The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

The Thermodynamics of Local Foods

Posted by Jason Bradford on September 16, 2009 - 8:33am
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> "No phosphorus, no thought."
> Frederick Soddy

Books, blogs, and articles about local foods have been popping up with high frequency recently. I am not going to get into who's involved or even what they are discussing in any detail, but instead refer readers here, here, and here for background. Or if you want to stick to The Oil Drum, similar discussions occurred here a couple years ago.

I am going to make an argument I don't see much. Reading the pros and cons on this subject is a bit like watching a pea roll around on a plate. My goal is to stick a fork in that pea and focus on something very fundamental. The point I will make is that one can say with high confidence bordering on certainty that only a predominantly local food system will ever be sustainable.

What I mean by sustainable is the ability to endure. Quite simply and irrefutably I conclude that the current globalized food system is a flash in the frying pan because it doesn't respect the first law of thermodynamics. Whatever other argument you might want to make against the global and for the local (and several legitimate ones come to mind) this fatal flaw is insurmountable. No quibbles, qualification or value judgments need to get in the way of this basic fact.

The Linearity Problem

The first law of thermodynamics is that matter and energy are never created nor destroyed, they only change form. The forms of matter and energy in the human body come from food, which primarily comes from soils. When plants and fungi occupy soil and grow, they ingest atoms in simple or mineralized forms and incorporate them into organic forms. This process essentially mines soils at an atomic scale.

The concentration of people into urban centers requires shipment of food far away from agricultural lands. Soils, therefore, are constantly depleted of nutrients. Currently, these nutrients are replaced by adding soil amendments and fertilizers that themselves derive from mining operations. In the same way that oil fields deplete, so do the mines that support current agricultural practices, whether based on man-made chemicals or imported organics, such as bat guano from Chile. In essence, the food system is predominantly a linear chain from mine to soil to food to plate to bodies and excretions to the treatment plants to the water ways and land fills and

to the oceans.

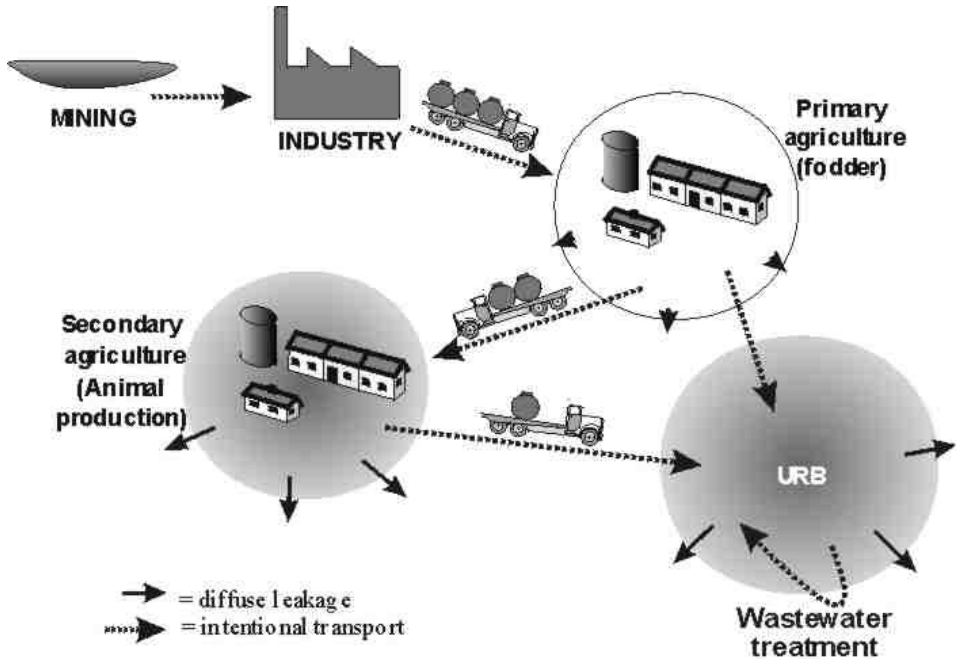

Fig. 1. The linear flow of minerals from mines to farms and then dense human settlements leads to depletion at one end, and the concentration of wastes or dispersion into water at the other. Graphic from Folke Günther.

Because we can't create matter out of thin air to replace these depleting resources (First Law) the system is unsustainable. To make it potentially sustainable we'd have to take the waste outputs and make them inputs again to yield a cyclical food system.

Transportation Constraints

A sustainable system must be primarily local because of energetic and logistical constraints. What is removed from a plot of land needs to be returned. Okay, not the exact atoms, but roughly the same kinds atoms in the original quantities and proportions.

This line of thinking has led me to a very important question: What is the average mineral composition of human urine and feces? My search has not been exhaustive, but I did come across two fairly recent publications that both reference a 1956 study by the World Health Organization. One of these, The Humanure Handbook is available online or in many bookstores. The other is a booklet published by Ecology Action titled affirmatively, "Future Fertility: Transforming Human Waste in Human Wealth." Here's a table from those sources, which are really one.

	Nitrogen	Phosphorus	Potassium	Calcium
Urine	7.5	1.6	1.6	2.3
Manure	2.8	1.9	0.8	2
Total (lbs/yr)	10.3	3.5	2.4	4.3

Table. 1. Mineral composition of human waste in pounds per year.

A classic composting method is to combine animal manure and urine with mature crop residues, usually straw. When mixed appropriately, this combination has an ideal ratio of carbon to nitrogen (C:N) leading to the formation of quality finished compost. Straw also includes various transformed soil nutrients, so the final product is nearly a perfectly balanced source of soil replenishment, which is what you'd expect given the First Law.

Let's put our mind in the toilet for a moment. What is going to be the best strategy for taking the contents of that porcelain bowl and mixing them with straw? Should the straw be brought to every home? Should it go to the municipal treatment plant? Or perhaps the straw should stay on the farm with the "precious cargo" shipped from city to country?

Fig. 2. Some of Fido's best ideas arise during moments like this. Right now he is thinking about all the plastic baggies that pick up his "deposits" in the neighborhood. Shouldn't that stuff get back to the farm, somehow? Would life be better as a country dog?

Folke Günther

These questions may amuse and be largely ignored, but they are completely fundamental. One of the few people I know of who studies this issue is the systems ecologist, Folke Günther. His website provides more up to date calculations for human waste, and he even uses the metric system!

To simplify the subject a bit, he focuses on phosphorus. The reasoning is straightforward--it is ten times more concentrated in the human body than in the Earth's crust and therefore the most

limiting nutrient in most locations. Essentially, if phosphorus can be reclaimed effectively so can everything else.

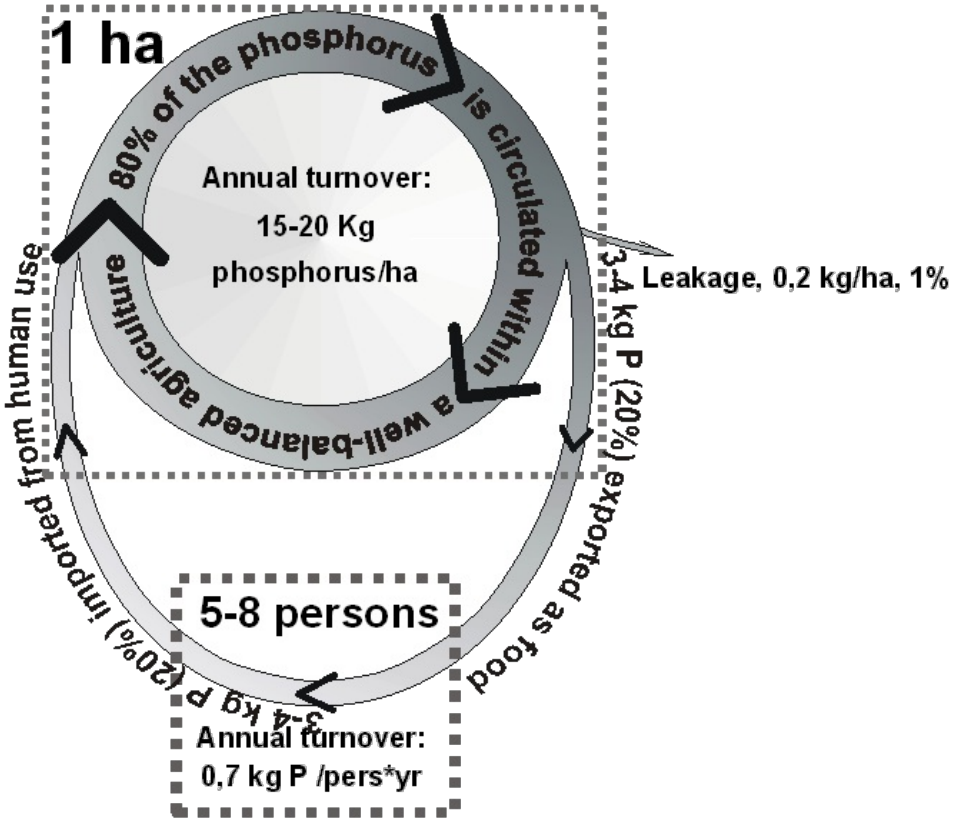

Fig. 3. Günther's model of the phosphorus cycle in a balanced agricultural system with exports of food being returned to the land in the form of processed human waste.

In Günther's writings and presentations on the requirements for sustainable cycling of nutrients, he suggests that the population of rural areas needs to be about twelve times larger than urban areas. He gives a scenario where ruralisation occurs in a region over 50 years based on the normal turnover rate of infrastructure—essentially as urban centers decay they are not rebuilt and investments in housing and other infrastructure are made instead in the adjacent hinterlands. Furthermore, assuming a rise in transportation costs, he also shows that a rural economy based on local food and energy weathers oil depletion well, in contrast to a city that must import basic needs.

I find these concepts obvious. I think a child can understand the basic premise operating here: If you take and don't give back, it runs out. The implications, on the other hand, are stunning. Will the migration to the cities, a demographic phenomenon that has gone on for so many decades, be necessarily reversed in the 21st century? If so, is it even remotely possible that this might happen in a thoughtful way as envisioned by Günther? And of course ruralisation in a region like Las Vegas is impossible.

Historic Model: China and Village Ecosystems

This topic has not gone unexplored on The Oil Drum. Phil Harris described the essentially local and long-term persistence of agrarian village ecosystems, especially in China. I have heard stories about farmers in China competing for humanure by building comfortable and decorative outhouses along roadside borders of their land. Please send pictures of these if you come across

any of them. I am looking for some design ideas for the future.

"The human mind...burns by the power of a leaf."
Loren Eisley