The Food & Farming Transition

Toward a Post Carbon Food System

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The Food and Farming Transition: Toward a Post-Carbon Food System
Post Carbon Institute

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I. Why Transition Is Mandatory

During the past century world annual agricultural production has more than tripled. This unprecedented achievement in humanity's quest for food security and abundance was largely made possible by the development of chemical fertilizers, pesticides, and herbicides; new hybrid crop varieties; the application of irrigation in arid regions; and the introduction of powered farm machinery.

Central to most of these strategies for intensifying farm productivity were fossil fuels, especially oil and natural gas. Natural gas provides the hydrogen and energy used to produce most nitrogen fertilizers, and both gas and oil are the sources for other agricultural chemicals, including pesticides and herbicides. Meanwhile, oil fuels most farm machinery (often including irrigation pumps), and has enabled growth in the scale and distance of transportation of crop inputs and outputs. Today, food items are shipped worldwide and enormous quantities of food are routinely transported from places of abundance to sites of scarcity, enabling cities to be built in deserts.

This application of fossil fuels to the food system has supported a human population growing from fewer than two billion at the turn of the twentieth century to nearly seven billion today. In the process, the way we feed ourselves has changed profoundly.

Particularly in industrialized nations, the food system has become more articulated (it has more basic components) and more centralized. Today in most countries, farmers make up a smaller proportion of the population, and they typically work larger parcels of land. They also typically sell their harvest to a distributor or processor, who then sells packaged food products to a wholesaler, who in turn sells these products to chains of supermarkets. The ultimate consumer of the food is thus several steps removed from the producer, and food systems in most nations or regions have become dominated by a few giant multinational seed companies, agricultural chemicals corporations, and farm machinery manufacturers, as well as food wholesalers, distributors, and supermarket chains. In the U.S., the process of getting food from the farm to the plate uses over four times as much energy as farming (Figure 1).

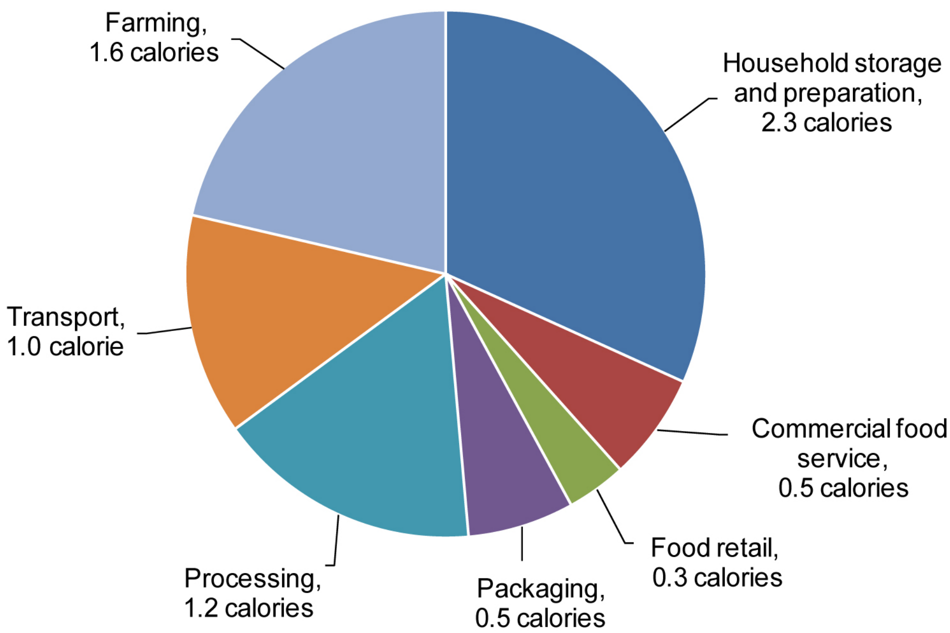

Figure 1. Energy expended in producing and delivering one food calorie. Approximately 7.3 calories are used by the U.S. food system to deliver each calorie of food energy. Farming accounts for less than 20% of this expenditure, but still consumes more energy than it delivers.[1]

Farming has also become far more mechanized. Fuel-fed machines plow, plant, harvest, sort, process, and deliver foods. The near-elimination of human and animal muscle-power from the food system has reduced production costs and increased labor productivity—which means that there is need for fewer farmers as a proportion of the population (Figure 2).

1 Adapted from: M.C. Heller and G.A. Keoleian, "Life Cycle-Based Sustainability Indicators for Assessment of the U.S. Food System," University of Michigan (2000).

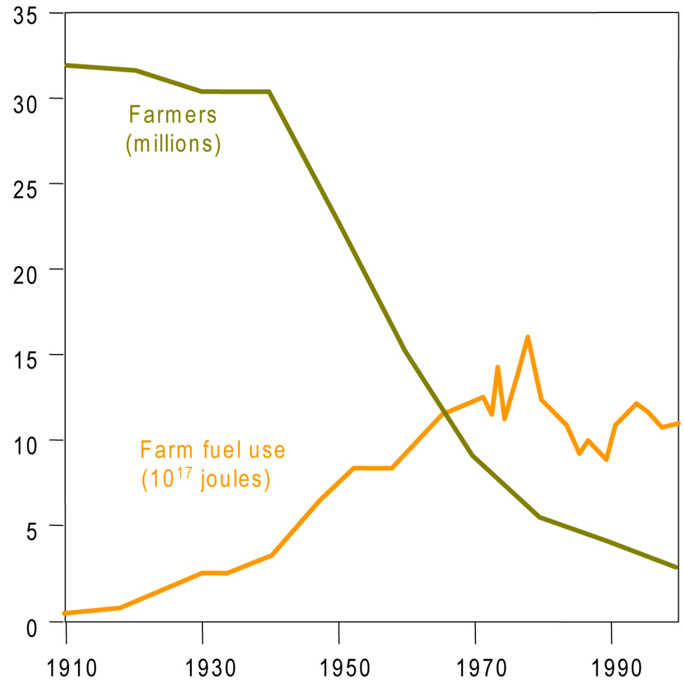

Figure 2. U.S. farm population and direct fuel consumption, 1910-2000. Direct farm fuel consumption includes only fuels consumed on farms. At least as much fuel is used to manufacture farm inputs, such as nitrogen fertilizers, pesticides, and plastics. Both direct and indirect fuel consumption peaked in 1979.[2,3]

Farm inputs have also changed. A century ago, farmers saved seeds from year to year, while soil amendments were likely to come from the farm itself in the form of animal manures (though in many instances manures were imported from off-site). Farmers also bought basic implements, plus some ancillary materials such as lubricants.

Today's industrial farmer relies on an array of packaged products (seeds, fertilizers, pesticides, herbicides, feed, antibiotics), as well as fuels, powered machines, and spare parts. The annual cash outlays for these can be dauntingly large, requiring farmers to take out substantial loans.

2 C.J. Cleveland, "The direct and indirect use of fossil fuels and electricity in USA agriculture, 1910-1990," Agriculture, Ecosystems & Environment 55 (1995): 111-121.

3 J. Miranowski, "Energy consumption in U.S. agriculture," (presented at USDA/Farm Foundation "Agriculture as a Producer and Consumer of Energy" conference, Arlington, Virginia, 24-25 June 2004).

From an energy perspective, industrialization presents a paradoxical reversal. Before the industrial revolution, farming and forestry were society's primary net producers of energy. Today the food system is a net user of energy in virtually every nation; this is especially so in industrial countries, where each calorie of food energy produced and brought to the table represents an average investment of about 7.3 calories of energy inputs (Figure 1).

Before the industrial revolution, farming and forestry were society's primary net producers of energy. Today the food system is a net user of energy in virtually every nation.

It has been possible to create and maintain net energy-consuming food systems only because of the development by society of ways to extract and use fossil fuels, a one-time-only gift from nature to humanity representing sources of energy of unprecedented cheapness and abundance.

The benefits of industrial (that is to say, fossil fuel-based) food production and distribution are easy to see: our modern food system delivers products that are themselves cheap and abundant. In 2005, for example, the average U.S. family spent less than 12 percent of income on food, whereas 50 years ago that percentage was about twice as high. Exotic foods are widely available in supermarkets, whose shelves display thousands of distinct food products. Famine, which used to be common throughout the world, is banished from most countries. Hunger, where it still exists, is nearly always due to an inability to afford food, rather than absolute scarcity.

A Mixed Blessing

But this enormous benefit has come at a cost. Out of all human activities, agriculture has arguably been the source of greatest human impact on the environment. Fertilizer runoff has led to the proliferation of oceanic dead zones fanning out from the mouths of rivers; the search for more arable land has driven widespread deforestation; irrigation has caused the salinization of soils; pesticide and herbicide pollution of air and water has adversely affected the health of humans as well as thousands of plant and

animal species; and the simplification of ecosystems for the production of monocrops has exacerbated the ongoing loss of habitat for birds, amphibians, mammals, and beneficial insects.[4]

Agriculture also contributes to climate change—principally through soil degradation, which releases carbon sequestered in soil into the atmosphere as carbon dioxide, but also through the combustion of fossil fuels.[5] Climate change in turn adversely impacts agriculture through extreme weather events, altered seasons, and changing precipitation patterns.

Out of all human activities, agriculture has arguably been the source of greatest human impact on the environment.

Meanwhile, the industrialization of the food system has lowered food quality.[6] Hundreds of millions of poor, middle-class, and even wealthy individuals in industrialized nations suffer from malnutrition, often hidden and sometimes paradoxically accompanied by obesity resulting from the consumption of highly processed foods low in essential nutrients. Four of the leading causes of death in these nations—heart disease, stroke, Type 2 diabetes, and cancer—are chronic diseases linked to diet.

Industrialized agriculture has reshaped the global economy in ways that have helped some but hurt many others. Poor farmers who cannot afford machines, fuels, and commercial farm inputs often find themselves at a disadvantage in the global food economy. Compounding this are agricultural policies in industrialized food-exporting countries that subsidize domestic producers and dump surpluses in poor nations (thus creating further economic disadvantage for smaller producers).

The result has been a systematic driving out of millions of small producers annually, the prioritization (in less-industrialized countries) of production for export, and the creation of a landless poor urban class

4 R.E. Green et al., "Farming and the fate of wild nature," Science v307 n5709 (2005):550-555.

5 United States Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006," (2008).

6 D.R. Davis. "Declining Fruit and Vegetable Nutrient Composition: What Is the Evidence?" HortScience 44 (2009): 15-19.

(whose immediate ancestors were subsistence farmers) that is chronically malnourished and hungry.

At the same time, the centralized and mechanized fossil fuel-based food system has had a more subtle but nevertheless significant psycho-social impact. Modern city dwellers are increasingly alienated from the sources of their food, and so they purchase packaged and highly processed food with little understanding of the health consequences of its consumption or the environmental costs incurred in its manufacture. These latter trends have provoked a response in the form of the burgeoning local food and Slow Food movements, which seek to rebuild the connections between food, culture, and place.

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The Depletion Dilemma

The inevitability of fuel supply problems is axiomatic, given the fact that oil and natural gas are non-renewable, with existing reserves constantly being depleted. Global oil discoveries have been declining since the 1960s (the peak year for discovery of new oilfields was 1964). The U.S. passed its moment of peak production in 1970, and since then many more nations have entered the decline phase of their oil production history.

Moreover, acute supply disruptions are increasingly likely over the short term given the economic and geopolitical challenges accompanying the current global economic downturn.

Oil analysts dispute the likely timing of the inevitable global oil production peak,[7] but even resource optimists concede that total non-OPEC crude oil production will begin its historic and terminal decline within the next few years, so that whatever spare production capacity remains will be concentrated in a few countries within a politically unstable geographic region.

The oil price spike of 2008 is an instructive harbinger of what is to come. Throughout 2006, 2007, and early 2008, world demand for oil grew, but supplies remained stagnant. Then, following a price surge during the first half of 2008, economic impacts from high fuel costs together with the unfolding of the world financial crisis caused oil demand to subside quickly and significantly. Oil prices plummeted in response (Figure 3).

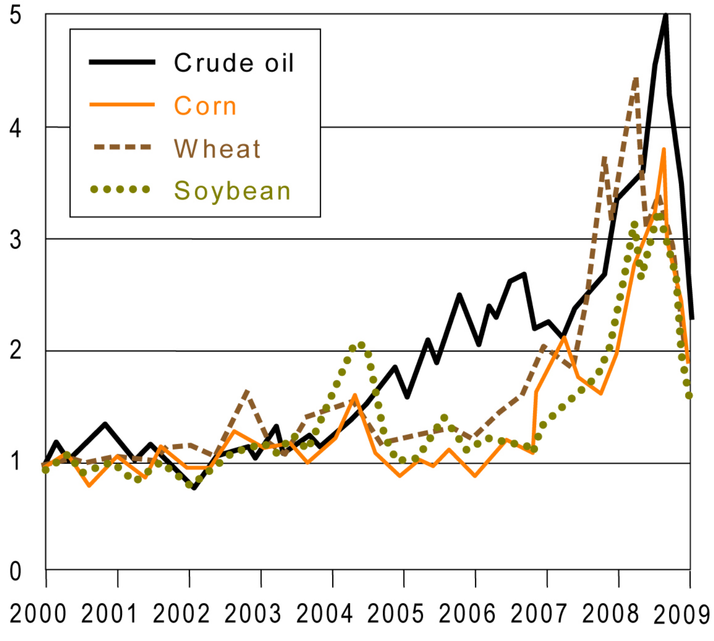

Figure 3. Relative price of crude oil, corn, wheat, and soybean on world markets, 2000-2008. (2000 price = 1).

7 Analysts' forecasts of global oil production peak have generally become more pessimistic in the last few years; the International Energy Association's authoritative "World Energy Outlook 2008" report particularly stands out in this regard. See http://www.worldenergyoutlook.org/2008.asp.

The 2008 oil price spike contributed to a near-simultaneous doubling of food commodity prices (Figure 3); other causes included poor harvests due to drought and other adverse weather conditions in several key countries, growing demand by expanding Asian economies, commodity speculation, the decline in the value of the dollar, and the growth in biofuel production. As a result of these high food prices, more than 30 nations saw food riots in late 2008.

The use of synthetic nitrogen fertilizer, made primarily with natural gas, peaked in the late 1980s in the industrialized world, but continues to increase steadily in less-industrialized nations, leading to continued growth in world demand (Figure 4). Fertilizer prices spiked with oil prices in 2008, reflecting the fertilizer industry's dependence on cheap energy (Figure 5).

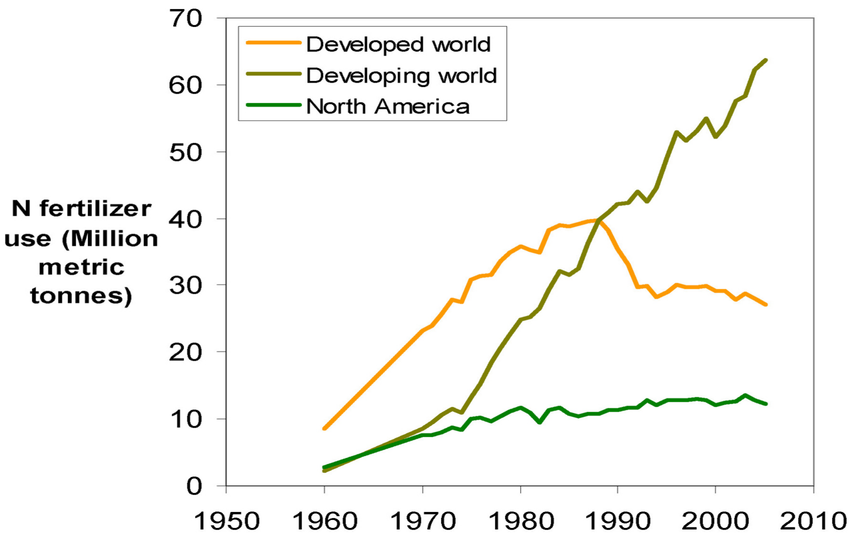

Figure 4. Nitrogen fertilizer use in industrialized and less-industrialized countries, 1960-2006.[8]

8 International Fertilizer Industry Association, IFADATA database, http://www.fertilizer.org/ifa/statistics.asp. Although synthetic nitrogen fertilizer use in industrialized countries has fallen since the late 1980s, it has risen slightly in the United States in the same period. See USDA Economic Research Service, "Data Set - U.S. Fertilizer Use and Price" at http://www.ers.usda.gov/Data/FertilizerUse/.

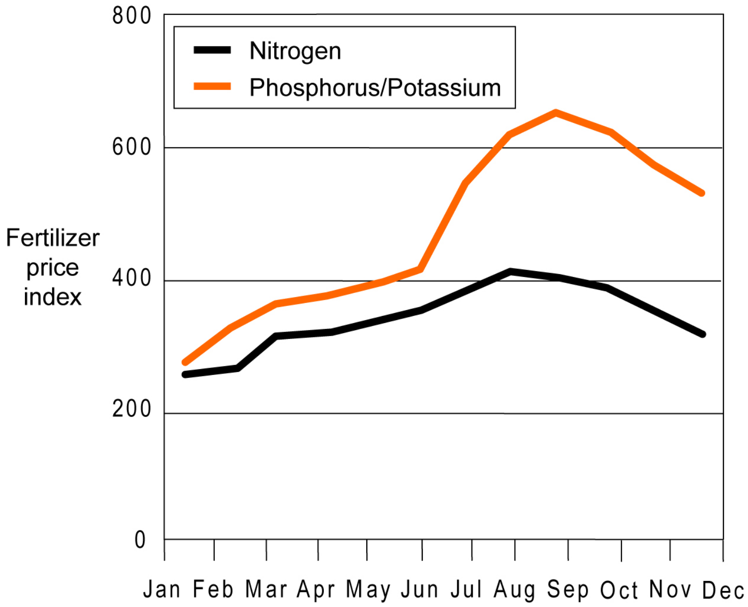

Figure 5. Fertilizer price index, 2008.[9]

Higher fuel costs hit not just farmers—who have to buy fuel for their tractors, as well as fertilizers and other agricultural chemicals made from oil and natural gas—but the entire food system: the cost of processing, packaging, and shipping food rose, making food costs a significant contributor to overall economic inflation.

An indirect impact of oil prices on food production has come by way of the push to expand biofuels production. As petroleum has grown more costly, governments have offered increased subsidies and other incentives for turning biomass into fuel. This inevitably makes food more expensive. Even non-fuel crops such as wheat are affected, as farmers replace wheat fields with biofuel feedstock crops such as maize, rapeseed, or soy.

The price spike of 2008, whose full impacts have yet to be calculated, was not an isolated event but the beginning of an inevitable trend. Higher oil prices and oil shortages will hit poor farmers first. Already, many farmers in Africa are seeing yields plummet as they try to maintain the

9 Bruce Erickson and Alan Miller, "Factors shaping price and availability in this year's fertilizer market," Purdue Extension, Purdue University (2009). http://www.agecon.purdue.edu/news/financial/Fertilizer_Market.pdf.

industrial methods they have been trained in (by the World Bank, IMF, and various aid agencies) while withholding the petrochemical inputs they can no longer afford.

Perhaps most frightening of all are the implications of fuel scarcity for food distribution: if high fuel prices, or a cut-off in supplies due to a sudden geopolitical event, were to keep trucks from delivering food to supermarkets (as nearly happened in Britain in 2000 and again in 2008 due to truckers' strikes), the shelves would quickly empty. Disruptions to the energy-intensive food processing, packaging, and preservation segments of our food system could be equally troublesome. While inevitable higher prices for petroleum are worrisome, protracted absolute scarcity would be a nightmare almost beyond contemplation.

The price spike of 2008, whose full impacts have yet to be calculated, was not an isolated event but the beginning of an inevitable trend.

A Survival Strategy

The only way to avert a food crisis resulting from oil and natural gas price hikes and supply disruptions while also reversing agriculture's contribution to climate change is to proactively and methodically remove fossil fuels from the food system. The methods for doing so are outlined in more detail throughout the remainder of this document.

It must be borne in mind that the removal of fossil fuels from the food system is inevitable: maintenance of the current system is simply not an option over the long term. Only the amount of time available for the transition process, and the strategies for pursuing it, should be matters for debate.

Given the degree to which the modern food system has become dependent on fossil fuels, many proposals for de-linking food and fossil fuels are likely to appear radical. However, efforts toward this end must be judged not by the degree to which they preserve the status quo, but by their likely

ability to solve the fundamental challenge that will face us: the need to feed a global population of seven billion with a diminishing supply of fuels available to fertilize, plow, and irrigate fields and to harvest and transport crops. Additionally, it should be noted that it is in farmers' interest to reduce their dependence on fossil fuels, as this builds resilience against future resource scarcity and price volatility.

While many tactics can be explored (and many will be place-specific in any case), some of the necessary outlines of a general transition strategy are already clear:

The only way to avert a food crisis is to proactively and methodically remove fossil fuels from the food system.

- In general, farmers can no longer assume that products derived from petroleum and natural gas (chiefly diesel, gasoline, synthetic fertilizers, and synthetic pesticides) will remain relatively available and affordable in the future—and thus should change their business plans accordingly.
- Farmers should move toward regenerative fertility systems that build humus and sequester carbon in soils, thus contributing to solving climate change rather than exacerbating it.
- Farmers should reduce their use of pesticides in favor of integrated systems of pest management that rely primarily on biological, cultural, and physical controls.
- More of the renewable energy that will power society can and must be generated on farms. Wind and biomass production, in particular, can provide farmers with added income while also powering farm operations.
- Nations and regions must deliberately reduce the energy needed to transport food by relocalizing their food systems. This will entail support for local producers and for local networks that bring

producers and consumers together. More efficient modes of transportation, such as ships and trains, must replace less efficient modes, such as trucks and planes.

- The end of the fossil fuel era must also be reflected in a change of diet and consumption patterns among the general population, with a preference for food that is locally grown, that is in season, and that is less processed. A shift away from energy-intensive, meat-centered diets should be encouraged.
- With less fuel available to power agricultural machinery, the world will need many more farmers. But for farmers to succeed, current agricultural policies that favor larger-scale production and production for export will need to change, while policies that support small-scale subsistence farming, gardening, and agricultural co-ops must be formulated and put in place—both by international institutions such as the World Bank, and also by national and regional governments.

If this transition is undertaken proactively and intelligently, there could be many side benefits—more careers in farming, more protection for the environment, less soil erosion, a revitalization of rural culture, and significant improvements in public health. Some of this transformation will inevitably be driven by market forces, led simply by the rising price of fossil fuels. However, without planning the transition may be wrenching and destructive, since market forces acting alone could bankrupt farmers while leaving consumers with few or no options for securing food supplies.

The Transition

Removing fossil fuels from the food system too quickly, before alternative systems are in place, would be catastrophic. Thus the transition process must be a matter for careful consideration and planning.

In recent years there has been some debate on the problem of how many people a non-fossil-fueled food system can support. The answer is still unclear, but we will certainly find out soon; substitute liquid fuels—including coal-to-liquids, biofuels, tar sands, and shale oil—are all

problematic and cannot be relied upon to replace cheap crude oil and natural gas as these deplete.[10]

There are reasons for hope, however. A recent report on African agriculture from the United Nations Environmental Program (UNEP) suggests that organic, small-scale farming can deliver the increased yields which were thought to be the preserve of industrial farming, without the environmental and social damage that comes with it.[11] Recent research from the University of Michigan also concludes that organic and low-input methods can increase yields in less-industrialized countries while maintaining yields in industrialized countries.[12]

Removing fossil fuels from the food system too quickly, before alternative systems are in place, would be catastrophic.

As a general rule, smaller farms have greater biodiversity,[13] more emphasis on soil-building,[14] and greater land-use efficiency than large farms.[15]

Nevertheless, no renewable food system can support an ever-expanding, ever more resource-demanding population. Given that current fossil fuel-based agriculture cannot be relied upon for much longer, the prudent path forward must coordinate agricultural policy with population, education, economic, transport, and energy policies. The food system transition will be comprehensive, and will require integration with all segments of society.

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10 Richard Heinberg, The Party's Over: Oil, War and the Fate of Industrial Societies (Gabriola Island, BC: New Society Publishers, 2003).

11 United Nations Environment Programme, UNCTAD, Capacity-building Task Force on Trade, Environment and Development, "Organic Agriculture and Food Security in Africa," (2008). http://www.unctad.org/trade_env/test1/publications/UNCTAD_DITC_TED_2007_15.pdf

12 Catherine Badgley, et al., "Organic agriculture and the global food supply," Renewable Agriculture and Food Systems 22 (2007): 86-108.

13 D. Hole, A. Perkins, J. Wilson, I. Alexander, P. Grice, & A. Evans, "Does organic farming benefit biodiversity?" Biological Conservation 122 (2005): 113-130.

14 Gerard D'Souza and John Ikerd, "Small Farms and Sustainable Development: Is Small More Sustainable?" Journal of Agricultural and Applied Economics 28 (1996): 73-83.

15 P.M. Rosset, "The Multiple Functions and Benefits of Small Farm Agriculture" (paper presented at "Cultivating Our Futures" FAO/Netherlands conference, Maastricht, The Netherlands, 12-17 September 1999).

This document is intended to serve as the basis for the beginning of that planning process. Our aim is to develop a template that can be used to strategically plan the transition of food and farming across the world, region by region, and at all scales (from the farm to the community to the nation), beginning in the U.S.

II. Elements of Transition

The following are some strategic elements of the food systems transition process that will need to be addressed at all scales, from the household to the nation and beyond.

The food system transition will be comprehensive, and will require integration with all segments and aspects of society.

Relocalization

In recent decades the food systems of the U.S. and most other nations have become globalized. Food is traded in enormous quantities—and not just luxury foods (such as coffee and chocolate), but staples including wheat, maize, meat, potatoes, and rice.

The globalization of the food system has had advantages: people in wealthy countries now have access to a wide variety of foods at all times, including fruits and vegetables that are out of season (e.g. apples in May or asparagus in January), and foods that cannot be grown locally at any time of year (e.g. avocados in Alaska). Long-distance transport enables food to be delivered from places of abundance to places of scarcity. Whereas in previous centuries a regional crop failure might have led to famine, its effects now can be neutralized by relatively cheap food imports.

However, food globalization also creates systemic vulnerability.[16] As fuel

16 For more on this complex topic, see Vandana Shiva, "Food, Finance & Climate," ZSpace, 22

prices rise, costs of imported food go up. If fuel supplies were substantially cut off as the result of some transient economic or geopolitical event, the entire system could fail. A globalized system is also more susceptible to accidental contamination, as we have seen recently with the appearance of toxic melamine in foods from China. The best way to make our food system more resilient against such threats is clear: decentralize and relocalize it.

Relocalization will inevitably occur sooner or later as a result of declining oil production, since there are no alternative energy sources on the horizon that can be scaled up quickly to take the place of petroleum. But if the transition process is to unfold in a beneficial rather than a catastrophic way, it must be planned and coordinated. This will require deliberate effort aimed at building the infrastructure for regional food economies—ones that can support diversified farming and reduce the amount of fossil fuel supporting the North American diet.

The best way to make our food system more resilient is clear: decentralize and relocalize it.

Relocalization means producing more basic food necessities locally. No one advocates doing away with food trade altogether: this would hurt both farmers and consumers. Rather, what is needed is a prioritization of production so that communities can rely more on local sources for essential foods, and long-distance imports are used largely for luxury foods (Figure 6). Regionally-adapted staples, which tend to have a low value and a long shelf life, should be grown in all areas as a matter of food security.

November 2008 (online at http://www.zcommunications.org/zspace/commentaries/3689).

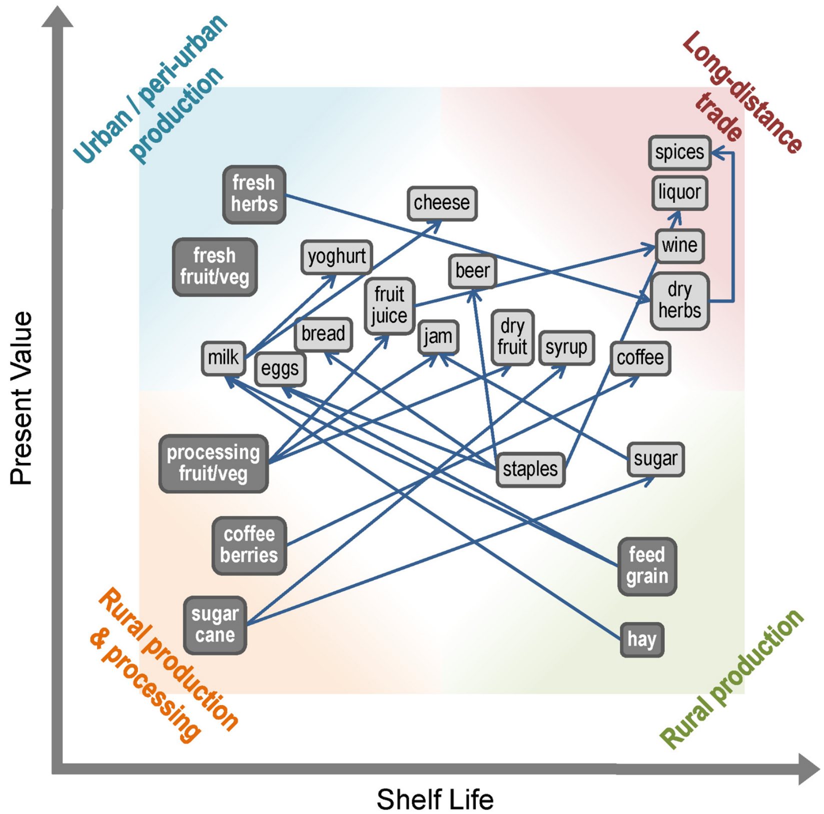

Figure 6. Relative position of selected food products on a plane defined by present value and shelf life. Arrows show common processes for food conversion. Long-distance hauling of food is best suited to high value, non-perishable products (red area). Urban and peri-urban agriculture is best suited to high value, perishable products (blue area). Rural production, requiring short hauls, is suited to lower-value foods for local processing (green area). Staples are usually relatively low-value, less-perishable starchy foods; urban production of staples can contribute to short-term food security during transportation crisis events, but rural production of staples is also necessary to meet long-term food needs. Processing usually increases food value and shelf life. Processing can reduce present value (e.g. drying herbs) or shelf life (e.g. making bread from grain), but not both; when present value is reduced, future value must increase through increased shelf life.

This decentralization of the food system will result in greater societal resilience in the face of fuel price volatility. Problems of food contamination, when they appear, will be minimized. Meanwhile, revitalization of local food production will help renew local economies. Consumers will

enjoy better quality food that is fresher and more seasonal. And transport-related climate impacts will be reduced.

Each nation or region will need to devise its own strategy for relocalizing its food system, based on a thorough initial assessment of vulnerabilities and opportunities. Vulnerabilities should be assessed by reviewing the myriad ways in which the local food supply is dependent on the relative affordability and availability of fossil fuels through all steps of the food production system and supply chain.[17] Opportunities will vary widely across communities and agricultural regions, although there are many things governments in most locations can do:

Each nation or region will need to devise its own strategy for relocalizing its food system, based on a thorough initial assessment of vulnerabilities and opportunities.

- Encourage the production and consumption of local food by supporting needed infrastructure like farmers' markets.
- Retrofit waste management systems to collect food scraps for conversion into compost, biogas, and livestock feed—which can be made available to local growers.
- Require that some minimum percentage of food purchases for schools, hospitals, military bases, and prisons is sourced within 100 miles of the institutions buying the food.
- Make food-safety regulations appropriate to the scale of production and distribution, so that a small grower selling direct off the farm or at a farmers' market is not regulated as onerously as a multinational food manufacturer.

Consumers must develop the habit of preferentially buying locally-sourced foods whenever possible, and they can be encouraged in this by "Buy Local" campaigns. Retailers can also assist by clearly labeling and prominently

17 See for example the work of the Irish organization Feasta, particularly Bruce Darrell's "Planning for Food Security" presentation, available online at http://www.postcarboncities.net/node/3215.

displaying local products.

Farmers themselves must rethink their business strategies. Most export-oriented farms will need to transition to production of staple foods for regional and local consumption, an effort that will require both seeking out local markets and growing crops appropriate for those markets; the Community Supported Agriculture (CSA) movement provides a business model that has proven successful in many areas). Small producers facing significant capital expenses for this transition can also create informal co-ops to acquire machinery, such as threshing machines for cereal and oilseed processing or micro hydro turbines for electricity.

The strategy of relocalizing food systems will be more challenging for some nations and regions than others. More urban gardens and even small animal operations (with chickens, ducks, geese, and rabbits) within cities should be encouraged, but even then it will be necessary to source most food from the countryside, delivering it to urban and suburban communities by fossil fuel-free transportation modes. Thus relocalization should be seen as a process and a general direction of effort, not as an absolute goal.

Energy

As society turns away from fossil fuels, the energy balance of farming must once again become positive. The transition could be complex and problematic. Farms will still use energy for their operations, but will need to provide much or all of that energy for themselves. Meanwhile, farmers could take advantage of opportunities to export surplus energy to nearby communities as a way of increasing farm income.

Farms must be powered with renewable energy. However, many energy needs on farms—such as fuel for tractors and other machinery—are currently difficult to fill with anything other than liquid fuels, which currently come in the form of diesel or gasoline made from crude oil. Farmers should first look for ways to reduce fuel needs through efficiency and the replacement of fuel-fed machines with animal power or human labor. This is most likely to be economically feasible in dairy, meat, vegetable, fruit, and nut operations.

Where fuel-fed machinery is still required, which is likely to continue being the case for grain production, ethanol or biodiesel made on-site could supplement or replace petroleum fuels. The key problem here is achieving a sufficient amount of energy returned on energy invested (EROEI)—that is, the amount of energy available in biofuels produced on-site must be substantially higher than the amount of energy consumed to produce those biofuels. Recent studies suggest that U.S. farmers could meet most on-site fuel needs by apportioning one-fifth of their cropland to the production of biofuels.[18]

Many other farm operations require electricity, and this can be generated on-site with wind turbines, solar panels, and micro-hydro turbines. Effort first must be devoted to making operations more energy-efficient. Because these technologies require initial investment and pay for themselves slowly over time, assistance from government and from financial institutions in the form of grants and low-interest loans could be instrumental in helping farmers overcome initial economic hurdles toward energy self-sufficiency. These renewable energy grants to small farmers should be a top national government priority.

Eventually farmers can be not just self-sufficient in energy, but capable of producing surplus energy for surrounding communities. Much of this exported energy is likely to come in the form of biomass: agricultural and forestry waste that can be burned to produce both electricity and hot water for space heating. While farmers can also grow crops for the production of liquid biofuels, the ecological and thermodynamic limits of this energy technology require that the scale of production be deliberately restricted. Otherwise, society's demand for fuel could overwhelm farmers' ability to produce food—and food must remain their first priority. In exporting biomass from the farm, growers must always keep in mind the productive capacity of sustainable agricultural systems, and they must strictly monitor soil health and fertility.

18 A leading EROEI scholar has proposed that the minimum EROEI needed for a fuel to make a real contribution to society is 5:1 (Charles A.S. Hall, "Provisional Results from EROI Assessments," The Oil Drum, published 8 April 2008 at http://www.theoildrum.com/node/3810"). Considering that a recent University of Idaho / USDA study claimed the EROEI of soybean biodiesel has increased to as high as 3.5:1 over the last decade (National Biodiesel Board, "Biodiesel proven to have a significantly positive net energy ratio," press release published 6 February 2008 at http://nbb.grassroots.com/08Releases/EnergyBalance/), and that the EROEI of other biofuels, such as palm oil biodiesel, can be as high as 9:1 (Worldwatch Institute, "Biofuels for Transportation: Global Potential and Implications for Sustainable Agriculture and Energy in the 21st Century," 2006.), 5:1 EROEI seems both a minimum and realistic goal for economically sustainable biofuel production. Thus, devoting one-fifth of a farm's land to efficient biofuels production should be sufficient to supply on-farm fuel needs.

The Food and Farming Transition

The transition of farms to renewable energy will require planning. Farmers, ideally with the assistance of regional and national agencies, should plan to increase energy efficiency, to reduce fossil fuel inputs, and to grow renewable energy production according to a staged, integrated program designed for the unique needs and capabilities of each farm. U.S. farms managed to reduce their fossil fuel use by approximately 30% between 1979 and 2000, largely by reducing their dependence on synthetic nitrogen fertilizer and pesticide inputs. A further 50% reduction by 2020 is an achievable goal if U.S. farms continue to aggressively pursue energy efficiencies and seek opportunities to replace fossil fuel use with renewable energy sources (Figure 7).

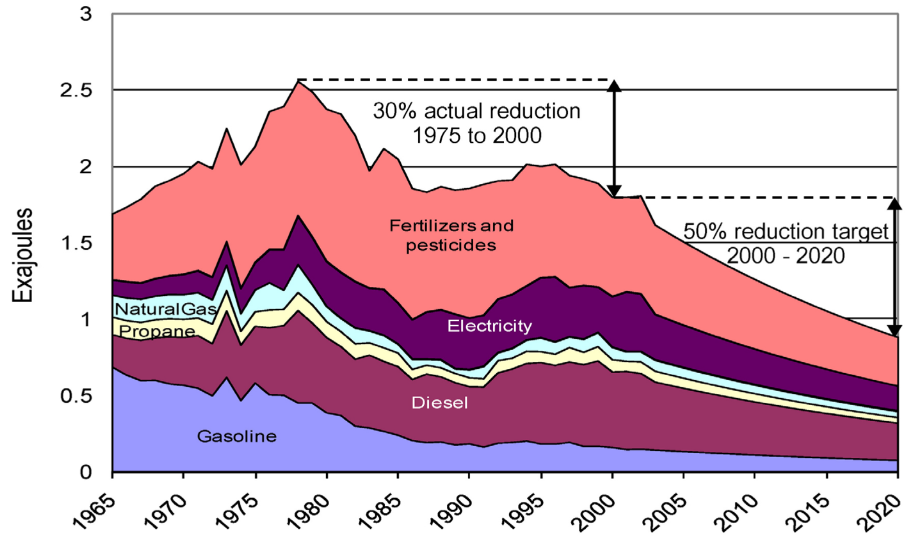

Figure 7. Total energy used by U.S. farms, 1965-2002,[19] with target for 50% reduction from 2000 levels by 2020. Future efficiency gains can come from further reductions in synthetic fertilizer and pesticide use; on-farm electricity generation from renewables including wind, hydro, and solar; and gradual replacement of liquid diesel fuel and gasoline with biofuels produced on farms. By 2020 U.S. farms should require less than 1 Exajoule from non-renewable energy sources.

19 J. Miranowski, op. cit.

Soil Fertility

In industrial agriculture, soil fertility is maintained with inputs provided from off-site. The most important of these are nitrogen and phosphorus. Nitrogen fertilizer comes from atmospheric nitrogen that reacts with hydrogen (usually derived from natural gas) under high pressure, high temperature conditions. Producing nitrogen fertilizer using this reaction consumes at least one-third (and likely much more) of the energy used for the cultivation of major crops such as wheat and rapeseed in the U.S.[20] Phosphorus comes from phosphate mines in several countries. While sufficient low-quality phosphate deposits exist to supply world needs for many decades, high-quality deposits are quickly depleting (Figure 8 shows a production profile for the US, which is by far the world's foremost producer), such that phosphate prices will likely rise in coming years.

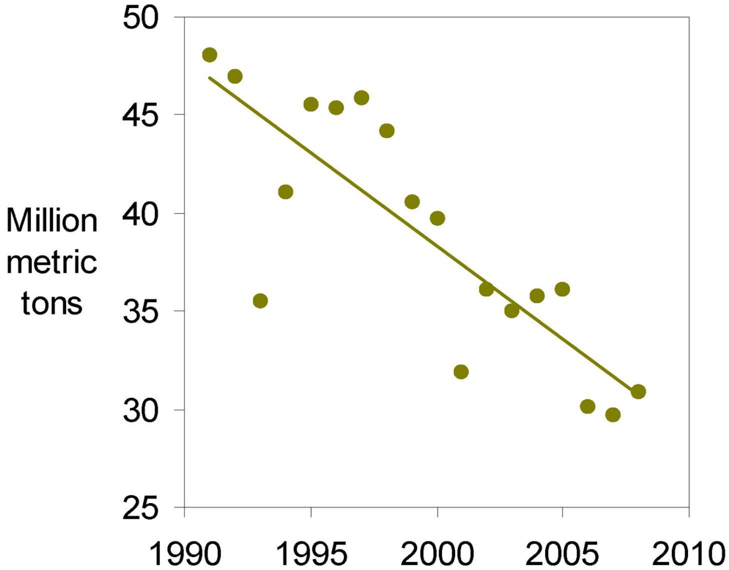

Figure 8. U.S. production of marketable phosphate rock, 1991-2008.[21]

20 Recent analyses of wheat and rape production show nitrogen accounting for nearly half the energy used in production: Gerhard Piringer and Laura Steinberg, "Reevaluation of Energy Use in Wheat Production in the United States," Journal of Industrial Ecology 10(2009): 149-167; see also Biopact, "Nitrogen fertilizer makes up 48% of rapeseed energy balance," English summary of original French study, http://news.mongabay.com/bioenergy/2007/04/nitrogen-fertilizer-makes-up-48-of.html (accessed 10 March 2009). For further reference see G.J. Leigh, "The World's Greatest Fix: A History of Nitrogen and Agriculture," (Oxford: Oxford University Press, 2004) and David Pimentel and Marcia Pimentel, "Food, Energy, and Society," 3rd edition (Boca Raton, FL: CRC Press, 2008), 137-159.

21 S.M. Jasinski, "Phosphate Rock," U.S. Geological Survey Mineral Commodity Summaries, accessed 3 March 2009 from http://minerals.usgs.gov/minerals/pubs/commodity/phosphate_rock/.

Both nitrogen and phosphorus are essential to agriculture, and our current ways of supplying both are clearly unsustainable. Unless alternative ways of maintaining soil fertility are quickly found, a crisis looms.

The long-term solution will depend on designing farm systems that build fertility through a two-fold strategy: rotating crops, and recycling nutrients.

Crop rotation can help with maintaining nitrogen levels. Simply planting a cover crop after the fall harvest significantly reduces nitrogen leaching while cutting down on soil erosion. Meanwhile, introducing nitrogen-fixing leguminous crops into the rotation cycle replaces nitrogen.

Cleverly designed polycultures sustainably out-produce monocultures on small and large farms in both the U.S.[22,23] and around the world.[24] Mixing crops, and reconnecting crop and livestock production, consistently makes more efficient use of land, nutrients, and energy, but usually requires more labor and farmer expertise.

Most industrial farmers gave up the practice of cover cropping when commercial fertilizers became the cheaper option. That cost equation shifted in 2008 as rising fertilizer prices outstripped the cost of seeding and managing nitrogen-fixing cover crops. Although fertilizer prices have fallen since the summer of 2008, they are likely to rise again. It is therefore important that farmers begin planning for higher fertilizer prices now by gearing up their rotation cycles and building natural soil fertility ahead of the immediate need.

In industrial agriculture, the soil is treated as an inert substance that holds plants in place while chemical nutrients are applied externally. Without efforts to maintain natural fertility, over time organic matter disappears from the soil, along with beneficial soil micro-organisms. In the future, as chemical fertilizers become more expensive, farmers will need to devote much more attention to the practice of building healthy soil. But rebuilding nutrient-depleted soil takes years of effort.

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22 M.P. Russelle and A.J. Franzluebbers, "Introduction to Symposium: Integrated Crop—Livestock Systems for Profit and Sustainability," Agronomy Journal 99 (2007): 323-324.

23 P.A. Jolliffe, "Are mixed populations of plant species more productive than pure stands?" Oikos 80 (1997): 595-602.

24 Food and Agriculture Organization of the United Nations, "Mixed crop-livestock farming: A review of traditional technologies based on literature and field experience," (accessed 4 March 2009 from http://www.fao.org/docrep/004/y0501e/y0501e00.htm).

Traditional farmers increase organic matter in topsoil through the application of compost, which not only builds soil fertility, but also improves the soil's ability to hold water and withstand drought. There is also mounting evidence that food grown in compost-amended soil is of higher nutritional quality.[25] In the current system, consumers, retailers, wholesalers, and institutions typically discard enormous quantities of food. Some communities have already instituted municipal programs for composting of food and yard waste; such programs could be expanded and made mandatory, with compost being sold or even given free to local farmers. This would reduce the amount of garbage going to landfills, as well as farmers' needs for fertilizers and irrigation, while improving the nutritional quality of the American diet.

Ultimately, there is no solution to the phosphorus supply problem other than full-system nutrient recycling.

In addition, recent research with "terra preta" (also known as "bio char"), a charcoal-like material that can be produced from agricultural waste, suggests that its introduction to soils could reduce plants' need for nitrogen by 20 to 30 percent while sequestering carbon that would otherwise end up in the atmosphere.[26] The potential of composting and the use of terra preta to mitigate the climate crisis is hardly trivial: a one-percent increase of soil organic matter in the top 12 inches of the soil is equivalent to the capture and storage of 250 tons of atmospheric carbon dioxide per square mile of farmland.

Ultimately, there is no solution to the phosphorus supply problem other than full-system nutrient recycling. This will entail a complete redesign of sewage systems and animal feedlots to recapture nutrients so they can be returned to the soil—as farmers in Europe, China, Japan and elsewhere did centuries ago. But if sewage systems (or simpler variants) are to become

25 P. Andrews, A. Mitchell and J. Glover, "Living Soil, Food Quality and the Future of Food" (paper presented at a meeting of the American Association for the Advancement of Science, 12-16 February 2009, Chicago, Illinois; accessed 4 March 2009 from http://www.organic-center.org/science.nutri.php?action=view&report_id=148).

26 United Nations Convention to Combat Desertification, "Use of biochar (charcoal) to replenish soil carbon pools, restore soil fertility and sequester CO2,"submission to the Ad Hoc Working Group on Long-term Cooperative Action under the Convention, Poznan, 1-10 December 2008 (online at http://terrapreta.bioenergylists.org/zteinerpoznanbiochar).

primary sources of phosphorus and other soil nutrients, they cannot continue to be channels for the disposal of toxic wastes. It is essential that separate waste streams be developed for the disposal of all pharmaceuticals, household chemicals, and industrial wastes. Thus the problem of soil fertility is one that farmers cannot solve on their own: it is a crisis of the food system as a whole, and must be addressed contextually and holistically.

Diet

Consumers' choices are as important to the makeup of the food system as producers' choices. During recent decades, consumer preferences have been shaped to fit the industrial food system through advertising and the development of mass-marketed, uniform, packaged food products that, while often nutritionally inferior, are cheap, attractive, and, in some cases, even physically addictive. The advent and rapid proliferation of "fast food" restaurants has likewise fostered a diet that is profitable to giant industrial agribusiness, but disastrous to the health of consumers. Not only are these trends lamentable from a public health standpoint, they are clearly unsustainable in view of the energy and climate crises facing modern agriculture.

Because processed foods, packaged foods, and fresh foods imported out of season add to the energy intensity of the food system, rich and poor alike must learn to eat locally-grown, less-processed foods in season. Public education campaigns could help shift consumer preferences in this regard. A shift toward a less meat-centered diet should also be encouraged, because a meat-based diet is substantially more energy intensive than one that is plant-based.[27]

Government institutions can help with a shift in diet preferences through their own food purchasing polices (see "Relocalization," above). The process can be helped even further by a more careful official government definition of "food." It makes no sense for government efforts intended to improve the nutritional health of the people to support the consumption of products known to be unhealthful—such as soda and other junk food.

27 Pimentel and Pimentel, op. cit., pp.133-134.

Farming Systems

During the past few decades farming has become more specialized. Today, a typical farm may produce only meat of a single kind (turkey, chicken, pork, or beef), or only dairy, or a single type of grain, vegetable, fruit, or nut.

This narrow specialization made economic sense in the era of cheap energy and farm inputs. But because nature is diverse and integrated, the deliberate elimination of diversity on the farm has led to problems at every step. For example, industrial scale feedlots (also known as concentrated animal feed operations, or CAFOs) produce enormous amounts of waste that end up in massive manure lagoons that pollute ground water and foul the air. Meanwhile, grain diets fed to the animals result in digestive problems requiring the large-scale administration of antibiotics that find their way into both the human food system and ground water, and that lead to antibiotic resistance among disease organisms that afflict humans.

By switching to multi-enterprise diverse systems, farmers can often solve a range of problems at once.

Farm specialization also impacts the grain or vegetable grower. Soils that annually produce these crops need a regular replenishment of nitrogen; but if the farmer keeps few animals, there may be no option other than to import fertilizers from off-site.

By switching to multi-enterprise diverse systems, farmers can often solve a range of problems at once. Feeding much less grain to livestock while giving them access to pasture in rotation with other crops maintains soil fertility while leading to better animal health and higher food quality. The farmer, the environment, and the consumer all benefit.

Organic agriculture stems from the ideas of Sir Albert Howard,[28] who championed small, diversified farming systems that mimicked natural

28 A. Howard, An Agricultural Testament, (London: Oxford University Press, 1943), available at http://journeytoforever.org/farm_library/howardAT/ATtoc.html.

ecosystems and promoted on-farm resource cycling. National organic standards, enacted in 2002, were an attempt to codify Howard's ideas in federal law. Although simple compliance with the organic standards does not guarantee a sustainable farming system, considerable recent research shows that organic farms tend to use less energy and fewer off-farm inputs,[29] support greater biodiversity,[30] and have healthier soil,[31] animals,[32] and plants[33] than their conventional counterparts. U.S. sales of organic products have grown exponentially for two decades. The growth in the organic sector has been accomplished by finding practical ways to grow food and fiber using ecosystem services instead of relying on energy-intensive synthetic fertilizers and pesticides.

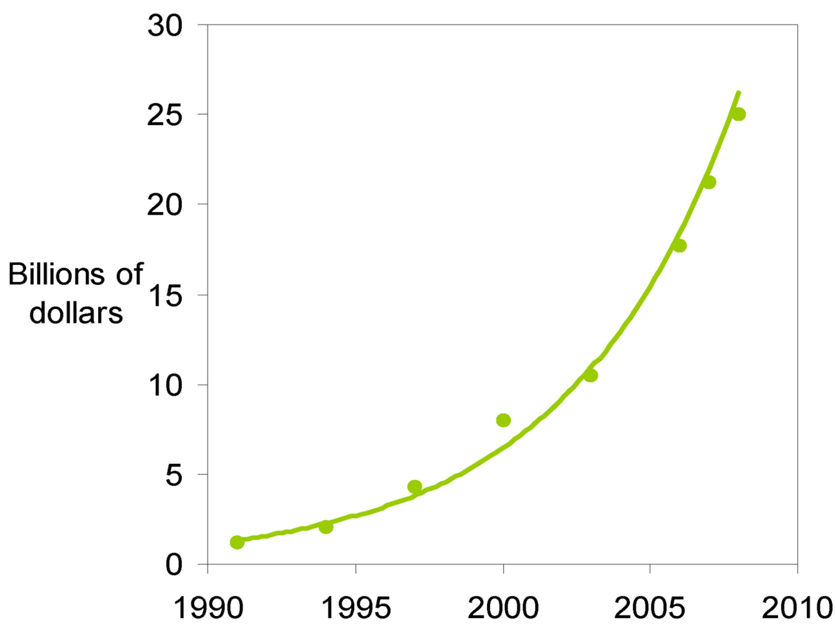


Figure 9. U.S. organic product sales between 1991 and 2008.[34]

29 H.M. van der Werf, J. Tzilivakis, K. Lewis, & C. Basset-Mens, "Environmental impacts of farm scenarios according to five assessment methods," Agriculture, Ecosystems & Environment 118, no. 1-4 (2007): 327-338.

30 D.G. Hole, A.J. Perkins, J.D. Wilson, I.H. Alexander, P.V. Grice, and A.D. Evans, "Does organic farming benefit biodiversity?" Biological conservation 122 no.1 (2005): 113-130.

31 E.E. Marriott and M.M. Wander, "Total and labile soil organic matter in organic and conventional farming systems," Soil Science Society of America Journal 70 no.3 (2006): 950-959.

32 V. Lund and B. Algers, "Research on animal health and welfare in organic farming—a literature review," Livestock Production Science 80 no.1-2 (2003): 55-68.

33 C. Benbrook, "The Impacts of Yield on Nutritional Quality: Lessons from Organic Farming," HortScience 44 no. 1 (2009): 12-14.

34 Organic Trade Association, "Organic Industry Overview" (accessed 6 March 2009 from http://www.ota.com/organic/mt.html).

The post-fossil fuel food transition may also compel a rethinking of the size of farm operations. The mechanization of farm operations and the centralization of food systems favored larger farms. However, as fuel for farm machinery becomes more costly, and as fossil fuel-independent farming requires more human labor and animal power, smaller-scale operations will once again become profitable. In addition, a smaller scale of operations will be needed as farms become more diverse, since farmers will have more system elements to monitor. Agriculture will thus become more knowledge-intensive, requiring a holistic attitude on the part of farmers.

In urban areas, micro-farms and gardens—including vertical gardens and rooftop gardens that include small animals such as chickens and rabbits could provide a substantial amount of food for growers and their families, along with occasional income from selling seasonal surpluses at garden markets.

Farm Work

With less fuel available to power agricultural machinery, the world will need more farmers. But for farmers to succeed, some current agricultural policies that favor larger-scale production and production for export will need to change, while policies that support small-scale farms, gardens, and agricultural co-ops must be formulated and put in place—by international institutions such as the World Bank, as well as by national, state, and local governments.

Currently the U.S. has fewer than two million full-time farmers. In 1900, nearly 60 percent of the population farmed; the current proportion is less than one percent (Figure 2, Figure 10). Today, the average farmer is nearing retirement age.[35]

In nations and regions where food is grown without machinery, a larger percentage of the population is involved in food production (Figure 10). For example, farmers make up more than half the populations of China, India, Nepal, Ethiopia, and Indonesia.

35 United States Department of Agriculture, Economic Research Service, "Briefing Room - Farm Structure: Questions and Answers," (accessed 10 March 2009 from http://www.ers.usda.gov/Briefing/farmstructure/Questions/aging.htm).

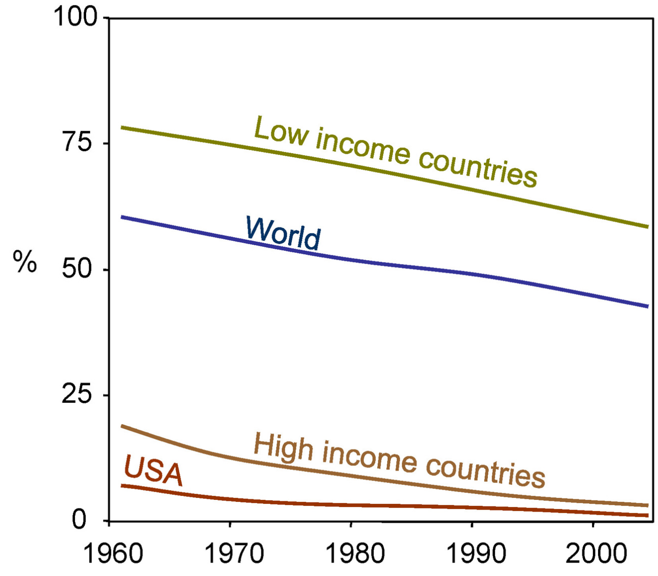
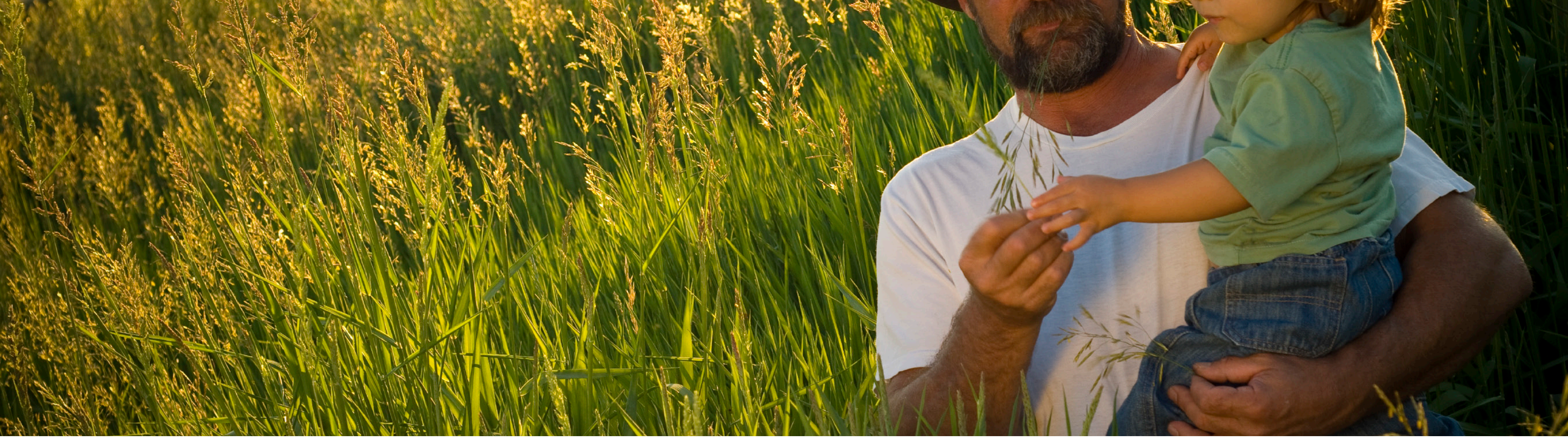


Figure 10. Proportion of population engaged in agriculture, 1961-2004.[36]

While the proportion of farmers that would be needed in the U.S. if the country were to become self-sufficient in food grown without fossil fuels is unknown (that would depend upon technologies used and diets adopted), it would undoubtedly be much larger than the current percentage. It is reasonable to expect that several million new farmers would be required—a number that is both unimaginable and unmanageable over the short term. These new farmers would have to include a broad mix of people, reflecting America's increasing diversity. Already growing numbers of young adults are becoming organic or biodynamic farmers, and farmers' markets and CSAs are springing up across the country (Figure 11). These tentative trends must be supported and encouraged. In addition to government policies that support sustainable farming systems based on smaller farming units, this will require:

Education: Universities and community colleges must quickly develop programs in small-scale ecological farming methods—programs that also include training in other skills that farmers will need, such as in marketing and formulating business plans. Apprenticeships and other forms of direct knowledge transfer will assist the transition. Gardening programs must be added to the curricula of all primary and secondary schools, especially in summer programs.

36 World Resources Institute, "EarthTrends," (accessed 4 March 2009 from http://earthtrends.wri.org).



Financial Support: Since few if any farms are financially successful in their first few years, loans and grants will be needed to help farmers get started.

Community and Cultural Revitalization: Over the past decades American rural towns have seen too many of their young people flee first to distant colleges and then to cities. Farming communities must be interesting, attractive places if we expect people to inhabit them and children to want to stay there.

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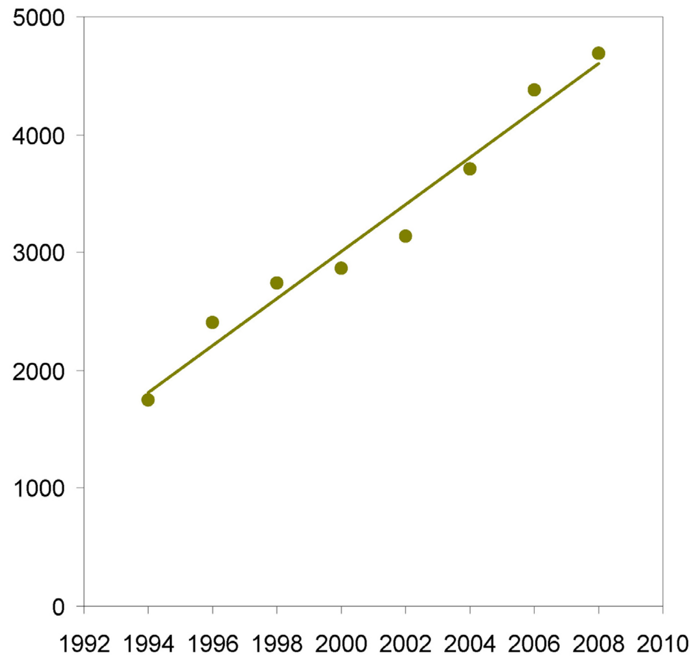

Figure 11. Farmers markets operating in the USA, 1994-2008. Approximately 200 new farmers markets have started each year for the past 14 years, more than doubling the number in operation nationwide.[37]

37 United States Department of Agriculture, Agricultural Marketing Service, "Wholesale and farmers markets—Farmers market growth, 1994-2008" (accessed 4 March 2009 from http://www.ams.usda.gov).

Seed

Today's seed industry is highly centralized. Many commercial seeds are hybrid annual varieties which must be purchased new each year.

Worldwide, a growing proportion of the commercial seed available for certain commodity crops—like corn, cotton and soybean—is genetically modified (GM). GM seed companies have long offered the promise that their products will eventually lead to more nutritious crops; however, currently patented genes merely confer resistance to insect pests or proprietary herbicides, while the promise of more nutrient-rich crops is years from realization.[38] Given that the need for transition is immediate, efforts to build a post-fossil fuel food system cannot wait for new technologies that may or may not appear or succeed. In any case, the GM seed industry depends on energy-intensive technologies, such as chemical fertilizers and herbicides, as well as centralized production and distribution systems, that are inextricably tied to the wider fossil-fuel based food system. Thus GM crops are unlikely to be of much help in the transition.

The transition process will undoubtedly be fraught with challenges to food processing and distribution systems.

What is needed instead are coordinated efforts to identify open-pollinated varieties of food crops that are adapted to local soils and microclimates, and programs to make such seeds available to farmers and gardeners in sufficient quantities. In addition, local colleges can begin offering courses on the techniques of seed saving.

Processing and Distribution Systems

The transition process will undoubtedly be fraught with challenges to food processing and distribution systems, which currently rely on large energy inputs and long-distance transport.

38 Golden rice is the most commonly-cited example of a GM crop designed to be more nutritious. It has been in development since 1992, but is not yet available for human consumption.

For example, the meat industry now depends on the long-distance transport of livestock to centralized facilities for slaughter. Relocalizing food systems will entail creating incentives for the emergence of smaller, more localized slaughterhouses and butcher shops. One interim solution would be for a fleet of mobile abattoirs to go from farm to farm, processing animals humanely and inexpensively.[39]

Many health regulations were originally designed to check abuses by the largest food producers, but such regulations may now inhibit the development of smaller-scale and more localized processing and distribution systems. For example, farmers should be able to smoke a ham and sell it to their neighbors without making a huge investment in nationally approved facilities. A small producer selling direct from the farm or at a farmers' market should not be subject to the same food safety regulations as a multinational food manufacturer: while local food may occasionally have safety problems, those problems will be less catastrophic and easier to manage than similar problems at industrial-scale facilities.

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Food processors must look for ways to make their present operations more energy efficient, while government agencies, consumers, and retailers find ways to reduce the need for food processing and also for food packaging. This gradual shift will require institutional support for families in storing, processing, cooking, and preserving food within the home. Small-scale commercial multi-use food processing centers can enable small local growers to make value-added products that are competitive with those that carry national-brand labels.[40]

39 Mobile meat processing units are in operation in Iowa, Kansas, Kentucky, North Dakota, Pennsylvania, and Washington state. See http://www.extension.org/pages/Niche_Meat_Processor_Case_Studies.

40 Shared-use commercial kitchen projects are succeeding nationwide. For examples see the Mission Mountain Food Enterprise Center (Ronan, Montana, www.mmfec.com), the Anson County Commercial Kitchen (North Carolina, www.nvbdi.org/services/kitchen.php), or the Chef's Kitchen (Los Angeles, California, www.chefskitchens.com).

Meanwhile, in view of inevitable problems with existing transport systems, national and regional food storage systems must be reconsidered. Regional reserves of grain, sufficient to provide for essential needs during an extended food crisis, must be kept and managed to avoid spoilage. Packaging of food should be regulated to minimize the use of plastics, which will become more scarce and expensive as oil and gas deplete—and which are also implicated as sources of toxins.

Government should institute policies that prioritize the distribution of food within the nation by rail and water, rather than by road, as trucks are comparatively energy inefficient (Figure 12). Supermarkets are currently the ultimate distribution sites for food in most instances. However, this model presupposes near-universal access to automobiles and gasoline. A resilient food system will require smaller and more widely distributed access points in the forms of small shops and garden or farm markets. Government regulations and tax incentives can help accomplish that shift.

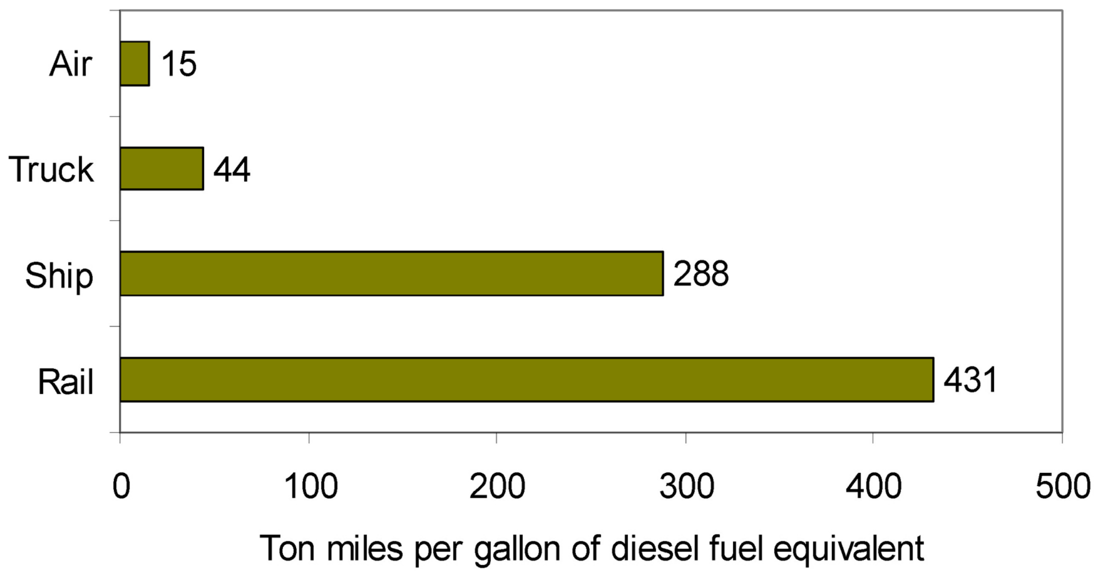

Figure 12. Relative efficiency of different methods of hauling freight domestically. A train can haul a ton of freight 431 miles on a gallon of diesel fuel. The same amount of fuel would carry a ton of freight only 15 miles by air. All figures are for domestic transportation; trans-oceanic freighters can be more efficient than the domestic shipping shown here.[41]

41 United States Department of Energy, "Transportation Energy Data Book: Edition 27" (accessed 4 March 2009 from http://cta.ornl.gov/data/download27.shtml).


Photo: Nick Saltmarsh / flickr

Wholesalers and distributors will have a changed role in a transitioning food system. They will still be needed to manage the supplies of various seasonally produced foods moving from producers to consumers. However, rather than favoring large producers and giant supermarket chains, they must alter their operations to serve smaller, more distributed farms and gardens, as well as smaller and more distributed retail shops.

III. Resilience Action Planning

The transition process will succeed by creating more resilience in food systems. Resilient systems are able to withstand greater magnitudes of disturbance before undergoing a dramatic shift to a new condition in which they are controlled by a different set of processes. One quality of resilience is redundancy—which is often at odds with short-term economic efficiency. Efficiency in the food system implies both long supply chains and the reduction of inventories to a minimum. This "just-in-time" delivery of products reduces costs, but it increases the vulnerability of systems to disturbances such as fuel shortages. As more attention is paid to resilience and less to short-term efficiencies, redundancy and larger inventories are seen as benefits rather than liabilities. Other resilience values include diversity (as opposed to uniformity), and dispersion (rather than centralization) of control over systems.

Building resilience into our food systems as we move toward a post-fossil fuel economy will entail all of the elements of transition detailed above. It will also require planning at four levels: Government, Community, Business, and Individual or Family. At each level the planning process will necessarily be somewhat different. This section delineates the main planning steps that will make sense at each of these levels. In some instances, steps within an action plan should be undertaken concurrently. In any case, what is offered here is merely a skeletal outline for a process that must be developed to fit the unique needs of those it will serve.

Government

The food system is a complex mix of private and public actors from the most local to the most global levels. As such, governments have a special responsibility to ensure that the system is resilient and meeting constituents' basic need for food as equitably as possible.

The following steps are applicable at any level of government—national, regional, or local. At the highest level of scale (the nation), each step will itself be the subject of detailed planning and delegation; an excellent example of a national-level food system assessment is the Soil Association's "Sustainable Food Plan for Britain" campaign.[42] At the lowest level of scale (small villages), government may lack the capacity to undertake any of these steps or do more than offer symbolic official support to volunteer citizen initiatives.

1. Assess the existing food system. Begin with a study of current systemic vulnerabilities and opportunities. How are farm inputs currently sourced? How much food is currently imported? What proportion of those food imports are staples, and what proportion are luxury foods? What are the environmental costs of current agricultural practices? How would the current food system be impacted by fuel shortages and high prices?

2. Review policies. How are current policies supporting these vulnerabilities and environmental impacts? How can they be changed or eliminated? Are there policies already in place that are likely to help with the transition? How can these latter policies be strengthened?

3. Bring together key stakeholders. Organizations of farmers, food processing and distributing companies, and retailers must all be included in the transition process. Many will wish simply to maintain the existing system, but it must be made clear that this is not an option. Many companies involved in the food system will need to change their business model substantially.

4. Make a transition plan. The transition plan that is formulated must be comprehensive and detailed, and must contain robust but attainable targets with timelines and mechanisms for

42 The Soil Association, "A Sustainable Food Plan for Britain" (accessed 11 March 2009 at http://www.soilassociation.org; also at http://tinyurl.com/af6w7c.)

periodic review and revision. A scoping exercise must be undertaken to assess the impact of the plan on agricultural output and to quantify the changes in kinds of commodities produced and in their volumes and prices.

5. Educate and involve the public. The public must not only be informed about the government-led aspects of the transition process but also be included in it. Citizens must be educated about food choices, gardening opportunities, and ways to access food from local producers. Their successes and challenges in adaptation will inform new iterations of the plan.

Citizens must be educated about food choices, gardening opportunities, and ways to access food from local producers.

6. Shift policies and incentives. This is the key responsibility of government, as it either limits or enhances the ability of community groups, businesses, and families to engage in the transition process. Policy changes must reflect stakeholder input, but must nevertheless be designed primarily to further the elements of transition, rather than the short-term interests of any particular stakeholder group.

7. Monitor and adjust. An undertaking of this magnitude will inevitably have unforeseen and unintended impacts. Thus it is essential that progress be continually reviewed with an eye to making adjustments to pace and strategy, while maintaining absolute adherence to the central task of methodically removing fossil fuels from the food system.

Community

The following are action steps for adoption by voluntary community groups, as opposed to governments (see above). The Transition Network (www.transitionnetwork.org) provides an excellent model for this kind of community action. Such efforts seem to work best when the scale of community is such that meetings can be managed by volunteers and meeting participants need not travel long distances. Thus in large cities, resilience action planning could take place at the neighborhood level, with neighborhood delegates sent to occasional city-wide coordinating meetings. The overlap and mutual support between community organizations and local government efforts must be a matter for discussion and negotiation.

1. Assess the local food system. This assessment process should be undertaken in cooperation with government, so as not to duplicate tasks. Volunteer citizen groups may be in positions to provide perspectives that otherwise might elude government assessment efforts—such as opportunities for community gardens, or problems with access to food from local sources.

2. Identify and involve stakeholders. Local growers, shop owners, public kitchens, restaurants, schools, and other institutions that produce or serve food should all be contacted and invited to join a voluntary relocalization initiative and to offer input into the process.

3. Educate and involve the public. Community groups can stage public events to raise awareness about food transition issues. "Buy local" brochures and pamphlets, paid for and distributed by a consortium of local businesses (but organized by volunteer groups), can list local producers, farm markets, restaurants, and shops.

4. Develop a unique local strategic program. This can include farmers' markets, CSAs, community gardens, school lunch programs, and public kitchens. The program, based on input from stakeholders, could feature targets and timelines established through a collaborative exercise aimed at envisioning the local food system as it might look in the future after fossil fuels have ceased to play a dominant role.

5. Coordinate with government programs. Local volunteer efforts can play a significant role in informing government policies and in implementing transition strategies. However, this will require maintaining of open channels of communication, which in turn will be

the responsibility of both government and the local groups.

6. Support individuals and families. Individuals are likely to change food habits and priorities only if they see others doing so as well, and if they feel that their efforts are supported and valued. Community groups can help by establishing new behavioral norms through public events and articles in local newspapers, and by working through existing social networks, schools, neighborhood associations, religious institutions, etc. Practical help can be offered via canning parties, garden planting and harvest parties, and gleaning programs. Local food and gardening experts can be made available to answer questions and concerns. Neighborhood food storage facilities can also be created to supplement household cupboards.

7. Monitor and adjust. All of these efforts must be continually adjusted to assure that all segments of the community are included in the transition process, and that the process is working as smoothly as possible for all.

Businesses and Institutions

Relevant businesses include farms, shops, processors, wholesalers, and restaurants. However, the following steps could also be useful to organizations such as schools, colleges, and hospitals that dispense food as an ancillary part of their operations.[43]

1. Assess vulnerabilities. Every business or organization that is part of the food system must take an honest look at the inevitable impacts of higher fuel prices, and fuel scarcity, on its operations. Examine scenarios based on a doubling or tripling of fuel costs to highlight specific vulnerabilities.

2. Make a plan. Develop a business model that works without—or with continually shrinking—fossil fuel inputs. Specify achievable interim targets that make progress toward the long term goal.

3. Work with government and community groups. Assuming that government will

43 For additional reference see Sustainable Table, http://www.sustainabletable.org/schools.

be developing regulations to reduce fuel use in the food system, and that community organizations will be offering support to local farmers and food shops that spearhead the transition, it makes good business sense to lead the effort rather than wait for others to act.

4. Educate and involve suppliers and customers. No business is an island. The transition will flourish through strengthened relationships on all sides.

5. Monitor and adjust. For businesses, one obvious and essential criterion of success is profitability. The bottom line will help indicate which adaptive strategies are working, and which ones need work. However, negative financial feedback is no reason to abandon the essential goal of transition.

Individual and Family

The food and agriculture transition ultimately comes down to choices made at the market and meals consumed at the dinner table. Therefore actions by individuals are just as important to the success of the transition as anything that can be done by farmers, governments, or food businesses. Anyone can undertake the following steps immediately.

1. Assess food vulnerabilities and opportunities. Take an honest look at typical monthly food purchases and give careful thought to their implications. How much food comes from within 100 miles? How much is packaged and processed? How many meals are meat-centered? Where is food bought? How would the family cope with a doubling or tripling of food and fuel prices?

2. Make a plan. Create an ideal food scenario for the family, including diet, shopping habits, and gardening goals. Identify concrete actions and a timeline to move toward this scenario. Post these at home in a prominent location.

3. Garden. Even families without access to land can grow sprouts in a jar or a few food plants in a window box. Join a community garden. Learn from, and teach, other gardeners.

4. Develop relations with local producers. Even families with large gardens probably can't grow all of their own food. Use local farmers' markets or CSAs to access locally-grown food and reduce dependence on the global food system.

5. Become involved in community efforts. Get to know neighbors and compare gardening experiences with them. Together, form a "tool library" from which members can check out garden tools and gardening books. Organize or participate in planting, harvesting, food-swapping, gleaning, and canning parties.

6. Monitor and adjust. Family plans should be revisited each month. Evaluate success at meeting family goals, and revise the plan if necessary.

Conclusion

The American food system rests on an unstable foundation of massive fossil fuel inputs. It must be reinvented in the face of declining fuel stocks. The new food system will use less energy, and the energy it uses will come from renewable sources. We can begin the transition to the new system immediately through a process of planned, graduated, rapid change. The unplanned alternative—reconstruction from scratch after collapse—would be chaotic and tragic.

The seeds of the new food system have already been planted. America's farmers have been reducing their energy use for decades. They are using less fertilizer and pesticide. The number of organic farms, farmers' markets, and CSA operations is growing rapidly. More people are thinking about where their food comes from.

These are important building blocks, but much remains to be done. Our new food system will require more farmers, smaller and more diversified farms, less processed and packaged food, and less long-distance hauling of food. Governments, communities, businesses, and families each have important parts to play in reinventing a food system that functions with limited renewable energy resources to feed our population for the long term.