How Much Did the Green Revolution Matter? or Can We Feed the World Without Industrial Agriculture?

"It is well that thou givest bread to the hungry, better were it that none hungered and that thou haddest none to give."– St. Augustine

There are many questions that have come up for me in writing a book about food, energy and climate, but the one that I find most engaging is the question of exactly what was gained and lost in the transition to industrial agriculture and the green revolution. While there have long been critiques of the Green Revolution, many, many people assume that without the work of Norman Borlaug and the other scientists who brought us new hybrids and who convinced much of the world to convert to nitrogen fertilizers and pesticides based on fossil fuels, we cannot feed the world. I am suspicious of this claim, and have been musing on it for some time. It is certainly true that grain yields rose dramatically during the Green Revolution, but how much does and did that actually matter?

Now some of this, all of us interested in the subject already know. We all know that the introduction of massive quantities of fertilizer, the replacement of traditional staple crops with hybrids and the rest of the Green Revolution meant total grain yield increase of 250% over 35 years, with an increase in fossil energy inputs of 50% over traditional agriculture. It would seem that that rate of return was quite gratifying – put in some energy and get five times the total food. That was, however, a short term success, one that couldn't be sustained. The quantity of fossil fuel inputs required to maintain these increased yields and keep up with population growth have grown steadily, and as Dale Allen Pfeiffer observes in *Eating Fossil Fuels* "Yet, due to soil degradation, the increased demands of pest management, and increasing energy costs for irrigation (all of which is examined below), modern agriculture must continue increasing its energy expenditures simply to maintain current crop yields. The Green Revolution is becoming bankrupt." (Pfeiffer, 9) For those who don't think much about agriculture, the last bit of information should disturb you. The world's population is set to grow for some time (by close to 1/3 before it levels off and begins declining towards the middle of the century, all factors being equal), and we are only just holding steady (actually, there's been a bit of a decline lately) in the amount of food we're able to grow, despite our best efforts. This matters – right now we still produce more than we need. But population is growing steadily, and the climate is changing steadily, and the day is not so far away when our total food yields may not feed the world. And if oil and natural gas peak soon, as seems not unlikely, yields will decline still further. That's a scary prospect.

But there's more to say about those Green Revolution numbers, because they leave out something very important – how much food was actually lost due to the green revolution. Look at the above numbers, the 2.5 fold increase in grain yields, and the situation will look hopeless. But that's not quite the end of the story. Because the

Green Revolution actually cost us something too – and not just the costs that all environmentalists are familiar with in fertility, soil erosion, aquifer depletion, etc... but a whole realm of food that we once used to grow and eat that we didn't anymore after the Green Revolution. While the Green Revolution increased grain yields, it also cut back on other food sources. For example, among rice eating people, the pesticides required for the cultivation of the miracle rices produced in the 1960s killed fish and frogs that provided much of the protein in the diets of rice eating people, resulting in, as Margaret Visser points out in *Much Depends on Dinner*, "...the sadly ironic result that 'more rice' could mean 'worse nutrition.' The same can be said of the loss of vegetables often grown in and at the edges of rice paddies. The famous "golden rice" that was supposed to alleviate blindness due to Vitamin A deficiency, a common problem among poor people who have little but rice to eat, ignored the fact that one of the reasons for the decline in Vitamin A consumption was that nutritious vegetables and weeds traditionally grown or harvested with rice were no longer available.

The same is true of food grown in the US, in our very own breadbasket. As our corn and wheat and soybeans were produced by larger and larger farms, with more and more industrial equipment, we began to stop producing other, smaller crops that were less amenable to industrialization, but that made up a significant portion of people's diets. For example, virtually every farm family in the US had a garden in the first half of the 20th century, and most of those gardens produced most or all of the family's vegetables. Since we're talking about a time when 1/3-1/5 of the US population lived on farms, that is an enormous quantity of produce. The significance of gardens is easy to underestimate, but it would be an error to do so. During World War II, 40% of the nation's produce was grown in house gardens. The figures were higher in Britain during the same period. In the late 1990s, a study done by the Louisiana Extension service suggested that the average house vegetable garden produced $350 worth of produce. Food produced in gardens was a significant part of our dietary picture not so very long ago, and much of it was lost to industrial agriculture, either directly, in the consolidation of family farms, or indirectly, through agricultural subsidies that made purchased food often nearly as cheap as growing your own, and even social policies that encouraged suburbs to become places of lawns, not vegetable gardens.
House gardens in rural areas, urban centers, and suburbs are another casualty of the Green Revolution – the artificial cheapness of food, created by industrial, subsidized agriculture in the second half of the 20th century drove the house garden out of existence. We went from producing 40% of our produce to less than 3% in home garden over four decades. And it would be a mistake to see "produce" as watery vegetables like lettuce, and thus believe that few of our calories came from our gardens – among the vegetables lost were dense calorie crops like potatoes and sweet potatoes, which can substitute for grains in the diet.

Going back to what the Green Revolution, and its ugly step-child globalization did to the American farm family – the exhortation by Earl Butz to "get big or get out" in the 1970s, and the systematic farm policies that favored large commodity growers and regional specialization cut back enormously on the quantity of food we produced. Small farmers in the 1940s might have raised corn or wheat as their central crop, but they also grew gardens, had an orchard, raised some pigs for sale and milked a house cow. The loss of all that food value, spread over millions of farm families, was a significant one. A farmer might have tapped his sugar maple trees and sold the syrup, and would probably have sold some eggs. He might also have sold a pig to a neighbor

or had a calf butchered and shared the meat. The industrial commodity farmer rarely does these things, and in many cases, the area that permitted them – the woodlot, the barn, the chicken coop have been removed to allow unhindered access to more acres. In a bad crop year, a farmer might have planted a late crop of sunflowers for oil seed, lettuce or something else, which is also not calculated into our total consumption. In many cases a family member might also operate a small truck garden and sell produce locally – even children did this routinely.

All these are foods that were removed from the food stream, and this systematic deprivation over millions of households reprents an enormous loss of total calories produced.

The economic pressure of farms to specialize also took its toll. Joan Dye Gussow, in *This Organic Life* (Gussow, 141) documents that in the 1920s, Montana was self-sufficient for 75% of its produce, including fruit. Now Montana is one of the harshest climates in the US and has very little water, comparatively speaking, and yet this was possible in part because the economic pressure of big business had not yet persuaded small farmers that they couldn't grow fruit effectively in Montana, but should leave it to Washington and Florida. None of us know how many calories were lost this way, but it is almost certainly an enormous quantity. And this systematic removal in the name of efficiency and specialization happened all over the world to one degree or another.

All this is particularly important because of the urgent distinction between yield and output. Peter Rosset has documented that industrial agriculture is, in fact, more efficient in terms of yield. That is, when five acres of soybeans and five thousand acres of soybeans are compared, you get more soybeans per acre by growing 5000 acres. But when you compare output – that is the total amount of food, fertility and fiber you get from small scale polyculture farms (that just means farms where you grow a bunch of different things, not a single commodity), the five acre farm comes out not just ahead, but vastly ahead in per acre output. It isn't just that five acres are more productive in terms of total output, they are often hundreds of times more productive (Rosset, www.mindfully.org/Farm/Small-Farm-Benefits-Rosset.htm). Rosset's figures are not in dispute, as Rosset points out here:

> Surveying the data, we indeed find that small farms almost always produce far more agricultural output per unit area than larger farms. This is now widely recognised by agricultural economists across the political spectrum, as the "inverse relationship between farm size and output". Even leading development economists at the World Bank have come around to this view, to the point that they now accept that redistribution of land to small farmers would lead to greater overall productivity.

And the difference in total output rises further when you talk about garden models. A half acre garden is often tens or hundreds of times more productive than the same acreage in industrial agriculture. The displacement of house and farm gardens by industrial agriculture represents a dramatic loss in important food crops due to the Green Revolution. On a given acre of land, the Green Revolution might have increased rice or wheat yields by several times, but since the garden, henhouse and berry bushes that could have been on that acre would have been many times more

productive in total than what was granted to us by fertilizers and hybridization, what we are experiencing is a net total loss, not a gain in many cases.
This is also important because most of us eat a fairly varied diet. Grain crops are important, but so is the enormous diversity of food in our diets. And many of the vegetable crops that have been lost were significant sources of food, or oil, or flavoring (now displaced by corn syrup and soybean oil). We cannot assess the global food supply correctly by focusing only on grains, or by failing to recognize how much of the calories produced in grain were once produced, often more nutriously, by vegetable and fruit crops. As Hope Shand notes:

> There is no doubt about the global economic importance of these major crops [rice, maize, wheat and soybean], but the tendency to focus on a small number of species masks the importance of plant species diversity to the world food supply. A very different picture would emerge if we were to look into women's cooking pots and if we could survey local markets and give attention to household use of non-domesticated species. (Hope Shand Human Nature: Agricultural Biodiversity and Farm-Based Food Security)

In the US, during most the last 50 years, we have had enormous grain surpluses, mostly of corn, and as Michael Pollan documents in *The Omnivore's Dilemma*, industrial food production has been challenged to keep finding new ways to use our spare corn up. Processed foods are all sweetened with our extra corn, made of processed corn, or of meat from corn fed to livestock. And we have seen a rise in obesity, type 2 diabetes and heart disease – all associated with high meat, low vegetables, processed food diets. We kept raising our yields, at the cost of our outputs, and our diets came to reflect that – we ate fewer kinds of vegetables and fruits, and fewer of them. To a large degree, what happened was that we gave up foods that we did need to be healthy and have good, varied, tasty diets, and replaced them with a couple of grain crops that we did not particularly need more of, and we harmed ourselves doing so.

I cannot find a single reliable number about how much food was lost to us, worldwide by the Green Revolution. It may never be possible for us to find out what we lost to industrial agriculture, and I will make no claims that I know precisely. If someone can locate such a number, I'd be fascinated. But there is no question that it was enough food to feed millions, maybe even billions of people. And we must, in our analysis of what the Green Revolution cost us, also recognize that we lost an uncertain, but enormous quantity of future food, mortgaging the future to overfeed the present.
As Dale Pfeiffer documents, we have reached the point where the damage caused by the Green Revolution and globalization mean that we can no longer raise our food yields by technological methods. We are constantly hearing about the latest genetically modified solution, and besides the dangers of GM food, so far none have produced as advertised. The price of industrial agriculture is uncalculated quantities of food that future generations will not have to eat. As the ability of soils to hold water decrease due to erosion and climate change, arable land becomes desert. As soils are depleted of nutrients and the price of natural-gas based nitrogen fertilizers rise, untold people will find the cost of growing their own food in their depleted environment prohibitive.

That said, however, we should not underestimate the resiliance and power of local, indigenous, sustainable agriculture. For example, in *Bringing the Food Economy Home* Helena Norberg-Hodge, Todd Merrifield and Steven Gorelick cite several World Bank and FAO papers that indicate that as recently as the mid-1990s, 2 billion people, 35% of the world's population were being fed by traditional agriculture with minimal or no fossil fuel inputs (Norberg-Hodge, Merrifield, Garelick, 4). This often occurs on marginal land, because the best agricultural land in the South has been turned to non-food, or luxury food items. Shrimp farms displace rice farms in coastal India, Coffee displaces small polyculture farms or food providing forests in Latin America and Africa, flowers displace food in much of Latin America and Asia, cotton, to feed our endless appetite for cheap clothing displaces food in many nations. It will be a non-trivial problem to return this land to sustainable food production, but it is possible. These statistics, along with the others here should at least raise some significant questions in those who believe we know what the earth's proper carrying capacity is. That does not make the issue of population irrelevant, but it does mean we may have time and choices that we did not know we had.

Vandana Shiva describes (and I will quote this at some length, because I think it is very important) what the Green Revolution has done in the third world, but it is important to remember that the loss of food that occurred there also happened to us – for us, the cost came in the form of our loss of health and nutrition. For the poor of the world, it came as a significant loss of calories and nutrition.

> Industrial agriculture has not produced more food. It has destroyed diverse sources of food, and it has stolen food from other species to bring larger quantities of specific commodities to the market, using huge quantities of fossil fuels and water and toxic chemicals in the process.
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> It is often said that the so-called miracle varieties of the Green Revolution in modern industrial agriculture prevented famine because they had higher yields. However, these higher yields disappear in the context of total yields of crops on farms.
> Green Revolution varieties produced more grain by diverting production away from straw. This "partitioning" was achieved through dwarfing the plants, which also enabled them to withstand high doses of chemical fertilizer. However, less straw means less fodder for cattle and less organic matter for the soil to feed the millions of soil organisms that make and rejuvenate soil.
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> The higher yields of wheat or maize were thus achieved by stealing food from farm animals and soil organisms. Since cattle and earthworms are our partners in food production, stealing food from them makes it impossible to maintain food production over time, and means that the partial yield increases were not sustainable. The increase of yields in wheat and maize under industrial agriculture were also achieved at the cost of yields of other foods a small farm provides. Beans, legumes, fruits and vegetables all disappeared both from farms and from the calculus of yields. More grain from two or three commodities arrived on national and international markets, but less food was eaten by farm families in the Third World.

> The gain in "yields" of industrially produced crops is thus based on a theft of food from other species and the rural poor in the Third World. That is why, as more grain is produced and traded globally, more people go hungry in the Third World. Global Markets record more commodities for trading because food has been stolen from nature and the poor. (Vandana Shiva *Stolen Harvest* 12-13)

As I said, I don't know whether in the net the Green Revolution gave us more food or not. But it is absolutely clear that it did not give us the enormous increases in food that were claimed for it. And it may well be that all of us experienced a loss of nutritious food, or food value. It is manifestly the case that not only may we not need industrial agriculture to feed us, we may well be better off without it.

Sharon Astyk, The Energy Bulletin, January 29, 2007