CHAPTER 8

Food-Energy: the Fragile Link Between Resources and Population

Every successful species harbors a genetic drive to reproduce more numbers than can be supported by a stable, sustainable environment. The limitations are food, non-energetic resources necessary as building blocks for life, competing species (also hungry for food), a hospitable ambience, and adequate physical space. Those who best adapt evolve as conditions crowd out or supercede those that don't. **This is simple Darwinism and most often infers a short, harsh individual life of competition and survival.** Changes in the environment by natural causes and/or environmental destruction add additional challenges to the status quo, and favor those species which are fortunate enough to adapt, **or smart enough to plan ahead.**

THE FOOD-ENERGY BALANCE

Humans acquire their energy from food which at one time came directly (or indirectly farther down the food chain from other plant eaters) from plant photosynthesis of incoming solar energy. As quickly as new offspring begin to grow on their own, increased demands are placed on the food supply although at first it may be as food-energy still supplied by a supportive parent(s). **As long as food is available the population will increase to the limits of the species' range, individual or collective skill (including tools), and individual energy available to procure the food and/or avoid being food for others**. It should be obvious that population is therefore limited first and primarily by the ability to access and store food. A quick look back to the energy-barrel analogy in Figure 11 may help explain the potential for growth or contraction of any system (including a human body) based on the input-output balance of energy, either stored from the past or acquired contemporarily, **but cannot be borrowed from the future.**

To continue our analysis, we will focus on the food-energy balance required for human survival **without** relying on a temporary surge of non-renewable energy capital, e.g., fossil fuels, or imported food from another location or time (inferring a surplus somewhere else). **For hundreds of thousands of years our predecessors lived as hunter-gatherers in a precarious, but on average, ratio which had to be larger than one between food-energy returned on (personal) energy invested (FEROPEI).**

Cultivation and agriculture

Then, about ten thousand years ago, humans learned to utilize favorable, unique, local growing conditions and crops. The age of agriculture began. A slight improvement of human FEROPEI, combined with reduced energy requirements and risk related to excessive travel, provided a tiny energy surplus to support the beginning of recorded history. The extra energy made possible early civilizations and the construction of ancient monuments many of which have survived to this day. To build anything of substance, the energy has to come from the excess over and above the primary requisite-energy required for personal food and survival. **Instead of a hunter-gatherer barely able to procure food for himself and enough progeny to perpetuate the species, a hard-working farmer with favorable ecological conditions could now feed additional dependents plus non-farmers.** Energy-intensive travel was still limited by human personal mobility, draft animals, and wind power for sailing.

Because of agriculture, the average FEROPEI improved, possibly up to 6:1. This provided the steady-state support for long-term societies like the Chinese, **but could not support continued growth** of extensive, non-agrarian expansion like the Roman Empire. Many societies flourished, then collapsed because of the inevitable conflict between growing population and the limitations and degradation of local food-carrying capacity.

Additional energy

Following the collapse of the Roman Empire, slow adaptation to wind, water, and draft-animals gradually improved local agricultural output by reducing the direct dependency of food output from human-energy alone. The food-energy return on human labor input (FEROPEI) slowly increased up to the 10:1 or 12:1 range. Still, population was held in check by disease, poor health care, unpredictable diet, infant mortality, and short life spans. But, the new energy surplus made possible multiple layers of non-farm population, societal admininstration, and cities. Marketing, money, and laws evolved on the backs of peasant (or slave) farmers. There was enough extra energy and manpower to support armies and wars required to wage territorial, resource, and cultural disputes.

A very erratic and slow increase in world population continued up to just several hundred years ago. Additional food sources and room for growth came primarily from exploration and settlement of new lands. Malthus's prediction of population limits was temporarily proven wrong because the exploitable world seemed limitless. Then, suddenly, inventions of new ways to exploit the convenient vast stores of finite fossil energy, far beyond renewable wind and water, made possible and began the industrial age. As would be expected, the unprecedented utilization of non-human energy escalated the food-energy available for human consumption and population growth.

A new (very short) high-energy age

The utilization of vast stores of pre-stored fossil energy, beginning with coal two-hundred years ago, and followed by oil and natural gas, suddenly jumped the ratio of food energy returned on personal energy invested (FEROPEI) to as high as 300:1. One farmer could now feed three-hundred people instead of six by himself or twelve with the help of animal power. Concurrently, in the same short period, as would be expected, world population soared from one-billion to seven-billion. This was due to many factors directly related to the sudden energy bonanza. Access to formerly remote lands, genetic crop improvements, inorganic nitrogen fertilizer, pesticides, energy-intensive farm equipment, irrigation, refrigeration, packaging, and long-distance mobility all contributed to the modern lifestyle now enjoyed by the industrialized world. Concurrently, giant strides in medicine and health care vastly increased life span and population. **But still, all must eat with the same basic individual requirement of 8000 BTU per day.** Figures 4 and 7 show the direct correlation between the sudden increase of oil consumption and population. Figures 1 and 8 combine both as per capita utilization by the average world inhabitant. Figure 1 shows the huge disparity in oil consumption between the world average and extreme consumers as are living in the U.S.

In the past several decades the "green revolution" maximized food production and made possible the seven-billion humans now needing food. However, this final push is unsustainable and is causing new problems; for instance, genetically modified (GM) foods may be linked to new health risks.

Resilience, an advantage of crop diversification, is absent. New pesticides, monoculture, and herbicides also lead to super-bugs and environmental contamination. The societal improvements promised by capitalism and industrialized agriculture are, in effect, just more examples of temporarily polarizing wealth between the masses and the few who control the system. **Finally, and obviously, the mechanization of modern agriculture cannot continue without oil.**

The link must break

Now, after a one lifetime span of almost free energy and resultant copious food, the entire world faces the imminent decline (and eventual demise) of finite, fossil-fuel capital and therefore must inevitably face a return to the food-production default range with a FEROPEI as low as 6:1 or, at most, 12:1. This assumes individual farmers can retain a semblance of traditional agriculture, knowledge, hard work, and renewable energy, while drastically reducing non-food energy expenditures for travel and keeping warm. This is the "end point" we must return to in the next 60 to 80 years while, **in the same one-lifetime span**, reducing the numbers to be fed from the present seven billion back to, at most, one or two billion who **must also be located very close to their food source.** Without fossil fuels, food can no longer be produced in one area and shipped thousands of miles to market. Nutrients must also be returned to their source. **To suggest that the world will be able to feed the UN projected population of nine billion by 2050 is totally incomprehensible in the face of declining oil. This food-energy disconnect is shown as a "food gap" in Figure 4 and this book's cover.**

Can we return to "sustainability"?

Homo Sapiens will survive. Our ancient ancestors lived off the land and survived ice ages (without metal or plastics). But, in order to avoid total collapse first, we must clearly recognize our predicament in quantitative terms and define exactly what to do. We must get started immediately to allow time for a commensurate population reduction through natural attrition instead of famine, war, and disease. **We will not make it without three basic prerequisites necessary in the time and direction available:**

1. **Explicit knowledge and broad publicity of what to do, and why we (including you) must get started immediately, especially networking this story.**
2. **Negative population growth at a level of not more than one child per female (or male).**
3. **A systematic reduction of American per capita energy consumption from 22 b/b/y to 3 b/b/y, including rationing, in the next thirty years.**

All must be done.

We should avoid wasting and/or fighting over the remaining oil. Never before in recorded history has there been so singular a resource as oil for food, or the urgency for a controlled descent from the ephemeral peak of energy usage we enjoy today. **No other species has achieved the feat of anticipating and systematically executing an energy and directly-dependant population reduction.**

In my office piled high with pertinent web print-outs I have one, in particular, a comprehensive classic (Theoildrum.com/node4628, Oct 20, 2008). It is a paper by Peter Salonius, a Canadian soil microbiologist. The title, *Agriculture: Unsustainable resource depletion Began 10,000 Years Ago*, and six parts including Part 4, *Intensive crop cultures are unsustainable*, cover the entire theme that "human population numbers will have to be brought into balance with the sustainable productivity levels of the local ecosystems upon which they rely for their sustenance."

In Part 6 is a wonderful concluding paragraph:

> *Balancing of human numbers to the productivity of their supporting local ecosystems may be accomplished by planned attrition, much lower birth rates and the economic dislocations and hardships that a retreat from classical economic growth will incur, or the balancing of human numbers may be accomplished by a catastrophic collapse imposed by natural resource scarcity. The species with the large brain must make the choice between economic hardship and catastrophic collapse.*

PERSONAL FOOD PRODUCTION

At this point, I will switch from a macro-overview of fossil energy and the energy-food dilemma to a few comments on all aspects of small-scale farming. Those who grow at least some of their own food will be far more prepared for the coming changes in the food-energy paradigm. **"When the music stops, know where your chair is."**

As a context for this part of the discussion I offer a brief background: I grew up during and after the second world war on a small "gentleman" farm in western Massachusetts. We were surrounded by commercial dairy farms, tractors, and work-horses. We had several riding horses and did our own haying. During the summers before going off to engineering college in 1952, and with the help of a prewar 9N Ford-Ferguson tractor, I would grow several acres of heirloom, Golden Bantam sweet corn "picked while you wait" to ensure the sweetness we take for granted today with sugar-enhanced hybrids. Fast forwarding to 1980**,** I left the fast paced business world. My wife, our one-year old son, and I moved to rural Maine to pursue new interests, a more peaceful life than world-wide new-product development, and the possibilities of self-sufficiency on an old 175 acre farm.

With nine generations of "hard-rock" Vermont farmers in my genetic makeup, I always feel a strong sense of satisfaction and renewal while growing our own food. I will also add, in the last thirty years, and with the focus on our own well-being and food sources, we have gradually segued from a home-grown meat diet to nearly one-hundred percent vegan. We attribute much of our personal good health to this transition. Now, after becoming immersed for the last decade in the looming oil-energy crisis, I am especially concerned about if, and how, we could feed just my wife and I without oil. We can argue about when, but someday within the several decades, oil and the plentiful super-market food we take for granted will be in short supply and/or very expensive. A gallon of gasoline in my chain saw or sixty-year old John Deere already seems extremely important. Long distance bananas, pineapples, and avocados will no longer be staples in our diet.

We must all start immediately to grow as much of our own food as possible. This is the fun part and is the subject of a vast popular movement highlighted by innumerable books, magazines, and web sites. Square-foot gardening, raised beds, and permaculture are the new rage. Everyone should begin some form of personal food independence. We don't need thirty-million acres of lawns. Flowers aren't very filling either. An added bonus is that at least a small part of our personal human-energy, inherently imbedded in our bodies for food acquisition, will again be put to use as nature intended … accessing more food. We will be far healthier and become more insulated from the poor nutrition and fragility of a giant, long-distance, energy-intensive food chain. In addition, if we were smart and resolved the battery problem, we could begin to integrate new solar-electric technology into our more self-sufficient low-energy lifestyle.

Without fossil fuels it will be impossible for the vast majority to live in cities or urban centers that are not directly surrounded or down river from extremely productive farmland. We do have some hope for a future far better than our hard-working ancestors who had no electricity or photovoltaic "slaves" ready to go to work when the sun shines. The magazine, *Acres*, (acresusa.com) carries a vast catalogue of hundreds of books from organic farming to eco-gardening. Another unique publication that seriously addresses post-oil age food challenges is *Countryside and Small Stock Journal* (countrysidemag.com). See quote on my book's back cover by *Countryside* founder: J. D. Belanger.

In addition to growing our own food, and while energy is still plentiful, we should begin to accumulate a personal and family food reserve. Dried, canned, or bottled foods will keep for years. Our rural ancestors always kept a winter's supply as well as seeds and feed for their animals. In addition to traditional canning and a root cellar, we can have a modern electric freezer to extend a surplus harvest, as long as grid or PV electricity is available. We have been routinely testing and eating dried lentils, split peas, rice, and beans that have been sealed and stored for over fifteen years. They may not taste quite the same as fresh, but when boiled are perfectly safe and would be far better than starving.

How much do we need?

From a base-line, human-energy requirement (assuming 5,000 btu per pound energy-equivalence of **dry** weight for food) and an average of 8000 btu (2000 kilo-calories) per day, **we each need about 500 pounds of food per year. Remember, we are always talking about dry weight.** Most of our food is harvested or purchased with over 60 or 70% water content (like our bodies) and water does not provide any of the energy/fuel we need. Fat and meat have higher concentrations of energy, closer to 10,000 btu per pound (pure fat is like petroleum products at 15,000 btu per pound). For food independence and security for one year, a vegetarian family of four would need a stash of a ton (2000 pounds) of dry weight plant foods.

Current "just-in-time" super market inventories will only last a couple of days in an energy crisis. The traditional dry-storage of dependable foods like grains, beans, and corn (and a heavier weight of potatoes, squash, root crops, or fruit) now make sense. If we don't eat them, we can replant or barter with neighbors. As an alternative, for ready-prepared survival food, good for up to 30 years of storage, a good place to start is: www.thefoodstore.com.

More quantitative details

To grow your own food, think of green leaves as photosynthesizing solar panels which chemically use solar energy to combine water and nutrients from the earth with CO_2 from the air. Because incoming solar radiation energy is very dilute and intermittent, it requires considerable time and area to grow a pound of dry weight (not including water) biomass. This is why the solid parts of a plant, like the stem, tree trunk, gourd or seeds, need much more green foliage spread out onto a wide area like a solar panel. It's the same energy storage problem again. The solid part of the plant conveniently concentrates and stores substantial energy for use later when needed for survival and reproduction.

To supply the average, individual, annual energy-requirement of 500 pounds (dry weight) in a one year growing season, about 1/4 of an acre (11,000 sq. ft.) of good productive garden surface area is required. Vertical plants like corn and pole beans need less area because they access more sunlight energy for a given ground area, but need more soil-nutrients and water. In addition (usually overlooked or ignored fact), if this system is to be sustainable, the human waste or equivalent biomass and nutrients removed **must be returned to their original source.**

Any permanent removal or burning of biomass destroys the cycle. This fact, plus extremely poor EROEI, are among the many reasons why biofuels for motive power are absolutely non-sustainable.

In addition to space requirements and nutrient-import/export problems, to grow meaningful quantities of food, we must confront the human-energy input requirement**. Assuming near-by arable land is available (not more than walking distance), how can one strong farmer do all the ground preparation, planting, cultivation, and harvesting to feed himself and five others from 1½ acres at the historical maximum of a 6:1 FEROPEI?** How do those, who are not farmers, reimburse the farmers? They must have something as valuable as food. How do we power the farm from a personal to nationwide level? These are the basic quantitative, physical, economic, and ecological limitations we must respect. They are the foundation for our entire food discussion, from a personal to a national level. To start, we could become much more food-efficient with respect to waste. But that would only postpone the inevitable tension between mouths to feed and supply limitations.

Richard Heinburg in his book, *Peak Everything*, suggests we need "fifty-million farmers" in a U.S. without oil and 300+ million people. This number agrees exactly with my 6:1 FEROPEI ratio. In their book, *A Nation of Farmers* Astyk and Newton would rather see everyone growing food. For protein, the affluent western world has become very dependent on animal products including dairy. Unfortunately this is a double-edged sword. Domestic animal food requires approximately ten times as much energy input for the net output of human-food energy. In addition, this practice has made us less healthy. Animal protein may be (along with excessive sugar consumption)one of the primary reasons Americans suffer from obesity and have over twice the per capita health care costs as the rest of the world. Studies have shown that many industrialized-world health problems can be traced directly to the substitution of animal protein for vegetable protein. See: Campbell, *The China Study* (Benbella Books, 2005); Lyman, *Mad Cowboy* (Touchstone Books,1998); Rifkin, *Beyond Beef* (Penguin Books, 1992); and, from an extreme athlete's perspective: Jurek, *Eat & Run* (Houghton Mifflin, 2012).

Water

So far in this short discussion about food and agriculture we have not considered the obvious need for plentiful water at the right time and place. **Droughts and climate change are hastening the tipping point of our demise.** The summer of 2014 was unprecedented for high temperatures and lack of water for more than 50% of the U.S. **California is nearing the point where rationing will be needed for equitable distribution.** Irrigation depends on power and an adequate water table. When there are food shortages we forget that, historically, population tends to increase to the limits of carrying capacity during the good years. Then the weather is blamed for crop failure and catastrophe; not the extra population added during the good times. The increased tension ("link") between a growing population and declining crops invariably leads to societal collapse. Which was the root cause, over-population or climate change?

Input power and energy

To provide a self-sufficient, personal level of food production using any size of garden larger than a few square feet **without** fossil energy is a huge challenge. Draft animals are problematic because of their requirements for year-round input energy (food), animal husbandry, replacement, and specific horse-drawn equipment. Besides, they don't interface well with electric power like lights or motors, especially in winter.

A modern answer to provide agricultural energy as a supplement to human labor is the solar panel. The farmer has complete control of this source and may or may not be connected to an electrical grid. Just two 175-watt PV panels in the direct spring and summer sun are equivalent in power to five adults working non-stop **without rest or food-input energy.** Four of these panels would provide one horsepower. They could provide the same energy/work in one hour as a draft horse, again, without food or rest.

The problem, as always, is to store the energy in a sufficient quantity to continue doing serious work for an extended period. A farmer can't graze a battery-powered tractor. He must return to, or have on-board, solar panels and plentiful sunshine. **He must also have provision for battery recycling as discussed in Chapter 5.**

A solar-powered vehicle like the 48-volt golf cart with two panels equaling 350 watts of PV described in Chapter 5 can do it all except the initial plowing or harrowing. With a long 14-gage extension cord, the on-board 2500-watt inverter will easily power a 24" rototiller/cultivator. It can also be used for personal transport of up to

100 miles with a 150 ampere hour lead-acid battery pack and no solar input. It can power a 3½ hp electric chain saw (try that with a workhorse), water pump, or an electric lawn mower if still needed after most of the lawns have been converted to food production. The solar-powered golf cart concept/size **is an excellent portable power source which could also supply grid back-up or minimal alternative power for one family's residential needs.** For gardening needs, one golf cart could support a neighborhood of up to six families and provide the mobility and food-transport between market and farm at fifteen mph. Traditional draft-animal power is limited to five mph and is much less desirable on a personal basis because of the needed skills, animal husbandry, and hay and grain input energy to feed the animals (horses or oxen).

Access and ownership

Still another hurdle barring the return to personal agriculture is who owns the land? In the days of share cropping and tenant farmers, a portion of each individual farmer's meager output answered that question in a form of rent. **Without ownership, legal access, fuel for travel, and nearby homes, how can individuals who are not close to, or do not own, arable land become farmers? Unless these questions are answered long before we run short of oil there will be a total collapse of property rights, law, and civility.** We cannot expect millions of small farmers to be suddenly, evenly and peacefully, dispersed across the land, or to invest their precious energy into reclamation and production of land they don't own.

By now it should be clear why excess energy for any non-food related form of travel, frivolous or otherwise, will no longer be available**. As this reality sinks in, we see why extending the oil age as far as possible with reduced consumption, improved efficiency, and equitable fuel rationing; all combined with controlled population reduction, are our best and only options to mitigate the descent from the oil age.** Familiar long-distance diesel for boat, rail, and air travel, and transport also cannot continue without liquid petroleum-based fuel. Chapter 7 expands a detailed discussion of energy, transportation, and rationing. All these perplexing challenges lead back to **the central theme beginning in Part I of this book: our only possible path to avoid collapse of our modern lifestyle is to immediately reduce American per capita oil consumption from the present level of 22 barrels per person per year (b/p/y) to the world average of 3 b/p/y.**

Local (community) food production

Contiuing the argument for rapid growth in personal agriculture, the aggregation of like-minded individual families into sustainable support groups is gaining popularity throughout the industrialized world. Community Supported Agriculture (CSA's), localization, eco-villages, and transition towns are becoming popular movements. These all offer potential economies of scale and specialization that are superior to individual farming. There is also more resilience against weather variations, individual farmer's health, mistakes, pests, and poor soil management. If all goes well, there should be a surplus for local sale but commercialization adds the requirements for distribution, product quality, dependability, marketing, and some form of currency beyond barter.

On the negative side, community-sized food operations are still limited by the same space vs. population-to-be-fed constraints as the individual family farms that are its base. No longer will there be availability of food imports from other communities or more distant farms. The limitations of decreasing fossil fuels, especially oil, will be universal. There will be less transportation energy to package, preserve, and ship food as we do today.

There will be less possibility to recycle exported nutrients. Ultimately, every farmer faces the physical need for at least 1½ acres of nearby arable land and provide one hard-working individual to support five people beyond him/herself. Community centers (towns) will have to revert back to the pre-oil days with not more than a 15 mile walking radius to the surrounding farms. This circular area of over 450,000 acres is more than enough for wood lots, pastures, and recreational space for thousands of families, providing the minimal area of tillable land is adequate to feed everyone in the encompassed community. The wood lots will also have to provide for home and public building heating at a sustainable level not exceeding one cord per acre per year. **How would the wood be harvested, fitted for firewood, delivered and reimbursed?** Even one cord per year is not truly sustainable if the nutrients (ashes) are not returned to the wood lot.

A solar-powered golf cart-sized machine cannot provide the power and energy storage for ground breaking like plowing, rototilling, harrowing, and other high-power tasks we take for granted. A scaled-up answer, other than reverting to draft animals, could be a larger solar- powered tractor as described in Chapter 5. A 20- to 30-horsepower tractor can do these heavy tasks as well as hay-mowing and bailing. Unfortunately, 1200 pounds of lead-acid batteries will only store about 12 kWh of energy at 60 % depth of discharge (DOD), the equivalent of 1½ gallons of gasoline.

This is only enough for up to one hour of typical 15hp work, enough to prepare about one-quarter of an acre. But it is far better than doing it by hand or having to support draft animals on a year-round basis.

More reality

A nearby 1½ kW (eight-panel) array requires at least eight hours of direct sunlight to recharge the large tractor. The 1200 pound lead-acid battery pack would cost about $3,000 and have to be recycled (where?) every 5 years or 500 cycles. An alternative might be a $20,000 lithium-ion battery pack which could store four times as much energy and plow more than one and a quarter acres (like a good team of horses in a long day); but the 1½ kW PV array would then take at least four days to replenish the 48kWh of energy. Grid charging works well and the 120 volt dc tractor battery pack matches the 120 volt ac grid voltage for charging with a simple rectifier and no transformer.

And always we must ask **the question: where does the grid energy come from?** Coal, natural gas, nuclear? All are finite sources and wind or hydro power are not even close to supplying a fraction of our total energy needs. We can hope that community-scaled agriculture has a potential yield and resilience beyond personal farming, but closer analysis reveals the same limitations plus additional problems of labor management (shirkers?) and equitable distribution of food, income, and nutrient return. More on these subjects in Chapter 9.

National (U.S.) Food Production

Unfortunately, without liquid fossil fuels, neither personal nor community-scale agriculture could supply a tiny fraction of our national food system and the population we have today. We cannot suddenly transition from one million farmers to fifty million. The present system of industrialized agriculture is based on only twenty-percent of the farms to supply eighty-percent of the food. **The U.S. agribusiness system and nation's population are totally dependent on oil (and natural gas for nitrogen fertilizer) for daily food requirements.** Without oil, one farmer cannot possibly feed 300 people, especially if the consumers are 2000 miles away. We can dream all we want about personal and community food production, but the numbers are totally unrealistic on a national scale. Maybe 100-hp electric tractors are conceivable, but where is the time and capital to build these machines and solar energy to recharge the batteries going to come from? **This is where reality sets in and why we must immediately begin to ration liquid fuels to buy time,**

conserve our country's oil, and shift away from an unsustainable system in the same (less than one lifetime) time frame required to downsize population. It seems totally absurd and myopic for Americans to go on burning through one-fourth of the world's (including our) remaining oil, to continue our oil party as fast as we can, when we can clearly see that, in the lifetimes of most of us alive, we will be short of food. A frivolous trip today wastes finite fuel better saved for a combine (or chain saw) thirty years from now**. We cannot plan on biofuels because they compete with food crops and take about as much input fossil-fuel energy to grow and process as they yield for useful work. Biofuels are also totally unsustainable because they abruptly break the soil-energy-nutrient cycle.**

We can envisage vast teams of mules or horses on the high plains, but we would still need concentrated energy for food preservation, packaging, and long-distance transport. As oil becomes more expensive, we are now leveraging it further to grow even more food with larger tractors and less labor. Presently, it is possible for two farmers to plant one-thousand acres (!) in one day with a 36-row corn planter. Americans can still go to the supermarket and buy pork or chicken "specials" for 99 cents per pound. It is exactly this trend and dependency on petroleum fuels that has driven the small farmer out of competition and idled millions of acres of old marginal farm land closer to the consumer. This is another example of profit-motivated capitalism leading us farther and farther out on the finite-energy limb without the foresight to turn around and climb down. Also, a steady increase in fossil-energy-dependent food-cost, combined with decreased surplus available for export is having devastating effects on third-world consumers who became "hooked" on imports, overpopulated, and lost their local subsistence food system. The question asked many times begs an answer: "Are humans smarter than yeast?"

A sovereign nation like the U.S., with a remaining endowment of oil, could conceivably extend an oil-based, high-energy, nation-wide food system, but only for a few more years. **Remember, fact: one-half of all the oil extracted and consumed to date, in the history of the oil age, has been used in the last 25 year-long, one generation span.** As is well documented, the extraction of United States (including Alaska) oil extraction peaked 40 years ago, then declined to one-half that rate. Now, because of higher oil prices which supported improvements in technology and production from non-conventional sources we have returned to 75% of U.S. peak extraction rate of the seventies.

The 2012 election year platforms from both parties promised to restore growth and prosperity while ignoring the steady addition of over three million mouths (approximately one-percent growth) to feed each year. Smaller, high-energy countries like

Japan and the UK are in much worse shape. Meanwhile, we Americans continue our lifestyle of fast travel in monster vehicles, fueled, in part, with corn-based ethanol. Very few Americans are ready to hear about downsizing population and rationing gasoline. The price of gasoline reached almost $4.00 per gallon in the spring of 2013 then collapsed in mid 2014 to half that level due to a temporary glut from decreased demand. How many Americans see fuel prices as part of a national food problem that can not be solved with proposals to substitute natural gas, ethanol, or algae biofuels for oil?

Global food production

Figure 4 shows the two-lifetime correlation (link) between oil extraction and population as a basic theme for this book. We are pushing the limits of our finite global carrying capacity made possible with one critical resource, oil. **One local region or community might temporarily flourish while others collapse, but the planet is a closed system with nowhere else for humans to go, and only "finite" resources to access.** All subsets of this complete system must average out to the numbers and X-axis time scale in Figure 4. Even in the oil age, already a third of the world is suffering from food shortages. Anarchy and riots will become more frequent as in pre-industrial-age revolutions when food ran short. The "food gap" is growing. We are at a point in time where fewer individual nations have a chance to cope with their own food security, energy conservation, and population reduction with a minimum of human suffering. Instead, we Americans expend prodigious amounts of our children's energy-legacy to police the troubled world and keep the remaining oil and exported food flowing into wealthier countries like ours. It is impossible to talk about the future of food without including the subjects of population and geopolitics. **We must begin a conversation about food and peak oil and how this nexus ("perfect storm") relates to almost every other serious subject in the daily news. Climate Change (man-made or not), water supplies, top soil loss, desertification, fisheries depletion, habitat destruction, peak phosphorous, peak potassium, and chemical pollution are all part of a bigger picture and cannot be considered separately.**