The Accelerating Biophysical Contradictions of Industrial Capitalist Agriculture

TONY WEIS

The productivity of industrial capitalist agriculture is central to dominant development narratives. It is also highly unstable, with intractable biophysical problems created in the substitution of labour, skill and knowledge with technology, and overridden with unsustainable ‘technological fixes’ and masked by a host of externalized costs. Relatively cheap oil is central to this, effectively subsidizing the low-priced industrial grains and oilseeds on which global food security has come to hinge. However, the chronic biophysical contradictions of industrial capitalist agriculture are accelerating, at the same time as the surge in biofuels has augmented the still-rising demand of livestock feed to embolden industrial producers. A period of acute and ominously regressive food price volatility looms in the short term, with more ruinous outcomes ahead. But this might also widen openings for rebuilding biodiverse food systems and remaking and valorizing agricultural work, which will involve rethinking agriculture’s place in conceptions of development and modernity.

Keywords: agricultural productivity, biophysical overrides, fossil energy, climate change

DECEPTIVE EFFICIENCY AND THE INSTABILITY OF CHEAP INDUSTRIAL FOOD

In his famed depiction of the stages of development, Rostow (1990, 8) noted how ‘the revolutionary changes in agricultural productivity are an essential condition for successful take-off’ towards a modern capitalist economy. These revolutionary productivity gains are generally framed by increases in basic indicators: per unit labour and per unit seed and livestock (i.e. yield). This conception of the productive efficiency of industrial capitalist agriculture is, in turn, an important foundation of dominant development narratives. For instance Sachs (2005, 36), in his more recent portrayal of capitalism’s development ladder, essentially defines ‘rising agricultural productivity’ as ‘food production per farmer’, and calls this a fundamental root of ‘modern economic growth.’ Enhanced productivity per worker, plant and animal are then linked in a normative way, as though inevitable aspects of development, to such things as the relative decline of the agricultural workforce, progressively cheaper
food and its declining share within household expenditure, and increasing con-
sumption of ‘high-quality’ foods, especially animal-derived protein. Promises of
more, cheaper and better food, along with an end to the drudgery of farm work,
are crucial aspects of the ideological justification for the myriad upheavals wrought
by industrial capitalist agriculture, and its enduring inequalities and tensions.

This framework for understanding efficiency and development is reflected in
various empirical trends, such as: the inverse relationship between a nation’s per
capita GDP and the percentage of the workforce in agriculture; enhanced yields,
most importantly in grains and oilseeds and their conversion to meat, milk and eggs;
the aggregate and per capita growth in the global food supply led by the world’s
temperate-industrial breadbasket; falling real food prices in world markets (with a
few blips); and the tight linkage between rising meat consumption and rising
affluence. The exultation of this last trend is also related to a view of nutrition that
frames the increasing share of meat and livestock derivatives in overall diets, and
especially protein intake, as a significant aspect of ‘improved’ diets.

However, the celebrated efficiency of industrial capitalist agriculture must also be
seen to depend on an array of un- and undervalued costs. Some of these costs can
be easily ignored and externalized, without posing a threat to the operative logic of
the system. These include: the contribution to chronic epidemiological problems
(e.g. obesity, cardiovascular disease) and the extensive burden on health-care sys-
tems;¹ the costs of managing and responding to disease threats such as swine and
avian flu, listeriosis, E. coli and mad cow; the diffuse impacts of fertilizer, chemical
and other waste runoff from industrial monocultures and factory farms on terrestrial
and aquatic ecosystems and human health; the associated costs of water treatment;
an assortment of workplace health concerns (e.g. high rates of repetitive stress and
accidental injuries); the psychological violence associated with factory farms and
industrial slaughterhouses; chemical-laden environments; and the immeasurable
suffering of rising populations of animals reared in intensive confinement, along
with the unquantifiable ethical issues that this entails.

Other externalized costs, however, are deeply contradictory in that they mask
the deterioration of the very biophysical foundations of agriculture. These include
the undervaluation of the damage associated with: soil erosion and salinization; the
overdraft of water and threats to its long-term supply; the loss of biodiversity
and crucial ‘ecosystem services’ (e.g. pollination, soil formation); and greenhouse gas
(GHG) emissions. In addition, there is a failure to account for the intractable
dependence of industrial methods upon a finite resource base, particularly fossilized
biomass. All of these biophysical contradictions – or sources of long-term instability
– are magnified by the increasing intensity and volume of livestock production.
Because so much usable nutrition is lost in cycling feed through animals,

¹ The erosion of nutritional quality within industrialized food systems starts, in a biophysical sense,
from the level of the simplified soils (Pollan 2008a). However, the systemic dynamics underpinning
the proliferation of unhealthy foods run far beyond the logic of on-farm production and into the
complex webs of industrial food refining, irradiating, preserving, reconstituting, packaging and
marketing, all ‘organized around the objective of selling large quantities of calories as cheaply as
possible’ (Pollan 2008a, 121). As Pollan (2008a, 122) puts it, the net result of ‘a diet based on quantity
rather than quality’ is to have ‘ushered a new creature onto the world stage: the human being who
manages to be both overfed and undernourished’.
agriculture’s ‘footprint’ in the landscape necessarily expands as per capita meat production rises beyond the densities of small integrated farms and non-cultivatable pasture, as does the use of energy and agro-inputs (Weis 2007). An expanding ‘ecological hoofprint’ is thus implicated in the loss of forests, grasslands and wetlands, which has a major impact on the carbon cycle, both in the release of carbon as diverse ecosystems are converted to agriculture, and in the diminished capacity for carbon sequestration. The world’s livestock population is also a leading source of two other GHGs, methane and nitrous oxide, which are much smaller by volume than carbon dioxide but more potent per unit. When this atmospheric burden is aggregated, the growth in global livestock population emerges as one of the largest contributors to climate change (Steinfeld et al. 2006; IPCC 2007a; McIntyre et al. 2009), which again fails to register in the conventional conception of productivity.

Externalities might also be understood as a vast series of implicit subsidies to cheap industrial food. Added to these are the massive explicit subsidy regimes supporting industrial farmers in rich countries. Together, implicit and explicit subsidies have enhanced the competitiveness of industrial capitalist agriculture relative to more labour-intensive agricultural systems, reducing the prices earned by small farmers in many parts of the world. This has also heavily influenced the highly imbalanced character of global food security, in particular the centrality of a very narrow temperate base of major net exporters of industrial grains, oilseeds and livestock products, and the deep import dependence of the world’s poorest nations upon cheap basic foods (Rosset 2006; Weis 2007).

The hegemonic power of industrial capitalist agriculture is further augmented by the control of transnational corporations (TNCs) over surplus value and decision-making. The growth and consolidation of agro-input TNCs (chemicals, fertilizers, seeds and animal pharmaceuticals) and agro-food TNCs (processing, distribution and retailing) have reduced options for both farmers and consumers. Agro-food TNCs have been particularly powerful not only in a material sense but at an ideological level, transforming dietary aspirations and cultivating strong brand loyalties. Here, commodity fetishism weighs heavily. That is, as food is progressively transformed into a highly branded, packaged and de-spatialized commodity, and severed from time, space and culture (or season, landscape and meaning), it shifts for many into the moral unconscious. Modern supermarkets teeming with ‘pseudo-variety’ are the cathedrals of this mystification (Weis 2007).

In short, the deceptive efficiency of industrial capitalist agriculture and its manifestation in cheap, bountiful food have long overshadowed the instability and

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2 To understand the environmental burden and social inequalities associated with rising livestock production, it is important to distinguish between grass-fed and cereal-fed production, the former which has largely maxed out and the latter which is soaring. While much of the world’s pastureland cannot be cultivated, a case for re-naturalizing some portion of this can be made on the grounds of its historic and ongoing implication in deforestation, desertification and reduced carbon sequestration capacity. If livestock were predominantly reared on some portion of non-cultivable land, small mixed farms and in pasture rotations, and not fed its current large share of the world’s cereal and oilseed production, meat consumption would be radically reduced towards its historic place on the periphery of human diets.

3 The per unit warming capacity of methane (where global ruminants factor significantly) is 21 times greater than that of carbon dioxide; nitrous oxide (of which livestock is the leading anthropogenic source) is roughly 300 times greater.
inequalities of the system. This illusion has begun to crack, with dramatic price volatility in world markets since 2005 and the draw-down of global grain stocks, with even The Economist declaring on its cover that a new era had begun, what it called ‘The End of Cheap Food’ (8 December 2007). However, this does not mean that the operative logic of the system has yet been destabilized. In fact, on the contrary, aggregate industrial grain, oilseed and meat production have continued to rise slowly, in spite of severe recent droughts in some of the world’s temperate heartlands, and new market pressures are actually emboldening the dominant actors in the short run.

This paper suggests that although industrial capitalist agriculture is simultaneously deeply implicated in and threatened by climate change, soil degradation and the over-exploitation of water, the most proximate factor affecting recent global food price volatility is the looming scarcity of fossil energy, which is generating pressures on both supply and demand for global grains and oilseeds. The immediate fallout has been utterly regressive: continued profitability for agro-TNCs and industrial farmers amidst food rioting, fast-rising import bills for many of the world’s poorest countries and a significant rise in global malnourishment. Beyond this, a period of acute instability looms, potentially for much worse but also potentially for better. As in all systemic crises, there is hope that seams for radical change can widen.

To explore this hypothesis, it is necessary to start with the basic biophysical problems posed by industrial scale in agriculture and how they are overridden.

INDUSTRIAL SCALE AND BIOPHYSICAL OVERRIDES

As a general rule, industrial economies of scale depend upon the standardization of production, the breaking down of work into smaller, more regular tasks, and the substitution of labour with technology wherever possible. A central tenet of capitalist economics is that economies of scale are synonymous with enhanced efficiency, an assumption that has typically been accompanied by little or no attention to the central and unsustainable role of fossilized biomass – ancient and irreplaceable stores of solar energy – and the impact that its combustion has on the carbon cycle and ultimately the atmosphere.

On a global scale, oil, natural gas and coal account for four-fifths of the total primary energy supply (for production, household/domestic use and transportation), with oil the most pivotal. Oil provides more than one-third of the world’s primary energy and virtually all of the liquid fuel that powers transportation systems (Heinberg 2005; IEA 2008). The failure to account for the atmospheric burden associated with fossil energy, and its impact on the Earth’s climate system, represents

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4 Global grains stocks fell by roughly 50 per cent in less than a decade, from a 115 day supply in 1999 to a 53 day supply in 2007. Global grain stocks refers to the total volume stored by national governments around the world, as a percentage of annual consumption translated into days, and this is seen as an indication of food security in case of a productive crisis.

5 Where the scale of this dependence is acknowledged within conventional economic paradigms, it tends to be accompanied by an unbridled optimism about how ‘human ingenuity’ can overcome resource limitations, sometimes to fantastical ends (York et al. 2009). The case of biofuels, as will be seen, presents a notable related example.
one of the most fundamental biophysical contradictions of industrial capitalism.6 The relatively cheap price of oil has been further subsidized by the US military–industrial complex,7 various military and political interventions and enduring tensions, such that both industrial scale and the compression of time and space might be described as having a great ‘geopolitical externality’.

Agriculture poses particularly difficult problems for industrial-scale production. Though farmers have long wrestled with declining soil fertility and problems posed by insects, weeds, fungi and diseases, the biological simplification and standardization needed for industrial production magnifies these problems and necessitates the chronic use of a range of biophysical overrides, or what amount to perpetual short-term ‘fixes’. Soil degradation has had widely destabilizing impacts through history; as Montgomery (2007, 81) puts it, ‘neglect of the basic health of the soil accelerated the downfall of civilization after civilization’. However, an array of industrial dynamics have dramatically increased the magnitude and pace of soil degradation, such as: the use of ever larger and faster machines in ploughing, planting, spraying and fertilizing; the over-irrigation of land; the reduction of ground cover between rows; and declines in practices of fallowing, as time horizons shorten and livestock is moved from pastures into factory farms to expand and intensify its production. These soil problems get larger still, given how the land space needed for agriculture grows with the expanding ecological hoofprint.

The problem of soil mining in industrial capitalist monocultures has primarily been overridden by the application of external sources of nitrogen, phosphorous and potassium (McKenney 2002). The loss of nitrogen is the most crucial limitation, and its fix has depended on the natural gas based manufacture of synthetic fertilizer, through the famous Haber–Bosch method of combining atmospheric nitrogen and hydrogen.8 Synthetic nitrogen fertilizer represents nearly 60 per cent of all fertilizer consumed in the world, and more than half of this is devoted to cereal crops (Gilland 2002). The manufacture of synthetic nitrogen fertilizer alone is a major source of total energy consumption and GHG emissions (both carbon dioxide and nitrous oxide) in industrial agriculture. The fix for phosphorous and potassium loss is based upon fossil fuel powered phosphate ore and potash mining, with extraction and refining processes generating considerable further environmental costs (McKenney 2002),9 while the phosphorous fix hinges on a finite supply. The

6 Though, as Foster (2009, 46) insists, it is still ‘essential to understand that this is only one part of what we call the environmental crisis’.
7 The US, with less than 5 per cent of humanity, consumes roughly a quarter of the world’s oil and spends as much on its military as does the rest of the world combined, with extensive, military bases positioned around the world’s large oil reserves (Harvey 2003; Foster et al. 2008).
8 Natural gas is the predominant, though not exclusive, energy source for this process. In addition to overcoming the soil mining practices of industrial agriculture, a big advantage of using inorganic fertilizers is that nutrients are released and absorbed by plants faster than many organic sources such as crop residues and weeds, which helps to provide a fairly consistent yield response, contingent on rainfall or irrigation.
9 Technological advances have reduced the release of airborne contaminants (especially fluorides) once associated with the manufacture of phosphate fertilizer, but large volumes of slurry continue to be generated for every unit of fertilizer produced. This ends up in highly acidic and toxic wastewater ponds, destroying immediate environs and posing leaching risks. Phosphate fertilizer production has also generated contaminants such as selenium and cadmium, which threaten ecosystem health through bioaccumulation. Potash mining is associated with some open-pit wastelands, well-water contamination (increased salinity) and risks of land subsidence from large underground mines.
energetic and atmospheric costs from fertilizer manufacture are augmented by the energy needed to transport a bulky product from factory or mine to field and to apply it across wide areas. The soaring application of inorganic fertilizer has been fundamental to the tremendous yield gains in industrial agriculture, with the rate of growth in fertilizer consumption dwarfing the rate of growth in yields since the mid-twentieth century (Brown 1996). Further, the rates of yield gains were much greater in the 1960s and 1970s, and began slowing down while fertilizer inputs were still growing (this ‘exhaustion’ of Green Revolution yield gains is used as an argument by advocates of genetic modification).

Biological simplification and standardization also increase vulnerability to the spread of pests, weeds, fungi and disease, which are most efficiently overridden by insecticides, herbicides and fungicides, many derived from petrochemicals. The chemical fix for industrial agriculture has routinely led to a treadmill of dependence as resistance develops, natural controls diminish and more or new inputs are applied. It is also connected to the loss of much localized and shared biological knowledge in farming, and its displacement by the intellectual property of agro-input TNCs. As with the fertilizer fix, the long-term rates of growth in global chemical consumption exceed the rates of growth in plant yields.

Another crucial dimension of the mechanization-driven need for biological simplification and standardization is the physical separation of crops and animals, the ascension of factory farms over integrated, small-scale animal husbandry, and the cycling of rising volumes of grains and oilseeds through growing livestock populations. Profit-making opportunities in value-added commodities, together with the assumptions about meat and modernity noted earlier, have stoked the ‘meatification’ of human diets. The average person today consumes 75 per cent more meat than a half-century ago. While this conceals huge disparities, it nevertheless reflects a less commonly recognized population explosion: livestock, which has long dwarfed human population growth. Roughly 90 per cent of the world’s total volume of animal flesh comes from pigs, chicken and cattle, with the share of the world’s pig and chicken meat raised in intensive confinement rising sharply in recent decades. Because global livestock populations now far exceed stocking capacities on rangelands and pasturing on small, integrated farms, the continuing meatification of diets cannot happen without the continued growth in factory farming and the cycling of industrial grains and oilseeds through livestock (Nierenberg 2005; Steinfeld et al. 2006; Weis 2007).

Rising industrial livestock populations also command a large energy budget, both directly and indirectly. The direct energy budget includes the controlled environments of factory farms and the rising scale of slaughterhouses and processing plants, though here the extent of fossil energy consumption is not qualitatively

A dimension of this, albeit difficult to quantify, relates to the magnified vulnerability to disease and behavioural neurosis associated with the intensification of livestock rearing, and how this is overridden by animal pharmaceuticals and brute violence (e.g. de-beaking, tail docking etc.), with some drugs and especially hormones contributing to enhanced yields. This pharmaceutical fix, like the fertilizer and chemical ones for large monocultures, also raises problems of a treadmill effect and downstream externalities, as does the burden of concentrated faecal waste from factory farms and corporal wastes from large-scale slaughterhouses. While these chronic impacts on ecosystem and human health are largely externalized in the costs of production, as noted earlier, they can be seen
different than other industrial sectors: it depends on the composition of a given energy grid (and could conceivably be substituted by different point-source energy forms). The indirect energy budget relates in large part to the ecological hoofprint noted earlier, and the fact that additional land must be given to industrial monocultures in order to cycle feed through livestock, with high rates of nutrient loss in the process. When all of the fossil energy in production is added together, it has been estimated that a unit of protein from factory-farmed meat requires eight times more energy inputs than a unit of protein from industrial grain (WorldWatch 2004; Nierenberg 2005). Pollan (2006) provides an evocative way of conceptualizing this, suggesting that a grain-fed steer in the United States will effectively consume almost a barrel of oil in its lifetime.

Finally, the separation of communities from agricultural systems and the centralization of control in large corporate intermediaries requires that the previously heavy friction of distance for most foods is overridden, which entails more undervalued energy costs. Cheap oil has obviously been central to this, allowing rising ‘food miles’ from field to plate. Another underappreciated dimension of the energy budget of industrial food as finished commodities is the extreme dependence of animal flesh and derivatives upon both mobile and \textit{in situ} refrigeration units.

In sum, in order to simplify, standardize and mechanize agriculture, and increase productivity per worker, plant and animal, a series of biophysical barriers must be overridden. Efficiency gains therefore hinge on many unaccounted, non-renewable and actively destructive fixes, with fossilized biomass having an indispensible role in this process. While it involves a complex calculation, one common estimate is that industrial agriculture requires an average 10 calories of fossil fuels to produce a single calorie of food (Manning 2004; McCluney 2005; Pollan 2008b), which grows further in the case of industrially reared livestock flesh and derivatives. Rising attention to this essential dependence is reflected in a number of recent eye-catching titles, such as ‘Eating Oil’ (Jones 2003), ‘The Oil We Eat’ (Manning 2004), \textit{Eating Fossil Fuels} (Pfeiffer 2006) and \textit{Soil Not Oil} (Shiva 2008). Best-selling author Michael Pollan (2006, 83) has also highlighted the geopolitical externality in this, noting that the system is ultimately ‘defended by the US military, another never-counted cost of cheap food’, given that ‘one-fifth of America’s petroleum consumption goes to producing and transporting our food’.

It is difficult to project precisely how long the biophysical overrides and externalized environmental burden of industrial capitalist agriculture might persist. Though it is clear that we are fast approaching the period when increasing awareness about the scarcity of fossil energy begins to drive rising costs, which will inevitably destabilize the prevailing conception of efficiency, this cost pressure is complicated in the short term by the countervailing demand pressure of biofuels. At the same time, the indefinite persistence of these overrides and the perpetuation of the system itself is a major factor committing the world to more severe climate change impacts, at a time when the window for mitigating the worst impacts is fast closing.

as implicated in an additional energy budget to the extent that they must be managed at some point (e.g. in water treatment facilities).
ACCELERATING CONTRADICTIONS

Fossil Energy Limits and the Centrality of Industrial Agriculture

While debates persist about whether the world has yet to reach the halfway point in the total consumption of the world’s oil reserves, or has already reached it, the fact that conventional oil production will soon peak is now widely accepted (Monbiot 2008). The essential concerns of ‘peak oil’ remain the same: easy-to-recover (i.e. low-cost) oilfields have all been discovered (most before 1980) and are declining quickly; the extraction of the remaining reserves will be increasingly difficult, costly and energy intensive; and the second half of the world’s oil supply will be consumed a lot faster than was the first half (Heinberg 2005). The Alberta Tar Sands in Canada are a classic example of this rising dependence on harder-to-extract oil (Clarke 2008). Peak oil is also stoking offshore oil exploration, as well as the new scramble for Arctic sovereignty, perversely heightened by the prospect that the melting of the polar ice cap could expose more areas for oil and natural gas exploration and extraction. Supply pressures are amplified by projections of population growth towards 8 billion people by 2025 and 9 billion by 2045 (UN Population Division 2008), and of rising demand. The US Energy Information Administration (EIA 2009a) forecasts that total global marketed energy will increase by 44 per cent from 2006 to 2030.

As noted, fossil energy currently generates roughly four-fifths of the world’s total primary energy supply, with oil the largest and most indispensable source. Leading industry authorities estimate the world’s proven oil reserves to be between 1.18 and 1.34 trillion barrels. By 2030, total world oil consumption is projected to be 106–7 million barrels per day (bpd), a 25 per cent increase from 2006 (IEA 2009; US EIA 2009a), which largely reflects demand from elites and middle classes in emerging economies as they approach the unsustainable lifestyles and automobility of the industrialized world. Although there are uncertainties about total reserves, future demand and future discoveries, the spectre of peak oil is clear. Even if present rates of consumption were held constant and set against the higher estimate for

11 The Tar Sands, which are now the second largest recoverable reserve of crude oil in the world, depend upon a very expensive extractive process that made little economic sense in the past, even under conventional cost accounting that barely registers the environmental burden. In addition to the deforestation, soil removal, huge tailings ponds, the diversion and pollution of vast freshwater resources, downstream health impacts and GHG emissions, there is the prospect of nuclear-powered steam generation to facilitate extraction. Thus, while the extent of the reserves has been well understood for decades, large-scale development has been recent, contingent on the prospect of high oil prices and abetted by sizable government subsidies (Clarke 2008). The Obama administration initially appeared reticent to support their expansion, given the professed commitment to taking action on climate change, but in August 2009 committed to build a major pipeline from Alberta to the US Midwest.

12 The US EIA (2009b) provides a useful summary table, drawing from the BP Statistical Review of World Energy, the Oil & Gas Journal and World Oil.

13 At present, roughly three-quarters of the world’s automobile fleet is in the developed world. While fuel efficiency is bound to improve with innovation and increasing regulation, efficiency gains must be set against the expectation that the world’s automobile fleet will continue to grow significantly in absolute terms. Dargay et al. (2007, 28) suggest ‘that the future strong growth in the vehicle stock in developing countries will lead to significant increases in oil demand from the transport sector’, led by countries such as China, India and Brazil, with China expected to be the world’s largest automotive market by 2030.
proven reserves, those reserves would last little more than four decades. Given that annual consumption levels have long far outpaced new annual discoveries, it is improbable to foresee future exploration extending this much further save for the possible discovery of new fields exposed by polar melting, which would signal a climatic catastrophe. Thus, while short-term volatility is likely to persist given the short-sightedness of global markets, the rising cost and ultimate supply limits to oil and its derivatives are inescapable.

This will have sweeping impacts on virtually all aspects of the global economy, posing colossal and complex challenges for energy generation in production, households and transportation. However, the problems posed by peak oil are less immediately destabilizing to point-source energy generation within the framework of conventional cost accounting. One reason for this is that the natural gas ‘peak’ is projected to be a few decades further away than with oil, and coal further still, while the climatic burden of coal continues to be largely externalized (if climate change mitigation was a priority, then coal – by far the worst form of energy generation from an emissions perspective – would be immediately and sharply reduced, placing great stress on energy grids). The revival, rebranding (as climate-friendly energy) and expansion of the global nuclear industry into new markets such as China and India, is another important dynamic in energy grids. However, with only 6 per cent of the world’s primary energy supply at present (IEA 2008), many dated reactors scheduled to come off-stream in the coming years, and the long-run constraint of a finite uranium supply, this potential should not be overstated (Harvey 2010). Hydropower is a durable source of electricity, though with most of the best resources already developed, the prospects of significantly increasing its scale are also limited and could only come with enormous social and ecological costs, seen vividly in cases such as the Three Gorges in China and Narmada in India. But with respect to point-source energy generation, there are at least many hopeful possibilities with established technologies, such as tidal and massive, well-positioned solar and wind farms (e.g. deserts, offshore), as well as the large potential of dispersed small-scale solar, wind and geothermal, and the similarly large and relatively easy gains in conservation through a more efficient built environment and urban form (Harvey 2010).

The problem of replacing oil in transportation is much more difficult and pressing. As the lifeflight of global transportation systems, oil is central to the compression of time and space. Thus, the increasing friction of distance in the age of peak oil raises momentous questions for the projection of geostrategic power, trade, travel, tourism (the world’s biggest industry) and remittance-dependent economies. This problem has been reflected in intense struggles to control the world’s remaining oil reserves (Harvey 2003), and is increasingly evident in the desperate search for new liquid fuels.

Coal maintains a central place within many energy grids, including in the US, China and India, and is expected to grow significantly in the latter two countries in the coming decades (Cowhig 2007). As with oil, rising consumption of natural gas and coal (including potential liquefaction to compensate for oil) could push both ‘peaks’ forward.

This will also place greater pressure on innovation in electric-hybrid engines, and in turn expand the need to increase both centralized and dispersed forms of point-source electricity generation. While innovation in rechargeable batteries might address some transportation challenges, the compulsion to find a source of liquid energy is still unavoidable.
Industrial capitalist agriculture is at the centre of the challenges posed by peak oil. The first and more straightforward pressure relates to the inevitably rising costs of production as crucial biophysical overrides become more expensive. The increasing friction of distance will, of course, affect all productive sectors dependent on long-distance flows of inputs and outputs. However, alternative forms of point-source energy generation could conceivably maintain the operative logic of industrial capitalism in other sectors much more easily than in agriculture, given how thoroughly oil is embedded in the biophysical overrides discussed earlier. As the long-term increase in the price of oil is reflected in rising production and transportation costs, it will in turn reverberate in rising food prices. This supply-side pressure was seen clearly amidst the global food price spikes between 2005 and 2007, when there was a relatively parallel movement between indexes of fertilizer and oil costs and of food prices (FAO 2008a).

The second pressure stems from the fact that industrial grain and oilseed production is increasingly positioned as a partial and ‘renewable’ fix for the looming crisis of liquid fuel as oil reserves decline.

The Biofuel Boom

Their advocates generally present biofuels as both ‘green’ and enhancing ‘energy security’. The promise seems plain: plants capture solar energy and sequester carbon on a renewable basis, and that energy can be converted into liquid form and then combust more cleanly, releasing the accumulated carbon. The biophysical budget of industrial biofuels is, however, far more complex, and the scale at which this might substitute for oil is extremely limited. To help contextualize the scale of substitution that is possible, at a basic level, it is helpful to remember that fossil fuels are ancient stores of solar energy, accumulated and compacted across millennia, and that the energy contained in the annual combustion of fossilized biomass far exceeds the annual net primary production of all plant biomass (i.e. the chemical energy derived by photosynthesis not used in respiration) (Dukes 2003; Field et al. 2008).

The dominant biofuels today are ethanol and biodiesel. Ethanol, a form of alcohol produced from the fermentation of carbohydrates, is the largest. The two primary sources of ethanol are maize and sugar. Until recently, Brazil (with sugar) was by far the world’s leading producer by volume, dating to an earlier energy crisis, but the USA (with maize) took over top position in 2006 and had a major role in the tripling of world ethanol production between 2000 and 2007 (FAO 2008b). Biodiesel is typically derived from a chemical reaction between edible oils (e.g. rapeseed/canola, soy, sunflower and palm) and an alcohol, and while much smaller than ethanol by volume, it is growing at a fast pace.16

Beyond current sources of ethanol and biodiesel, there is also what is known as ‘second-generation’ biofuels, which are not yet commercially viable. The key to second-generation biofuels is the development of enzymes that can efficiently

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16 Low-ratio blends of both ethanol (with gas) and biodiesel (with diesel) can power standard engines, while high ratios require modifications or special engines. Biodiesels can generally be blended at 20 per cent (B20) without problems. E85, dubbed a new green ‘flex fuel’, and 100 per cent biodiesel (B100), are both becoming more common.
convert plant cellulose into ethanol, and allow liquid fuel to be derived from a wider range of source materials, such as some non-edible grasses, woody biomass, straw and some ‘wastes’ from food crops. In addition to expanding the scale of potential biomass inputs, this could reduce competition with food crops, require less biomass and energy in refining per unit output, enable the use of permanent crops, and in turn reduce ploughing and erosion and enhance soil-based carbon (World-Watch and CAP 2006). While second-generation biofuels hold some promise, there are still many uncertainties about their potential energy budgets, timelines and possible scale, and the extent to which they might coexist with conventional (or ‘first-generation’) biofuels rather than displacing them, particularly given the enormous capital recently invested in conventional ethanol refineries. According to the Renewable Fuels Association (RFA n.d.), there were 170 bio-refineries in operation in the USA in 2009, more than double the 2005 number and triple that for 2000. It seems probable that for at least another decade and possibly beyond, the biofuel boom will be centred upon first-generation biofuels. Reflecting this, the FAO (2008b) projects a doubling of both global ethanol and biodiesel production by 2017.

This boom is occurring in spite of the increasing understanding of very poor biophysical budgets. That is, when the fossil energy used in producing and transporting inputs, running farm machinery and irrigation systems, transporting grains and oilseeds, and processing the biofuels are all aggregated – and set against the energy contained in biofuel outputs – the balance is invariably at best thin, at worst negative. For most forms of biofuel production the input yield ratio is negative, in many cases wildly so, meaning that more fossil energy is going in than can be replaced with biofuels (Pimentel and Patzek 2005; Patzek and Pimentel 2006). Though there are worse crops in terms of net energy budgets, maize is the most problematic because maize ethanol is dominant in the USA, the USA has long had a pivotal role in world maize exports, and industrial maize production demands great volumes of nitrogen fertilizer and pesticides.

The biophysical contradictions of biofuels grow worse yet. Even discounting the role of fossil energy inputs into industrial biofuel production, biofuel output per land area is low, meaning that vast areas of arable land have to be devoted to its feedstock to make even a small dint in current levels of oil consumption. Ethanol is now mixed into roughly one-third of all gas in the USA, predominantly as a 10 per cent additive (E10), which replaces only a small fraction of total gas consumption while commanding a fast-growing share of the US maize harvest (noted below). Based on output per land area, it is estimated that roughly two-fifths of all cropland in the USA and EU would need to be devoted to biofuels to substitute only 10 per cent of current oil consumption. And the prospect of transforming any more forests, wetlands and grasslands into industrial monocultures is utterly illogical from the standpoint of climate change when the immediate release of carbon and the long-term loss of carbon sequestration capacity are considered (Righelato and Spracklen 2007). Nowhere is the net negative carbon flux of deforestation-for-biofuels worse than in Malaysia and Indonesia’s destruction of tropical forests for biofuel-driven palm oil plantations. Moreover, Righelato and Spracklen (2007) argue that if reducing emissions and mitigating climate change were the driving factors (i.e. the claim that biofuels are green or ‘carbon neutral’), it would be better
to not only not expand production, but to take the land space given to biofuels and restore it to forests for carbon sequestration.\textsuperscript{17}

In short, rather than providing a partial fix for the crisis of liquid energy, the current biofuel boom is based upon an irrational biophysical budget and threatens to worsen rather than reduce anthropogenic climate change: it at once fortifies the operative logic of industrial capitalist agriculture and exaggerates its contradictions. Not surprisingly, then, leading advocates include grain–oilseed trading TNCs (e.g. ADM), agro-input TNCs (e.g. BASF), big farmer lobbies (e.g. American Farm Bureau, National Corn Growers Association), the automobile industry (e.g. General Motors) and even the oil giants (e.g. Chevron, BP).\textsuperscript{18} Some recent corporate advertisements put this push in vivid display:

\textit{ADM}. The world’s demand for energy will never stop growing. Which is why a farmer is growing corn. And a farmer is growing soy. And why ADM is turning these crops into biofuels. The world’s demand for energy will never stop. ADM will not stop. We’re only getting started.

\textit{BASF}. Thanks to BASF agricultural innovations in crop protection and plant health, farmers can expand the amount of raw materials available for alternative fuels. This generates more renewable resources for fuel producers. Plus, BASF catalyst technologies enable crops like soybeans to be converted into biodiesel fuels. That’s good news for farmers, and even greater news for drivers of the future.

\textit{General Motors}. FlexFuel vehicles are helping provide a choice. High gas prices have increased the focus on reducing our dependence on petroleum. You should have the ability to choose an alternative. GM provides that choice by offering 18 different FlexFuel vehicle models that can run on gasoline, E85, or any combination of the two. With more than 3 million FlexFuel vehicles on the road, and many more to come, GM is enabling the potential of ethanol to meet our nation’s increasing energy needs — today and tomorrow. In the U.S., there are already over 7 million E85-capable vehicles on the road. GM is the leader in E85 FlexFuel vehicles, with over 3.5 million FlexFuel vehicles on the road in the U.S. We are well on the way to meeting our goal of having half of annual vehicle production be E85 or biodiesel capable by 2012.

Learn about E85 ethanol and how GM is developing FlexFuel technology to make use of this exciting domestic energy source.

\textit{Chevron}. While biodiesel from crops could never replace conventional diesel entirely, this renewable fuel can be a bigger part of the energy mix. That’s the reason

\textsuperscript{17} Righelato and Spracklen (2007, 902) note that: ‘In all cases, forestation of an equivalent area of land would sequester 2–9 times more carbon cover a 30 year period than the emissions avoided by the use of the biofuel. Taking this opportunity cost into account, the emissions cost of liquid biofuels exceeds that of fossil fuels.’

\textsuperscript{18} The confluence of industrial capitalist agriculture and the automobile industry has another dimension that could potentially affect food supplies. In Ontario, the heart of Canada’s automotive sector, it has been suggested that as much as 100 lbs of agricultural output could be embedded as physical inputs into every car manufactured in the province (e.g. textiles, dashboard etc.), with GMOs seen as a key means to this (Surgeoner 2007).
Chevron is investing millions to help build one of the first large-scale biodiesel plants in the world.

Many governments have also jumped on the biofuel bandwagon, none more so than that of the USA. By 2005, it was estimated that the USA was providing between US$5.5bn and $7.3bn in annual subsidies to biofuel production (Koplow 2006), though precise calculations are difficult. In tallying up the extensive government subsidies and protections, Washington Post business columnist Steven Pearlstein (2006) suggested that ethanol ‘has now overtaken Manhattan real estate, derivatives trading and high-tech start-ups as the investment opportunity du jour for the smart-money set’. Governments in the EU, India and China have indicated ambitious goals for biofuel growth, and the governments of Malaysia and Indonesia are heavily implicated in the expansion of palm oil for biodiesel. In many of the world’s most food insecure countries in Sub-Saharan Africa, governments and aid agencies are holding up the biofuel potential of jatropha as a significant new agro-export hope. Monbiot (2007) helps to frame this growing state support for biofuels, arguing that it is largely ‘a means of avoiding hard political choices’ about transportation, infrastructure and the sacrosanct individual (and partly class-based) power over space that the market affords with public subsidy, even as this power is becoming increasingly unsustainable with peak oil and climate change.

Given these political blinders along with the operative economic logic, industrial biofuel production seems primed to continue growing quickly in the coming years.

The Intensifying Competition for Food, Feed and Fuel

Just under half of the world’s total grain production (48 per cent) is directly consumed by humans, while 35 per cent is fed to livestock and 17 per cent to biofuel production (Halweil 2008a). The surge in the latter two comes at time when the yield gains associated with the Green Revolution have effectively maxed out, and the volume of per capita grain production on a global scale has been level since peaking in 1986. On a global scale, arable land per capita has fallen by more than half over the past half-century, declining from 0.46 ha per person in 1961 to 0.21 ha per person in 2006 (FAOSTAT n.d.). When UN projections of population growth are set against FAO projections of land degradation, with the recognition that there is limited land space left which could be productively converted to agriculture, an obvious outcome is that arable land per capita will continue to fall.

Though this trajectory obviously threatens to intensify competition for food supplies in the future, the effective demand for grains and oilseeds as food is driven primarily by population growth, while failing to register the more than one billion malnourished people in the world. In the short term, this means that intensifying demand in world grain and oilseed markets primarily comes from biofuel and livestock production. The biofuel boom is already having a major impact on global demand for grains and oilseeds. In 2006–7 alone, when food prices were spiking, the volume of coarse grains given to biofuels increased by 15 per cent, a rise equivalent

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19 This difficulty is partly because maize is already the most subsidized crop in the USA, and also because ethanol subsidies come in a large variety of forms such as fuel tax rebates, refiner mandates, tax credits, import tariff barriers, grants and subsidized loans (Pearlstein 2006).

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to roughly half the draw-down of global grain stocks (Economist 2007; Halweil 2008a). US ethanol production grew roughly seven-fold from 1998 to 2008, during which time the share of US maize production devoted to ethanol increased from 5 to 25 per cent (RFA n.d.; US Department of Energy n.d.).

The pull of biofuels on grain and oilseed supplies is augmented by the rising demand for animal feed. One estimate is that total human meat consumption will grow to 465 million tons by 2050, a 70 per cent increase from the 2007 production level of 275 million tons (Halweil 2008b). The epicentre of this growth is China and other fast-growing ‘emerging economies’. China already produces nearly one-third of all meat in the world (FAOSTAT n.d.), has increased per capita meat consumption from 20 kg in 1980 to 50 kg today (now dwarfing the developing world average of 30 kg), and plans to approach developed-world levels in the coming decades (Nierenberg 2005; Economist 2007; Halweil 2008a). To conceptualize the demand pressure on global grain and oilseed supplies, it is important to consider not only the absolute increase in livestock populations but that this will be overwhelmingly concentrated in factories and feedlots, given the limits to further rangeland stocking densities. By far the fastest growing livestock populations in the world are poultry birds, two-thirds of which are already reared in factory-like conditions (FAOSTAT n.d.; Halweil 2008b).

Grain–oilseed trading giant ADM provides a vivid window into intensifying competition, as it now defines its various revenue streams as flowing into three major channels: food and nutrition ingredients; animal nutrition; and fuels and industrials. For industrial producers and grain–oilseed traders, the surging demand for fuel and feed is a strong counter-force to rising production costs, and both pressures point towards higher prices for basic foods – which must be juxtaposed against the extent to which global food security hinges on cheap industrial surpluses. The USA alone is responsible for more than 40 per cent of world maize production and 70 per cent of world exports, Brazil and Argentina being other key maize exporters. These three countries are also responsible for roughly 80 per cent of the world’s soybean production. Wheat exports are slightly more diversified, but still come from a very narrow base of countries such as the USA, Canada, Australia, Argentina and a small number of European countries. Conversely, in the world’s Low Income Food Deficit Countries (LIFDC) identified by the FAO, the total volume of cereal imports in 2005–7 (81 million tonnes) had almost tripled from the level of three decades earlier (29 million tonnes in 1975–7). As world cereal prices spiked between 2005 and 2007, the vulnerability associated with this dependence was plain to see: though the volume of cereal imports in the LIFDCs was slightly less in 2007 than in 2005, their cost had risen by a staggering 37 per cent, from US$15.5bn to US$21.3bn (FAOSTAT n.d.).

In short, the global class dynamics associated with rising food prices are stark, with biofuels increasingly central to this. For instance, Lester Brown calls the ‘competition for grain between the world’s 800 million motorists who want to maintain their mobility, and its 2 billion poorest people’ as something that is fast

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20 Global grain stocks declined in 2007 in spite of a record global harvest (2.35 billion tons), including a record 792 million tons of maize (FAOSTAT n.d.). Also, as industrial farmers race to plant more maize in response to the biofuel boom, this has a spillover effect on other grains, most notably wheat.

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becoming ‘an epic issue’ (in Vidal 2007). Jean Ziegler, the UN Special Rapporteur on Human Rights, was more blunt, describing biofuels as a ‘crime against humanity’. Even the head of the International Monetary Fund, Dominique Strauss-Kahn, has insisted that biofuels ‘posed a real moral problem’ and called for a moratorium on using food crops in vehicles (UNEP 2008a, in ‘Biofuels under Attack as World Food Prices Soar’).

Though the inequality associated with cycling grains and oilseeds through livestock might appear less conspicuous than with cycling them through cars, it is beginning to draw attention as well, primarily with respect to the associated atmospheric footprint. In this regard, it was notable that the Chairman of the IPCC, Rajendra Pachauri, highlighted the role of meat-centred consumption patterns as a major contributor to GHG emissions (Black 2008).

*Agriculture in the Anthropocene*

Average global temperatures are 0.7°C warmer than before the Industrial Revolution, and the scientific evidence is now such that it is ‘unequivocally’ understood that human activities are driving the warming of the Earth’s climate system (IPCC 2007a, 5). With the Earth’s climate system being pushed beyond the range of climatic variability of the Holocene, the geological era in which agriculture began roughly 10,000 years ago, it has been suggested that we are now entering a new epoch in Earth history: the Anthropocene, to mark the role of human economies in destabilizing physical processes (Crutzen and Stoermer 2000).

The uneven responsibility for, and uneven vulnerability to, climate change overarches the intensifying competition for food discussed in the previous section. At one end, the world’s wealthiest countries possess the greatest per capita atmospheric footprints, as well as being responsible for the large majority of historic GHG emissions. At the other end, many of the world’s poorest nations – with the smallest atmospheric footprints – are located in tropical lowlands and savannah regions, which are projected to be affected first and worst by problems such as hotter average temperatures, more heatwaves, increasing aridity, shorter and more variable rainy seasons, the rising frequency and intensity of extreme weather events such as storms and droughts, and salt seepage into groundwater with sea-level rise (IPCC 2007a).

Atmospheric GHG concentrations are already more than one-third greater than pre-industrial levels. These concentrations, the length of time for which GHGs (especially carbon) persist in the atmosphere, and the thermal lag associated with warmer ocean temperatures together entail a certain level of continued temperature warming irrespective of future emissions. Climate science has grown increasingly adept at reconstructing past climates and modelling future impacts within different GHG emission and concentration scenarios. Though the vast complexity of the climate system and the interplay of many changes and feedbacks means that there is inevitably some degree of uncertainty (and uneven spatiality), the IPCC (2007a) assessment is that the world is now ‘very likely’ (the official term given to a 90–95 per cent probability) already committed to a 1–2°C increase from pre-industrial global average temperatures (i.e. 0.3–1.3°C warmer than the present). At the same time, the upper end of this committed change, a 2°C increase, is widely treated as the ‘safe’ upper limit beyond which there is likely to be ‘dangerous’ changes and
positive feedbacks, or mutually amplifying effects. Climate models project that without urgent (now measured in years rather than decades) and large-scale emission reductions, atmospheric GHG concentrations will soon approach levels that would drive more ‘dangerous’-scale warming.\textsuperscript{21}

Making this even more worrisome is the fact that the targets for what is ‘safe’ or ‘dangerous’ GHG concentrations and average warming are partly based in science, partly in politics. Many leading climate scientists suggest that the level of changes and positive feedbacks associated with a 2°C degree warming are far from ‘safe’ (Ackerman 2009). Further, while sceptics have long fixated on modelling uncertainties, many empirically measurable changes are near or exceeding the higher-end projections, such as the decline in mid-latitude glaciers (with profound regional impacts on water availability in parts of Latin America, Africa and Asia), in the Greenland and West Antarctic ice sheets, and in the Arctic Sea ice mass, with polar melting having potentially disastrous positive feedbacks and implications on a global scale.\textsuperscript{22}

As noted, the range of already committed changes looms most ominously for many poor countries. For instance, the IPCC reports that drought intensity began worsening with climate change in the late twentieth century in parts of Africa, including in the Sahel and southern African regions, and highlights some frightening near-term projections for Africa. These include a dramatic increase in water stress and decline in ‘the area suitable for agriculture, the length of the growing seasons and yield potential, particularly along the margins of semi-arid and arid areas’, with a warning that by 2020 as many as 250 million Africans could face intensified water stress and that yield reductions in some areas could be in the order of 50 per cent (IPCC 2007b, 10).\textsuperscript{23}

In spite of this, one way that inaction on emission reductions is rationalized is through the hope that climate change might enhance agricultural productivity in temperate regions to compensate for declines elsewhere. The essential hypotheses are that warming temperatures will allow earlier plant dates with reduced frost risks, extend temperate growing seasons and push arable lands northwards towards the Arctic. A more complex hypothesis is that increased atmospheric CO\textsubscript{2} could lead to the more efficient use of water and heighten the photosynthetic rate in crops.

\textsuperscript{21} Atmospheric GHG concentrations are measured in terms of CO\textsubscript{2}-equivalents, or the concentration of CO\textsubscript{2} that would have the same climate impact as all GHGs combined. The CO\textsubscript{2}-equivalent in 2005 was 379 ppm, compared to the pre-industrial level of roughly 280 ppm. The IPCC’s ‘safe’ maximum is 450–499 ppm, while models indicate that the dreaded ‘doubling scenario’ versus pre-industrial levels will drive an average planetary warming of 3°C (within a range of 2–4.5°C).

\textsuperscript{22} The positive feedbacks in the high latitudes are especially potent. These include: the reduced albedo (and solar reflectivity) of the Earth’s surface as water and land are exposed by melting ice; the thawing of permafrost and release of large stores of frozen carbon and methane; and the weakening of thermohaline circulation (the ‘ocean conveyor belt’), which is driven by Arctic sea ice and is an important physical control on climate.

\textsuperscript{23} Investment in water conservation and distribution might have reduced (and might still reduce) some of the vulnerability to rainfall variability in Africa, but the long-term underinvestment and rundown of such infrastructure is one of the many legacies of debt, adjustment and austerity. However, there are deep concerns that changes in temperature and moisture across large areas of the continent could soon exceed the range within which plant physiology can respond, irrespective of any such investment.
However, there are other indications that these potential gains could be cancelled out, or worse, by an array of other changes in temperate regions. Warmer temperatures could enhance the survival of pests and pathogens in winter and change their dynamics and range, generating new and unexpected threats. Increasing temperature variability could negatively affect critical germination or flowering periods, and speeding growth cycles could actually result in less time for the food portions of cereal crops to fill out. Additionally, already severe erosion problems in industrial monocultures would be magnified by heavier and more intense precipitation and wind events, while greater intensity and frequency of heatwaves and droughts would increase evaporation, reduce soil moisture, and place greater water and heat stress on livestock and crops in some areas (Howden et al. 2007; Schmidhuber et al. 2007; Tubiello et al. 2007). With respect to the latter point, the IPCC (2007b, 11) projects that ‘by mid-century, annual average river runoff and water availability are projected to . . . decrease by 10–30 per cent over some dry regions at mid-latitudes’. In the case of the US Midwest, the world’s most important grain-producing and exporting region, the threat of water stress is magnified by the long-term draw-down of the Ogallala reservoir, what Opie (2000, 326) calls ‘an unrepeatable and irreversible experiment in continuous depletion’. In short, though many projections suggest that net agricultural productivity in temperate regions would not be destabilized within the range of already committed warming, there are still tremendous uncertainties about responses.

Further, the ‘northward expansion’ of agriculture into the Boreal can only be seen as a dangerous chimera. While temperatures are projected to become more suited to agriculture in higher latitudes with climate change and the barriers of acidic soils might potentially be overridden by a chemical fix, any productivity gains would rest on clearing some of the last great frontier forests in the world. This would entail a very dangerous climatic impact, both in the release of carbon and in the loss of sequestration capacity (to say nothing of habitat loss and the impacts on other species).

Thus, the range of already committed warming is poised to intensify the competition for food, feed and fuel in a terribly regressive way. Even in best case and highly optimistic scenarios for climate change and agriculture – which start from quick emission reductions and stabilization of atmospheric GHG levels emissions relatively close to present levels – many of the world’s poorest countries face the most severe threats to their agricultural systems, which threatens to magnify their already significant dependence on the world’s temperate breadbasket regions. At the same time, the danger of worst-case scenarios with abrupt and irreversible changes increases in likelihood so long as industrial capitalist agriculture continues on its current course, as a result of its large atmospheric footprint.

24 A number of major grain-producing areas, including Australia, Argentina, Canada and the Punjab in India, have been adversely affected by drought in recent years, highlighting the great risks associated with projections of increasing heat and water stress in temperate regions. Australia, one of the world’s largest wheat exporters and a key supplier to Asian markets, suffered from severe drought in 2006, which was described as ‘a frightening glimpse of the future with global warming’ by the premier of South Australia (AAP 2006) and ‘a disaster unprecedented in Australian history’ by the head of the Australian Horticulture Council (Wahlquist 2007).
THE PRECIPICE: MORBID SYMPTOMS AND THE CORPORATE ‘FIX’

Have you seen what’s happening down on the farm? In case you’ve missed the fun, these are boom times for farmers, and for companies that sell them the inputs they need to grow crops like corn, wheat and soybeans . . . All Star Fund Trader recommends buying the MOO [Market Vectors Global Agribusiness Exchanged-Traded Fund] insisting ‘This is a pure play on the red hot agriculture space . . .’ (Dobosz 2008, Forbes.com)

It’s a system that’s perfectly happy to leave hundreds of millions of people unfed. (Darrin Qualman, National Farmer’s Union – Canada, in Leahy 2006)

The crisis consists precisely in the fact that the old is dying and the new cannot be born: in this interregnum a great variety of morbid symptoms appears. (Gramsci 1971, 276)

This paper has argued that while the accelerating biophysical contradictions of industrial capitalist agriculture constitute a crisis of potentially catastrophic proportions, they are not yet destabilizing the operative logic of its dominant actors. On the contrary, industrial capitalist agriculture has been reinforced as demand pressures for industrial grains and oilseeds associated with the biofuel boom and the continuing metatification of diets are trumping the cost pressures from peak oil, while climate change has so far spared aggregate levels of productivity. For an indeterminate period, then, we can expect the dominant actors to attempt to manage the system in some nuanced form of the status quo (through technology, legislation, more coercive labour regimes etc.), as biophysical problems and inequalities intensify, producing ‘a great variety of morbid symptoms’. The Forbes.com stock report from 2008 quoted above – from around the time of widespread food rioting, desperate appeals by the World Food Programme that aid dollars were buying less food and evidence of rising levels of malnourishment – provides one clear indication of how the productive logic remains as yet unshaken. Rather than crisis, these remained ‘fun’ and profitable times for industrial farmers, grain–oilseed trading TNCs and agro-input TNCs, as well as providing financial capital with seemingly safer investment opportunities amidst turbulent capital markets.

Within the world’s Low Income Food Deficit Countries, there is a tragic confluence of vulnerability to food price rises and the most immediate climate-related threats to production. The dependence upon cheap surpluses from global breadbasket regions, which has long been cultivated by the deceptive measures of efficiency discussed earlier, is bound to become more expensive as the pressures from peak oil and the intensifying demand for fuel and feed all unfold.25 The problem of hunger, as Qualman (above) suggests, simply does not appear within the operative logic of the system. Someone putting corn into their car clearly has more effective demand than someone on the edge of malnourishment or starvation.

25 The rising cost of food aid also affects its availability. In 2007, the World Food Programme issued warnings that it could not afford enough supplies for disaster relief with a constant budget amidst rising prices, while the volume of food aid contributed by the USA (the world’s largest bilateral donor) has fallen by half since 2000.
The challenges associated with climate change can be framed according to two basic, interlocking imperatives: mitigation and adaptation. The most immediate and fundamental challenge is to mitigate the magnitude of change, primarily through immediate, very large reductions in GHG emissions. These are, for now at least, deemed politically impossible, while grossly watered down or lengthened targets get debated and negotiated multilaterally (Ackerman 2009). The second challenge, largely contingent on the extent of mitigation, is to adapt to the hotter and more variable climate that the world is already committed to. Here, there is a great risk of exaggerating human ingenuity and the capacity to engineer solutions, thereby capitulating to the prevailing political inertia and the false belief that it is more ‘realistic’ to manage the impacts than to make significant emission reductions. The promise that genetic modification might create heat- and drought-resistant crops, and provide a partial fix for climate change in Africa (what some have called the ‘poor-washing’ of GMOs), is one example of how excessive faith in adaptation might be used to help absorb action on mitigation. There is clearly good reason to fear that the diffuse, uneven and future costs of climate change will continue to be largely externalized, without destabilizing the operative logic of industrial capitalist agriculture, even if this guarantees ever more difficult and extensive adaptation challenges over time.

The more proximate threat to this operative logic stems from peak oil, given how crucial fossil energy and derivatives are to the biophysical overrides to scale and distance, and to the substitution of technology for labour in agriculture. This is bound to drive the search for a range of risky technological fixes – for example, increasing genetic modification of plants and animals, new chemical approaches to bolster soils and contain undesirable species, and methane-capturing and -burning factory farms – as well as more benign ones such as solar-, wind- and battery-powered farm machinery. The problem of labour substitution might also lead to a more simple ‘fix’: re-substituting human labour for technology and intensifying its exploitation. The growth of large-scale organic farms in places such as California provides one glimpse of how a more ecologically sustainable but highly unequal system might take shape if corporations and large landowners drive a de-industrialization of agriculture, and are able to dominate a low-paid, non-unionized and highly insecure workforce. Here, it is worth highlighting how agricultural labour is already described as a ‘“super-exploited’” segment of the US working class’, with high levels of poverty amongst working people and many lacking immigration status and prospects (Majka and Majka 2000, 163). It is not hard to imagine how the growing global population of environmental refugees, expected to intensify depending upon the severity of climate change, could fit into such a scenario.26

Yet however capitalist agriculture might be reconstituted beyond fossil energy – in a world in which roughly one in seven are already malnourished, the class-based

26 The United Nations describes an environmental refugee as a ‘person displaced owing to environmental causes, notably land loss and degradation, and natural disaster’. According to the UN High Commissioner for Refugees, climate change and rising food prices led to an increase in the global population of refugees (to 11.4 million in 2008), and a report produced by the United Nations University suggests that environmental vulnerability could lead this figure to soon spike and top 50 million people (UNEP 2008b).
competition for grains and oilseeds is intensifying, rising food costs and climate change impacts loom portentously and unevenly, and world population continues to grow towards 9 billion – there is much reason to believe that any such reconstitution will only speed the world towards capitalism’s ultimate precipice: revolution or barbarism. As Foster (2008, 7) puts it: ‘we have reached a turning point in the human relation to the earth: all hope for the future of this relationship is now either revolutionary or it is false’.

OPPORTUNITY IN CRISIS: REMAKING FARM WORK

Though it is not always understood in this way, the conceptualization of agricultural productivity – and with it, the efficiency gains of industrial agriculture – is an ideological exercise. As has been emphasized, various unaccounted costs underpin industrial agriculture’s exceptionally high levels of productivity per unit labour, plant and animal, and with it the ability to cycle increasing volumes of monoculture grains and oilseeds through concentrated livestock populations, and now cars. A very different conception of productivity would emerge, including a much greater range of measurable costs and ‘outputs’, if agricultural systems were designed with goals such as minimizing GHG emissions, soil erosion, toxicity, unhealthy food, violence and humanity’s overall footprint in the landscape and atmosphere, and maximizing soil conservation and the land space for forests, wetlands, carbon sequestration, soil formation, aquifer recharge, wildlife habitat and human recreation. The need to radically restructure agriculture is at the very core any hope of making the ‘human relation to the earth’ more ecologically sustainable.

It is also, simultaneously, at the core of attempts to build more socially just and humane societies. Agricultural systems must be vastly more labour-intensive and biodiverse, and geared towards much less meat production, as finite biophysical overrides diminish and in order to reduce the untenable environmental and atmospheric burden of industrial methods. There is no substitute for skillful and dense human labour, decentralized agricultural knowledge and careful, passionate stewardship in order to pursue a large range of necessary efforts, such as:

- conserving and building soil fertility (e.g. contouring, digging in agricultural wastes);
- using (predominantly) biological controls for insects, weeds, fungi and diseases;
- employing intercrops;
- managing multiple, smaller harvest periods;
- selecting and saving seeds;
- conducting (and sharing) localized ecological research;
- using animal traction; and
- integrating small-scale grazing and pasturing.

These imperatives butt up against some of the most hegemonic ideas associated with industrial capitalism, namely that agrarian labour is backwards, back-breaking and something to be ‘released from’ in the course of progress and modernization, and that increasing meat consumption and affluence march together.

The assumption about modernity as de-ruralization has had a powerful hold for good reasons. In addition to the allure of towns and cities, agrarian social relations
have rarely been equitable or even sustainable in a biophysical sense, particularly with respect to the soil (Montgomery 2007). But this assumption also masks large, unanswered questions about present and future labour absorption, which have both quantitative dimensions (what jobs are there going to be for displaced small farmers?) and qualitative ones (what kind of jobs will these be?). There is a need to ponder the current absorptive capacity of sectors such as heavy industry, light manufacturing, call centres, public and private security forces and informal-sector vending, and other common destinations for dislocated small farmers today, relative to the scale of rural dislocation, particularly given the wretched conditions on today’s fast-growing urban margins (Davis 2005). Rising food prices will only intensify the problems of persistently high unemployment and precarious incomes, which could become a strong force driving urban-to-rural migration.27 Even in countries such as China and India, which are undergoing rapid manufacturing and service-sector growth, the ability to absorb the rural poor cannot keep pace with the magnitude of agrarian distress and dislocation, and this growth depends upon the unsustainable and environmentally costly expansion of energy grids (through coal, nuclear and mega-hydroelectric dams). And further than this, there is reason to question the whether the stultifying, unfulfilling, unhealthy and insecure nature of much of the work in industrial capitalism represents ‘progress’. For instance, in Sachs’ (2005) rosy ladder imagery of development, he suggests that sweatshops and call centres represent a step up for the rural poor, giving a few anecdotal examples. While such work and its associated wages may indeed be an improvement upon life in many rural settings, this reflects the uneven nature of agrarian landscapes and social relations in agriculture rather than anything essential about the nature of agrarian livelihoods. But if various compulsions can be overcome, and agriculture is freed from the scorn of development theorizing, it has an unmatched potential to generate autonomous, skillful, experimental, healthy and meaningful work, or what might be understood as dignified labour (Weis 2007).

In sum, while the biophysical need for labour-intensive, low-input agricultural systems does not guarantee either greater justice or long-term sustainability, and should not lead to an uncritical veneration of tradition or hearkening back to a lost golden age, there is a need to understand agrarian livelihoods in a potentially positive light, for what they must represent in quantity and can represent in quality. It is obviously easier to envision more equitable and ecologically rational agricultural systems emerging where there are strong rural social movements, and where there still significant percentages of the population working the land under various arrangements, in places where industrialization has been limited or highly uneven and cheap industrial surpluses have sowed deep food import dependence. In La Vía Campesina, there is also considerable hope that various grassroots struggles confronting industrial capitalist agriculture will build momentum as they scale up beyond local or national levels (Desmarais 2007; Borras 2008).

It is harder to envision strong pressure emerging from below at the ‘apex’ of development amidst industrial monoculture and factory farm landscapes, the pseudo–diverse bounty of mega-supermarkets, fast food strip malls and extremely

27 The confluence of urban poverty, unemployment, food price volatility and rising food insecurity could well become a new and significant dimension of future land reform struggles.
small farming populations (generally between 2 and 4 per cent in the OECD, and ageing),28 where many who have managed to persist in farming have done so by internalizing the logic of the system and growing in scale. However, van der Ploeg (2008) gives evidence of how some farmers in the North are increasingly opposing industrial capitalist imperatives and practising alternatives. In addition, there is a range of organizations, activism and budding consciousness at the levels of both production and consumption which suggests that the contradictions of industrial capitalist agriculture are becoming more widely visible. These ‘seams’ include: small farmer organizations; efforts to mobilize farm workers and legalize ‘illegal’ migrants; organic food movements (both associations of ecological farmers and consumer co-operatives); civil disobedience (e.g. GMO crop-burners; guerrilla gardening on public space); food labelling struggles; the slow food movement; the permaculture movement; seed-sharing networks; fair trade networks; school and public health advocacy on junk food; the resonance of the ‘100 mile diet’ (and attention to ‘food miles’); community gardening; community share agriculture (CSAs) and local food boxes; public concern over climate change; the farm animal welfare movement; community-level resistance to factory farms; and vegetarianism/veganism.

While these seams may be mostly patchy and not typically anti-capitalist, there is a possibility that the accelerating biophysical crisis of industrial agriculture will serve to widen and radicalize them. As noted in the preceding section, dominant actors will assuredly work to design new fixes ‘from above’ as fossil energy and derivatives get scarcer, costs rise and key biophysical overrides become more difficult. But the implausibility of finding a new, wide-ranging set of technological fixes, and the likelihood of heightened ecological risks and labour exploitation, together suggest that the illusion of cheap industrial food will continue to crack, making scale, distance and centralized control more difficult with time.

Amid these potentially decentralizing tendencies, there is tremendous urgency for progressive farmer, farm-worker and consumer movements to work at communicating the problems of industrial capitalist agriculture as broadly as possible, to find and debate common ground, and to expand and connect nascent alternatives. The intricacies of this challenge are far beyond the scope of discussion here, but at its centre is the big, multilayered challenge of remaking farm work into something to aspire to, which affords an invigorating and stable living, is accessible to non-farmers (particularly young ones), and is guided by ecological imperatives rather than those of competitive accumulation based in a particular logic of efficiency. On a practical level, this means finding ways to valorize the skill, localized ecological knowledge and much higher labour demands that are necessary to manage low external input, biodiverse farms (while throwing out the dominant conception of agricultural productivity), and in this bridging much more remunerative agricultural labour with the needs of food consumers. One potentially useful concept that could help in this – especially in a transitional period – is the public provision of income supports to farmers for ‘ecosystem services’.

28 The shrinking and ageing farming population within industrial agriculture is another conceivable source of inertia across much of the world’s dominant agro-exporting nations. For the OECD as a whole, agriculture represents only 4 per cent of the total labour force, with the average age of a farmer now topping 50. In the USA, for instance, the average age of principal farm operators in 2007 was 57.1 years, having increased steadily over the past two decades (USDA 2009).
Valorizing local ecological knowledge will also widely need to start from rebuilding it, which requires nothing short of a complete reversal of what is understood as modern agricultural science. Agricultural innovation under industrial capitalism centres on enhancing monoculture yields, engineering biophysical overrides and generating commodified knowledge. It is largely driven by agro-input TNCs, with much of the public investment that remains in agricultural science subsidizing this model (along with legal frameworks designed to support intellectual property), and farmers approached principally as consumers of inputs and recipients of externally designed 'solutions'. Modern agro-ecological research will be geared to enhancing functional diversity, complementarity, natural controls, nutrient cycling, and soil conservation and formation, with scientific knowledge as a public good and farmers as active participants and co-learners in research rather than in a hierarchical way. Here, the idea of open-source seeds is a compelling one (see Kloppenburg 2010, this issue), though the mass promotion of modern agro-ecological science will also require major public investments in research, education and extension, especially in a transitional period (where a heavy emphasis on youth outreach would be necessary). Nourishing farmers' experimental impulses and the sharing of ecological knowledge could also have a crucial role in the essential challenge of climate change adaptation in agriculture (Howden et al. 2007).

Still, this need to radically remake labour-intensive and knowledge-dispersed agricultural systems is bound to be derided by some as backward-looking, hopelessly romanticized or simply implausible, given how profoundly it strikes at the heart of dominant development narratives and how they are braced by the economic, political and cultural power of corporate agribusiness. Yet far from fading away into modernity, struggles over agriculture are bound to intensify as the promise of cheap industrial food breaks down, and might well come to occupy a pivotal place in broader anti-systemic movements at the precipice of mitigation and adaptation or climate change disaster.

REFERENCES


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