The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

How Might We Be Fed? Part Two

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This is a guest post by Phil Harris, a plant scientist based near the Scottish border in the UK. He has worked for government agencies in such areas as food safety and plant quarantine. Since 1997, he has worked amid the agricultural results of system-collapse in ex-communist countries of Europe.

In Part One, I looked at trends in primary production and their consequences. Here, we look at possible bases for more sustainable approaches, including the biological fixation of nitrogen and the Village Ecosystem approach. It is likely that changes will be hard in a complicated world.

Even within 'Western' agriculture where NPK fertilizer is fully available, there are different productivities per acre and the primary yields of calories and protein can be handled in very different ways. According to this USDA booklet:

> To average consumers, U.S. agricultural production seems uncomplicated – they see only the staples that end up on grocery store shelves. The reality, however, is far from simple. Valued at $200 billion in 2002, agriculture includes a wide range of plant and animal production systems.

This complicated web of sub-systems, input/output budgets, economics and 'demand' has sent 'Western' agriculture 'upmarket', to promote meat and a-seasonal fruit and vegetables, and has even taken large 'Western' acreages out of production. Biofuels are seen as a smart (subsidized) way of using spare land. The system extends much wider than the USA. In the big picture, urbanization underpinned by industrialization continues to expand globally. But just as in the story of the Great Plains: "… **they had no strategy for the very long term**." We must again talk about food security.

Agricultural ecosystems

We don't always think about it, but whenever there are cities, it is not just the calories and protein that are shipped to the cities. The soil nutrients are also shipped to the cities, depriving the soil of nutrients needed to maintain its fertility. In the book *On the Great Plains*, we read that the 1000 year accumulation of soil nutrients was quickly spent:

> They applied manure as it was available, rotated legumes when it was convenient. But

> they had no strategy for the very long term. By the 1930s, Rooks County fields had been planted, cultivated, and harvested sixty times without rest. Soil nitrogen was about half what it had been at sod-breaking and crop yields declined steadily. And now no western frontier remained. From the vantage of 1930s, crop agriculture in Kansas does not appear very sustainable. All the arable land in Rooks County - and in the nation for that matter – had been identified and plowed. Soil nitrogen and organic carbon drifted steadily downward, and with them yields and profits. Faced with this dilemma, farmers implemented a dramatic innovation in soil nutrient management. Rather than adopt one or more of the ancient strategies, farmers (and the industrial nation behind them) created a new option. They appropriated abundant cheap fossil-fuel energy to import enormous amounts of synthetically manufactured nitrogen onto their fields. ..." *page 219, 'On the Great Plains: Agriculture and Environment', Cunfer 2005; preview in googlebooks*

Now, the world faces long term decline in fossil fuels, certainly of the cheap and convenient variety. Looking ahead there has been one very large, hopeful albeit academic claim (Can organic agriculture feed the world? C. Bagdley et al., 2005) that biological farming could supply world needs, in terms of total calories and adequate nitrogen. Not surprisingly, this was greeted with skepticism, and cries of 'bad science'. The authors though make a good point: "Food security depends on policies and prices as much as on yields".

Biologically fixed nitrogen, 'western organic agriculture' and energy

Despite the overwhelming modern connection with natural gas and coal, and oil for transport, nitrogen fertilizer is not 'fossil fuel'; it can be recycled and is to a degree, renewable.

Firstly, N fertilizer rains from the sky, although amounts are relatively small. Some N is fixed by free-living soil micro-organisms. If proper care is taken, soils can often maintain yields for many years from these sources and releases from remaining plant residues. If no attention is paid to maintaining nitrogen level, this publication indicates that, for example, in Iowa yields go down to a quarter to a half for corn (maize). On the other hand, in a high-end example, temperate clover/grass sward can fix 200 kg/ha N in a year (see this publication), which is about what is needed for a modern high-yielding cereal crop in a 'favourable' location (a crop yielding in excess of 8t/ha or 119bu/acre). Alfalfa can do the same.

There are large systems losses whether using either synthetic or biological sources (see links in 'village ecosystems'). In the 'West', what we think of now as 'organic agriculture' started in Europe circa 1650, when 'clover' and related swards increasingly replaced the previous practices that had variously combined elements of nutrient recycling with leaving ground idle (fallow), and/or rotating cereals with beans that self-fix nitrogen. In England, from circa 1750, after clover, the soil N is thought to have increased in some areas by as much as three times; the sward input typically being 'churned' in situ using livestock and a root fodder break. This was a major factor in raising England's population ceiling from ~5.7 million to ~16.6 million by 1850 when 22% of the workforce just about fed the rapidly rising urban population. (Food imports were increasingly obligatory.)(Agricultural Revolution in England 1500 - 1850) Farms obtained large 'leverage' of manpower by using horses and increasingly ingenious (and cheaper) horse-powered machinery, increasingly originating from North America during second half of the 19th century.

Early on, the new agriculture was one of George Washington's interests (see diary), but exhausted ground was fairly typical in America. Alfalfa is also an excellent N fixer, but see again what happened 'On the Great Plains …extract above and pages 212, 217, and Cunfer's expert account of 'export' of nutrients (to towns and cities) and of nitrogen balances. The 1000 year accumulation of soil nutrients was quickly spent.

Also the story of mechanization is critical when we consider present dependence on fossil fuel. 'Peak Horses' was 1920 on the Great Plains (page 134). The economics of the fall-back to 'Old Dobbin' horses in 1930s, however, seem worth a mention – the cash value of home-grown fuel and spare parts.

It is a different world now. As I quoted in Part One, "A farmer in England tells me that if his John Deere equipment breaks down the parts are flown same day from Texas". More energy from fuel-oil seems to be used producing and transporting 'Western' crops than generally is embedded in the nitrogen application, although the fertilizer can be a very significant 'energy-cost'. A Scottish example also reiterated from Part One, suggests 10 – 45% of energy input into high-yielding oilseed cultivation on any one farm could be due to N fertilizer 'energy'.

Recent work in Montana illustrates some USA 'organic' wheat potential. From a world perspective, Montana seems not to be an ideal place to grow wheat (usually too hot and dry). But this analysis indicates respectable wheat yields by US standards (>50bu/acre; 3.4t/ha) are available long-term using biological N (… but not every year; data from trials suggests individual farms could expect 'catastrophic' losses in some years unless they used pesticides).

There is an important caveat that soil phosphate and other nutrients must be replenished over decades. Trial plots can achieve higher yields >80bu/ac (>5.4t/ha).

> In short term, green manures [e.g. winter peas, alfalfa, supplying soil N] may be able to make P more available.
>
> In long term, organic P fertilizers such as rock phosphate, bone meal, or manure will need to be added.
>
> [There is] only about 50-100 years of P left in Montana soils at typical removal rates.

Clain Jones researcher's power point presentation outlines some of these technical issues, including deficits in Montana of the range of essential soil minerals.

Village ecosystems

'Subsistence agriculture' can, under favourable conditions, be both high yielding and need less of both NPK and fossil fuel than required by a modern Western farm.

In contrast to our industrialised countries, up to very recently (Marsh & Grossa 1995, cited by Ellis 2000), almost half of humanity lived in village ecosystems on modest inputs (e.g. biological N, river mud) and recycled nutrients.

> Subsistence agriculture villages still feed, clothe, and house nearly half of Earth's human population …. In densely populated agricultural regions of Asia, 1 million km2 have been

> cultivated for so long [~2000 years] that natural vegetation patterns are unknown.
>
> ... We estimate the 1930s global area of intensive subsistence agriculture to be ~8 million km2, two-thirds the global area of tropical rainforests or nearly half the current global area of cultivated land (Matthews 1983).

I want to emphasize that such villages have rarely been completely 'self-sufficient'. They must always buy inputs, such as tools from the associated economy, and will trade in high-value local specialities or surplus commodities to enable these inputs. In their traditional settings, with their relatively small 'craft' economy, the top-layer of such civilizations can provide 'security', and some 'insurance' against shortages and local transient crop failures, but must be careful not to routinely extract too much from the agricultural base. Constraints appear to have limited the size of bureaucracy, military, and towns, and often put a 'ceiling' on overall population (see England, as an example above). Cities in the past seem to have needed the kind of support available from empires.

Villages in China in favourable areas have always – 2000 years - supported high density populations in the villages on cereal / legumes, for example obtaining yields of as much 4t/ha, by recycling biological inputs, and over the long term were able to sustain losses from the system. Manures always involve system loss of nutrients, particularly nitrogen to air and both nitrogen and potassium to water. Since 1960s, despite the key advantage of keeping up with population pressure (by doubling yields), there have been serious downsides to modern nitrogen fertilizer supplements, see Ellis link above; particularly increased waste of fertilizer: e.g. by eutrophication and contamination of water. The connection between levels of N application to rice paddy and large system losses is also explored here. Efficiency of modern fertilizer N utilization of 30 – 45% seems in line with estimates world-wide.

Waste ('system losses') however can be reduced. One village in China in a favourable area carrying a very high density of people was seen (at least until early 1990s) to adapt to very high-yielding production, minimize waste fertilizer and improve human nutrition, while the inhabitants in the village still consumed 80% of an astonishing 12t/ha/year cereals from double cropping. The continuing use of manures in this village reduced the N fertilizer to only 100kg/ha for the high yield cereals crops. (In this example there were net imports of feed materials for pig/fish production that contributed 'organic' NPK to manures; although in cash terms 'imports' were more than balanced by high cash value of pig and fish 'exported' outside the system.) An abstract is found here.

It is worth noting that these places even when producing top yields did not need to use a lot of herbicides (many hands available), nor were they mechanized in a western sense. They also used straw for cooking. The relationships with fossil fuels were profoundly different from ours, but see this discussion of a rapidly changing China and constraints. Mechanization, labour scarcity, upmarket meat and horticulture are very recent trends. If there are mistakes in policy, it is possible, in my opinion, for modernity to pauperize these essential rural hinterlands in China, India and elsewhere.

Food emergencies in cities in fully industrialized countries?

Britain began planning for a food emergency 3 years before entering WWII when "[government] formulated some broad principles that should guide the policy of feeding the nation in wartime." Not a moment too soon, it has to be said.

Industrialized Britain, 50 million in 1939, which could best be considered in those days a set of large cities with a rather small run-down agricultural area, imported 70% of food-as-calories. What we import now days seems hard to calculate, although the more than doubling of pre-1960s yields of home-grown grains to around 7-8 tonnes per hectare, which now includes provision of 80% of bread flour, should make a difference. A very wide range of foods and a very significant proportion of animal feed is imported, however.

The First World War without rationing had brought us close to a food disaster. So in 1939 rationing was obvious (e.g. meat, eggs and sugar), and we cut out imported vegetables and fruit. Numbers of sheep, pigs and poultry fell substantially, although cattle numbers valuable for milk production rose 10%. Land was brought back into cultivation with 50% more under the plow; the workforce was increased 10% by recruiting mostly inexperienced women, but mechanization went from 2 million to 5 million horsepower. The use of NPK fertilizer more than doubled. Home production in calories was doubled and imports halved during the war. This was in effect an almost overnight modernization of British agriculture. The extra fuel and the machinery were heavily prioritized. If there had been serious shortages of these, we would have been desperate.

Citizenry were encouraged to use parks and gardens to raise vegetables in what was partly a morale boosting exercise. Wonderful vegetables were grown for instance in the drained moat of the Tower of London!

The numerate were needed: there was massive recruitment of academics into the civil service. There was a dramatic change in policies and 'ideology' for the duration of the emergency, which went on in part until early 1950s and involved subsidies as well as rationing.

"Food for all at prices all can afford"
"Health is purchasable"
"Preferential supplies of certain essential foodstuffs for children."
"Special restaurants cater for the needs of industrial workers."
"75% of family purchases are for goods which are price controlled (by 1943)".
"Regulations impose sentences of up to 12 years penal servitude for black market operators."
"Science and state intervention combine."
"[Local] farmers' executive committees, with experts, have wide powers to bring land into cultivation."
(Sources; Hobsbawm 1968, Industry & Empire; Gangulee 1943, The Battle of the Land)

A longer term view

Clearly, even with substitute energy that could allow continued use of technological inputs, there must be increasing reliance on sustainable biological inputs. This can take many forms. One hopes China and India for example can protect, and not pauperize, their vast rural hinterlands.

How the USA can protect and enhance all the different farming areas during what one hopes will be a gradual and lengthy transition is certainly not obvious to me as an outsider. The USA however has retained a strong agricultural science base, and given different priorities, could bring detailed knowledge of cultivation and crop responses to management, right down to detailed inventories of natural resources for each field. I guess you could even have enough natural gas for long term fertilizer production, if you put a high enough value on the latter. I suspect even the existing phosphate and potash resources could be optimised for very many decades.

Whether you could see a change in human feeding habits is about as conjectural as seeing a change in driving habits, but a combination of need, subsidies aimed at 'health', and a growing culture of urban and suburban personal vegetable and fruit cultivation, and the mutual co-operation needed to achieve that, could only help. I am inspired by the transformation of a suburban street plot into a water retaining landscape achieved by a ToD contributor in a dry climate. It is beautiful.