WITH ENERGY INTO 2014

Among the words the ancient Greeks gave us is Energy. Energy transforms. What most transformed our world is agriculture.

Consider natural energy. A billion solar collectors we've come to call plants produce carbohydrates, proteins and some other essentials that provide energy for the animals on the planet. It's against this model we must compare the geobotanical aspect of agriculture as energy.

Geobotanists, too, write books. Last year Hansjörg Küster of Hannover, Germany published his *Am Anfang war das Korn* ("In the Beginning was Cereal Grain"). It contains some good research pertaining to environmental changes caused by the different stages of agriculture preceding the current one.

At its beginnings, and only at its very beginnings, farming made little difference in the natural system of energy. Although, as Küster points out, pre-agrarian technologies had already had ecological impacts. The disappearance of the mammoth and other large mammals from North America can serve as evidence; whereas we must stress that this over-hunting hypothesis still lacks proof, it is clear that hunter-gatherer tribes did set forest fires in some regions, so, yes, some environmental disruption by humankind did occur before farmers stumbled onto the stage. After all, cooking – the partial digestion of food outside the body – freed up energy for *Homo sapiens* long before agriculture.

It must also be noted that it's wrong to think of nature's energy model as something stable, because it's not. The benign climate equilibrium of the past few centuries is the exception, not the rule. Küster writes that climate swings of the past 2 million years resulted in drastic landscape changes, from forest during the warmest periods, to shrub-steppe when the climate cooled, and to tundra when it got colder still.

He explains why agriculture started at a few specific locations: Plant domestication in the Stone Age presupposes species mutation; radiation has been shown to be one strong factor that causes mutations; radiation from the sun is more intense on steppe than in forest. When the Fertile Crescent founding crops were domesticated, from 30,000 to 10,000 B.C., coolness reigned, namely the *Würm-Eiszeit* (which corresponds to the Wisconsin Glaciation in North America) that caused the spread of steppe in Mesopotamia, the "Land Between the Rivers" Tigris and Euphrates. Lots of sunshine there. Hello! mutated Einkorn, Emmer, Barley, Lentil, Pea, Flax.

The first settlements: Seasonal river flooding supplied soil nutrients necessary for farming, while upland the livestock grazed. But after the domestication of sheep and goat you also had a new kind of nomad, the herding peoples, which engendered Cain-and-Abel friction of land use in addition to raids by the still traditional hunter-

gatherer nomads. Thus settlement required defenses, in short order shifting the energy equation. The safety-in-numbers concept made for ever larger settlements, and soon the first walled cities grew.

The first machines were organized muscle power. Küster's bias is that agriculture made things better for humankind, an astounding ignorance of overwhelming evidence to the contrary. Paleopathologists have ascertained that agriculture resulted in humans growing less tall (in the case of men in Anatolia a shrinkage from 5 foot 10 inches at the end of the Ice Age to 5 foot 3 inches in 4000 B.C.) as humans also began suffering from diseases formerly unknown or very rare, including epidemics of measles, tuberculosis, leprosy, cholera, smallpox, bubonic plague. So Jared Diamond points out in his *The Third Chimpanzee;* the decline of health he attributes to the reduced diversity in the diet of settled peoples. The bottom line: "Only in a farming population could contrasts between the disease-ridden masses and a healthy, nonproducing elite develop."

Ah, the machine organized from 1000 workers, from 10,000 workers. All that admired architecture of early antiquity is rather less grand from the perspective of the multitude of slaves who had to build the walls, isn't it. Not to mention armies and all the havoc they wrought with hack-and-stab warfare.

Küster writes that for farming to expand in the Fertile Crescent, irrigation systems were necessary, and the building of those systems required much organization, a considerable amount of energy. But even with irrigation early farming was not sustainable, which is why civilizations rose and then fell. And the climate wasn't helped by deforestation; not only was wood use indiscriminate, but persistent livestock grazing prevented natural reforestation.

Aagriculture as a form of, a force of, energy spread from its founding-crops origin to other lands. The whole Mediterranean region is marked by unwise farming-grazing practice to this day, Küster points out; instead of oak forests that would grow here naturally, two shrub environs prevail – the *Macchia* of tall shrubbery, and the *Garrigue* of low shrubs.

Whereas the prevention of forest by grazing is an energy deficit climate-wise (even a small-size wood, a copse, has a considerably moderating influence on temperature and therefore benefits farm yields, Küster emphasizes), the Garrigue conditions encouraged the spread of lime-tolerant plants that became an essential part of human diet, namely aromatic spices such as sage, thyme, lavender, rosemary and many others. Some of these species were transplanted into gardens, although one can in this case not speak of domestication, Küster notes. Spices were especially important because they mask the taste of meat after it has begun to spoil.

According to Küster, the importance of certain spices can be measured by the

Romans' reaction to the disappearance of Silphium about the time of Nero. Silphium had been over-harvested to the point of extinction: "...they searched feverishly for an herb to replace Silphium." Cyrene (in present-day Libya), from where Silphium was exported across the Mediterranean, experienced economic downfall due to the plant's extinction.

Back to our energy theme: Trafficking in spices – *Curcuma longa* for curry dishes and *Piper nigrum* black pepper from India included – consumed a significant energy amount what with Roman use of over 80 spice species. In addition, agricultural goods were traded on a grand scale, mainly due to periodic crop failures caused by gnarly weather. It was not uncommon for severe cold snaps to decimate Mediterranean crops. "But never did a cold snap affect the whole Mediterranean," Küster writes, so ships with grain would ply the waters, supplying "the richer of the citizens."

Since agricultural sustainability continued to be limited, some empires had established colonies for food production, Athens for instance. By then horses had been domesticated and the wheel invented. Horsepower would be a huge contribution to the bulging energy needs for many centuries. When mining and smelting of metals began, energy demand enlarged greatly.

If agricultural development of early civilizations was brutal mostly, not to mention socially unjust, a positively idyllic farming epoch would develop north of the Alps. Küster writes that analyses of human genetic material give credence to two hypotheses, that Central Europe's first farmers had migrated from the East, as well as that indigenous people adapted farming. Küster concludes that it must have been a cultural blending of farming knowledge from the East with a local grasp of the conditions inside the then densely forested regions where oak, elm, ash, and lime tree (basswood) were the predominant species.

It was a particular legacy of the ice ages that gave rise to farming in Central Europe, namely the loess soils. Not only is the fine-grained loess a very fertile soil, but the absence of rock in loess made working the fields a relatively easy chore, Küster explains. Where creeks washed the loess away the livestock was kept for grazing, overseen by the village at the edge of the loess that was farmed uphill from the village, up to the forest edge. The villages of this earliest central European farming period were tribal, self-contained in character, there is no evidence of hierarchical organization as was necessary in the Fertile Crescent and around the Mediterranean.

Sometime later in those mists of time an agricultural influence pushed into Europe west of the Alps, from the south. The spread of opium poppy farming is archeobotanical evidence of that, Küster writes.

Yet the settlements on the loess disappeared sporadically as well. Whereas the shift of farming centers in the Near East can clearly be attributed to environmental decline,

the reason for Central Europe's early settlements being relocated is open to speculation, Küster remarks; one guess is that over-logging of nearby forests was the reason. A contrast to the Mediterranean is that these first-farming villages were not reestablished at a later point in time, archeologists typically find only one layer of settlement.

Exceptions to the impermanence of settlements were stable settlements in Britain and western France. Küster does not mention the Celts, but their Castros in Galicia and Asturias (today's northern Spain) would endure into Roman times, in fact, the Romans would take over Celtic Castros and build on, the Celts having built round houses, whereas the later Roman structures of the Castros are rectangular mostly. During the Celtic era many Castros were located near ocean shore, fish a major staple, and trade by sea an important facet. The horse was very important in the Castro culture. In terms of energy the Castros were still a fairly contained system until, of course, the Romans with their legions had to be fed.

The Imperium Romanum is held in high regard in Germany. All those different peoples under yoke, agriculture centralized and organized, roads built and the whole thing walled in with the *Limes!* As a good German Küster delights in his description of that imperialist period. The Romans brought with them the concept of garden and vineyard.

Gardens had grown into an agricultural notion as the exchange of cultivated plant species between Orient and the Near East and Mediterranean began, very soon after agriculture's advent, in fact. Walled gardens protected fruit trees and rows of spice and medicinal plants. In raising trees it's notable that the art of grafting developed very early (whereas plant breeding would have to wait until the late 1800s). Olives were routinely grafted onto a wild relative.

Rome fell amid the great population migrations of the Goths and Huns. This left Central Europe to its former free-farmer system for a few more centuries. Küster notes that once the Roman system collapsed, north of the Alps the gardens and vineyards disappeared again.

What shook out eventually, agriculturally, was the three-field system of Central Europe. Küster does not speak of the robber barons, armed thugs in hilltop burgs who raided one another's territories and pried on trader caravans. A system of extortion was established whereby farmers were promised protection but had to provide food stuffs and services. Over time the thugs became the so-called nobility who would rule Europe, in some countries to this day. By the 16th century 90 percent of Germans and 80 percent of Europeans were farmers under some degree of serfdom. Worst off were the *Leibseigene* who had no right to leave the *Gut* but were in bondage from the moment they were born. The only difference to slaves was that they couldn't be bought and sold.

We haven't touched on religion, but from the earliest agriculture onward religion played a key role in civilizations. Brute force alone could not keep whole peoples under the yoke of ruling classes, so gods were evoked, and later arose monotheism.

In the Middle Ages, monasteries became great agricultural centers, often with inventive approaches. At Kloster Heilsbronn in Franconia, for example, we find records of an aquaculture that had a number of benefits for the farm crops. Altogether 93 ponds were created, many in series at shallow valley bottoms, producing over 1800 pike, over 1200 white fish, and a whopping 19,000 carp annually. For fish harvest the ponds were emptied, the water flood-irrigating and thereby fertilizing nearby acreages. Just as fields were fallowed on regular schedule so were the ponds left empty of water periodically; in those years crops were raised at pond bottom. A byproduct of this aquaculture were cattails that at the time were harvested for building purposes.

Küster writes that monasteries grew the gardens of the time, although many plants that we consume as vegetables today were actually raised as medicinal herbs in that era. The now-famous farm gardens didn't come into existence until the 1800s. Before then the adage held that "what the farmer doesn't know he doesn't eat."

According to Küster, the church wanted to structure the workday. "The church spires had to be tall enough so the bells could be heard on all acreage of a community... This was especially important in the Middle Ages since only few people wore a watch."

The three-field system: The village divided its arable ground into three sections of periodic rotation, one for production of winter grain, one for spring crops which were either grain or lentils or peas; the third section was fallowed, the volunteer growth there serving as livestock graze. Each section was divided into narrow, long strips for the individual farmer. Küster explains that strips were the most practical lay-out because it required the least turns for the plow horses. Harvest logistics dictated that farmers raised the same type of crop as was grown on the adjacent strip. The most prominent farmer, called Meier (after the Latin *Major,* Meyer appears in various spelling as a very common German surname to this day), would organize the crop rotations and also the various payments (usually in grain) such as the *Zehnt* (a tenth) that the church demanded.

In most regions of Central Europe and up into Scandinavia, rye was the most predominant grain due to its hardy growing habits (not until the 1960s did wheat become Germany's main cereal crop). For bread, rye flour was often blended with lentil flour, Küster notes. The aristocracy of course preferred the whiter wheat bread. South Germany and Switzerland grew primarily the winter Spelt they called *Dinkel,* and also *Sommer Dinkel* ("summer spelt") which was spring-planted Emmer. To a

lesser extent Einkorn was also raised, it was especially valued for its straw length, Küster writes.

If the three-field system endured for many centuries, other farming types special to particular environments also existed. On the sandy ground in Northern Germany, for example, fields were fertilized with top soil from heather-grown reaches. In the U-shaped valleys of the Austrian Alps, villages were seasonally left behind as livestock was herded on higher ground in the summers.

Flour mills were typically built along creek and river; many of Europe's cities began as a mill around which an ever greater number of buildings congregated.

According to Paul Roberts' *The End of Food* © 2008, population fluctuations in the time of agriculture were enormous. In every single period of good harvests the populations exploded; invariably bad-yield years would follow with hunger and outbreaks of epidemic plagues decimating those exploded populations.

We argue that the final output of agriculture was human population. Energy in human form, that is, humans for building cities and castles, roads and ships. And, of course, humans to make war. Once there were cannons, humans became quite literally cannon fodder.

The eminence of religions was fuel for wars. Agriculture in the Middle Ages had to produce enough energy for the many crusades.

Meanwhile the building of cathedrals and palaces expanded greatly. To finance that construction boom, church and aristocracy further upped their demands on Europe's farmers. The push-back, when it came, originated in the church itself as a few priests rallied for reformation. From the farmer perspective, Thomas Müntzer was the most important originator of the Reformation because he included human rights in his teachings and preachings. Müntzer became a leader in the German Peasant War of 1524 - 1525. This revolt was brutally put down by the aristocracy whose armies slaughtered over 100,000 peasants in those two years. Müntzer, too, was cruelly put to death. In contrast, Martin Luther sided with counts and kings.

The Reformation movements resulted in almost continuous wars in Central Europe for two centuries.

Agriculturally this period is marked by big changes in Central Europe. New World crop seed began arriving soon after Columbus' sailings. Maize and potato particularly added to the cropping scenario, Küster writes. In addition the trend was to agricultural diversification in general, with a greater variety of vegetables and fruits on offer in the farmers markets by the 1500s.

Coal mining transformed the energy equation in that it unlocked solar energy from millions years ago. The first steam engine, in 1712, was engineered to pump water from a coal mine.

Early industrialization increased the demands on agriculture. Several system changes in farm lay-out occurred in Central Europe, each successive system increasing yield per farm, Küster emphasizes. Hay production extended – the longer time the livestock spent inside the barns the more manure for fertilizer was collected. Grazing in open forest was discontinued, which gave foresters the chance to make the woods more productive, especially now that coal was widely available.

The French Revolution and the political ripples emanating from it across Europe finally, finally freed the farmers from serfdom. We all owe a big thank-you to the folks who stormed the Bastille in July 1789. Unfortunately the wars didn't stop.

The railroads led to specialization in farming, Küster notes. Now that the cities were expanding even more rapidly, production of the more perishable goods, dairy in particular, was concentrated near the population centers, while less perishable food stuff such as cereal grain was brought in from farther away.

In American farming the year 1831 was a milestone, that's when Cyrus Hall McCormick demonstrated his Reaper machine. In his *This was Wheat Farming – A pictorial history of the farms and farmers of the Northwest* – Kirby Brumfeld writes that with the sickle "a good man" could cut a half an acre of wheat a day; with a scythe the daily harvested area increased slightly, and after a cradle was added on to the scythe a man could cut up to two acres a day. McCormick's invention was a leap even though this mechanization was still somewhat primitive, requiring a man on a horse pulling the contraption while "a negro servant named Jo Anderson raked the platform clear of the cut grain." The photograph, courtesy of International Harvester Company, shows Jo fairly running beside the platform while he's raking; Mister McCormick strides behind in coattails, top hat in hand.

In 1870 the first oil, petroleum! Although, it would be a relatively long time before agriculture would adapt gas- and diesel-powered machinery. A rash of farm implement inventions happened after McCormick's Reaper, from new plows – gang plows – and grain drills and summer-fallow weeders and rotary rod weeders and harrows, to all kinds of harvesting machinery, headers and wheat binders and stationary threshers. Even before the 19th century ended the first machines that combined header and thresher – hence the term *combine* – harvested in the Pacific Northwest.

If machinery obviously changed the energy equation of agriculture, for many decades the big shift was to horsepower in some regions, including the Pacific Northwest. It took 30-horse teams to pull some of the early combines; altogether wheat harvest

required about 40 horses. Quite a horse culture developed in those days, with the Shire from England a preferred breed because Henry VIII had commanded that all Shires less than five feet tall had to be destroyed as useless, Brumfield writes.

As late as 1926, a three-year economic analysis of 65 Pacific Northwest wheat farms concluded that "... wheat farms having less than 1000 acres... find horse-power operation more profitable than tractor-power operation." Brumfield's quoting from an O.A.C. (Oregon Agricultural College, precursor of today's OSU) publication; one specific of the report is that at a total net cost of a bushel of wheat $1.34 and $1.06 respectively, the percentage return on total farm investment was 4.4 percent on tractor farms versus 5.6 percent on horse farms.

It must be noted that even the tractor farms cited in the study had an average of 14.6 horses per farm. And the necessary manpower was considerable as well, at least five workers per combine.

The Great Depression coinciding with the 1930s Dust Bowl droughts resulted in environmental chaos in the Pacific Northwest, according to NRCS (Natural Resource and Conservation Service) researchers. Farmers who had been told by the government to increase their grain yields in preparation for World War One had cleared marginal lands that should have stayed shrub steppe, and when the big farmer exodus happened in the 1930s, many folks left their horses behind to fend for themselves. Having thousands of horses turn wild on marginal lands caused a geobotanical energy deficit, the aftermath of which the region suffers to this day.

After World War Two the switch to motor-driven farm machines was complete; Green Revolution genes to serve chemical farming systems were introduced; and, agricultural specialization was organized on a grand scale, with Pacific Northwest wheat production shifting to almost exclusively soft white wheat for export to the Pacific Rim. Taken together, these developments stood the agricultural energy equation on its head. Yes, agriculture was still producing energy for growing populations, ever more so, but now agriculture is sucking up fossil-fuel energy in enormous quantities. It's not only those huge tractors that guzzle, but most farm chemicals are formulated from fossil fuel as well, and, what with global trade and ever more food processing, the accumulated fossil fuel energy need of the food system has skyrocketed.

That we're fast running out of water is a whole other chapter.

Modern medicine has become successful in death control (up to a point, anyway), while birth control is less widespread an accepted practice. Pray tell, what are all those billions-with-a-B humans for? The cities have been built and the machines. Industrial agriculture has wiped out whole cultures of subsistence farming. What's left for humans but to produce endless gadgets, and employment in the so-called service

industries, each job of course sucking energy.

Obviously the human race is not so *sapiens.* Not since farming started...

What's to be done? As a country, Germany appears to be in a leading position when it comes to green approach.

Let's take a look: Recycling is enforced. A 42-page directory lists 450 types of garbage, from A to Z, and prescribes precisely where each refuse must go; every household has three *Tonnen,* that is, small barrels designated respectively for compostable material, paper and cardboard, and general household waste. In addition the city distributes "yellow sacks" for plastic waste. For broken appliances there is a collection facility. Periodically a collection of "problem waste" such as household chemicals takes place. Many types of bottles require deposit and are recycled through the supermarkets. Stores also are required to provide recycling for things like batteries.

Germany's enforced recycling system takes a huge amount of organization – all those different garbage pick-ups by calendar make for complex logistics, inclusive of chips embedded in the *Tonnen* for keeping track of billing –, but the system works.

Out in agriculture, Germany raises a lot of rapeseed for biodiesel, and much maize that's processed into ethanol.

Greenhouse gas emissions: Public transport is fast and efficient, mostly running on electricity. Which electricity is produced to a fairly large extent with wind and photovoltaic cells; the government's committed to a complete switch to renewable energy, and to a total phase-out of nuclear power plants in the near future. The drawback is a high electricity bill, though it can be argued that a high price for energy is realistic.

Also important is Germany's thriving *bio*-market: Strong demand for organic means energy savings as more acres become *bio* and *öko* farms. Leading research on even more progressive – speak: less energy-intensive – organic farming systems is ongoing.

Last not least, Germany registers a negative birth rate for decades.

All this amounts to a positively green outlook. But it's not so positive in the big picture, the fine example of political will to do environmental good overshadowed by rapture of rampant consumerism. Planned obsolescence is the rule in manufacturing. And all those cars, causing a ridiculous 415,000 traffic jams on the *Autobahn* in 2013, all those cars, the car industry a major driver of the German economy – one doesn't dare suggest that folks shouldn't be buying a new car every few years. Automobile

export is flourishing, steadily adding pollution elsewhere.

A particular disturbing aspect are fields of solar panels. Initially, after the German government had created incentives for switching to renewable energy production, rural regions changed for the better in that solar panels were put on roofs, especially on the roofs of big barns and large farmhouses. But soon investors started buying up farmland to install acres upon acres of solar panels. In many cases it's prime farmland that's turned into eyesore. It seems strange that the government can stipulate that new apartment buildings must have adequate (usually underground) parking space for cars, but doesn't insist on solar panels at least on new roofs.

What are we left with?, is the question. We'd make a big mistake were we to take the current system for granted, is the conclusion our geobotanist Küster reaches. "Because new climate changes... and shortages and cost increases of energy could cause an instantaneous breakdown. In such a case *Homo sapiens* must newly react."

Here's how we read it: The jury's still out on the worth of farming.