoning, an unprecedented global expansion of Hochschild's (1989) "second shift," an audacious expansion of absolute surplus value. Finally—and almost universally ignored by environmentalists—cheap labor was made possible through a new regime of "forced underconsumption" (Araghi, 2009), such that hunger and nutrient deficiencies today affect nearly three billion people, including 50 million people in the United States (Keats and Wiggins, 2010).

By 2003, the world-ecological surplus had stopped rising, and began to decline. Registered by the slow-, then fast-moving, commodity boom (Jacks, 2013), this was the *signal* crisis of neoliberalism as a way of organizing nature (Moore, 2010c). This expression of crisis signals the beginning of a cyclical contraction of the ecological surplus. The clearest indicator of this signal crisis was the rising price of metals, energy, and food commodity prices. But this was not just any commodity boom, not least because of its unusual durability, now ten years and counting. What does this seemingly endless commodity boom indicate? At a minimum, the peculiar character of this boom—which includes more primary commodities, has lasted longer, and has seen more price volatility than any previous commodity boom in mod-

ern world history (World Bank, 2009)—indicates an exhaustion of neoliberalism's cheap nature strategy. Notably, neoliberalism's strategies for reducing the Big Four input prices began to falter at least five years prior to the financial events of 2008. Economists talk of this very long commodity boom as a "supercycle"—a decadeslong increase in basic commodity prices. But so far, they have invoked an abstract "world of scarcity" (Jacks, 2013) rather than consider the possibility that today's supercycle represents a historical limit to capitalism's *longue durée* regime of "cheap ecology" (Araghi, 2010).

Even cheap labor may be fading fast. In other words, the signal crisis of neoliberalism is not merely a question of extra-human natures—reflected in the commodity boom—but of human nature too. In China, real wages increased 300 percent between 1990 and 2005 (Midnight Notes, 2009, 4). Manufacturing wages grew six times faster than the rate of inflation, and unit labor costs rose 85 percent between 2000 and 2011 (USDC, 2013). Meanwhile, the usual strategy of moving to cheap labor frontiers—seeking new streams of unpaid work in support of low-wage workers—is in motion, but with rapidly diminishing returns. Within China, the government's "Go West" policy, which has aimed to attract industry to the interior, has narrowed labor costs between interior and coastal regions to a "surprisingly...paltry wage differential" (Scott, 2011, 1). Rural-to-urban migration has slowed considerably in recent years (Fegley, 2013). By 2012, per capita foreign investment in Cambodia moved ahead of China (Bradsher, 2013). But Cambodia is much smaller than China, which is part of the broader problem: the frontiers are shrinking at the very moment when capital needs ever-greater commodity frontiers to resolve the overaccumulation problem. Meanwhile, the very information and communication technologies that have made possible global production are now also being used in the class struggle:

Workers in Cambodia today have begun syndical action after only a few years, not after twenty-five. There are strikes and pressure for higher wages and benefits, which they are receiving. This of course reduces the value for the multinationals of moving to Cambodia, or Myanmar, or Vietnam, or the Philippines. It now turns out that the savings of moving from China are not all that great. (Wallerstein, 2013)

The ongoing erosion of cheap labor is not exclusively an East Asian story. Less well understood, but no less significant, is the transition across the Global North to a "second (and third) shift"—wage work plus unpaid reproductive labor. This transition enacted and embodied one of the last great commodity frontiers of historical capitalism. Unpaid household labor has been a pillar of endless commodification since the sixteenth century (Mies, 1986). What happened in the Global North, and especially in North America, after 1970 was the accelerated proletarianization of women. This marked the demise of the Fordist one-income family and the rise of the "flexible" two-income household. This 1970s acceleration had been prefigured

by Soviet developmentalism (Sacks, 1977), and also by the fast entry of American women into paid work since the 1930s (Goldin, 2008). This too was a commodity frontier, marked by the progressive commodification of work-potential and the progressive appropriation of (human) nature's "free" gifts. Hence the imposition of multiple "shifts," and the double squeeze on women's time via the simultaneously operating pressures of capitalization and appropriation; even as early as the mid-1960s a growing number of married American women had traded in their 55-hour work week at home for the 76-hour work week at home and work (Hartmann, 1981). If this were all—as in Hochschild's (2002) rendering of the commodity frontier—there would be little to add. What the theory of the commodity frontier illuminates is not only the pattern of successively paired commodifying/appropriating movements, but the finite opportunities inscribed in each such movement (Moore, 2013a; 2013b). In the United States, the extraordinarily rapid increase in mothers' labor force participation—50 percent between 1975 and 1995 (BLS, 2009)—was not only a powerful moment of neoliberal wage repression while maintaining effective (consumer) demand. It was also a *one-shot deal*. The commodity frontier is a oneway ticket. Frontiers, once appropriated and commodified, are no longer frontiers they do however move on, as we've seen in the roll out of the proletarian relation for women across the Global South since the 1980s (Kabeer, 2007; McMichael, 2012).

Capitalism as frontier: Abstract social natures

Commodity frontiers may roll onwards, but only to a point. Capitalism not only has frontiers; it is fundamentally defined by frontier movement. The conceit of early modern cartographic revolutions was to conceive of the Earth as abstract space rather than as concrete geographies. The latter, abolished (or at least controlled) in theory, would continually reassert itself, as geographical particularities (climates, soils, topographies, diseases) entered into dynamic tension with bourgeois fantasies of abstract space. The great advantage of mapping the world as a grid and nature as an external object was that one could appropriate the wealth of nature in a fashion profoundly efficient for the accumulation of capital. The very dynamism of capitalist production is unthinkable in the absence of frontier appropriations that allowed more and more materials to flow through a given unit of abstract labor time: value's self-expanding character depends on an exponential rise in the material volume of production without a corresponding rise in the abstract labor implied in such production. This incessant reduction of labor-time can occur, however, only to the extent that cheap energy, cheap food, cheap raw materials, and yes, cheap labor can be secured through strategies of appropriation outside the immediate circuit of capital. This can only occur through the continual enlargement of the geographical arenas for appropriation. Thus are capital and capitalist power joined in the co-production of cheap natures.

For this reason, frontiers are much more central to the expanded reproduction of capital and capitalist power than commonly recognized. When Harvey (2003, 131) opines that capitalism, confronting the end of frontiers, might "actively manufacture" such frontiers, he reflects the common sense of the contemporary radical critique. But this is a misinterpretation. The processes of privatization and finance-led dispossession, insofar as they operate within the domain of capitalized relations, cannot revive accumulation by themselves; indeed, these processes worked in the neoliberal era because they were bound to the release of cheap labor-power, food, energy, and raw materials *into* the circuits of capital from *outside* those circuits.

Historically, frontier zones of low or minimal commodification have provided capital's greatest opportunities to reduce the Big Four input prices: labor, food, energy, and raw materials. These costs directly or indirectly reflect the value composition of commodity production as a whole, in their variable, fixed, and, above all, circulating moments. (Note that *circulating* capital refers to the inputs used up in a given production cycle; it is different from the circulation of capital.) Frontiers are pivotal to long waves of accumulation for an elementary reason: they check the rising organic composition of capital, and therefore the tendency of the rate of profit to fall. The reduction of the value composition of these four inputs is significant because it is inversely related to the formation of a global rate of profit, and therefore to world accumulation. In Marx's rarely-cited "general law" of underproduction, the overproduction of machinery tends to lead to the underproduction of raw materials, which in turn enter into the determination not only of the value composition of non-human labor (raw materials) but also, over the course of successive accumulation cycles, of fixed capital itself. Cheap coal, for example, reduced not only the costs of circulating capital (energy costs) but also the costs of manufacturing steam engines and other vital forces of production in the second half of the "long" nineteenth century.

Depeasantization, the reorientation of peasant agriculture towards the world market, the extraction of abundant energy and 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 proletariat; directed abundant energy flows to, and boosted labor productivity within, commodity production; and channeled gigantic volumes of raw materials into industrial production, driving down the value composition of both fixed and circulating capital even as the technical composition of capital rose mightily (Moore, 2011a; 2011b). Put simply, the Great Frontier that opened the capitalist epoch did so by making nature's free gifts—human natures' too—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.

Frontier appropriations occur not only on the horizontal edges of the capitalist system—as in world-historical reckonings of incorporation (e.g., Hopkins and

Wallerstein, 1987)—but also on the "vertical" axis of socio-ecological reproduction within the heartlands of commodification. Although the horizontal and vertical moments of these frontier appropriations unfolded in distinct geographical zones with specific socio-ecological inflections, they were unified through their relation to the accumulation process. Commodity frontiers worked in both heartlands and hinterlands by appropriating and transferring unpaid work from the zones of socio-ecological reproduction towards zones of commodification. In the heartlands, the appropriation of women's unpaid work was central to the cheap reproduction of labor-power; in the hinterlands, the appropriation of extra-human natures (forests, soils, mineral veins) was often primary. The secret of the law of value is in this epochal synthesis of the exploitation of labor-power and the appropriation of the unpaid work of human and extra-human natures. The formation of abstract social labor occurs only partly, not wholly, within the zone of commodification. The regime of abstract social labor—premised on socially necessary labor-time—emerged historically, and restructured cumulatively, through the formation of regimes of abstract social nature.

The argument here is that abstract social nature—understood as a systemic family of processes aimed at rationalizing, simplifying, standardizing, and otherwise mapping the world—is directly constitutive of producing external natures that can be cheaply appropriated. In this, abstract social nature is immanent to the law of value; the praxis of external nature was pivotal to the generalization of commodity production and exchange. The cascading and converging processes of commodification, capital accumulation, and symbolic innovation 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 neither an adequate history of capitalism, nor a sufficiently dynamic theory of capitalist limits, is possible without taking value relations as a methodological premise focused on the trinity of capital/power/nature.

In this perspective, value relations are grounded historically in successive configurations of abstract labor and nature. Those configurations may be called *historical natures*. Each historical nature, co-produced by the law of value, enables the renewed exploitation of labor-power and the renewed appropriation of life-activity as unpaid work. The appropriation of unpaid work must outstrip the exploitation of labor-power, else the Four Cheaps cannot return, and neither can capitalist prosperity. Abstract social nature names those processes that extend, through new forms of symbolic praxis and knowledge formation, the frontiers of accumulation—both accumulation by capitalization and, especially, accumulation by appropriation.

Value is therefore *not* an economic form with systemic consequences. It is, rather, a systemic relation with a pivotal "economic" *expression* (abstract social labor). One cannot think the accumulation of capital without abstract social labor and the struggle to reduce socially-necessary labor-time. By the same measure, one cannot think the accumulation of capital without the symbolic praxis of abstract social na-

ture, allowing for the appropriation of unpaid work on a scale that dwarfs the exploitation of labor-power. Unifying these two moments calls for a mode of inquiry that brings together the circuit of capital with the appropriation of life, and this necessitates a *world-ecological* framework for interpreting the history of capitalism and value's contingent and fluctuating gravities of nature, power, and capital.

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 surveying and property-making, schools of painting and music, accounting practices, and scientific revolutions. These abstractions marked the birth of abstract social nature (Mumford, 1934; Merchant, 1980; Harvey, 1993; Crosby, 1997; Pickles, 2004; Cosgrove, 2008). The infant would begin to walk by the close of the sixteenth century. We find the new face of world moneyand credit-creation in the rise of the Amsterdam Bourse after 1602. Here, 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 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" (Langley, 2002, 45; also Petram, 2011).

Of course, abstract social nature is still with us.

For the history of capitalism may be read, in part, as a succession of 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. The point has been underscored most dramatically 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, 2009). 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 invention of recombinant DNA) became a powerful lever for producing new conditions of accumulation premised on redistribution and speculation—patenting life forms, starting with the microorganisms recognized in 1980 by the U.S. Supreme Court. 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, geographic information systems, 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)

This is what Luke (2009) calls "planetarian accountancy." But planetarian accountancy is more than biophysical. 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.

[Beginning] in the 1970s, an "arms race" to develop new financial techniques for commodifying uncertainty spurred innovators competing for profits to ever-new heights, and by the 1990s terms such as "financial product" and "financial products division" were enjoying an unprecedented vogue. The relevant mode of "production" was what might be called "quantism": the material and social processes of isolating, laying claim to, objectifying, simplifying, abstracting, quantifying, commensurating, pricing and reaggregating masses of unknowns by which derivatives were manufactured and financial uncertainty commodified. Computers and top mathematical talent were given free rein in greatly expanded efforts to break down, reframe, mathematise, diversify across, appropriate and charge rent for the future. (Lohmann, 2009, 19)

Both "scanning and appraising" the world and the scramble to produce ever-more exotic financial instruments may be read as efforts to transcend the problems of a capitalism that has entered uncharted territory: the terrain of post-peak appropriation, which is to say, the end of cheap nature.

By way of conclusion

The rise of capitalism launched a new way of organizing nature, mobilizing for the first time a metric of wealth premised on labor productivity rather than land productivity. This was the originary moment of today's fast-fading "cheap nature." This strange law of value, taking shape out of the vast frontier appropriations and productive innovations of the long sixteenth century, allowed for capitalism's unusual civilizational dynamism: appropriating the whole of nature within its grasp to advance the rate of exploitation of labor-power. From the 1450s, there commenced a succession of movements of productivity and plunder, joining the vast appropriation of nature's free gifts with extraordinary technical innovations in production and transport. Each wave of capitalism that followed depended on great frontier movements, the agrarian counterpart to the spatial and productive "fixes" of capital accumulation in the metropoles. Together these movements of accumulation by appropriation and accumulation by capitalization constituted world-ecological revolutions through which new opportunities for peak appropriation were realized, and capital accumulation maximized. These world-ecological revolutions—and the

organizational structures they implied—encompassed innovations in industry and finance no less than agriculture and resource extraction. These innovations at first liberated accumulation, only to fetter it over time, as the great windfalls of frontier expansion and accumulation by appropriation gradually—sometimes rapidly—disappeared: newly proletarianized workers began to organize, farming regions became exhausted, coal seams were mined out. The tendential result has been a lurching movement towards a rising organic composition of capital and a declining ecological surplus, squeezing the rate of accumulation as opportunities for new productive investment dried up. These developments were, at all turns, linked closely with rising costs of inputs (circulating capital) and with them, the amplified tendency of the rate of profit to fall.

This is of course a provisional model for taking nature seriously in the theory of capital accumulation. It is an invitation. To what? To a conversation over how we might elaborate a more radical, dialectical, and historical *synthesis* of capitalism-in-nature: a synthesis suggested by O'Connor (1998) and Burkett (1999), but whose implications have scarcely been explored.

How to move forward? Certainly, any synthesis worthy of the name will go bevond the Cartesian dualism of "nature" and "society." In this respect, I am struck by Marx's (1973, 748) insight that the fertility of the soil could "act like an increase of fixed capital." The English agricultural revolution had proceeded on precisely this basis, "cashing in on reserves of nitrogen under permanent pasture for shortterm gain" (Overton, 1996, 117), and stagnating after 1760. Much the same process of "cashing in" occurred in the American Midwest between 1840 and 1880, after which yield growth slowed until the 1930s (Kloppenburg, 1988; Friedmann, 2000). The same arc of peaking and post-peak appropriation could be seen in South Asia's Green Revolution between the 1960s and 1980s (Moore, 2010c). Capitalism's agricultural revolutions—is it so different for energy and other "modes of extraction"? (Bunker, 1985)—are always premised on such appropriations, combining cuttingedge industrial production with frontier enclosures. In this way, food could be produced cheaply and a double-gift presented to capital: peasant dispossession and cheaper reproduction costs for those already proletarianized. Thus we might extend Marx's observation to all forms of "fertility."

Capitalism's *longue durée* cheap nature strategy has aimed at appropriating the biological capacities and geological distributions of the earth in an effort to reduce the value composition of production, thereby checking the tendency towards a falling rate of profit. As opportunities for accumulation by appropriation contract, we would expect to see a profound shift from spatial to temporal fixes (Harvey, 1989), moving from the appropriation of space to the colonization of time: the greatest strength of neoliberal financialization. By the early twenty-first century, the end of cheap nature was in sight. More violence, more biopower, and more guns restored the Four Cheaps for two decades after 1983. But the bloom was off the rose by the early years of the new millennium. Appropriation was faltering. Rising costs of pro-

duction and extraction in agriculture, energy, and mining began. The price movement was made official by 2003, with the onset of the seemingly endless commodity boom. Labor-power seemed cheap for a time, but here too the cheap labor regime showed signs of wear. Cheap labor became less cheap. The "Great Doubling" no longer seemed so great. But the rising capitalized composition of nature did not stop there. Appropriation not only faltered in all the old ways; it now carried forth a new stench of unfathomable toxification: hydro-fracked aquifers, mountaintop removals, the overnight devastation of the Gulf of Mexico.

The problem today is the end of the *Capitalocene*, not the march of the Anthropocene. The reality is not one of humanity "overwhelming the great forces of nature" (Steffen et al., 2011), but rather one of capitalism exhausting its cheap nature strategy. (This is 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 very low expenditures of money and energy is the history of capitalism's great commodity frontiers, and with it, of capitalism's long waves of accumulation. The appropriation of frontier land and labor has been the indispensable condition for great waves of capital accumulation, from Dutch hegemony in the seventeenth century to the rise of neoliberalism in the 1970s and 1980s (Moore, 2010b; 2012). The crucial "work" of these commodity frontiers has been *unpaid*; on that basis, the cheap nature strategy has renewed the Four Cheaps.

With frontiers fast closing, the cheap nature strategy is failing in a double sense. On the one hand, new streams of unpaid work are materializing slowly, if at all. On the other hand, the accumulation of waste and toxification is now threatening the unpaid work that *is* being done. Climate change is the greatest example here. It is increasingly certain that global warming constitutes an insuperable barrier to any new capitalist agricultural revolution—and with it, any return of "cheap food" (Kjellstrom et al., 2009; Zivin and Neidell, 2010). From this perspective, the greatest problem of the twenty-first century may well not be one of resource "taps" at all. The end of cheap garbage cans may loom larger than the end of cheap resources (Parenti, 2012). The shift towards financialization, and a deepening of commodity relations in the sphere of reproduction, has been a powerful way of postponing the inevitable blowback of modernity's cheap nature strategy. It has allowed capitalism to survive. But for how much longer?

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