

Transcending the metabolic rift: a theory of crises in the capitalist world-ecology

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The theory of metabolic rift is among the most dynamic perspectives in critical environmental studies today. This essay argues that the problem with the metabolic rift perspective is not that it goes too far, but that it does not go far enough. I take a ‘use and transcend’ approach that takes metabolic rift theory as an indispensable point of departure in building a unified theory of capitalist development – one that views the accumulation of capital, the pursuit of power, and the production of nature as differentiated moments within the singularity of historical capitalism. My response unfolds through two related arguments. First, the theory of metabolic rift, as elaborated by Foster, Clark, and York, is grounded in a Cartesian binary that locates biophysical crises in one box, and accumulation crises in another. This views biophysical problems as consequences of capitalist development, but not constitutive of capitalism as a historical system. The second part of this essay moves from critique to synthesis. Drawing out the value-theoretical implications of the metabolic rift – through which capitalism’s greatest contradiction becomes the irremediable tension between the ‘economic equivalence’ and the ‘natural distinctiveness’ of the commodity (Marx) – I illuminate the possibilities for a unified theory of capitalist development and crisis over the *longue durée*. This is the theory of capitalism as world-ecology, a perspective that joins the accumulation of capital and the production of nature in dialectical unity. This perspective begins from the premise that capitalism does not act upon nature so much as develop through nature–society relations. Capitalism does not have an ecological regime; it is an ecological regime.

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The theory of metabolic rift is amongst the most dynamic perspectives in critical environmental studies today. How can we take the core insights of this perspective, and at the same time move towards a theory of crisis and development that views the accumulation of capital, the pursuit of power, and the production of nature as differentiated moments within the singularity of historical capitalism? My response

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unfolds through two related arguments. First, the theory of metabolic rift – especially the ‘Oregon school’ represented by John Bellamy Foster, Brett Clark, and Richard York – is grounded in a Cartesian paradigm that locates biophysical crises in one box, and accumulation crises in another.¹ Environmental degradation, in this view, is a *consequence* of capitalist development, an output of the system. But it is not *constitutive* of capitalism as a historical system. Nature and society appear as a binary; the dialectical relation is reduced to the examination of ‘how these *positions* [“nature” and “society”] interact and transform each other’ (Clark and York 2005a, 396, emphasis added). This emphasis on the interaction of positions confuses the *results* of the dialectic of human and extra-human natures with the dialectic itself. This dialectic, what I call the *oikeios*, gives rise to the singular abstractions of ‘nature’ and ‘society’ in their specifically capitalist forms.

The point of critique is synthesis. In the second part of the paper, I argue that the problem with the metabolic rift perspective is not that it goes too far, but that it does not go *far enough*. Drawing out the value-theoretical implications of the metabolic rift – through which capitalism’s greatest contradiction becomes the irremediable tension between the ‘economic equivalence’ and the ‘natural distinctiveness’ of the commodity (Marx 1973, 141) – I illuminate the possibilities for a unified theory of capitalist development and crisis over the *longue durée*. This is the theory of capitalism as *world-ecology*, a perspective that joins the accumulation of capital and the production of nature in dialectical unity. This perspective begins from the premise that capitalism does not act upon nature so much as develop through nature–society relations (Moore 2000a, 2000b, 2003a, 2003b, 2003c, 2007, 2008, 2009a, 2009b, 2010a, 2010b, 2010c, 2010d). Capitalism does not *have* an ecological regime; it *is* an ecological regime. The theory of capitalism as world-ecology is built out, first, through an engagement with Marx’s value theory, rehabilitating his underappreciated theory of crisis, one rooted in a dialectic of *underproduction* and *overproduction*, both moments rooted in the tendency towards a rising organic composition of capital. This basic crisis tendency – Marx’s ‘most important law’ (1973, 748) – has been held in check over the history of capitalism by the system’s capacity to appropriate nature’s ‘free gifts’ faster than it has capitalized their reproduction. This dialectical antagonism of accumulation by appropriation and accumulation by capitalization is central to understanding the conditions for a revival of accumulation in the present conjuncture.

Capitalism as world-ecology, or, the *oikeios* as dialectic

‘We have mixed our labor with the earth, our forces with its forces too deeply to be able to draw back and separate either out’, Raymond Williams first argued in 1971 (1980, 83). In an extraordinary essay, Williams directs his critique towards those ‘singular abstractions’ – society and nature – that confuse and obscure the historical relations between humans and the rest of nature. But this is only part of what makes Williams’ argument so extraordinary. While we may perceive (or fail to perceive) the ‘products’ of humanity’s ‘complex dealings with the physical world’, Williams outlines an approach that would demolish the fictions inscribed in these singular abstractions, and deliver ‘not only a more sophisticated, but a more radically honest,

¹Foster and York teach in the University of Oregon’s sociology department, where Clark took his PhD.

accounting'. This alternative accounting is one premised on *relations* rather than 'products':

We ourselves are products: the pollution of industrial society is to be found not only in the water and in the air, but in the slums, the traffic jams, *and not these only as physical objects but as ourselves in them and in relation to them* . . . The process . . . has to be seen as a whole, but not in abstract or singular ways. We have to look at all our products and activities, good and bad, and to see the relationships between them which are our own real relationships. (Williams 1980, 83–4, emphasis added)

Too often in environmental studies, we are riveted to the consequences issuing from society's footprint on nature. And this is the way that many would put it (York *et al.* 2003, Jorgenson 2003, Wackernagel and Rees 1996, Wackernagel *et al.* 2002, Altvater 2007). Debt leads to deforestation. Neoliberal programs drive cash-crop monocultures. Industrialization causes CO² emissions. Are these not reasonable causal statements?

The short answer is yes and no at the same time. All social research must explain change over time, necessarily implicating some mix of cause and effect. But the nature of the story changes according to the ingredients of each moment. One's point of departure – nature? society? the relations between them? – shapes the range of possible destinations. What I wish to highlight in this essay is an uneasy fracture within a broadly conceived left ecology.² On the one hand we find a set of sophisticated arguments that nature and society make a dialectical whole. On the other, a set of empirically rigorous arguments that social causes (capitalism, industrialization, globalization) drive biophysical consequences (deforestation, CO² emissions, pollution). A relational ontology in the realm of social theory rubs elbows with a mechanical ontology in the realm of social history. (Although 'social' may no longer be the way to put it!) The problem is not with the attention to 'social' drivers or to 'environmental' consequences, or with causal statements as such. Rather, a difficulty emerges with the elevation of these 'singular abstractions' to the status of actor and *acted-upon*, foot and *footprint*, as the conventional metaphor would have it. In this metaphor, we see a symbolic enclosure (and alienation) at work, which effects an idealized separation of producer and produced, manifest in a purified *social* repertoire of agents and a purified bundle of *environmental* effects. It is an eminently Cartesian way of seeing, one that accounts for capital's depredations upon the 'environment' in the same way that capital surveys, accounts, and quantifies nature's utility for accumulation. It is an ontology that produces a critique of the social domination of nature while valorizing its inner logic. It is a line of critique, in other words, that reproduces the very alienation of nature and society it seeks to transcend.

If not the singular abstractions of society and environment, what? The shortest answer, as Williams suggests, is to adopt a method premised on the dialectical movement and interpenetration of the (so-called) social and the (so-called) natural.

²Major points of reference in left ecology include Altvater (1993), Benton (1989), Blaikie and Brookfield (1987), Braun and Castree (1998), Bunker (1985), Burkett (1999, 2006), Enzensberger (1974), Foster (1999, 2000), Harvey (1974, 1996), Levins and Lewontin (1985), Martinez-Alier (1987), O'Connor (1998), Peet and Watts (1996), Peluso (1992), Peluso and Watts (2001), Schnaiberg (1980), Smith (1984), Watts (1983), Williams (1980), Worster (1990). Recently, Panitch and Leys (2006), and Heynen *et al.* (2007), have collected two important clusters of perspectives within this current.

There is nothing new itself in this answer, so long as one remains with the spheres of social theory and the study of regional transformation. And what about our stories of the modern world? Translating this relational method from social theory to world history has been an enduring challenge. That is to say, ‘green’ social theory has not (yet) given rise to a ‘green’ history of capitalism. Now, it is certainly true that today we enjoy a vast and enormously rich literature on environmental history. But an inspection of this literature, especially its world-historical component, reveals a series of narratives whose motive forces are irreducibly social – the great thrusts of European colonialism, of commercializing imperatives, of civilizing projects large and small (e.g. Ponting 1991, McNeill 2000, Richards 2003).

This sort of social determinism was indeed where I began (Moore 2000a). Nearly a decade ago, I argued that ‘environmental crises’ and long ‘systemic cycles’ of environmental transformation *complemented* capitalism’s phases of development. It was clear, for instance, that the rise of monopoly capitalism in the later nineteenth century entailed a set of far-reaching agroecological transformations, from the wheatfields of the American Midwest to the copper mines of Chile and the rubber plantations of southeast Asia. I soon found that one could travel only so far with such a model. It was an approach that proceeded from a set of *a priori* constructions ontologically prior to the relations I wanted to discern: the game was rigged, the outcome determined in advance. The rise of monopoly capitalism, in this scheme of things, *caused* changes in ‘the’ environment. But such a view begs an important question. To wit, How does the nature–society relation ask for a rethinking of capitalism and its phases of development? Perhaps even more important: What can a socio-ecological *method* reveal about capitalism that was previously underappreciated or mis-recognized?

This was a much more intriguing line of questioning. I appreciated the flood of critical scholarship that accounted for capitalism’s environmental depredations, but after a certain point, I wasn’t learning anything that most of us didn’t already know: Capitalism is bad news for the birds and bees, the water, the soil, and pretty much all living creatures on the planet. Empirical evidence might be amassed to verify this or that ‘environmental’ impact, but within the limits of the Cartesian scheme, the socio-ecological constitution of capitalism itself remains unexplored. It is not that we don’t need an analysis of impacts. Rather, the problem is that Cartesianism narrows, rather than expands, the kinds of impacts under investigation – farming is important, and so are CO² emissions, but not global finance and its mania for securitization, or the Washington Consensus, or the dollar as world currency.

In an expansive sense, the big question turns on how we *think* capitalism, or if you prefer, modernity, industrialization, imperialism, and the many other possible ‘master processes’ (Tilly 1984) of world-historical change. The alternative is between differing ‘ways of seeing’ – between, say, a capitalism (or modernity, or industrial society) that acts *upon* nature, and one that develops *through* human and extra-human natures. We have, I believe, arrived at a powerful eductive moment – one that allows us to erase old boundaries and open new vistas, and one where we can reconstitute each of these processes on the *historical* basis of the nature–society relation.³

³ I counterpose ideal-type conceptions of capitalism – from the left and the right – in favor of a methodological and theoretical approach that enables the construction of *historical* capitalism over large space and the *longue durée* (Hopkins 1982, McMichael 1990, Tomich 2004, Wallerstein 1974, Moore 2007).

Easier said than done! From this perspective, the call for ‘integrating’ human and natural history is very much to be welcomed (Costanza *et al.* 2007, Beddoe *et al.* 2009). I worry, however, that in the absence of *synthesis* – relative to integration – we are left with models that cobble together multiple observed trends without explaining their interrelations. The ‘interplay’ of factors is recognized as decisive, but the constitutive *relations*, underpinning the descriptive trends, remain something of a black box. Costanza and his colleagues, for instance, characterize the twentieth century as a ‘Great Acceleration . . . [whose] *engine* . . . is an interlinked system that consists of population increase, rising consumption, abundant cheap energy, and liberalizing political economies’ (2007, 525). As such, the argument for causation in global environmental change tends to fall back on *social* drivers – rather than socio-ecological relations.

And yet, everything need not be ‘deep history’. There is much to be learned from an examination of the interplay of distinct long waves (and distinct temporal logics) framing the rise and fall of world hegemonies, financial complexes, and yes, specific forms of ‘environmental’ change in the modern world. But the relations of the whole cannot be reduced to the sum of these interactions, and interactions *look different* from the standpoint of the whole. A mass of evidence indicting capitalism (or modernity, or industrial society) for its manifold environmental stressors and stresses does not explain how these stresses are generated (and how they are *generative*), how they turn into crises, and what kinds of crises they implicate.

The problem that I faced in seeking to extend my original argument can be stated simply enough. To say that every phase of capitalist development is *complemented* by a specific regime of environmental transformation makes about as much sense as saying that every phase of capitalism is complemented by new bourgeoisies, new imperialisms, new socio-technical innovations. But where the generative capacities of new bourgeoisies, imperialisms, and innovations in the making of successive capitalist orders have been self-evident, the hegemony of Snow’s ‘two cultures’ (1964) obscures still the socio-ecological relations constituting capitalism as a whole.

Simple enough, perhaps, and also profoundly disruptive of our received analytical categories, even within Marxism. The enduring legacy of the ‘two cultures’ is an analytical vocabulary that reproduces the Cartesian divide, and occludes the messy bundle of relations that give rise to what we call ‘nature’ and ‘society’. If Nature and Society are the *results* of this messy bundle of relations, what do we call the bundle itself? My term for it is the *oikeios*, coined by the philosopher–botanist Theophrastus ‘to indicate the *relationship* between a plant species and the environment’ (Hughes 1994, 4, emphasis added). It is an imperfect term, and doubtless one with which I have taken some interpretive liberties. Nevertheless, taking the *oikeios* as our point of entry draws attention to the constitutive relations that give rise to the problematic, *a priori*, categories of Nature and Society and their cognates.

Ecology, in what follows, signifies the relations of the whole. The shorthand, ‘ecological’, crystallizes the matrix of human and extra-human natures, and the historically-specific ways through which symbolic and material relations are interwoven and provisionally stabilized in the modern world-system. Ecology qua *oikeios* stands in sharp contrast to scholarly vernaculars of *environment* and *nature* as one pole of a Cartesian binary. The problem with most scholarly deployments of ‘the environment’, as noun or adjective, is the *a priori* narrowing of the field of inquiry. The ‘environment’ is taken as largely exogenous, and primarily defined in terms of

extra-human nature; alternatively, in some promising initiatives (Sellers 1999), this definition extends to the body as a site of environmental history. But many of the most important aspects of the ‘environment’ in the modern world-system, for humans and the rest of life on the planet, can be found in what are typically regarded as ‘social’ forces and relations: financial markets, scientific revolutions, cartographic technologies, new forms of business organization such as the vertically-integrated corporation, colonial governments, property-rights, warmaking. Cutting into both ‘environmental’ moments – forests and financialization – as a differentiated unity calls for a conceptual vocabulary and methodological approach that jettisons the ‘preconceptualized’ biases of the Cartesian binary (Haila and Heinen 1995). So if the *oikeios* is a linguistic distinction in part, it is also a conceptual one that opens the possibility for a holistic perspective on the organism-*environment*/society-*environment* relation, through which each dialectical moment is actively constructed by (and through) the other (Levins and Lewontin 1985).

I have therefore refrained from the language of *environmental crisis* (pace Moore 2000a), and embraced that of *ecological transformation*. I do so because a singular object, *the environment*, ‘does not exist and ... because every species, not only the human species, is at every moment constructing and destroying the world it inhabits’ (Lewontin and Levins 1997, 98). And yet, if new vernaculars are needed, the old ones cannot be simply ignored. So I retain the phrasing of ‘nature and society’ and ‘socio-ecological’ but signal here that these are the results of an underlying relation, the *oikeios*. Such a perspective poses different questions from the Cartesian model. Rather than write a history of capitalism’s impact on the environment, then, we might investigate a generative relation between ‘endless accumulation’ and the ‘endless production of nature’.⁴ Instead of a method that identifies ‘society’s’ footprint on the rest of nature, we might well ask how the provisionally stabilized relations between these two end-points create, simultaneously, a ‘footprint’ on society no less than upon the so-called ‘environment’. It is the difference between the ‘capitalism and nature’ ontology of the metabolic rift perspective and the theory of capitalism-*in-nature*.⁵ The accumulation of capital and the production of nature are distinct rather more than discrete categories, so intertwined as to make the one unthinkable without the other.

If these are distinctive moments within a dialectical unity, what are the methodological frames and conceptual premises necessary to illuminate these relations? The theory of metabolic rift, so long as it is taken as a methodological premise rather than falsifiable proposition, offers one promising point of departure for a fruitful response to this dicey question.

The theory of metabolic rift

In Foster’s original formulation (1999, 2000), capitalism is dialectically bound to an epochal shift in the town–country division of labor – Marx’s ‘urbanization of the countryside’ (1973, 479). The point is crucial, for the category of metabolic rift is

⁴At the risk of stating the obvious, the production of nature does not mean that humans produce the atmosphere, the evolution of species, geological strata, or any other such foolishness. Rather, the production of nature registers the unassailable fact that humans come to know the rest of nature through conscious and creative life activity.

⁵Here I adapt Araghi’s innovative turn of phrase: ‘labor-in-nature’ (2009).

now widely understood as the ‘separation’ or ‘disruption’ of superficially ‘social’ and superficially ‘natural’ systems (McMichael 2009, Clark and York 2005a). In my view, however, the town–country division of labor does not produce a metabolic rift; it *is* a metabolic rift, and one that continually (if unevenly) drives successive recompositions of capitalist space (Moore 2000a, 2007, 2010a, 2010b). In Foster’s early conceptualization, the separation of the direct producers from the means of production – and the progressive liquidation of seigneurial power in the countryside – implies a new geography of wealth and power. The emergent disciplines of the law of value directed all manner of biophysical wealth – labouring bodies and the cheap food to nourish them, above all – towards urban spaces. In the transition to capitalism, the *rift* appeared as these ‘original sources’ of wealth were largely produced in agrarian spaces, but increasingly consumed in urban spaces. Absent a systemic mechanism to encourage the recycling of urban-industrial wastes to the countryside – as was the case, for instance, with the ‘night soil’ traffic of Late Imperial China or Tokugawa Japan (Xue 2005), or even the Dutch Republic of the seventeenth century (de Vries and van der Woude 1997, 202–4) – historical capitalism tends to produce nutrient depletion in the countryside, and pollution in the cities. The secular trend towards escalating biophysical exhaustion and pollution – Foster’s ‘absolute general law of environmental degradation’ (1992) – has been punctuated by a ‘series of successive, historical breaks in nutrient cycling’ (Foster 1999, 399; also Moore 2000a). Highlighting the rise of ‘industrial agriculture’ after World War II, followed by the emergence of large-scale feedlots, and global feedstock sourcing in recent decades, Foster and his colleagues have illuminated important connections between capitalism, its geographical patterns (the metabolic rift), and the system’s immanent tendency towards biophysical degradation (Foster and Magdoff 1998, Clark and York 2008).⁶

The central contribution of the metabolic rift perspective is to locate socio-ecological contradictions *internal* to the development of capitalism. But the conceptualization follows a different road than O’Connor’s theory of the second contradiction, which we will consider momentarily (1998). The distinctive explanatory power of the metabolic rift rests on three decisive, spatio-temporal connections: (1) primitive accumulation imposes value relations on the countryside, compelling rising labor productivity in primary production, and establishing the conditions for geometrically rising throughput relative to labor – there is no *capitalist* metabolic rift without agricultural revolution; (2) the subsequent generalization of value relations, implying a powerful contradiction between the ‘natural distinctiveness’ of commodities and their ‘economic equivalence’, necessitates the progressive ‘urbanization of the countryside’ (Marx 1973, 141, 479); and (3) the

⁶To my knowledge, environmental degradation is nowhere conceptualized by Foster, Clark, and York. A working conceptualization would begin by emphasizing capital’s utopian project to remake the world in its own image – a world of interchangeable parts. The vision of the biosphere as a great storehouse of ‘natural capital’ is a symbolic rendering of this tendency, materialized in the new genetic technologies of the neoliberal era, and earlier, through the mass production systems of the Fordist era, the cartographic technologies of cadastral grids in North America and elsewhere, cash crop monocultures, and even the ‘standard’ slave, measured in *piezas de Indias*. Such strategies of ‘radical simplification’ (Worster 1990) do not exhaust the possibilities of course. Let us note that every long century of accumulation has been accompanied by qualitative shifts in the toxification of the planet, today transforming human bodies, on an unprecedented scale, into walking toxic waste dumps.

tension between the country and the city is therefore central, not simply as empirical fact, but as the geographical pivot of value accumulation, mediating biophysical flows from farm to factory through the built environments of the circuit of capital. In this view, ‘town and country’, no less than ‘bourgeois and proletarian’, emerges as a relational expression of the underlying contradiction between value and use-value in historical capitalism.

My objection is not that the theory of metabolic rift has gone too far, but rather that it has not gone *far enough*. There is, it seems to me, a rift within the metabolic rift perspective, one movement holding fast to a nature–society binary, another seeking to transcend the underlying Cartesianism of modern social thought. In the first place, we can identify a tendency to move away from the centrality of the town–country dialectic in Marx and Engels’ understanding of capitalism (1970), and in Marx’s thinking about the emergence of an ‘irreparable rift in the interdependent process of social metabolism’ (1981, 949). Demoting the town–country dialectic to the status of a secondary contradiction allows York, for instance, to formulate the metabolic rift as the way that capitalism ‘*disrupts* the exchange *between* social systems and natural systems’ (York 2007, emphases added; also Mancus 2007, 277, Clausen and Clark 2005, Clark and York 2005a). In Clark and York’s hands, the town–country dialectic appears as a ‘*particular* geographical manifestation of the metabolic rift,’ which may be dissolved into the latter’s ‘*general* properties’ (2005a, 400, 391, emphasis added). From these conceptions, capitalism becomes a socially-constituted subject, one that creates an exogenous ‘crisis of ecological sustainability’ through the ‘disruption’ of ‘natural cycles’ (Foster 2001, 473, Clark and York 2005a, 406, Clark and York 2005b). The systemic logic of this ecological crisis tendency is found in an uneasy pastiche of Marxist and neoclassical political economy, with pride of place given to the neoclassical ‘Jevons Paradox’: technological innovation drives down unit prices for inputs, thereby widening the sphere of input consumption and amplifying resource exhaustion (Foster 2000, Jevons 1906, Clark and York 2008). It is a perspective that locates accumulation crisis in one sphere, and the ‘crisis of the earth’ in another (Foster 2009, 1997, Burkett 1999, 2003, 2006, Foster and Magdoff 2009). There is a relation between the two, but one that strikes me as rather more Cartesian than dialectical.

Such Cartesianism is, however, only one tendency; my point is that the metabolic rift perspective has been enacted in ways Cartesian and dialectical, *at the same time*. There is no denying that the dialectical method has been central to the metabolic rift project. While I am less convinced than Clark and York in their certitude that such a thing as ‘society’ exists, they are assuredly correct in arguing that, ‘while social history cannot be reduced to natural history, it is a part of it’ (2005b, 21). The difficulty lays in the recasting of modernity’s meta-categories – capitalism, in their view, *has* a metabolic rift. But the central question posed by our shared commitment to a dialectical method and historically-grounded theory is this: *How do we think capitalism differently* as a result of metabolic rift investigations? In what ways can we see the metabolic rift as ‘directly given in the concept of capital itself’ (Marx 1973, 408)?

Surely part of the answer is directly given in Foster’s reading of Marx himself. In this interpretation, Marx’s critique of capitalism emphasized how ‘bourgeois society’s . . . domination of humanity’ rested on its ‘domination of the earth’, especially in the form of large-scale landed property (Foster 2000, 74). The endless accumulation of capital is, in other words, the endless commodification of nature.

But rather than corral accumulation crisis in one pen, and biospheric crisis in another, might we instead begin from the *relations* that connect the two? I am therefore concerned that the particular distillation of the metabolic rift into ‘general properties’ loses sight of the whole as a ‘rich totality of many determinations and relations’ (Marx 1973, 100). For Clark and York, in their groundbreaking exploration of capitalism’s enclosure of the atmosphere (2005a), the town–country dialectic becomes a particularity dissolved into a general whole. This marks a retreat from the geographical promise of the metabolic rift perspective. In substituting a contradiction between ‘society’ and ‘nature’ exogenous to the spatiality of society and nature (town and country), they produce a crisis theory that is, quite literally, ‘lost in space’ (also Magdoff and Foster 2010). Where Clark and York see the relations of town and country as empirical facts, would it not be more fruitful to see town and country as one of several decisive *internal relations* ‘directly given in the concept of capital itself’?⁷

So when I argue that the metabolic rift has not gone far enough, I am saying that the socio-ecological contradiction (as *oikeios*) goes much deeper than even Foster, Clark, and York acknowledge. Part of this stems from an imprecise deployment of nature as analytical concept. Clark and York (2005a, 408), for example, rightly point out that value represents an alienated appropriation of human nature (*qua* ‘abstract social labor’), superficially divorced from extra-human nature. In the same breath, however, they argue that ‘money mystifies the relation between labor *and* nature’ (p. 408). A tiff over words? Possibly. But I think it is more than this, with definite implications for bounding the phenomena under investigation. For Clark and York, the ‘exploitation of nature’ emerges as discrete process alongside the exploitation of labor. This occludes the inner relation between the labor process – including science as a way of knowing the rest of nature (Young 1985) – and the reproduction of the *oikeios*. It is this occlusion that gives rise to a Cartesian separation of ‘accumulation crisis’ and ‘environmental crisis’ (e.g. Foster 2009).

If we look beyond the binary of labor and nature in favor of ‘labor-*in*-nature’ (Araghi 2009), we can see this binary resting on the (Cartesian) re-coding of human labor power as ‘social’. But is not human labor power eminently socio-*ecological*? The intergenerational (re)production of labor power is itself a ‘natural cycle’ whose socialized flows are registered in the determination of socially necessary labor time (Secombe 1992). From biorhythms (proliferating shift work) to bioaccumulation (rising toxicity), on closer inspection we find it challenging indeed to determine the boundaries of the allegedly social and the seemingly natural.

Within the metabolic rift perspective, Burkett (1999) has gone farthest in this direction, rooting the analysis in the theory of value. Demonstrating that Marx’s value theory is unthinkable in the absence of the contradiction between the ‘natural distinctiveness’ and ‘economic equivalence’ that constitutes the commodity form, Burkett’s pioneering analysis shows how the metabolic rift might be theoretically

⁷One might reasonably argue that town and country could be subsumed within the category of imperialism. This would be unwise in my view, for the simple reason that town and country and core and periphery are not synonymous. Nebraska corn farming is agrarian but not peripheral; Mexico City is urban but not a core zone. In the study of historical capitalism, core and periphery implicate value composition and value flows (e.g. capital-intensive vs. labor-intensive production) whereas town and country implicate the geographical moment of the origins and reproduction of conditions for the globalization of value relations (e.g. the ‘urbanization of the countryside’).

re-situated within the theory of value. Just as it unclear how the circuit of capital links up with actually existing technological and environmental change in Clark and York's account, it is unclear how Burkett's now-classic 'red-green' accounting of Marx's theory of capital translates into the history of capitalism. The challenges confronting the theory of metabolic rift therefore represent a particular instantiation of the broader problem of translating 'green' social theory into a 'green' theory of socio-ecological change.

Extending the key insights of the metabolic rift perspective, we might posit the accumulation of capital – in its manifold relations with actually existing regimes governing energy, labor, food, agriculture, and resources (*inter alia*) – as an ecological crisis-generating, and crisis-attenuating, formation. If there are many possible forms of 'ecological crisis' in the modern world, the relations underpinning these forms are found in a many-layered process through which the dynamics of accumulation link up with the nature-society relations that are value's point of departure, and point of return. Here the essential limits of expansion are 'external' only in a highly abstract sense, since the external can only be discerned through the labor process (Young 1985, Levins and Lewontin 1985). (This hardly denies that limits exist!) The guiding thread on offer opens up an analysis of these limits as internally constituted by the contradictions of humans with the rest of nature forged through the globalization of value relations. These contradictions, while highly variable across the time and space of historical capitalism, find their common ground in the inner contradiction of the value form itself – between value and use-value, between the commodity in 'general' and the commodity in 'particular' (Marx 1973, 141). Whereas the former moment (in general) presumes limitless expansion, the latter ('in reality') drives the contradiction to a series of crises on an ever-'higher scale', combining the 'highest development of productive power' with the 'most straitened exhaustion' of human and extra-human nature (Marx 1973, 750).

From this vantage point, the metabolic rift can be read as a methodological premise that allows us to move from the theory of capital to the history of capitalism, rather than a generalizable proposition about capitalism's tendency towards the exhaustion (underproduction) of extra-human nature. This means, for instance, that one may understand references to 'successive, historical breaks in nutrient cycling', not primarily as a falsifiable hypothesis and particular historical claim, but as a methodological statement on the significance of biophysical rents in the history of capitalism – rents that include the bonanza of 'cheap' food, energy, and water that are now widely acknowledged to be exhausted in the present conjuncture.

From here we may begin to puncture the myths of infinite substitutability on offer from neoclassical economics, and pose new questions about how the accumulation of capital over the *longue durée* has been a spectacular moment of temporal deferment, one realized through the widening and deepening of capital's hegemony.

Crisis, what crisis? Capitalism and nature, or, crises of the capitalist world-ecology?

At some point, these strategies of temporal deferment reach a point of diminishing returns, and then we begin to speak of crisis. These days, we are treated to an especially promiscuous use of this grand signifier, 'crisis'. The term itself has become more slogan than explanatory concept, and nowhere is this more clear than in the axiomatic formulation that capitalism drives ecological crisis, conceptualized as

unfolding or potential ‘catastrophic problems’ (Magdoff and Foster 2010, Foster 2009). I will use ‘crisis’ in two historically-specific ways, first, to specify turning points from one mode of production to another (epochal crises), and second, to illuminate qualitative transitions from one phase of capitalism to another (developmental crises).

The difficulty in formulating a world-ecological theory of crisis of capitalism is reinforced by a Cartesian, and social-determinist, way of seeing that views qualitative biophysical transformations (e.g. global warming, species extinction) as theoretically independent of the accumulation process. In this scheme of things, environmental degradation may lead to partial, but never general, crises of the system. This is particularly the case with Foster, but with implications that extend well beyond the metabolic rift perspective.

Let me offer a simple statement that we can take as a guiding thread. *Historical capitalism does not create ecological crises so much as it has been created through them.* It is the relation between social power and biophysical process (the *oikeios*) that has given rise to such crises. As I have noted, the problem of language is inescapable. The symbolic distinction itself – ‘social power’ and ‘biophysical process’ – becomes possible only through the forcible separation of the direct producers from the means of production and its symbolic expressions, emerging during and constitutive of the rise of capitalism (Moore 2007, Crosby 1997). Not for nothing did Merchant call the origins of this symbolic distinction, codified in the Scientific Revolution, ‘the death of nature’ (1980).

Of these crises, two great forms can be readily observed – epochal and developmental ecological crises. We may consider these in turn. First, capitalism, from its origins in the ‘long’ sixteenth century, emerged out of an *epochal* ecological crisis (Moore 2000, 2003a, 2007). This was the crisis of the long fourteenth century, which marked the end of European feudalism. Far from a narrowly-conceived biophysical crisis, the late medieval transition was a multivariate transition in which nature-society relations were pivotal. ‘Ecological crisis’, in this formulation, was not so much a cluster of consequences (demographic collapse, soil exhaustion) as constitutive of the era’s manifold crises – of states, of class structures, of markets. Soil exhaustion was indeed a consequence of feudalism’s socio-ecological contradictions, but so was the proliferation of peasant revolts and the escalation of warfare (see Moore 2003a).

Second, since the long sixteenth century, capitalism has developed through successive *developmental* ecological crises (Moore 2007, 2009, 2010c). That is to say, the world capitalist system has developed *through* the cyclical emergence of ecological crises, not in spite of them. Successive long centuries of accumulation emerged through new crystallizations of nature-society relations that extend from agricultural revolutions to new centres of world finance.

How we periodize capitalism has everything to do with how we understand the system, and shapes how we analyze the present conjuncture of possibilities and constraints. Of these latter, surely the *apparent* ecological moment looms large as we confront a series of challenges that reads like a page torn from the Book of Revelations: global warming (Monbiot 2006), species extinction (Leakey and Lewin 1995), peak oil (Heinberg 2003), water scarcity (Barlow 2008), unpredictable new disease patterns (Davis 2007, Davis 2005). But the relations that underpin these trajectories are not at all apparent in this list; the construction of an ‘ecological crisis’ driven by, but not constitutive of, capital accumulation hardly makes things better.

Identifying a ‘crisis of the earth’ may be a reasonable way to cut into the problem (Foster 1997), but it begs the question, If endless accumulation is the strategic mediating relation of humans and the rest of nature in the modern world, how do we *know* the crisis of the earth except through this relation?

The problem, for left ecology, is that our constructs of capitalism as a historical–geographical formation, and of its phases of development, are scarcely rooted in the *relations* between human- and extra-human nature in the capitalist *oikeios*. Instead, we tend to view today’s biospheric challenges as *consequences* of capitalism – rather than *constitutive* of the capitalist mode of production.⁸ Capitalism has been premised on a fragmented relation of nature, pivotal to its expanded reproduction: the internalization of nature *qua* human labor power (reclassified as ‘social’) and the externalization of nature as ‘free gift’, to use Marx’s well-turned (and emphatically critical) phrase. (As we shall see, these free gifts include *human* nature.) A periodization of capitalism premised on just one of these moments is manifestly insufficient to the challenges of the present conjuncture. Amongst the crucial questions are these: How does the history of capitalism *look different* from the standpoint of the nature–society dialectic? In what ways might these differences lead us to (re)think capitalism in ways that inform our analysis of, and our political responses to, the present crisis?

In posing such questions, my intention is push the broadly constructionist perspective on nature–society relations onto the terrain of actually existing capitalism. The task immediately calls for a grasping of the deep structures connecting accumulation crisis and ecological crisis, as conventionally understood. If the alienation of nature and society has been de-stabilized in social theory (e.g. Braun and Castree 1998, Dickens 1992, Redclift and Benton 1994, Barry 1999, Foster 1999), social reductionism remains secure in its hegemony over the theory of social change, represented by a broadly defined historical sociology (Moore 1966, Wallerstein 1974, Wolf 1982). Here I refer to the categories bounding, and the analytical narratives emerging from, modernity’s ‘master processes’ (1984) – commercialization, industrialization, demographic movements, social revolutions, development, imperialism, financial expansions, geopolitics, the accumulation of capital.

Perhaps most fruitful has been O’Connor’s notion of a ‘second contradiction’ (1998). O’Connor’s innovation was to attempt a synthesis of the capital–labor antagonism (a ‘first contradiction’ of overproduction) and the capital–*ecology* antagonism (a ‘second contradiction’ of underproduction). For O’Connor, rising costs issuing from the degradation of the conditions of production has set in motion a dynamic that will fetter accumulation from the supply-side. This contradiction reinforces difficulties the system already faces in the realization of surplus value through the sale of commodities. I have characterized the second contradiction as a dialectical antagonism of capital and *ecology* (not nature, not environment) for a specific reason. The second contradiction is emphatically not a narrow theory of ‘environmental’ degradation but rather one of the degradation of the socio-ecological relations and conditions (the *oikeios*, in my terms) necessary for the vigorous accumulation of capital. This might take the form of soil exhaustion or deforestation; but it might also take the form of defunding public education or the

⁸The enclosure of the atmosphere as a trash bin for capital’s CO² emissions, for example, has been a necessary condition of production for capital as a whole in the era since the Industrial Revolution.

deterioration of vital infrastructures. However provisionally, O'Connor's great contribution is to lay out a guiding thread for excavating and connecting the socio-ecological relations inscribed in both contradictions. Whatever the pitfalls of O'Connor's innovation, the act of bringing 'political ecology' and 'political economy' together into a unified theory of accumulation crisis can only be applauded.

The challenges of weaving together such a unified theory are considerable. To help us in the task, we may turn to the great divide between the theory of accumulation and the production of nature in the work of John Bellamy Foster and David Harvey – two of our leading theorists of accumulation and (but not *in*) the environment (*inter alia*, Foster 1992, 1999, 2000, 2001, 2002a, 2002b, 2009, Foster and Magdoff 2009, Harvey 1982, 1989, 1996, 2001, 2003, 2005). We may begin with the observation that the production of nature enjoys little traction in either scholar's theory of accumulation. Foster, heir to Baran and Sweezy's (1966) monopoly capital theory, has had little to say about the political ecology of the 'tendency of the surplus to rise' and 'normality' of stagnation in late capitalism. Harvey's enduring contribution is the theory of spatial fix (1982), highlighting the irreducibly geographical character of crisis formation and crisis resolution in metropolitan accumulation. And yet, the theory of spatial fix remains at some distance from the elegant simplicity of his argument that all social projects are ecological projects and vice-versa (Harvey 1996). What is the political ecology of the spatial fix, of time-space compression (Harvey 1989), of the body as accumulation strategy (Harvey 1998b)?

How do we bring together these mighty contributions, such that accumulation becomes a bundle of socio-ecological relations? Such that, to paraphrase Williams (1980, 83), we have mixed these two moments so deeply that the relation between them is always visible?

The landscape of crisis theory is treacherous ground. Crisis theories are fundamentally predictive enterprises. They build up and out from the analysis and experience of previous crises. At their best, they discern underlying forces that have not generated crisis, but will do so if they continue unchecked. Foster (2002a) criticizes O'Connor on the grounds that while rising costs from environmental degradation may have some purchase on regional developments, the theory of the second contradiction cannot account for the stagnation of the world-economy since the 1970s. Criticizing any tendency to define 'ecological Marxism' as a narrow crisis theory confined to the second contradiction, Foster rejects the possibility that the capitalist remaking of world nature might fetter accumulation. He puts the matter baldly: 'there is no such feedback mechanism [as O'Connor would have it] – at least for capitalism as a whole' (Foster 2002a; also Burkett 2003). Capitalism, contends Foster, will not likely be fettered by 'the most blatant ecological destruction'. Underproduction crises, in this reckoning, belong in the past, not the future, of capitalism:

Logically ... rising raw material costs and other costs associated with natural scarcity could undermine profit margins and generate economic crisis. This factor played a role in nineteenth century accumulation crises, as reflected in the classical theory of the tendency of the rate of profit to fall. It is always important to capital that such costs, associated with natural scarcity, be kept down. Yet, there is *no evidence* that such costs constitute serious, insuperable barriers to accumulation for the system as a whole today. (Foster 2002a, emphasis added)

There is a problem here, however. O'Connor's theory of the second contradiction does not posit 'natural scarcity' as the prime mover. Foster has projected his own binary onto O'Connor's theory and reduced the diversity of the 'conditions of production' into rising input costs from natural scarcity. Quite understandably, from his Cartesian perspective, Foster confuses one of the phenomenal forms of the second contradiction with its inner logic. This logic, capitalism's tendency to degrade the conditions of production necessary for its own survival, plays out in finance *no less than* farming, a matter to which we turn presently. The second contradiction, in other words, is not centrally about resource exhaustion as commonly understood. Rather, it is about capitalism's tendency to fetter the provision of the human labor power, built environments, and resources necessary for expanded accumulation.

In these terms, Wall Street is a way of organizing nature. The financial speculation that reinforced underlying contradictions in the production of food, energy, and metals in the period 2003–2008 was a decisive moment of the 'degradation of the conditions of production', every bit as much as soil exhaustion or toxification. It makes no difference to capital if it is financialization, geological depletion, or 'resource nationalism' that undermines cheap oil. This is no mere quibble. Foster's Cartesianism prevents him from noting that the large-scale penetration of finance capital into the global reproduction of human and extra-human nature represents a new phase of nature–society relations in historical capitalism. From the agrofood sector to working class households that depend on credit cards to pay medical bills, global nature (as *oikeios*) has become dependent on a circuit of capital that has superficially liberated itself from the direct production of physical commodities – M-M+ rather than M-C-M+ (van der Ploeg 2010, Labban 2010, Moore 2010c). Finance capital in the neoliberal era has penetrated Braudel's 'structures of everyday life' (1981) and in so doing has sought to remake human and extra-human nature in its own image. Beginning in the 1970s, finance capital has decisively reshaped the rules of reproduction for the totality of nature–society relations – extending, horrifically, to the molecular relations of life itself (McAfee 2003). The 'time–space compression' immanent to capital's drive to reduce turnover time (Harvey 1982, 1989) has not only led to a frantic and frenetic expansion of fictitious commodities (collateralized debt swaps and the like) and their global trade. The latest round of time–space compression has also realized a gruesomely peculiar mixture of the speed-up in the production of all nature: the shift from the 45- to the 57-second 'minute' in autowork (Moody 1997, 88); faster-growing transgenic salmon (Kelso 2003); faster-milking, hormone-injected cows (DuPuis and Geisler 1988); and perhaps most spectacularly, the transition from the 73-day chicken in 1955 the 42-day chicken in 2005 (Boyd 2002, 637, Weis 2007, 61).

If accumulation unfolds *through* the production of nature–society relations – in factories and financial centers no less than forests and fields – Foster's critique may generate more heat than light. Foster rightly objects to any excessively narrow conception of biophysical crisis that derives its motive power from a narrow conception of accumulation crisis. But this objection goes only so far. Deconstruction calls for reconstruction. What unifies the 'rich totality' of accumulation crisis and biophysical tipping points? If O'Connor's second contradiction tracks the emergence of a new crisis tendency within late capitalism – and in part, the reassertion of an older, underproductionist crisis tendency that ruled the roost during the formative centuries of early capitalism (Moore 2007) – then one would

expect the accumulation crises emerging from the second contradiction to be slow in building, rapid and explosive in their detonation.

A theory of capitalism that identifies the convergence of rapidly moving and explosive contradictions need not succumb to catastrophism. (A word that runs like red thread though Foster's work.) Harvey (1998a) rightly observes that a perspective premised on 'the view that environmental catastrophe is imminent is a sign of weakness'. But invoking catastrophe and theorizing crisis are distinct. Harvey is surely amongst our most powerful exponents of a relational ontology of nature–society relations and a groundbreaking theorist of accumulation crisis. And yet, in his recent accounts of neoliberalism, the connection between the two is unclear (Harvey 2003, 2005). We are treated to a social reductionist narrative that, however brilliant, leaves behind nature–society relations as an organizing principle. My point here is to underscore the enormity of the larger challenge, that of translating relational ontologies into narratives of modern world history – of moving from a red–green social theory to a red–green theory and method of world–historical change. As I will show later, Harvey provides a big part of what is needed to meet this larger challenge. For in Harvey's (1982) theory of spatial fix, the initial flexibility of capital and acceleration of turnover time achieved through a 'built environment' favorable to capital in one era becomes a fetter upon accumulation in the next. In this way, the remaking of nature–society relations in successive eras liberates accumulation only to imprison its 'future paths' (Harvey 1991).

If we can agree that civilization today is moving through a transition that will compel fundamental revisions in the organization of all life on this planet, any attempt to grasp the whole of this transition implies a transcendence of the structures of knowledge implicated in the crisis itself. There are of course many necessary points of departure in such a process, and on offer is only one. This is the case for grasping the origins and development of capitalism's crisis tendencies in their totality, differentiated and contingent, yet unified, as *oikeios*. I have drawn upon O'Connor, Foster, and Harvey for this radically reconstructive purpose; to identify the synthesis that is now possible (and necessary!) on the basis of these accounts of crisis. O'Connor's unified theory of accumulation crisis points towards, but does not provide, a history of capitalism. Foster's brilliant history of capitalism (1994) points towards a 'red–green' world-historical synthesis, but elides the possibilities for such a synthesis offered in the theory of accumulation crisis. Harvey pioneered a historical–geographical materialism whose core principles are the irreducibly spatial character of accumulation 'fixes' and crises, and the irreducible socio-ecological nature of all 'social' relations, but has yet to systematically combine these. How do we mobilize the potentialities inscribed in these mighty contributions?

With Foster and Harvey, we begin by returning to Marx. For Marx, thinking capitalism consists of two dialectical movements. The first is the theory of capital, as we see in the first volume of *Capital* (1976). The second is the history of capitalism, such as we see, quite early, in *The German ideology* (Marx and Engels 1970). The productive tension between the two moments is central to the present exploration. It is no mere happenstance that Marx reordered the 'general law of capitalist accumulation' (theory of capital) and the discussion of 'primitive accumulation' (history of capitalism) into a single concluding part of *Capital* in the last edition (the French, 1882) he prepared before his death (Dunayevskaya 1982). This dialectic, between the theory of accumulation crisis and a historical account of capitalism as ecological regime, has scarcely been explored in left ecology.

Taking value as an educative method acknowledges the increasing centrality of value relations in the modern world-system over the past five centuries. My point of departure for such a method proceeds from the irreducibly socio-ecological constitution of ‘value’ itself (as process *and* project) – its internalization of human nature through commodified labor power, and its externalization of extra-human nature through the treatment of nature as a free gift. Value emerges in and through Braudel’s ‘market economy’ (1982), weaving together the ethereal valences of finance capital and the prosaic routines of everyday life in new world-historical crystallizations of power and profit, pivoting on the commodity. In this light, the apparently external relations of capitalism *to* nature – codified in the metabolic rift and its closely linked theory of dual crises (Magdoff 2002) – are revealed as *inner* relations (capitalism-*in*-nature), constitutive of new, and profoundly restless, socio-ecological configurations.

In order to move from value as educative method to a world-historical, and world-ecological, theory of value as guiding thread, I now turn first to Marx’s theory of value, and then to a neglected aspect of Marx’s theory of crisis premised on the *underproduction* of circulating capital (raw materials and energy) in the accumulation process.

Value as method: capital, capitalism, and the commodity frontier

If everything is ecological because ecology is everything, let us be clear from the outset that the search for unified theory of crisis in historical capitalism – grounded in the contradictory mass and mess of the *oikeios* – does not entail the collapsing of distinctions. Far from it! Rather, the approach on offer opens up the very possibility foreclosed by the Cartesian theory of dual crises – the construction of *relational*, rather than substantialist, distinctions.

In what follows, I take Marx’s lead and begin from the production of value (1976). Mine is, as Bernstein rightly notes (2010), a capital-centric approach that brackets the necessary questions of class struggles and social movements. Alas, we cannot do everything at once. The emergent contradictions of the accumulation process constitute the point of departure for a larger project that unifies the history of capitals, natures, and class struggles as mutually relational movements in the modern world-system; only the barest outlines can only be suggested at this moment. Capital-centrism is not by nature capital-*reductionism*. Certainly, these contradictions provide only a necessary, and not sufficient, explanation of historical change.⁹ The law of value itself emerged only as class struggles in late medieval Europe propelled the expansion of commodity production and exchange overseas (Moore 2003a, 2007). The contradictions of value, embodied in the commodity form, are variously enabled and constrained by the contest of classes ‘from above’ and ‘from below’. These contradictions and contests have intertwined with the

⁹Marx himself pointed out that the abstract scheme of capitalist development was not enough to provide any predictions about the actual world. All crises in capitalism must be explained out of the given empirical conditions, “out of the real movement of capitalist production, competition, and credit” [Marx]. The value analysis of capital development postulates “the possibility of crises by a mere consideration of the general nature of capital, without regard to the additional and real relations that form the conditions of the real production process” [Marx] (Mattick 1969, 61).

production of nature from the beginning of capitalism – the German Peasants' War (1525) was in great measure a class struggle over the forest commons, retreating quickly at the time as metallurgical capitalism advanced rapidly in Central Europe (Blickle 1981, Moore 2007, chapter two).

My decision to begin from value theory emerges from three observations. First, the law of value, established through capital's ruthless drive to commodify everything existing, establishes the durable and pivotal 'stakes of the game' (Bourdieu 1990, 110) that have been struggled over since the sixteenth century. Just as the history of class struggle in the feudal era emerges in and through the contest over the rate of seigneurial levy (Bois 1978), so the struggles of capitalism unfold through the contest over the rate of surplus value. I do not mean to suggest that this is the end of the story; but it is hard to begin the story without reference to these stakes.

Second, value as world-historical project presupposes something false, that all of nature can be reduced an interchangeable part; at the same time, it powerfully effects the partial transformation of nature into simplified spaces, such as cash-crop monocultures. Perhaps most significantly, the emergence and development of the law of value as historical-material movement is inconceivable without the symbolic and scientific revolutions that 'discovered' the homogeneity of time and space in early modern Europe (Crosby 1997). Progressively consolidated as the metric of wealth in the modern world – after 1450 there would be no systemic reversals of commodification – the value form enabled all manner of 'metrical revolutions' outside the immediate circuit of capital (Scott 1998), but clearly homologous to value's simplifying thrust. Foucault's biopolitical 'power of regularization' (2003) is unimaginable except in a symbolic-material world orbiting around value's fantasies of homogenizable time and space. Indeed, successive revolutions in the 'measurement of reality' (Crosby 1997) have been the necessary precondition for subsequent movements of widening and deepening the commodification of all life.

Finally, I begin with a historically-grounded approach to value because we have a situation where, on the one hand, advocates of a relational ontology of society-*in*-nature have been reluctant to move towards an interpretation of capitalism as world-historical and world-ecological process.¹⁰ Environmental historians, on the other hand, are (quite reasonably) focused on landscape change, energy consumption, pollution, and so forth – the surficial expressions of modern nature-society relations – but have been wary to move from 'environment' to *oikeios* and back again.¹¹ A world-historical recuperation of value theory offers, I believe, a fruitful way forward without abandoning the insights of either camp. With Marx, I will move from the analysis of what *makes* capital to what capital makes, from the logic of capital to the history of capitalism.

¹⁰Smith takes pains to distinguish his 'production-of-nature thesis' from social constructionism, and persuasively so (2006). For my purposes, I wish to bracket this debate as one unfolding with a broader camp of non-Cartesian left ecology (e.g. Braun and Castree 1998, Harvey 1993, 1996, Levens and Lewontin 1985, Smith 1984, Williams 1980).

¹¹Pivots of discussion in environmental history include Cronon (1983, 1991, 1996), Crosby (1972, 1986), Dean (1995), Gadgil and Guha (1992), Grove (1995), McNeill (2000), Merchant (1980, 1989), White (1995), Worster (1985, 1990). McNeill (2003) and Hughes (2006) offer impressive surveys.

Value theories are of course hotly contested, Marxist, green, and otherwise (Harvey 1996, Daly and Townsend 1993). My deployment of Marx's theory takes value as a means of understanding how such an extraordinary circulation of wealth has come to move about with such relative autonomy from the practices and utilities of everyday life, human no less than extra-human nature (the sources of all wealth, as Marx emphasized). In my reading, the crystallization of value as abstract social labor in the capitalist era represents: (1) a fundamental contradiction between value and use-value, whose inner contradiction finds (temporary) resolution in the secular trend towards the commodification of everything; (2) not merely an objective process of accumulation, but equally a subjective *project* of world power; and (3) a world-historical process and project of reordering the totality of the nature–society dialectic, 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. The production of nature, in other words, is constitutive of capitalism's inner logic – the contradiction between monetary value and use-value, between nature as labor power and nature as resource, between competition for endless gain and cooperation for necessary survival.

Why Marx's value theory? Is this not an anti-ecological formulation that explicitly denies nature's contribution to capitalist development?¹² Allow me to interweave two responses, one from the theory of capital, another from the history of capitalism. We can begin by clarifying that value, in Marx's hands, represents a historically-specific form of wealth – whose 'original sources' are land and labor (Marx 1976, 638). Taking shape during the long transition to capitalism, here was a form of wealth that pivoted on endless commodification. During this era, a most peculiar valuation emerged, one centered on the activity of that 'value forming substance', human labor power (Marx 1976, 129). This crystallization of value as socially necessary labor time – the average social labor time embodied in any given commodity – illuminates an ever-widening disjuncture in the history of the modern world, between value and use-value. In a system such as capitalism, driven towards endless accumulation through the surreal compulsions of ceaseless competition, there unfolds a widening gap between the accumulation of value and the socio-ecological relations that enable such accumulation. When this gap widens too far, developmental ecological crises occur.

If 'land productivity' was given primacy in pre-capitalist civilizations, 'labor productivity' became the metric of wealth in the capitalist era. It is a simple, and simplifying, logic. More and more extra-human nature attaches to every quantum of socially necessary labor time. Fewer people produce more stuff. Land is sacrificed on the altar of labor productivity. I would go so far as to say that an intuitive (and certainly indirect) sense of Marx's value theory has been a centerpiece of green consciousness since the 1970s: the recognition of (so-called) 'industrial' agriculture's colossal energy- and nutritional-inefficiency (Perelman 1977, Pimentel *et al.* 1973). Indeed, capital-intensive agriculture has become more, not less, central to rising energy consumption in the Global North, contributing a stunning '80 percent of energy flow increases' in the US between 1997 and 2002 (Canning *et al.* 2010, 1). The flip side of such profligate energy consumption was a greater than eightfold increase in the labor productivity of advanced capitalist agriculture between 1945 and the

¹²See, *inter alia*, Bunker's classic critique (1985). A useful review of the 'value problem' in ecological economics is found in Burkett (2006).

mid-1980s (Bairoch 1989). What the more-or-less conventional green critique is unable to explain is how this colossal inefficiency is not merely an output of the system, but constitutive of it. For this peculiar valuation of wealth as abstract social labor – labor productivity – favors socio-ecological developments that reward the rapid exhaustion of nature (including human nature), so long as external supplies can be secured.

We can glimpse the emergence of this peculiar valuation from the earliest moments of the transition to capitalism, during Braudel's (1953) 'long' sixteenth century (1450–1648). In this era, value, as world-ecological process, began to take shape out of the global extensions of commodity production and exchange, stretching from the silver mines of Saxony and Potosí, the sugar plantations of Brazil and Barbados, the timber frontiers of Scandinavia and the Baltic. This was early capitalism's 'commodity frontier' strategy, and it was decisive to an epochal shift because it raised labor productivity by treating uncapitalized nature as a substitute for machinery. At every turn, land (forests, silver veins, fertile soils) was organized by empires, planters, seigneurs, yeoman farmers and many others, *as a force of production in servitude to the commodity form, as a mechanism for maximizing the productivity of labor*. It was precisely the emergence of this value relation – driving a growing disjuncture between monetary accumulation on the basis of abstract social labor and the 'physical body' of the growing mass of commodities – that explains an extraordinary shift in the production of nature after 1450 (Moore 2007, 2010a, 2010b).

Civilizations before capitalism transformed landscapes on a large scale: feudal Europe, the Greek city-states, the Romans, successive Chinese empires, the Sumerians, and many more. In every instance, there were vital clusters of commercial activity and commodity production that were often quite important to such episodes of transformation. What changed after 1450 were the relevant units of time and space. Premodern civilizations transformed regions over the span of centuries. Capitalism transformed regional landscapes in mere decades. Through the capacities of monetary capital to command, and indeed to produce, space, there emerged a fundamentally globalizing mode of producing wealth, nature, and power centered on the commodity form. As central to its era as railroads or automobiles to others, sugar production moved, in roughly half-century cycles, across the Atlantic world after 1450, from Madeira to São Tomé, enclosing in successive turns Pernambuco, Bahia, Barbados, and thence the wider Caribbean. Silver mining flowered in central Europe, moving restlessly from one site to another (Freiberg to Jáchymov). It then relocated through the alchemies of imperial power and finance capital to Potosí, half a world away, only to give way in turn to the great silver mines Zacatecas and Guanajuato in the eighteenth century. Commodity frontiers premised on forest products, on fish, on iron and copper, on cereals and flax, moved with the same socio-spatial rhythm (although as dance, not lockstep), occupying, producing, and exhausting in serialized fashion the ecological formations of the North Atlantic, from the shores of Newfoundland to southern Norway to the banks of the Vistula and the foothills of the Urals (Moore 2010a, 2010b). And far from the facile representation of early capitalism as technologically or socially inert, every movement of global occupation and transformation signaled a new phase of social organization, technical deployment, and landscape discipline. Never before had any ecological regime *qua* mode of production moved so fast, so far. Something decisive had changed.

To call that 'something' nature–society relations would merely restate the very problem we seek to answer. But if we can accept, even provisionally, that value theory

identifies a ‘deep structure’ of historical capitalism that gives priority to labor productivity, and mobilizes extra-human nature without regard for the socio-ecological conditions of its (uncapitalized) reproduction, we have more than a simple restatement of the problem. We have an interpretation of capitalism premised on a fundamental disequilibrium in the (value) relation of nature and society that makes the system. If we, moreover, follow Marx and identify the external vent (the frontier) as central – recall how he moves in successive chapters at the end of *Capital* from the ‘conquest’ of the national ‘home market’ to the ‘commercial wars . . . which [have] the globe as its battlefield’, to the ‘growth of the international character of the capitalist regime’ and its mounting systemic contradictions (1976, 913, 915, 929) – then we may *begin* to see the successive resolutions of the disequilibrating tendency as essentially self-limiting. And yet, let us be clear, such a formulation ‘impl[ies] the possibility of crises, though no more than the possibility’ (Marx 1976, 209). To realize this possibility analytically, one must move from the logic of capital to the history of capitalism.

It would be mystifying to say that the limits of capitalism are ultimately determined by the biosphere itself, although in an abstract sense this is true. More to the point, the possibilities for overcoming the antagonism inscribed in the value form itself are determined by capitalism as a system, that web of relations interconnecting value accumulation with the socio-ecological relations that variously enable and limit the endless accumulation of capital. Most fundamental, the historical conditions through which a series of ecological revolutions have been realized – each yielding a quantum leap in the mass of ‘physical bodies’ available for commodity production – may be understood as essentially non-substitutable, or at best, substitutable only within very definite limits. Capitalism has moved from peat and charcoal to coal to oil, from the breadbaskets of the Vistula, southern England, the American Midwest, from labor frontiers in Europe and Africa, Latin America, and South and East Asia. These are not repeatable events. Substitutability does not unfold through infinite time and space.

Marx’s conception of value seems to offer a useful way to cut through the mass of appearances and to discern not merely the patterned movements of nature–society relations over the *longue durée*, but the logic animating the emergence and evolution of those patterns. I have called this method *eductive* because we are locating value as a ‘gravitational center’, to borrow Shaikh’s (2004) nicely turned phrase. The patterns themselves move at once in quasi-linear and contingent fashion. Premised on the dialectical antagonism of monetary accumulation (‘into which all commodities dissolve themselves’) and material transformation in commodity production (where money ‘dissolves itself into all commodities’) (Marx 1973, 142), and a recognition of capital accumulation as both objective process and subjective project, Marx’s value theory offers a promising way to comprehend the inner connections between accumulation, biophysical change, and modernity as a whole. From this vantage point, we may begin to formulate a provisional theorization of capitalism’s tendency towards underproduction as a missing constitutive moment in the theory of capitalist crisis.

Marx’s theory of underproduction, part I: capitalization, appropriation, and the ecological surplus

We have become accustomed to thinking that crises in historical capitalism are overproduction crises. David Harvey, for instance, identifies the 1840s as the

occasion of the ‘*first*’ capitalist crisis (2003, 42). If this is so, such crises are a very recent development in the history of capitalism. So powerful is the sense that capitalism’s *fundamental* crisis tendency is overproduction, that the decisive passage in the Penguin translation of the third volume of *Capital* (1981) reads ‘overproduction’ when it should read ‘underproduction’.¹³

The major crisis tendency of early capitalism, from the 1450s to the early nineteenth century, was *underproduction* – the insufficient flow of food, energy, and materials relative to the demands of value production. Early capitalism’s greatest problem centered on the delivery of cheap food and inputs *to* the factory gate, not in selling the commodities that issued from manufacturing centres. The Dutch Republic was the ‘model capitalist nation’ of the seventeenth century (Marx 1976, 916) because it organized and led a world-ecological regime that delivered cheap grain (from Poland), cheap energy (from domestic peat), and cheap timber (from Norway and the Baltic) to the northern Netherlands (Moore 2010a, 2010b). When this regime faltered, definitively by the 1760s, the British married technical ingenuity with geological good fortune to move from increasingly expensive woodfuel to increasingly cheap coal. This marriage inverted the dialectical primacy of underproduction and overproduction in favor of the latter, setting the stage for two centuries of remarkable expansion. But take note that we are dealing with a matter of dialectical primacy, not a transcendence of early capitalism’s inner logic; *both* crisis tendencies are always present. The international crisis of 1847, to stick with Harvey’s example, was driven by the ‘excessive expansion’ of the railroads, an overproduction crisis that was facilitated by a moment of underproduction, as crop failures swept through northwestern Europe and cereal prices moved sharply upwards in 1845–47 (Mandel 1971, 1972).

Marx’s theory of underproduction crisis – he calls it a ‘general law’ of accumulation – holds that ‘the rate of profit is inversely proportional to the value of the raw materials’ (1967 III, 111). The cheaper the raw materials and energy, the higher the rate of profit. And yet, the dynamism of capitalist production leads the ‘portion of constant capital that consists of fixed capital ... [to] run significantly ahead of the portion consisting of organic raw materials, so that the demand for these raw materials grows more rapidly than their supply’ (pp. 118–119). Here, the ‘overproduction’ of machinery (fixed capital) finds its dialectical antagonism in the ‘underproduction’ of raw materials (circulating capital) (Marx 1967 III, 119).¹⁴ Thus, an enduring priority of capitalism has been to drive down the share of circulating relative to fixed capital, driving down the value composition of inputs and energy while simultaneously expanding the material volume of commodity production. Hence the centrality of frontiers of appropriation throughout the history of capitalism. Not only has capital sustained itself on the basis of cheap

¹³‘The more capitalist production is developed, bringing with it greater means for a sudden and uninterrupted increase in the portion of constant capital that consists of machinery, etc., the greater is the relative overproduction of machinery and other fixed capital, the more frequent the *overproduction* [sic] of plant and animal raw materials, and the more marked the previously described rise in their price and the corresponding reaction’ (Marx 1981, 214, emphasis added).

¹⁴I have stuck to convention and spoken of material inputs to production as ‘raw material’. The category itself is part of the problem I am addressing: “‘Raw materials’ is a euphemism, because in the world of human beings no materials are truly raw. They are all “cooked” in some degree. There is simply no such thing for humans as “nature in the raw”’ (Young 1985).

inputs, but by revolutionizing the socio-ecological relations of production on a systemwide level, it has mobilized a succession of ‘great leaps forward’ in the relative ecological surplus. (About this surplus, I will have more to say presently.) These great leaps forward in the relative ecological surplus are perhaps most apparent in the great energy transitions of the modern world, with their resplendent free gifts: from peat and charcoal (1450s–1830s), to coal (1750s–1950s), to oil and natural gas (1870s–present). They were *great* expansions of the relative ecological surplus because the appropriations of nature’s free gifts were sufficiently massive to induce the rising productivity of labor while reducing the capital intensity of production in general. But I would caution against the conventional view that sees a ‘structurally invariant’ capitalism (or industrial society) incorporating new external resources (e.g. Heinberg 2003). These energy sources did not make capitalism so much as capitalism remade itself through their incorporation.¹⁵ To paraphrase Marx, coal is coal. It becomes fossil fuel ‘*only in certain relations*’ (1971, 28, emphasis added).

That is, every phase of capitalism marks not only an upward ratchet in material throughput, but also produces and confronts a historically-specific ‘nature’. Industrial capitalism gave us Darwin and the Kew Gardens; neoliberal capitalism, Monsanto and biotechnology.¹⁶ This dialectic of quantitative and qualitative variation in humanity’s engagements with the rest of nature is important for historically-grounded theory. A cornerstone of neoclassical thought, I would note, rests on an ahistorical and nature-blind paradigm that views humans and the rest of nature as essentially interchangeable and inexhaustible – this is the theory of substitutability (Perelman 2007). Strikingly, some of the most widely circulated conceptual tropes in critical environmental studies – the ‘ecological footprint’ and ‘ecologically unequal exchange’ – engage in the same flattening of nature’s diversity. It is a fetishized nature that moves through time and space but not history and geography; through ‘economies’ but not the socio-ecological relations of capital and capitalism.

Ecological revolutions, then, revolutionize the specifically capitalist *oikeios*, and in so doing, revolutionize both human nature (‘society’, ‘economy’, ‘culture’, and so forth) and extra-human nature. The cumulative development of the capitalist world-ecology unfolds through qualitative ruptures in humanity’s symbolic and material engagement with the web of life. By driving down the capitalized share of world

¹⁵“[R]esources” can be defined only in relationship to the mode of production which seeks to make use of them and which simultaneously “produces” them through both the physical and mental activity of the users. There is, therefore, no such thing as a resource in abstract or a resource which exists as a “thing in itself” (Harvey 1974, 265).

¹⁶Yes, there is a ‘nature’ that exists independently of what one thinks of it. But the fact remains that our best guide to the relation between signifier (nature) and signified (the biological, geological, etc.) is historically-grounded theory. Young cuts to the heart of the issue: ‘[N]ature exists apart from us, but only as a *noumenon*, a category of the last instance, without any qualification or characterization. For [capitalism], nature is an object of labor, a resource, a manifold, an attic, or a cellar, or a boxroom to be ransacked . . . It is a *potential to be actualized by different epochs with different goals, different priorities, different cosmologies, different world views and agendas*. The metaphysical basis of reality, of experience, of investigation, changes. Ontologies change, epistemologies change, methodologies change. At a more mundane academic level, there are paradigms, research programmes, disciplines, grand theories – all of which are formed and constituted by the contradictions and moving resolution of class forces of different epochs. This is a dynamic, dialectical historical process, born in conflict and struggle. At any point in time science and technology, medicine and philosophy, art and the theatre reflect the existing state of tension of the historical forces at work’ (Young 1985, emphases added).

nature and increasing the share that can be freely appropriated, these revolutions of the capitalist *oikeios* 'work' by expanding the *relative ecological surplus*. This surplus finds its chief phenomenal expressions in *cheap* labor power, food, energy, and non-energy inputs such as metals, wood, and fibers – *cheap*, in a world-historical sense, to the degree that they issue a downward revision of systemic capitalization relative to appropriation.

'Ecological surplus' is the share of world surplus value produced through two forms of accumulation by appropriation, one pivoting on processes of biophysical reproduction (labor power, forestry, agriculture), the other, on geological extractions (energy and minerals). In ecological revolutions, both forms raise labor productivity above the prevailing systemwide average without a corresponding increase in constant capital (machinery and inputs). They also reduce the costs of reproducing labor power in highly capitalized zones of the system – cheap energy, for instance, made possible the highly suburbanized and automobilized working classes of North America (Huber 2009). We may consider these in their respective turns. The first comprises the appropriation of socio-ecological relations whose reproduction is relatively autonomous of the circuit of capital. This is of course one of the great storylines of capitalism's long history of depeasantization. Labor power 'produced' by peasant formations within reach of capitalist power, but not yet subordinated fully to the law of value, is labor power with a low value composition. If capitals and empires can secure new frontiers with bountiful supplies of such cheap labor power (which necessarily rest upon extra-human webs of reproduction), the effect on the accumulation process is tantamount to a global wage cut or a rising rate of exploitation. In the rise of capitalism, when peasantries within much of Europe proved capable of resisting feudal restoration, the African slave trade, eastern Europe's 'second serfdom', and colonial labor regimes such as Peru's *mita* played a similar role to the dispossession of peasantries (Moore 2007, 2010a, 2010b). The same story can be told, with different backdrops and casts of characters, for all manner of 'biological' commodity frontiers – the great forests of North America and Atlantic Brazil, whaling grounds and fisheries, cash-crop agricultures such as sugar and cotton historically, and even soybeans today.

The second great moment of appropriation pivots on 'non-renewable' resources, and above all energy. From the standpoint of world accumulation, the phase of appropriation spans that era when the production of 'strategic' resources drives down the value composition of systemwide commodity production. Such strategic resources are *mass commodities*, 'markers for entire historical epochs' (Retort 2005, 39). Silver and iron, coal, then oil have served this function in successive long centuries of accumulation. Energy sources are especially important because they hold a special kind of labor productivity bonus; rising energy prices and stagnant labor productivity growth are closely linked (Jorgenson 1981, 1984). Although geological conditions are obviously crucial, this form of appropriation is not essentially (but only relationally) a geological affair. This is the interpretative problem with the 'Hubbert's Peak' approach – turning on lagged discovery-production curves – underpinning the notion that ours is an era of 'peak everything' (Heinberg 2007). Coal, for example, was epoch-making because it facilitated productivity *and* plunder in the long nineteenth century. It boosted labor productivity dramatically, and, thanks to steampower on land and sea, it opened vast new frontiers for the appropriation of ecological reproduction, whose free gifts included massive depeasantized labor flows from China, India, and eastern Europe to North America, the Caribbean, and white settler zones worldwide

(Northrup 1995, Wolf 1982). From this perspective, recent discussions of *impending* ‘peak coal’ are surely misplaced (e.g. Höök and Aleklett 2009), because the only ‘peak’ that capital as a whole cares about is *peak appropriation* – the point of maximal reduction of the value composition of all moments of commodity production (variable, circulating, and fixed capital within any accumulation cycle). For coal, this point was reached sometime before World War I, driven partly by a strong global movement towards oil as Middle Eastern production came of age, partly by strong mineworker unions in the leading coal producing states (UK and US), and partly by rising capital intensity (mechanization), itself driven forward by geological depletion and worker militancy (Podobnik 2006).

For oil, arguably the decisive ‘mass commodity’ of the postwar era, we can safely say that peak appropriation is now passed. I think this is the kernel of truth in the popular expression, ‘The end of cheap oil’ (Campbell and Laherrère 1998). It is not that the oil business has somehow become unprofitable; rather, production is increasingly financialized in ways that undermine the world oil sector’s capacity to deliver the goods – to deliver enough cheap oil to *capital as a whole* to check the rising organic composition of capital. Depletion certainly plays a role in the rising costs of production for petro-capitalists, and therefore influences oil commodity prices. But financialization is the decisive socio-ecological vector here. The rising attractiveness of M-M+, in full swing since the mid-1980s, induced a decades-long ‘underinvestment’ in the extractive apparatus proper (IEA 2008).¹⁷ Financialization not only exerts upward pressure on oil prices and encourages market volatility. To the extent that activities associated with M-M+ are more profitable than investing in exploration and extraction, financialization renders the latter insufficiently profitable, an effect homologous to (and reinforcing) the rising costs of production stemming from depletion. Financialization’s logic has, moreover, given rise to all manner of cost-cutting, now horrifically evident at the time of writing (June 2010) in the Gulf of Mexico. For oil, gas, and coal, the transition from appropriation to capitalization has brought with it a monstrous turn towards toxification on a gigantic scale – from unprecedented oil spills to the ‘hydraulic fracturing’ of natural gas exploitation to coal’s mountaintop removals, energy production in late capitalism increasingly manifests as a qualitative leap forward in the erosion of the conditions of human, never mind extra-human, well-being.

Ecological revolutions, then, set in motion an ecological surplus that benefits capital as a whole by ‘freeing’ a critical mass of appropriated nature sufficient to reduce the value composition of systemwide production. This has been important in order to offset problems issuing not only from the rising capital intensity of production within the metropolitan centres (the falling rate of profit), but also from the rising capitalization of *all life* within these centres (the rising cost of inputs and

¹⁷By 2008, the global oil sector had experienced more than two decades of ‘investment famine’ (*The Times* 2008). The top five supermajors spent just one percent of total expenditures on stock buybacks in 1993, and nearly 14 percent on exploration. By 2006, they were spending 37 percent on equity repurchases, and just 5.8 percent on exploration (Jaffe and Soligo 2007, 21). In 2004–2005, stock buybacks by the six largest firms jumped 60 percent (Mouawad 2005). Far from limited to the private sector, the same logic underpinned a 75 percent decline in OPEC’s spare capacity in the quarter-century after 1979 (Jaffe 2004). The revival of financial markets after the 2008 meltdown has only exacerbated the tendency, with the International Energy Agency estimating a 21 percent decline in global oil and gas investment between 2008 and 2009 (Lawler 2009).

labor power). The problem is that rising capitalization in the absence of rising appropriation entrains the rising costs of production, tendencies which can be counteracted by a massive enlargement of accumulation by appropriation on a world-scale. Productivity-maximizing technologies (capitalization) revive system-wide accumulation when it sets in motion the large-scale appropriation of uncapitalized nature. This is why early capitalism was propelled by the 'proto-industrial' appropriation of peasant labor power (human nature); and why twentieth century Fordism was unthinkable without the North American and Middle Eastern oil frontiers (extra-human nature). The class offensives of metropolitan ruling strata after the downturn of the 1970s, the acceleration of dispossession and its shock doctrines, and the ensuing financial expansion were of a piece – all aimed at redistributing wealth in the face of the progressive dilapidation of metropolitan 'real economies', manifested in the non-appearance of the 'third' scientific–technological revolution and its promise of a quantum leap in labor productivity (Balakrishnan 2009, Harvey 2003, 2005, Moore 2010c, Petras 2002, Philips 2008). The savage nature of this neoliberal counter-revolution surely owes something to the exhaustion of opportunities for appropriation sufficient to counteract the rising costs of human and extra-human nature induced by rising capitalization.

The long history of colonialism, enclosure, and 'accumulation by dispossession' – aimed at mobilizing abstract social nature without the costs and risks associated with M-C-M+ – may be understood in this light. The ecological surplus is therefore a relational movement in multiple readings of the term: between capital and labor, between metropolises and frontiers, between capitalization and appropriation. If the value of any given commodity is determined by its abstract social labor, and if this average quantum of social labor embedded in commodities determines price movements over the long run, then high labor productivity is the first priority of any capitalist enterprise. High labor productivity allows the capitalist, via the market, to capture the surplus value of competing production units with lower productivity. The great catch to this, which we will explore momentarily, is that rising labor productivity is often mediated through rising capital intensity, and this sets in motion the tendency towards a falling rate of profit (Marx 1981). If, however, a means can be found to increase labor productivity without a corresponding increase in constant capital, a new set of possibilities emerges.

These possibilities take shape through vast frontiers of appropriation – a relatively high share of appropriation in world value production constitutes a high ecological surplus – that have characterized capitalism's greatest waves of accumulation. By reducing the systemwide capitalization of nature through global appropriations that enabled a rising volume of nature's bounty to attach to a given unit of capital, these ecological revolutions have checked the tendency towards the rising organic composition of capital. Directly, such revolutions cheapened raw materials (circulating capital) and, indirectly, reduced the value composition of fixed capital itself. Cheaper steel, for example, rendered the mass production of fixed capital cheaper as well. In so doing, these revolutions created the necessary conditions for new long waves of accumulation. Marx once observed that the 'natural fertility of the soil can act like an increase of fixed capital' (1973, 748), and is this not equally true for the wealth of forests, of peat bogs, of coal seams and oil fields? Once English capitalism was forced to rely on managed forests (coppices) for a critical share of its iron production, it faced a situation of

declining labor productivity and rising costs for fuel – and therefore, a rising value composition for circulating and variable capital – sure signs of a declining ecological surplus (Moore 2007, chapter two). The ensuing large-scale movement towards coal *via* steampower represented the opening of a new large-scale frontier of appropriation.

These movements of appropriation have spanned the history of capitalism. They are the underappreciated moment of socio-technical innovation. The history of ‘capital-intensive’, epoch-making innovations – the early modern shipbuilding-cartographic revolution, the nineteenth century steam engine, and the internal combustion engine of the twentieth century among others – has been characterized by important technical advances that ratcheted upwards the capital-intensity of production in specific places, above all in the heartlands of the Dutch, British, and American hegemonies. But these innovations were successful because the new technologies operated through ecological regimes that expanded the opportunities for the appropriation of human and extra-human nature. Indeed, socio-technical innovations in commodity production have been epoch-making to the degree that they have been linked with even more dramatic movements of appropriation. For example, Manchester’s textile mills were dialectically bound to the American South’s cotton frontier, this frontier was in turn was bound to Whitney’s cotton gin, enabling the revolutionary expansion of short-staple cotton, and this was possible through the globalizing credit chains pioneered by Scottish factors and the City of London’s financial institutions (McMichael 1991). This angle of vision brings into focus the combined and uneven development of highly capitalized pockets of production and the globalizing appropriation of all nature as a dialectical unity. ‘Technological’ revolutions became epoch-making through their generative relations with hegemonic projects, revolutionizing world-ecological space. In these three great hegemonic eras, timber, coal, and oil were freely appropriated, with relatively minimal capital outlay. *Each epoch-making innovation has therefore joined together productivity and plunder in a world-historical act that drives down the share of world nature directly dependent on the circuit of capital.*

The greatest of these movements was the railroad revolution of the ‘second’ nineteenth century, roughly between 1846 and 1914, the apogee and *belle époque* of British hegemony (Headrick 1988). While railroad construction absorbed gigantic amounts of capital – greatly attenuating the tendency towards overaccumulation crisis (Baran and Sweezy 1966) – its greatest accomplishment was the radical extension of the geographical arena for the *appropriation* of world nature as a free gift. The epoch-making capital formation of railroadization turned on its capacity to radically extend the appropriation of world nature. The rise of American capitalism turned on the annihilation of space by time, materialized through those continent-devouring ribbons of steel, appropriating the soil, water, forests, and metals of North America into feedstock for monopoly capitalism (Moore 2002). But the process was hardly limited to US ascent. Through railroadization – and later, automobilization – vast ecological surpluses could be won from the minimally-capitalized extraction of mineral resources, cereal cultivation, and so forth.¹⁸ Today, in contrast, quite modest surpluses are now won from maximally-capitalized extraction and cultivation.

¹⁸Bunker highlights the indispensable role of transport revolutions in the modern world-system (see Bunker 2005, for a useful synthesis of nearly two decades of conceptual work).

Marx's theory of underproduction, part II: the combined and uneven development of the capitalist world-ecology

We may now return to the dialectic of overproduction and underproduction. On the one hand, competition drives capitalism to expand geographically, to zones where extant commodification is low, and the opportunities for appropriation high. To the degree that capital can 'jump scale' in this way, always in some concert with territorialist agencies, it can drive down the cost of inputs and labor power, and in so doing, increase the rate of profit. On the other hand, competition compels individual capitals to innovate through rising capital intensity, such that relatively less human nature (labor) and relatively more biophysical nature is embedded in every commodity. This accelerates the uptake of human and extra-human natures into a geometrically expansive production process, which intensifies the drive towards geographical expansion. In this fashion, the quasi-linear movement of 'time-space compression' finds its dialectical counterpoint in the quasi-linear movement of 'time-space appropriation', the reworking of external spaces through the imposition of capitalist time (Harvey 1989, Hornborg 2006).

For Marx, rising capital intensity – the rising organic composition of capital – places downward pressure on the general rate of profit. The operative assumption here is that aggregate profit, on balance, flows from aggregate surplus value, which is generated and distributed unevenly (Marx 1976, 1981). Walker (1998) nutshells the underlying tendency with typical verve:

Why [do] profit rates fall? The argument is simple. It is because the numerator in the profit equation, surplus value, is outrun by the denominator, capital stock (both measured in annual terms) . . . That is, too much capital stock builds up in factories and equipment around the world, pitting companies against each other in an ever-fiercer competitive brawl for markets. This holds prices down, leads commodity output to outrun demand at prevailing prices, and/or lowers capacity utilization rates – thereby lowering profit margins, leaving goods unsold and running equipment at less efficient levels.

If expansion across space (appropriation) represents one fix to the falling rate of profit, innovation through time (capitalization) represents the second. The first moment extends the net of energy-resource consumption ever more widely and deeply, driving down the costs of circulating capital (inputs); the second accomplishes the production of more commodities with fewer workers in less time, driving down the costs of variable capital (labor power). Neither can be amplified endlessly. Global space is not only relational, but asymptotic and finite from the standpoint of endless accumulation. And although in theory, 'constant capital's material volume' may be augmented without limit (Marx 1981, 317), the rate of exploitation operates within a much stickier field of power.

How does profitability revive? Marxists usually respond by emphasizing the role of crises in propelling creative destruction by (1) devaluing fixed capital (such as factory shutdowns), over the short-run; (2) increasing the rate of exploitation through technical innovation; and (3) increasing absolute surplus value through wage freezes or reductions (Walker 1998, Harvey 1982).

There is, of course, enormous debate over the relation between accumulation crisis and the falling rate of profit.¹⁹ For the purposes at hand, I would prefer to

¹⁹Useful surveys can be found in Mandel (1981) and Choonara (2009).

bracket these, and simply point to a fourth moment. This turns on circulating capital (inputs), but with important implications for variable capital as well. What I wish to underscore is that Marx's (1973, 748) 'most important law' can be more fully grasped – and its explanatory power radically extended – by taking *as a whole* the contradictions between 'first' and 'second' nature (inputs relative to machinery) as well as those within second nature (constant relative to variable capital). In what follows, I treat Marx's 'progressive tendency' towards a '*gradual fall in the general rate of profit*' (1981, 318–9) as a historical proposition on the long-run relation between the overproduction of machinery and the underproduction of inputs. I am concerned less with a precise operationalization of this proposition at a sectoral or national level, and rather more with its heuristic utility for illuminating a decisive point of fracture in the *longue durée* movement of historical capitalism.

I am tempted to say that the crucial weakness in falling rate of profit arguments has not been the theory itself, but rather an overemphasis on *one* moment of constant capital – on fixed rather than circulating capital. Could it be that since the 1830s, capitalism has forged agro-extractive complexes capable of outrunning the tendency towards the underproduction of inputs? If a sufficient mass of cheap energy and raw materials can be mobilized, the rising organic composition of capital can be attenuated – especially if 'capital saving' innovations run strongly alongside labor saving movements²⁰ – and the tendency towards a falling rate of profit not only checked but (for a time) reversed.²¹

The same logic applies to variable capital. If a sufficient volume of cheap food can be supplied to workers – and cheap food's biophysical costs externalized, for the time being – the rate of surplus value may be augmented in a manner roughly analogous to wage freezes and technical innovations. The most spectacular booms in the capitalist era have woven these two moments together – think of English industrialization with its heavy reliance on cheap energy (coal) and cheap calories (sugar).

One may well object that underproductionist tendencies, at least since the 1830s, have been swept into the dustbin of history by the competitive–technical logic of capitalism (e.g. Burkett 2006). There's a kernel of truth here. The 'great depression' of the late nineteenth century is arguably the paradigmatic example. World prices for raw materials imported by Britain began to rise sharply during the 1860s and 1870s, at the very moment of its peak industrial supremacy (Hobsbawm 1975, Rostow 1938, Mandel 1975). The inflationary moment was, as we know, quickly turned inside-out. World market prices *generally* declined quite sharply after 1873 (Landes 1969). At the same time, an inflationary undercurrent was at play, manifested in episodic and uneven movements of underproduction in such key raw materials sectors as cotton, indigo, rubber, palm oil, copper, nickel, lead, tin, jute, and sisal (Headrick 1996, Mandel 1975, Brockway 1979, Barraclough 1967, Bukharin 1915, Magdoff 1969, 30–40). These inflationary undercurrents were set in motion by the rise of new industrial powers, Germany and the US. They were amplified further still

²⁰Between 1980 and 2005, the 'relative price of capital goods has declined by between 25 and 40%' in the US and Japan (BIS 2006, 24).

²¹Harvey (2003, 150, 139; 2005), as if to prove the point, views the 'release' of cheap raw materials as 'just as important' as other strategies in reviving accumulation, but pays it little attention in his recent analyses of neoliberalism.

by the *qualitative* shifts inscribed in the 'second' industrial revolution's production of nature, premised on oil and petrochemicals, the auto, steel, and electrical industries, and the first synthetic plastics (Barracough 1967, 45–63).

The underproductionist tendency was therefore checked, but not abolished, by the second industrial revolution. At the dawn of the long twentieth century, Malaysian rubber and tin, Chilean copper, Australian gold, and Canadian nickel all entered the world-historical stage as key moments in an ecological revolution that was 'far quicker, far more prodigious in its results, far more revolutionary in its effects on people's lives and outlooks' than anything known before in the history of capitalism (Barracough 1967, 44). The tendency towards underproduction was moderated through the dialectic of productivity and plunder characteristic of capitalism's successive global ecological fixes. In the first place, industrial capital – German, and especially American and British, firms – moved strongly into raw materials production (Mandel 1975, 61). Metals such as copper were especially important to late nineteenth century industrialization, and the pace of technological innovation was fast and furious. What bears emphasizing is that this moment of 'productivity' (capitalization) was enabled by one of 'plunder' (appropriation). That is, this 'massive' flow of investment (Mandel 1975, 61) was possible because the rapid geographical expansion of the capitalist world-ecology signified the rapid expansion of opportunities for accumulation by appropriation. The biophysical 'rents' enjoyed by industrial capital in this era were remarkably high. And yet, for all the dynamism of production and the restlessness of commodity frontiers, the tendency towards underproduction would not go away. Copper production surged tenfold between 1870 and 1914 without any price decline. This despite massive capital investment *and* a dynamic commodity frontier that reached from sub-Saharan Africa to Chile and the American West (Bridge 2009, Frederiksen 2009, Schmitz 1986). One needn't take a resource-determinist view of the 'new imperialism' of the nineteenth century to understand that the reorganization of world-ecology – at times coercive-intensive, at times capital-intensive – was central to the trajectory of power and progress in the long century that followed.

From the standpoint of world accumulation, the challenge has been to strike the right balance between regularizing supply (which is always rising) and making those supplies cheap enough to permit expanded accumulation. Rising capital intensity tends to regularize supply but does so by accelerating the place-specific exhaustion of the conditions of profitability. Capitalism has been remarkably adept at finding ways to overcome the basic tendency. Through capital intensification and innovation, capitalist agencies have found ways to make more out of less in the short- to middle-run. More out of less, however, is not something for nothing. The counterpoint to the underlying tendency of input underproduction has therefore been a frontier movement. From the sixteenth century, the appropriation of biophysically- and geologically-rich frontiers, combined with cheap labor and sufficiently mobile capital, has periodically resolved the underlying contradiction.

It is far from clear that another great burst of appropriation sufficient to a launch a new golden age of accumulation, is possible today. Where will the next phase of capitalism find reservoirs of uncaptured nature comparable to that offered up by conquest of the Americas, the incorporation of Africa, the subordination of India? Let us recall for the moment the unusual expansiveness of neoliberalism's appropriations, captured in a long series of phrases now part of the everyday parlance of critical scholars: 'accumulation by dispossession' (Harvey 2003),

'biopiracy' and the new 'enclosures' (Shiva 1997), 'disaster capitalism' (Klein 2007), a new 'scramble for Africa' (Watts 2006), resurgent 'resource wars' (Klare 2001), and many more. From this, neoliberalism may be understood as an ecological regime premise on *taking*, first, and *making*, second. This is an epochal shift in the history of capitalism that expresses the (asymptotic) exhaustion of frontiers, and with it, the promise of renewed accumulation offered – and delivered – over the past five centuries.

Capital's great need is for low-cost energy, food, and raw materials. The response to this imperative has been endless geographical expansion and endless innovation. They are not independent. *They are in fact so closely connected that the technical fixes of capitalism have always been intertwined with movements of global expansion.* This is what I call the pairing of plunder and productivity in world accumulation. The pattern can be reduced to a two phase process: (1) skimming the most easily-won surpluses, such as Amazonian rubber tapping prior to Malaysia's plantation revolution in the early twentieth century (Brockway 1979, Tucker 2000); and (2) reorganizing a widening sphere of world nature on an increasingly capitalist basis, such as the progressive rationalization of forest-product industries worldwide since the end of the nineteenth century (Rajala 1998). But it would be a mistake to see this simply as a logical-historical succession. The capitalization of nature that characterizes this second phase issues short-run windfalls, to be sure. It is an eminently modern variant of the 'yield honeymoon' that early modern planters enjoyed when their slaves planted Eurasian cane on New World soils (Dark and Gent 2001, Moore 2007). The concert of favorable biophysical conditions with cutting edge agronomy issues yield bursts that invariably turn bust over the course of 50–75 years. (Perhaps more quickly in late capitalism.) Thus, the very innovations that create yield booms invariably undermine supply conditions over the middle-run. From the standpoint of the *oikeios*, the contradictions are unified, while their expressions diverge, comprising 'social' transformations in, say, the global agrofood regime no less than 'biophysical' feedbacks in weed control. As these contradictions unfold in ways that limit accumulation, the search for new frontiers reappears with savage power. If frontiers are unavailable, ferocious acts of redistribution are visited upon those populations least able to offer effective resistance – from poor to rich (as in neoliberalism), or from peasantries to heavy industrialization (as in Soviet collectivization).

The rising organic composition of capital, as we have seen, drives a contradiction between the overproduction of machinery and the underproduction of inputs. But rising capital intensity in the technical division of labor enters into dialectical tension with a distinctive, if broadly homologous, process within the social division of labor. This process is the *rising capitalized composition of world nature*. Capital is compelled to capitalize an ever-growing share of world nature, whose free gifts can only be enjoyed to the extent that they remain uncapitalized. The 'coercive laws of competition' drive capital to remake the rest of nature according to the temporal logic of 'socially-necessary turnover time', a far cry from the reproduction time of forests and fields, not to mention mines, oilfields, and aquifers (Marx 1976, 44, Harvey 2001, 327).²² In order

²²Marx was not necessarily wrong to prioritize time over space. The aim and objective of those engaged in the circulation of capital must be, after all, to command surplus labor *time* and convert it into profit within the *socially-necessary turnover time*. From the standpoint of the circulation of capital therefore, space appears in the first instance as a mere inconvenience, a barrier to be overcome' (Harvey 2001, 327).

to keep this ecological face of socially-necessary turnover time from getting out of control, and radically undermining the conditions of production (e.g. resource exhaustion) or the conditions of profitability (rising capital intensity), the system has historically extended the sphere of capitalized nature in recurrent, great bursts of global expansion – hence, every great era of capitalist development has been accompanied by a ‘new’ imperialism. There is, then, a tension between that quantum of socio-ecological relations dependent on the circulation of capital and that which remains within the gravitational pull of accumulation, but whose reproduction is not yet capital-dependent. Just as capital prefers to employ workers located in semi-proletarian households (where a decisive share of income is located outside the wage relation) (Smith and Wallerstein 1992, Wallerstein 1983), so capital prefers to mobilize biophysical natures capable of reproducing themselves relatively autonomously from the circuit of capital.

There is a clear homology with Marx’s account of the relation between the active and latent strata of the reserve army of labor. It is, in my reading, a theory of capital’s tendency to drive human nature beyond its limits – to turn ‘blood into capital’ (1976, 382). This tendency takes shape through the systemic imperative to appropriate human nature (itself historically contingent), by continually drawing uncanceled (yet exploitable) reservoirs of labor power into its field of power. ‘It would seem’, Marx observes (1976, 377), ‘that the interest of capital itself points in the direction of a normal working day’. A longer and more intensive working day ‘shortens the life of the . . . worker’, which would seem a costly venture of capital, as ‘the forces used up have to be replaced more rapidly, and it will be more expensive to reproduce power-power’. But there is a crucial geographical caveat to this surficial logic. Enter the frontier. If such labor power can be ‘supplied from foreign preserves’ – appropriated, in our terms – from zones where the reproduction of labor power does not pivot on the accumulation of capital

... the duration of [the worker’s] life becomes a matter of less moment than its productiveness while it lasts. It is accordingly a maxim of slave management, in slave-importing countries, that the most effective economy is that which takes out of the human chattel in the shortest space of time the utmost of exertion that it is capable of putting forth. It is in tropical culture, where annual profits often exceed the whole capital of plantations, that negro life is most recklessly sacrificed . . . *Mutato nomine te fabula narratur* [The name is changed but the tale is told of you!]. For slave trade, read labor-market, for Kentucky and Virginia [in the slave trade], Ireland and the agricultural districts of England, Scotland, and Wales, for Africa, Germany. (Marx 1976, 377–78)

For labor power, read nature. *Mutato nomine te fabula narratur!*

Far from an artifact of the Industrial Revolution, this tendency was in motion from the earliest moments of capitalism. The environmental history of the rise of capitalism turned decisively on *the centralisation of economic power combined with ‘economies of speed’* (Chandler 1977). While accumulation was sustained through geographical expansion and therefore early capitalism’s ecological regime is rightly called *extensive*, the uneven synergies of generally rising demand translated to agro-extractive strategies of hit-and-run. Hit where the ecological wealth was most accessible (cheapest), extract it as fast as possible, then move as quickly as possible once declining biophysical returns (and therefore rising capitalization) registered a significant contraction of profitability. But far from merely plunderous, early capitalism’s appropriations were enabled by significant technological advances,

especially conspicuous in the sugar plantation complex, one of the birthplaces of the modern factory system (Moore 2007, Mintz 1985).

The contradiction between the overproduction of machinery and the underproduction of inputs can, therefore, be overcome to the extent that the inner contradiction finds an outer vent. The rising organic composition of capital, quite independently of the appearance of underaccumulation *crisis*, instanciates an immanent tendency towards socio-ecological disequilibrium, whose systemic expression is the rising capitalized composition of world nature. To the extent that this rising capitalization of nature is not offset by special stimuli that appropriate significant social ecologies, there is a clear crisis tendency: *the tendency of the ecological surplus to fall*. This can be counteracted, as we've noted, through geographical expansion. But take note of the relational process. It is not simply that a large mass of use-values is now easily skimmed once geographical expansion reaches critical mass. More to the point, once critical mass is reached, the quantum of socialized nature dependent on the cash nexus *declines*. This was the case in the long sixteenth century, and at the beginning of the long twentieth century, in the classic instance of the 'new imperialism'.

The extension of capitalist power into new frontiers works to propel world accumulation so long as two conditions hold: (1) the newly incorporated formations reproduce themselves relatively independently of capital, but deliver sizeable contributions to the ecological surplus; and (2) the mass of use-values taken up is sufficiently large, relative to value accumulation, so as to *reduce* the capitalized share of the commodity production in general. As geographical expansion slows, relative to rising capitalization, the quantum of socialized nature dependent on the cash nexus *increases*. At some point (and as capital drives the acceleration of turnover time ever closer to the speed of light, this point approaches ever more quickly), the quantitative advance of commodification reaches a tipping point within any given socio-ecological formation. At this point, socialized natures give way to capitalized natures, representing the moment of capitalist transformation at which neither governing structures nor production systems nor the (newly transformed) forests, fields, households, and other ecologies can reproduce themselves *except through deepening participation in the circuits of capital on a world-scale*.

The more that *social* ecologies – fields, forests, fisheries, and so forth – become *capitalized* ecologies, the more their reproduction is entrained within the reproduction of capital. Rising capitalization tends to produce short- and medium-run windfalls, but undermines systemic conditions of accumulation in the middle- to long-run. This issues, *first*, from rising capital intensity itself (independently of soil exhaustion, deforestation, etc.), and *second*, from the progressive exhaustion of the ecological regime as its reservoirs of uncanceled land and labor become dependent on the circuit of capital. If the 'natural fertility of the soil can act like an increase of fixed capital' (Marx 1973, 748), and therefore can check the tendency towards a falling rate of profit, soil exhaustion and resource depletion can set the stage for a dramatic reversal of profitability – an underappreciated moment of the boom/bust cycle of extractive regimes. The rising organic composition of capital and the rising capitalized composition of world nature are therefore dialectically bound – one operating in the technical division of labor, the other, in the social division of labor. In the first instance, competition compels capital to increase the productivity of labor through the installation of new machinery; to the extent that it is unable to increase the rate of exploitation faster than the rising composition of dead labor (a more

daunting challenge), there is a strong tendency towards a declining rate of profit. At the same time, competition compels capital to find ways to drive down the costs of circulating capital such as energy and other raw materials. To the extent that sufficiently cheap energy sources and other inputs are secured, this favors a rising rate of profit. The best way to do this is to extend to the geographical field. The new technologies, invariably facilitated by territorial power, work on a large scale insofar as they appropriate nature's free gifts so effectively that they reduce the costs of production not only for the sector in question, but on a systemwide basis. The five-fold rapid increase in world oil consumption at declining prices after World War II (1950–70) is a good example (Hoogeveld 1997, 47). The very effectiveness of these technologies rests on their rapid appropriation, and ensuing depletion, of the natures in their grasp. This undermines the very conditions of success that they initially served to create. Resource exhaustion under the law of value is the rising organic composition of capital. For fractions of capital – one thinks of the oil – this tendency can be overcome through property rights that confer 'surplus profit' in Marx's sense (1981), and may allow that fraction's leading firms to secure value produced elsewhere. To the extent that the resource in question is crucial to the expanded reproduction of capital as a whole, however, the gains of one fraction can undermine the systemwide conditions that would maintain or revive profitability.

Transcending the metabolic rift: a theory of capitalism *as* ecological regime

Foster's understanding of the metabolic rift took shape out of his intellectual history of Marx's materialism (2000), and the effort to provide a 'classical foundation' for environmental sociology (1999). With Clark, he has deployed the category to narrate capitalism's environmental depredations (e.g. Clark and Foster 2009, Foster and Clark 2003), but the narratives themselves have not moved far beyond a grafting of dependency theory onto environmental history. Although replete with references to accumulation and the 'pursuit of profit', there is little effort to ground these terms in global value relations. Indeed, there is little to show that the theory of metabolic rift has any traction at all in Foster's theorization of monopoly capitalism – environmental change is consequential, but it is not *constitutive*. The theory retains its Cartesian way of seeing, embracing 'ecologically unequal exchange' (with its reification of production relations) and an 'environmental footprint' approach that posits the key issue as one of 'demands placed on ecosystems' (Clark and Foster 2009, 314).

My earlier formulation (Moore 2000a) comes closer to the present argument, but retains a Cartesian distinction – albeit a much softer one than Foster – in the notion that 'systemic cycles of agroecological transformation' complemented Arrighi's (1994) 'systemic cycles of accumulation'. In my 2000 essay, I highlighted many of the decisive *elements* of successive phases of world environmental change in the capitalist era, rooting these in Arrighi's language of 'declining returns'. Descriptively, the theory provides a way of making linkages, but refrains from specifying the inner relations between the two systemic cycles. I offered an ensemble of elements – new rural built environments, such as railroads, or new productive organizations, such as the nineteenth century family farm – as decisive factors in establishing the conditions for new waves of accumulation. But I left to the working out of the metabolic rift the socio-ecological mechanisms for growth and crisis. The metabolic rift's common sense reckoning of resource depletion, as nutrients flowed from agrarian to urban spaces, and returned only in exceptional cases, was necessarily partial. I did not

explain the ways that ‘depletion’ translates to rising difficulties in world accumulation. And this is exactly what Marx’s conception of global value relations and the dialectic of overproduction and underproduction helps to explain.

My early world-historical engagement with the metabolic rift pointed in the right direction, but did not go nearly far enough. Capitalism does not *have* an ecological regime; it *is* an ecological regime. Or rather, capitalism is constituted through a succession of ecological regimes that crystallize a qualitative transformation of capital accumulation – for instance the transition from manufacture to large-scale industry – within a provisionally stabilized structuring of nature–society relations. Ontologically speaking, historical capitalism emerges through the dialectic of the accumulation process and nature–society relations. I am making a deliberately provocative argument here for a simple reason. So long as we continue to view class structures, state-machineries, geopolitics, industrialization, cultural production, *interalia*, as *complemented* by a specific socio-institutional mode of governing ‘first’ natures and primary production, we find ourselves in a Cartesian trap.

Nevertheless, to leave the argument at this level of abstraction would miss a magic opportunity. Ecological regime, in this sense, opens a new angle of vision on capitalism’s ontogenesis: capitalism *as* ecological regime. Far from seeking to flatten the system’s constitutive socio-ecological relations, a theory of capitalism as ecological regime opens up a means of relating and constructing a deeper, and more differentiated, complex of metabolic rifts, food regimes (Friedmann and McMichael 1989, McMichael 2009, Weis 2007), resource regime studies (Bunker and Ciccantell 2005), energy regime analyses (Podobnik 2006), and many more beyond.

By ecological regime, I highlight those relatively durable patterns of governance (formal and informal), technological innovations, class structures, and organizational forms that have sustained and propelled successive phases of world accumulation since the long sixteenth century (c. 1450–1640). Ecological *regime* signifies the historically stabilized process and conditions of extended accumulation; ecological *revolutions* mark the turbulent emergence of these provisionally stabilized processes and conditions. The focus is not on the interaction of social and biophysical essences – these are ‘coupled’ only in the sense that the fish in a pond are ‘coupled’ with the pond itself.²³ Rather, proceeding from value relations as our guiding methodological principle, our focus is the socio-ecological constitution of modernity’s strategic relations. Such an eductive approach opens up a field of investigation that extends far beyond the manifold ‘changes in the land’ commonly associated with environmental history (Cronon 1983): property relations, commodity-centered resource extraction, cash-crop agriculture, energy complexes, and so forth. In world-ecological perspective, environmental history is every bit as much about factories as forests, stock exchanges, shopping centers, slums, and suburban sprawls as soil exhaustion and species extinction.

These ecological regimes comprise, at a minimum, those market and institutional mechanisms necessary to ensure adequate flows of energy, food, raw material, and labor surpluses to the organizing centers of world accumulation. But the story does not end here. We should also attend to the production complexes that consume these surpluses and set in motion new (and contradictory) demands upon the rest of nature. That is to say, the town–country antagonism – overlapping, but not be

²³Pace Berkes, *et al.* (2003).

confused, with the core-periphery divide – is the decisive geographical relation. Ecological regimes constitute a matrix of relations governing ‘town’ (consuming surpluses) as well as ‘countryside’ (producing surpluses). Foster’s ‘metabolic rift’ becomes, as we have seen, not merely a particular output of capitalism, but constitutive of the capitalist mode of production (1999). Every phase of capitalism *emerges through* a revolution in nature–society relations that creates new possibilities for the expanded accumulation of capital. What constitutes these possibilities? At base, every great wave of capital accumulation has unfolded through and upon a greatly expanded ecological surplus, which finds its phenomenal expression in cheap food, cheap energy, and cheap inputs. To the extent that new labor surpluses can be mobilized through deruralization, labor costs can be driven down as well – through cheap food (driving down the minimum wage necessary for social reproduction) and cheap energy (central to rising labor productivity).

But just what does ‘cheap’ really mean? The vernacular may be translated to more precise analytical language. Long waves emerge only when these ecological surpluses can be delivered significantly below systemwide production costs, those in primary production above all. Britain’s mid-nineteenth century efflorescence as the ‘workshop of the world’, for instance, was nicely linked up with the agricultural revolution of the American Midwest. North American grain replaced, on an extended scale, the relative exhaustion of England’s ‘agricultural district’ in Ireland (c. 1780–1840), and would in time be complemented by new granaries in Russia, India, and elsewhere. Between the 1846 repeal of the Corn Laws and the downturn of the 1870s, Britain’s grain imports increased 254 percent. Grain arriving from the US, however, increased 40-fold, from 25,000 tons to over a million, providing more than half of Britain’s total grain imports by the end of the period (calculated from Atkin 1992, 17–18). It is true that grain prices fell only modestly in this golden age of British capitalism (Barnes 1930, 290), but this is surely a major accomplishment in light of England’s rapid population growth (16–23 million) and rapid industrialization (one third of world manufacturing). Prices would tumble sharply downwards in the generation after 1873, even as England came to consume 80 percent of its daily bread from external sources (Mulhall 1892, 444, Thomas 1982, 336, O’Rourke 1997).

Long waves of accumulation take shape when and where the conditions for profitability are re-established after a downturn. But it is not easy to establish these conditions. They depend not only upon socio-technical ingenuity, but also upon vast rivers of biophysical wealth without which the new innovations are useless. (This is why new technologies often languish for a time before their generalization.) Think, for instance, of the puddling techniques that allowed for the fertile marriage of mass produced coal and iron in late eighteenth century England (Gordon 1996, 133–34). The Industrial Revolution, to stick with our example, unfolded through the unprecedented collection of cotton, iron, and coal surpluses whose value composition (the average social labor inscribed in these commodities) was very low – relative to, say, shipbuilding or watchmaking. To be sure, there were variable reasons for such low value composition – favorable geology and canal infrastructure (English coal), the alluvial soils of the Mississippi Delta (cotton), the deployment of serf labor and simple manufacture in the Urals (iron). (Would we expect otherwise from the combined and uneven development of capitalization and appropriation?)

In other words, inputs and labor power had to be mobilized cheaply, ‘cheap’ because they were abundant *relative to* the conditions of commodity production and exchange on the eve of a renewed long wave. Historically, we have seen two key

moments in the formation, and successive decomposition, of this relative ecological surplus. First, recurrent waves of geographical expansion have opened vast opportunities for channeling a growing share of biospheric wealth into the apparatus of capital accumulation. Capitalism's genius has been to take advantage of these opportunities in a manner no other civilization was able to do – composing a succession of socio-technical innovations that maximized biophysical throughput relative to labor, and which continually revolutionized the very 'nature' of the biophysical throughput itself. Simply put, modernity gave rise not simply to more efficient iron smelters, but to new steam engines; not simply to more efficient steam engines, but to internal combustion engines.

This is a much more discontinuous story than is often recognized. It is rarely appreciated that the rise and demise of successive ecological regimes does not turn on new phases of biophysical exploitation and thence exhaustion as self-evident facts. Rather, new agricultural and industrial revolutions emerged in response to the relative exhaustion of those spaces not only occupied by – *but indeed produced by*²⁴ – the old ecological regime. The crises of historical capitalism are crises of the nature–society *relations* that enable (or fetter) the endless accumulation of capital. They are crises of the actually existing relation of socialized nature *through* the law of value, not of an abstract nature of 'wilderness' one, twice (or even thrice!) removed (Cronon 1996).

Capitalism does not move through its successive phases of development *by* organizing new ecological regimes that govern the expanded reproduction of food, energy, and materials surpluses. (Although these latter are in fact pillars of every ecological regime, and can be fruitfully analyzed through the specification of regime concepts for each of these mediations.) Rather, every epochal refashioning of the circuit of capital – from money to commodity production and exchange, and back again – is enabled by, represents, and creates new ensembles of nature–society relations. Capitalism emerges as this accumulation process mobilizes through (and reshapes) the uneven conditions of possibility and constraint drawn by the ecological regime, which finds its geographical limit in the socially necessary division of labor of the system as a whole.

How might we begin to move from value theory to the history of capitalism, from capital to capitalism? If the construct of 'ecological regime' is to prove useful, it must be more than a large descriptive category (*pace* Beddoe *et al.* 2009). In what sense can this perspective *explain* something of the rise and future demise of the modern world-system? For some measure of guidance, we might turn to Giovanni Arrighi's systemic cycles of accumulation perspective (1994), and Harvey's theory of the spatial fix (1982).

In Arrighi's theory of historical capitalism, ascendant world powers have risen to global preeminence (hegemony) through varied 'organizational revolutions' in the structures of capitalist and territorial power. Such revolutions achieve their *qualitative* shifts in response to – and on the basis of – the accumulating (*quantitative*) contradictions of the previous era. The systemic crises that are the occasion of such qualitative shifts are internally constituted – the limits of capitalist development in any era are registered by the exhaustion of an older organizational revolution and its regime structures, and the emergence of new ways of knitting together the capitalist *oikeios*. Crucially, these new organizational revolutions must

²⁴With a nod to Lefebvre (1991).

innovate by finding new ways to mobilize, lead and coordinate, vast new additions to the geography of capitalism. While capital may regard space as an inexhaustible and infinitely substitutable zone of conquest and commodification, Arrighi reveals each such great expansion of the world-economy as a constitutive moment of special stimuli, whose underlying conditions are progressively exhausted over the *longue durée*. And so the crises generated in successive accumulation cycles have called forth organizing centers of progressively greater geographical breadth – from the Genoese city-state of the sixteenth century to the American continental-state of the long twentieth century.²⁵

Harvey's theory of spatial fix (1982) adds two further connections of the greatest significance. First is the contention that modernity's great financial expansions, so central to Arrighi's perspective, are dialectically connected with 'accumulation by dispossession' (Harvey 2003). Second, in Harvey's broader theory of spatial fix, the initial flexibility of capital, and acceleration of turnover time, achieved through a 'built environment' favorable to capital in one era, becomes a fetter upon accumulation in the next. In this way, '*environments* are created that simultaneously facilitate but imprison the future paths of capitalist development' (Harvey 1991, 218, emphasis added).

Arrighi and Harvey point towards a theory of the capitalist world-ecology and its developmental phases that illuminates the socio-ecological conditions of accumulation boom *and* bust over the *longue durée*. In this scheme of things, the 'limits to growth' give way to the conditions *and* limits of accumulation, directly given in historical capitalism itself. Successive phases of capitalism have unfolded through ecological revolutions in the dynamics of accumulation (the civilizational project), and the nature–society relations within its gravitational field (the historical process). These have been organizational revolutions in the webs of governance enacted by capitalist and territorialist agencies, and revolutions in the built environments of world commodity production and exchange. Their signal accomplishment has been the radical enlargement of the ecological surplus through the radical expansion of opportunities for accumulation by appropriation relative to accumulation by capitalization.

To echo Harvey, these globalizing ecological revolutions at first liberate accumulation. Was not this the world-historical accomplishment of British hegemony in the 'first' nineteenth century (c. 1763–1848)? Over time, however, these new ways of producing nature – through political regulation, built environments, industrial organization, agricultural innovation, not to mention class struggles – begin to generate contradictions through the corrosive effects of plunder and productivity. The widening and deepening movements of accumulation by appropriation undermine the extant capacities of human and biophysical natures to reproduce themselves independently (or relatively so) from the circuit of capital. Sooner or later, but typically in the ballpark of a half-century, the *rules of reproduction* change in the direction of capital-dependency. Peasant cultivators become capitalist farmers; old-growth timber stands give way to tree plantations. Inter-generational reproduction becomes mediated by the cash nexus. The relative

²⁵Not to mention geographical *depth*, as modes of extraction have plunged ever deeper into the earth itself. Geographical expansion itself comprises both horizontal and vertical movements, the latter overlapping, but not to be confused, with the socio-spatial intensification of rising capital intensity at a system-wide level.

ecological surplus falls as the capitalization of world nature rises. This undercuts the basis of expanded accumulation, culminating in a developmental ecological crisis.

The ecological regimes emerging out of these developmental ecological crises confronted, and indeed produced, *historically-specific natures as webs of liberation and limitation for the accumulation of capital*. The point can scarcely be overemphasized if we are to take seriously the idea that *all* the ‘limits to capital’ emerge historically, out of the relations of humans with the rest of nature. This historical specification is not idiographic, but rather acknowledges the multilayered spatio-temporal character of the *oikeios*. The natures that neoliberalism has produced operate within the *epochal* nature of historical capitalism, and perhaps even a sort of *civilizational* nature of humanity since the Neolithic revolution. Such a multilayered comprehension of historical nature (qua *oikeios*) opens up the possibilities for distinguishing the cumulative, the cyclical, and the genuinely novel in the present conjuncture. Here I would make an elementary, and I think also underappreciated point: what constitutes a limit in one mode of production (or *phase of capitalism*) ‘may not constitute a limit for another’ mode of production (or phase of capitalism) (Benton 1989, 79). Thus may we begin to think of successive phases of capitalism as creating, and created by, an increasingly capitalized world-ecology. The historical limits of the early capitalist ecological regime – for example, agricultural exhaustion and relative energy scarcity throughout central and western Europe – had been reached by the middle of the eighteenth century. These *were* ecohistorical limits to capital accumulation as it was then organized. Clearly, they were not absolute limits.

Arrighi’s systemic cycles approach becomes exceedingly useful in offering a spatialized sociology of how capitalism’s limits have been transcended over the course of modern world history. My proposal is an ecohistorical twist on Arrighi’s (1994, 226) fruitful notion that phases of world development pivot on ‘particular organizational structure[s], the vitality of which [is] progressively undermined by the expansion itself’. The resulting ‘increasingly vicious competition’ between and amongst capitals and states eventually reaches a boiling point, with the ensuing crisis of profitability resulting in the demise of the very ‘organizational structures on which the preceding material expansion’ was based (p. 226). If we bring the *oikeios* into such a world-historical frame, it becomes clear that something more than escalating inter-firm and geopolitical competition, and something more than class struggle (as conventionally understood), undermined the great phases of world economic growth – one can think of successive ‘golden ages’ of capitalism, c. 1450–1520, 1848–1873, 1947–1973. The very burst of capitalization characteristic of such golden eras enabled, and was enabled by, even greater busts of appropriation.²⁶ The ‘organizational structures’ specific to these phases of appropriation were progressively exhausted by the very strategies that enabled the delivery of a massive ecological surplus in the boom decades of successive long centuries of accumulation. Here is a way to talk about limits without invoking neo-Malthusian conceptions – a still present danger (even from those on the left) revealed in recent discussions of peak oil (e.g. Newman 2008).

²⁶Even many Marxists regard the long nineteenth century as decisive because of the generalization of the wage-labor relation, when in fact the share of world households within capitalism’s division of labor was no greater (and probably lower) in 1914 than it was in 1763.

By way of conclusion: towards a unified theory of capitalist development and crisis

By locating today's socio-ecological transformations within long-run and large-scale patterns of recurrence and evolution in the modern world – *including* the human natures of the capitalist labor process, household reproduction and family formation, the 'informal economies' of the South and much more – we might begin to illuminate the distinctive contradictions at play in the present crisis. I write in the midst of neoliberalism's 'signal crisis' (Moore 2010c) – the point at which a developmental ecological crisis appears first, manifesting in rising, rather than declining, commodity prices for food, energy, and crucial inputs. This is a good sign of a developmental ecological regime's transition from accumulation by appropriation to accumulation by capitalization. Clearly there are many novel developments unfolding that complicate the established ways that one phase of capitalism gives way to another. Is the present conjuncture also a turning point in historical capitalism: not just a developmental, but an epochal ecological crisis?

While the left has offered a series of perceptive analyses of the events of 2008 and the unfolding 'world slump' ever since (McNally 2009, Foster and Magdoff 2009, Harvey 2009, Kotz 2008, Panitch and Konings 2009, Beitel 2009, Lapavistas 2009, Rasmus 2009), these analyses have remained largely nature-blind, or have corralled 'environmental' problems outside the core of the accumulation process. There persists a powerfully Cartesian divide between accounts of (so-called) 'economic' crisis and (so-called) 'environmental crisis.' This is not only theoretically untenable and analytically problematic. It is politically counter-productive. It is impossible to discern, with the necessary clarity, the constitutive relations between the socio-ecological processes and projects of financialization, trade liberalization, food security and food sovereignty (and many more beyond this) without a provisional theory that can guide our analysis of how these projects not only represent new weaves of human and extra-human nature, but also constitute a world-ecological whole that is more than the sum of these parts. At the core of the provisional theory on offer is a theoretical claim about development and crisis (the dialectics of appropriation and capitalization, overproduction and underproduction) and a methodological proposition (Wall Street is a way of organizing nature). If financialization is an ecological project in its own right, the scarcities induced by it (through commodity booms) are neither more nor less directly connected to *all* of nature than crop failures, species extinctions, and climate shifts.

The theory of metabolic rift stands as one of critical political ecology's most powerful ideas. The argument that capitalism's eco-geographical logic, is immanent to the system's rise, development, and ongoing demise is a signal contribution to world scholarship. How can we amplify and elaborate the essential core of metabolic rift theory? I have argued two major points: (1) that the perspective of capitalism as world-ecology, unifying the production of nature and the accumulation of capital, offers a new 'way of seeing' the metabolic rift; and (2) that a historically-grounded reading of Marx's value theory offers a powerful methodological proposition for constructing socio-ecological totalities. Taken together, these offer an alternative to the Cartesian grafting of 'natural' and 'social' processes and the corresponding alienation of the 'economic' and the 'environmental' in the history of capitalism. Such a reformulation provides one necessary

point of departure – but far from the final word – for rethinking the contradictions of capitalism as irreducibly socio-ecological, and for imagining, and enacting, the transcendence of capitalism in favor of new and liberatory world-ecological projects.

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