

The problematic nature of agriculture: Understanding the perils and pitfalls of improving on nature

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Abstract:

It is our contention that agriculture as an economic activity has not been adequately theorized. As a consequence, the social and ecological roots of agriculture's accelerating ecological difficulties are misunderstood. The key to theorizing agriculture is the recognition that farming is an effort to create and sustain artificial (man-arranged) ecosystems, of varying degrees of instability, in order to increase what liberal economists would call "the productivity of natural capital." This article attempts to develop a systematic model of agriculture which will incorporate 1) a clear delineation of the work processes involved, 2) their particular form of dependence on the biosphere, 3) the source of social pressure towards expansion of production, 4) the particular reasons for the forms of environmental degradation which these cause, and 5) the ecological consequences of this degradation for the continuance of farming itself.

1. Introduction

Determining the conditions under which an economic activity will be ecologically sustainable requires a consideration of the economy-ecology relationship involved in this particular activity in a specific society. This requires knowledge both of the specific relationship of that economic activity to the natural environment, and of the effects of the specific social process governing the conduct of that activity. Some forms of economic activity are more disruptive of the biosphere than others, a consideration which determines what production practices and scale of production will be sustainable. Some forms of social organization have more tendency than others to push the practices and scale of production toward unsustainable levels, a consideration which determines which forms of social organization of production are liable to be conducive to respecting ecological limits. No such clear understanding of agriculture is in wide use.

Some may argue that developing an explicit theory of agriculture is unneeded; everyone thinks they understand agriculture: people on tractors growing crops, or in the barn raising animals. We argue this "common sense" understanding is very superficial, failing to specify the relationship between agricultural work activities and the metabolism of the natural environment upon which they depend. What we propose is a "theory of agriculture" rooted in its labour process and its relationship to the biosphere in any mode of production. It is from this vantage point that the destructiveness of capitalist agriculture can be most broadly understood, the true dimensions of agriculture's metabolic rift grasped, and the great difficulties inherent in developing an ecologically sustainable food system appreciated.

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2. Agriculture as a productive activity: the “artificial productivity expansion” (APE) model

In defining agriculture, the first distinction to make is between “farming” and “agriculture”. Farming is the central activity of agriculture, but agriculture in the modern use of the term covers the provision of industrial inputs to farming as well as the food processing sector. Indeed, the dominant actors in agriculture in the advanced capitalist economy are the corporations that control farm inputs and the processors who absorb most of the farm output. The central arena of biophysical action in agriculture, however, remains farming.

To define farming — and to present a theoretical model of it — we must begin at the interface between the work activities of the farm and the natural environment. We must specify the human work activities (the labour process) involved in farming, how they engage the biosphere, and how they cause a wide range of ecological disruption. Then we must understand how, and to what ends, the conduct of farming is socially organized, and the specific environmental consequences of that social organization. We start with this section on the biophysical dimensions of farming. We argue there are six work activities involved in the “full”² farming system, activities whose combination defines “farming”:

(Step 1) — selecting and modifying desired plants and animals from the biosphere. We choose to grow wheat, or raise cattle (not nettles or rattlesnakes). Modern biotechnology expands the possibilities but humans have genetically altered plants and animals for millennia through selection and hybridization.

(Step 2) — disturbing or even destroying the original ecosystem where we wish to farm. We cut down or burn the forest, drain the marsh, or plough up the grasslands, cutting out the dominant plant species and driving off or killing the larger animals.

(Step 3) — creating an artificial agricultural “ecosystem”. Selected plants and animals are implanted into remains of the original ecosystem of the land, i.e., soil, hydrology, insects and micro-organisms which create conditions necessary for growth of selected plants and animals.

(Step 4) — artificially, and temporarily, stimulating the “fertility” of the “land”. We enhance and sustain the farm ecosystem’s ability to support the growth of our chosen plants and animals through fertilization, irrigation, etc. In addition, in industrial farming systems animals are frequently raised in concentrated facilities using feed grown some distance away. Thus, the soils of the crop farms raising animal feeds require frequent and large doses of commercial fertilizers while the accumulation of nutrients on the concentrated animal farms become sources of pollutants.

(Step 5) — fighting an on-going battle with Nature’s tendency to replace our artificial “ecosystem” with a more diverse one. We attack “weeds”, undesired insects and other “pests” which already exist on site or invade from surrounding habitats.

(Step 6) — harvesting. We kill the plants and animals we desire to use directly or sell and often remove them a considerable distance from the farm “habitat” for consumption or use as raw materials in manufacturing, depriving the habitat of nutrients and creating pollution elsewhere.

The first advantage of our “APE” model is that it shows farming is not the simple exercise “common sense” imagines it to be. In terms of its relationship to the biosphere agriculture is far more complex and far more ambitious than manufacturing. Farming does not simply appropriate energy and materials from the biosphere and Earth’s crust, transform them in the factory and then dump the wastes of production into the biosphere in the hope they will disappear or be naturally recycled (Clow, 1998 a and b). Farming actively seeks to alter the construction and operation of the biosphere for human purposes. In farming we rearrange elements of the local biosphere in order to more broadly appropriate the biosphere’s bio-chemo-physical processes to grow desired

² Less developed activities involve less than a full set of these work processes: for example, “hunting and gathering” (as well as the wild fishery and simple “tree-harvesting”) involve only step 1 and step 6 activities.

plants and animals more intensively. We modify species and habitats, and alter the Earth's chemical and physical cycles, to produce plants and animals in greater and more concentrated quantities than naturally occur in the biosphere, often in "exotic" locations far from where the species evolved. We have found increasingly sophisticated ways to modify habitats and divert more and more of the biomass of living things into our agricultural production system. In fact, farming is nothing less than an effort to create and (try to) sustain artificial (man-arranged) ecosystems, "agroecosystems", embedded in the biosphere in order to increase what liberal economists call the "productivity of natural capital". Agriculture is an incredibly ambitious effort to "improve upon Nature"—in modern times on a massive scale and intensity.

3. Defining the source of agriculture's environmental disruption

The second advantage of our model of farming is that it makes it easy to see why the agricultural endeavor is inherently environmentally disruptive. We group the forms of ecological degradation produced by agriculture below by reviewing brief illustrations of how each of the phases of the agricultural work process can cause patterns of environmental degradation:

(Step 1) — selecting and modifying desired plants and animals from the biosphere.

Much has been made of biotechnology without recognizing that domestication, cross-breeding and genetic manipulation are as old as pastoralism and early crop growing. Increasing efforts at patentable breeding and biotechnology are accompanied by the disappearance of natural diversity and heritage crop varieties and animal breeds – native crops are displaced by uniform hybrids that require massive and expensive type 4 and 5 interventions. And older varieties are lost because they are no longer kept in production (Boyens, 2001: 161-174). Much of this loss has apparently happened relatively recently with the widespread penetration of farming by the hybrid and now biotech-based seed companies. As to the long-term impact of biotechnology, we do not know the consequences of mixing genes from widely separated species of plants and animals but they will certainly produce "exotics" in any habitat (step 3).

(Step 2) — disturbing or even destroying the original ecosystem

Agriculture is, in itself, an ecologically disruptive activity. Farming destroys existing natural ecosystems as they are taken-over for farming. Places where farming occurs, at both terrestrial and aquatic sites, are torn out of the network of living communities of plants and animals and their supporting air, water and soil cycles are drastically modified, even as our agroecosystems remain connected to the remainder of the biosphere. The biomass appropriated from the biosphere by farming, and all the materials and energy in the air, water and soil cycles and sunlight appropriated by the same processes, are being pulled out of their roles in the normal operations of the biosphere. Farming replaces stable natural habitats with unstable artificial ecosystems which leak pollutants (steps 4 and 5), invented strains of natural flora and fauna (step 3) and eroded soil in massive quantities (steps 4, 5 and 6). But farming can be conducted in more or less ecologically disruptive fashion. It is the combination of the large human population, the large land area appropriated for farming, the lack of ecological knowledge (at first) and ecological responsibility (later), and the consequences of the requirements of capitalist farming and the capitalist agricultural sector for forever expanding profits and investment opportunities, that has led to the current scale of environmental disruption by agriculture.

(Step 3) — creating our artificial "ecosystem"

The artificial ecosystems of farming are unstable; that is, they require continued human effort and intervention to continue to exist. Even though rice has been grown for thousands of years in South Asia, rice crops persist only through continued human intervention. Diverse natural ecosystems are generally more stable than simpler ones, and agroecosystems are more

simplified than the natural ones they supplant. That is why agroecosystems require so much more work to sustain productivity (step 4 measures) and to defend them against the biosphere's tendency to destroy them (step 5 measures). For this reason more diverse farm ecosystems, polycropping, good crop rotations, and the use of covercrops, all create more stable agroecosystems than simpler ones (Chant, 1972:11). Plants and animals from surrounding habitats inevitably invade the agroecosystem, tending to break down the artificial ecosystem and turn it to a more diverse and stable one; this is the reason we must devote ourselves to such prodigious labour freeing our agricultural ecosystems from "weeds" and other "pests". Agricultural ecosystems also run down the stock of nutrients and water in the soil, requiring an artificial supply; this makes the problem of weeds more intense and this requires more step 5 measures to counteract the problem. As well, agriculture (and its sub-species, gardening) have frequently introduced plants and animals into habitats in which they did not originate, there being no natural predators or disease mechanisms to keep them in check. The result has been widespread driving out of native species as the "exotics" introduced by agriculture escaped the farm and garden. It then falls to humans to control the "collateral damage" done by the exotics.

(Step 4) — artificially, and temporarily, stimulating the "fertility" of the "land".

Irrigation, the provision of water for farming by artificial means, has been a key component of many farming operations. Irrigation involves diversion of water from natural watercourses or deep wells, often on a very large scale. It affects established watercourses or the local water table, disrupting established environments, and contributing to climate change and soil salination (Sparrow, 1984; McLaughlin, 2002). Intense artificial fertilization without attention to maintaining soil organic matter can damage the soil and harm its many agriculturally necessary small and micro-organisms, but it follows from the fact that most of the biomass produced in agriculture is seldom returned to the soil from which it came (see step 6 below). Fertilizers also escape the farm by leaching to groundwater and in agricultural run off, polluting streams and other bodies of water with many detrimental effects. The heavy machinery that delivers fertilizer to the field compacts the soil, negatively affecting its absorption of water and its permeability to oxygen (needed by the small and micro-organisms of the soil). Nitrogen fertilizers can increase the rate of organic matter depletion in the soil. Organic matter not only helps aerate the soil, it also provides nutrients for micro-organisms and holds clay, sand and silt particles in place by forming stable aggregates. Without organic matter, soils may become more compacted. This compaction and deterioration of the soil converts it into "dirt" that is easily eroded by the increased water runoff and by wind blowing over the large expanse of open flat fields favourable to the use of larger machinery.

(Step 5) — fighting an on-going battle with Nature's tendency to replace our artificial "ecosystem" with a more diverse one.

High intensity petrochemical fertilizers create growing conditions for the seeds of other plants, and intensive monocropping with genetically uniform modern varieties creates ideal feeding grounds for insects and diseases that harm the crop. The flow of biocides used in the war against the tendency of the biosphere to restore farmland to a more diverse and natural state not only escapes the farm to kill indiscriminately in its environs, but also damages and destroys the micro-ecosystem of the farm itself and contaminates the crop. The development of biocide resistance creates "super-pests", such as in the Colorado potato bug, the diamondback moth (a major pest of the cabbage family), the tobacco hornworm, and the corn borer (Boyens, 2001). Heavy machinery used in the application of biocides makes its contribution to soil deterioration and erosion. There is also significant evidence that biocides used in agriculture affect the health of farmers, farm workers, and the surrounding populations. And the routine use of antibiotics in industrial-style animal facilities has contributed to the rise of antibiotic resistant bacteria.

(Step 6) — harvesting.

Harvesting with heavy machinery is not good for the soil, disturbing it and the non-crop elements of our agricultural ecosystem. But more fundamentally in modern agriculture the larger food system connected with agriculture may remove the harvested crops to a great distance so that the land is robbed of nutrients and pollution problems from sewage are created elsewhere. The national and international circuits of agribusiness create the situation where the bulk of the biomass produced by farming ends up as sanitary waste in urban areas of the most developed countries and as manure on concentrated animal production facilities, a contribution to water and land pollution rather than being recycled back into farming. Land that is steadily mined of its natural fertility requires increasing applications of macro and micro crop nutrients to artificially maintain crop yields.

Attempts to increase productivity involve an increasingly greater intensive effort to modify plants and animals to “improve” them for our purposes; to stimulate more vigorous growth with “better” fertilizers; to simplify the agricultural ecosystem in order to channel more of the available energy and nutrients into the crop, and to suppress competing plants and animals more vigorously. It should also be clear that intensifying production using conventional approaches makes the agroecosystem simpler, more vulnerable to invasion and less resilient. “Victory” over the limits of our agroecosystems is temporarily achieved at a steeper and steeper price: ever greater need for energy-intensive high-cost inputs, the gradual creation of more biocide resistant “pests”, greater exposure of farm families and agricultural workers to biocides, a disappearing diversity of natural varieties, development of genetically modified organisms (GMOs) to help simplify the system even more, foods laced with pesticide residues, greater off-farm environmental damage from chemical run-off, soil compaction and massive wind and water erosion. These efforts are progressively less effective at increasing productivity (Northwest Area Foundation, 1994).

4. Agriculture under capitalism

Our model indicates that intensive farming is inherently problematic under any and all social systems. For example, agriculture caused large-scale ecological degradation and undermined itself in ancient slave societies like Babylon (Wagner 1974:23). But the tendency of agriculture towards ecological destructiveness in contemporary society is much, much greater and more widespread than in past eras. To understand why, we must connect the agricultural endeavour to the mode of production in which it is embedded — namely the capitalist mode of production.

Here we follow the well-established reasoning of other Marxist scholars of environmental degradation. The capitalist economy is under the control of employers and investors whose unrelenting goal is to accumulate more and ever more wealth in one round of investment and profit-making after another (Foster 1994; Schainberg and Gould 1994; Schainberg 1980; and Clow 1992 and 1986). One can achieve such a goal over the medium and long term only by increasing production and/or lowering the costs per unit of production. Increasing production over the medium and long term requires increasing the rate of environmental degradation (Clow 1998a, 1998b and 1992) — trashing more and more of the Earth. The logic of capitalist agriculture is to continually intensify efforts to re-engineer the agroecosystems in order to become more and more productive and open to more profitable investment opportunities.

Capitalist agriculture per se – that is farming where the farming enterprise’s production is organized on a wage-labour basis — is inherently driven by the logic of increasing production and the rate of profit as in any and all capitalist endeavours. Where farming remains in the hands of petit-producers, farming is usually subject to the ‘cost-price squeeze’. This arises from the fact capitalist enterprises control the price of farm inputs and buy their outputs; there is an observable

secular trend for input prices to rise and commodity prices to fall. The resulting 'cost-price squeeze' facilitates the integration of primary producers into the drive to intensify agricultural production, while the state actively promotes the complementary policy for producers to "get big or get out" (Machum 1992:141). Many small producers are thus induced to pursue the direction of new technologies and intensification of agricultural practices in order to stay in commercial production in a food system dominated by the capitalist imperative.

If the logic of the agricultural endeavour is to increase the productivity of the land, the demand under capitalism is for this to be done ever more and more aggressively, regardless of its ecological consequences or the increasing instability of the food production process itself. Farmland in use to support subsistence must be brought under the ambit of capital and commercial production (by one means or another), and the productivity of "natural capital" must be continually increased, regardless of the predictable consequences for the biosphere or people. Continually increasing the productivity of "natural capital" in agriculture is part of the same effort as the drive to increase the productivity of labour. Both are sought in order to accumulate more and more capital from this, as from every economic activity in capitalist society.

5. An ecologically sustainable food system

There is lots of room for "organic food" within capitalist agriculture. Organic food is an exciting new niche market for more affluent consumers from which profit and new investment opportunities can be created. But an ecologically sustainable food system requires more than "organic food". Indeed, our model suggests that creating ecologically sustainable agriculture is a much bigger problem than not using GMO crops (a step 1 problem) or using natural weed and pest management (a step 5 issue). Indeed, the very idea of ecologically sustainable agriculture is inherently far more problematical than generally acknowledged (McLaughlin and Clow, 2003).

We should start with the fundamental question: What does ecological sustainability in agriculture mean? We argue the concept of an "ecologically sustainable" food system can only mean a pattern of economic activities whose scale, intensity and production technologies can be borne and sustained on an indefinite basis by the biosphere without ecological disruption – in other words, agricultural practices that do not exceed the biosphere's ability to tolerate our intrusion. Our model suggests there are three sets of conditions required for the existence of an ecologically sustainable food system:

1. Limited areas of Earth utilized for agricultural production: We cannot endlessly expand the reach of agriculture by commandeering more and more of the world's arable habitats for farmland. Large areas of the globe must be left in natural ecosystems to keep the balance of Earth's biosphere intact and enough wild land set aside to maintain local bio-diversity.
2. Limited energy and capital intensity of farming, since the harder we push to increase the productivity of our agroecosystems, the simpler, more vulnerable to invasion from "pests" and less resilient our farming system is, and the more collateral havoc it creates in the biosphere.
3. Appropriate scales, intensities and forms of agricultural practice designed to produce relatively diverse, stable agricultural ecosystems that can be sustained from internal biological resources and human labour inputs. The latter implies a food system that returns the wastes of food consumption (and food-product manufacture) to the land as fertilizer.

We argue there can be little movement towards such an ecologically sustainable food system within capitalism. What is required for ecological sustainability directly conflicts with the requirements of successful capitalist agriculture:

1. Limiting the land used in agricultural production limits new investment opportunities in the food system (and thus opportunities for expanded accumulation of capital).

2. Limiting the effort to increase the productivity of farming restricts the possibility of increasing profits in the agrochemical/biotech sector (and thus opportunities for expanded accumulations of corporate capital). Corporate profit and growth is the *raison d'être* of industrial farming's larger and larger scale, ever more "productive", monocultures.
3. An ecologically sustainable food system would be local and relatively 'direct' — it would principally supply basic foodstuffs for local people to prepare for their own consumption — and so would not provide inputs to a world-wide food system organized for profit and new corporate investment opportunities. A local and eco-friendly food system offers none of the possibilities for business presented by a global food system run by corporations selling people more and more value-added, highly processed food products, preferably through fast food restaurants in a cultural climate created through intense and sustained advertising.

It is easier to specify the biophysical than the social dimensions of an ecologically sustainable food system, if only because more thought has gone into those dimensions. At the very heart of environmentally sustainable agriculture is carefully planned "mixed farms" which create the most diverse self-balancing farm ecosystem (to present a smaller target for pests and weeds), careful choice of crops for a particular environment, multiple and mutually supporting crops in one field, the use of organic wastes as fertilizer, and weed and pest control measures that do not rely on persistent biocides. Animals should be raised on farms that grow their feed. And human waste, theoretically, should be returned to the farms from which their food came—implying local or regional production systems should become the norm (see Magdoff, 2007). We can expect that environmentally sustainable agriculture will more labour intensive – more people will be needed to produce our food and the costs of food will be greater. Though it does not preclude some long-distance movement of foodstuffs, the geographic length of an ecologically sustainable food system will be much shorter. The question of the ownership and social organization of farming, food-product manufacture, distribution and waste recycling is much harder to specify, since these questions replicate the long debates about the best form of socialist economic organization.

6. Conclusion

At the most general level, this article illustrates what should be obvious to environmental sociologists. We cannot understand the causes of ecological degradation or their solution without understanding both the specific ways human economic activity appropriates and disrupts the systems of the biosphere, and how these economic activities are driven by the social properties of the specific way people are organized to accomplish these activities. Agriculture and its environmental consequences cannot be understood without recognizing that the effort to increase the "productivity of natural capital" is at the heart of farming.

While farming is always fraught with the potential for widespread ecological disruption and its own collapse, capitalist agriculture has taken agriculture's inherent problems to new heights by applying scientific knowledge in the simplistic, reductionist, and single minded attempt to continually and without limit increase the productivity and profitability of agroecosystems. The capitalist global food system incorporates farming as part of a wider set of enterprises. It is incorporated as both a sector to which to sell many inputs (fertilizers, pesticides, seeds, tractors, etc.) and the source of raw materials for more value-added enterprises. Exploiting its global reach, capital seeks to bring more exotic foods to the affluent consumer, to produce more and more value-added food products in factories using the cheapest labour available, and to prepare and serve more of these food products to consumers through 'restaurants' dependent on the efforts of cheap service workers. All of this conflicts with the features of an ecologically sustainable world food system.

Ecological sustainability requires more than untainted 'organic food'. It will require limiting agricultural production and the productivity of agricultural techniques, and change in the social organization of farming and the food system. Building an ecologically sustainable food system, as in all areas of economic activity (see Clow, 1992 and 1998), requires a social system that limits economic activity and conducts it in a manner consistent with reducing our biosphere use. To paraphrase the old adage, as long as agriculture and the food system remain integrated into the capitalist economy and subject to the imperatives of the capitalist mode of production one cannot get to an ecologically sustainable agriculture and food system. The choice is capitalism or ecological sustainability. You cannot have both.

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