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Next Economy: Risks and Solutions

Next Economy is the term we use at Green Alpha to refer to future iterations of human enterprise that represent significant and measurable de-risking vis a vis global economics, underlying ecosystems, natural resources, and human welfare. Said more simply, it is the way we should be doing business to ensure there is still a planet left to do business on, and in good enough shape to provide an environment in which humans can thrive. De-risking economic activity then logically leads to human economic endeavors that are by design and construction indefinitely sustainable. Burning fossil fuels to make electricity or move a vehicle is inherently more *risky* to non-living natural resources, living natural resources, and humans than consuming electricity from some form of clean and renewable energy as delivered over the grid or stored in a battery. Risks from burning fossil fuels are easily identified: reduced air and soil quality, increased public health damage (which is largely unaccounted for by industries profiting from the consumption of fossil fuels), polluted waterways and more acute human health risks such as explosions, blow-outs, methane leaks, etc. To the extent that fossil fuel companies are able to avoid prosecution and financial and reputational damages, these risks are largely born today by the global commons, and paid-for in reduced lifespans, lower quality of life, and eventual (or ongoing) ecosystem collapse. This is to say absolutely nothing of catastrophic climate change, which is the *global* risk of fossil fuel consumption, as opposed to the more *localized* risks elucidated above. The energy industry is only one of many that present existential risks to the natural capital producing systems of the Earth.

The risks to health and safety listed above are not the only risks, and due to a robust legal system where deep pockets can significantly influence fines, prosecutions, and remediation efforts, they are not even necessarily the most important risks that businesses face. Should the United States adopt a carbon tax or pricing scheme, fossil fuel interests will bear the financial brunt of such a rule. This represents significant political risk to their business, as would a commitment to keep global warming under a certain target. Competitive risk also represents a significant factor in the long-term viability of both specific firms and even entire sectors. This can be spurred in a virtuous cycle with changing popular sentiment from health and safety risks, political headwinds, or simply delivering better products and services at better or at least fair prices.

Therefore, when asked about our investing thesis at Green Alpha Advisors, we try to explain it in terms of risks and solutions at a macroscopic level. If fossil fuel based power heats the Earth and pollutes its air and water, what are the viable, profitable, alternatives? If conventional agriculture destroys top-soil, releases excess carbon and nitrogen, and results in decreasingly nutritious food all while demolishing biodiversity and total productive biomass, how else can we grow food? Business as usual in the two above given examples represent existential risks to the global economy, but fortunately there is hope. Due to necessity, we will over time adjust how we do business and make energy, products and services and deliver food and water on the Earth. There will be winners and losers along the way, and our thesis is that by selecting the best firms who represent the best chance of getting to the next era of human existence is probably a good starting point. Being a solution to a risk is a competitive advantage, and is an essential part of enabling the transition to indefinite sustainability.

Food Production and the Environment: Historic Appetite for Destruction

I. Prehistory

Though disagreement remains around certain particulars, there is relatively good consensus that at some point around the 15,000 to 20,000 year ago (y.a.) timeframe, our ancestors transitioned from nomadic hunter/gatherers to domesticators and farmers. This meant going from collecting wild grasses, fruits, roots, and vegetables to intentionally staying in one place and growing them. Clearing large areas of existing flora through burning became rampant, allowing for large, open grassy areas where coveted ruminants could graze and be easily hunted, milked, and reproduced. Eventually, these ruminants became sheep, oxen, reindeer, and pigs. Approximately 12,000 y.a.. humans entered the Neolithic period, characterized by Fertile Crescent (modern day Middle East) farming settlements, but also in places like China and in Central America around 10,000 y.a. Even these early attempts at cultivation of food crops by humans encompassed an aspect of destruction: burning vast swaths of wooded land to make room for crops and grazing animals was an essential first step in humanity's eventual worldwide conquest. It was certainly not the last. Maximizing short-term yields was paramount, and it must have been hard to contemplate that that approach would one day give rise to serious risks with the power to undermine the entire enterprise.

II. Crop Rotation

Agricultural production methods followed a relatively linear path as human populations increased, and the size of settlements grew to become cities. Early technological breakthroughs included things like small and large-scale irrigation projects, invention of the plow and domestication of draft animals. For a long time however, the damage wrought by agriculture and animal husbandry was limited by the power exerted by humans and conscripted animal labor. By around 1700 A.D. in England a new revolution was started in the form of crop rotation. While still lacking most of the chemistry and biology necessary to understand the specifics, farmers were coming to the realization that growing the same crop over and over again on a plot of land eventually led to lower yields over time. By rotating different crops such as legumes, farmers were able to massively increase crop yields and output per worker[1].

III. Phosphate Revolution

The explosion in food production resulted in a population explosion as well. Over time, as British colonial ambitions took them to places like South America, large deposits of sodium nitrate from the Atacama Desert began to allow massive external fertilization. By the mid 1800s, the demand for bone (and the calcium phosphate contained therein) was so great that the British were importing mummified cats from Egypt and scouring African deserts for bleached animal bones to crush and add to soil[2]. Simultaneously, the British were mining their fossil heritage in Pliocene rock layers, searching for coprolites and phosphatized ancient bones. This was alternatively called fossiling or fossiliting. Coprolites are fossilized dung, generally of dinosaurs other large animals and so quite large. Like the dung of living animals, coprolites are high in phosphate, and make excellent fertilizer. Over time it was learned that some of these objects they were digging for with such gusto were not true coprolites, but in fact bones that over millions of years attracted phosphate from the sea bed they fell to due to their own high internal phosphate[2].

The other great source of historical phosphate found in this time period were bat and bird droppings. Guano as they're more commonly called remains an important source of phosphate today. Phosphate is one of the most crucial nutrients in soil for growing crops, and despite great advances in chemistry, geology, and manufacturing, conventional agriculture has only come to consume more phosphate in the last two centuries. Further environmental destruction and reconfiguration for the sake of agriculture occurred with the help of Dutch neighbors. The Dutch were familiar with marshy, wet farmland and canal building, leading to large-scale geo-engineering projects to drain the fens that dotted the English countryside to make way for fields of grain.

IV. Epoch Change: Anthropocene

The human induced change apparent by 1600-1700 was so great that today scientists who are in the business of defining global epochs, generally geologically driven, have begun settling around a consensus that the Earth entered a new geological epoch around 1600 known as the *Anthropocene*. Some scientists have rejected such trivial events as earliest human use of fire, the previously discussed beginnings of formal agriculture, and the industrial revolution as demarcation of the epoch change. Instead, they argue that the monumental global low point in atmospheric $C0_2$ that occurred in 1610 was the inception of the Anthropocene. They argue that dip was the result of ~50 million indigenous deaths in a short time period, and the consequently sharp fall-off in agriculture as a result. Even in 1610, human agricultural activities was a large net contributor to greenhouse gases (GHGs)[3]. Some researchers believe the put the Anthropocene start date as closer to 1964, which was when industrialized countries in the world were growing $C0_2$ emissions at the greatest rates as rural electrification massively increased the amount of coal burned, and increasing numbers of people bought and drove internal combustion engine cars. Adding to this were massive gains in agricultural output (itself a net $C0_2$ contributor when fertilized productive), and application of fossil fuel derived fertilizers (nitrogen itself is a potent greenhouse component in gaseous form) and fossil fuel powered farm equipment. The application of fossil fuels top powering farm traction not only led to a great increase of GHG emissions, but also to total arable land under cultivation, and subsequently to a huge explosion in human populations.

V. 20th Century Excess and the Environmental Backlash

In the United States, the period from the 1700s to the 1900s was characterized by massive investment and harvest of cotton, sugar, tobacco, and other food crops. Before 1865, a great deal of this agricultural output was the direct result of the institution of slavery. From 1915-1920, as a result of the mechanization and industrial boom provided by World War I, mechanical gear boxes and engines were developed that were suitable for agricultural work. The mechanization of American agricultural was in and of itself a miniature revolution. By the 1940's and 1950's, use of fertilizer had risen over 2 million tons a year, and use of herbicides and insecticides had begun to take root. Throughout the 1960's and 1970's, the United States went through a period of radical environmental concern, resulting in some of the most important laws ever written out of environmental concern. These included the Clean Air, Clean Water, and National Environmental Policy Acts, resulting also in the creation of the EPA by President Richard Nixon in 1970 by executive order. Due to the charged political environment, and still very prominent power of famer lobby's and organizations, the Clean Water Act did not legislate any sort of provisions for nitrogen and phosphate pollution due to farm wastewater run-off. So-called “non-point” pollution is not regulated by the Clean Water Act, and excess fertilizer, insecticides, and pesticides from farming operations are classified as “non-point”, since farms rarely actually pump any wastewater away from their fields[4].

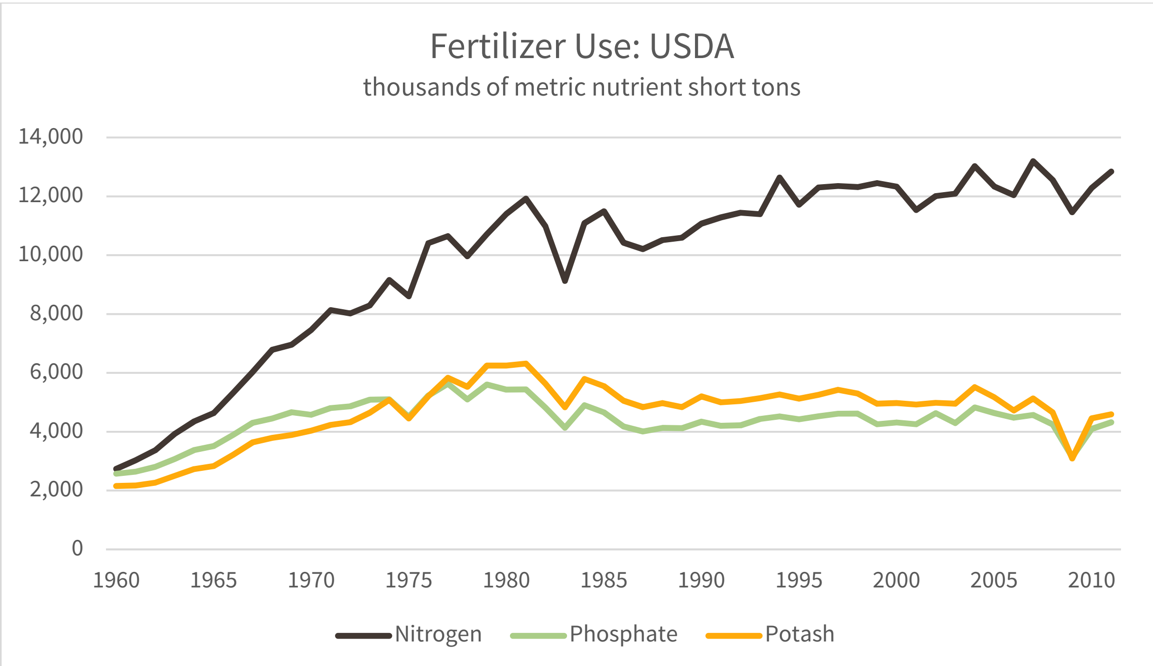


Figure 1: Fertilizer Use in the US, 1960-2010[5]

Additionally, natural watershed activity caused by rainfall and snowmelt exempt agricultural pollution from regulation. This is also true of the sometimes even more dangerous ammonia and nitrogen rich waste streams that occur as a result of large livestock operations. Waste holding ponds from CAFOs (concentrated animal feeding operations) are so powerfully dangerous that they are directly regulated by the USDA, though not to everyone’s satisfactions. Perhaps as a reaction to the oversights in the Clean Water and Air acts (among other federal and state legislation), the Organic Foods Production Act was passed in 1990.

Organic versus Conventional Agriculture: Next Economy Food Production

What Does Organic Mean?

The organic foods designation is specific, and maintained by the USDA through the National Organic Program (NOP). This organization maintains lists of prohibited and permissible products and techniques for engaging in organic agriculture, and setting uniform and consistent standards by which the certification is awarded.. This includes accrediting the organizations who certify organic operations, establishing import and export policies, investigate violations, and provide training and financial support.
The organic designation requires organic seed stock, which cannot be GE (genetically engineered) or have come from plants that were treated with prohibited substances. If seeds have been treated with prohibited substances, the land they were planted in cannot be certified organic for three years from the time of planting. Generally, if there is an organic seed stock for a given

crop, the NOP requires the use of that commercially available seed. If none is reasonably available, untreated seeds may be used in place.

The most well-known aspect of the organic agriculture is the prohibition on synthetic (and some naturally occurring) chemicals in the growing and processing of organically certified products. Virtually all pesticides (including insecticides, herbicides, and fungicides) used on conventionally grown products are banned for use in organic produce. Synthetic fertilizers are also banned from organic produce, though there are a number of ways in which organic products are fertilized from things such as bone meal, worm casings, and other naturally occurring high NPK (nitrogen, phosphorus, and potassium) sources. Generally, these have been composted for some time before application to kill any possible infectious agents and increasing their bio-activity by encouraging microbial growth of other sorts. Crop rotation is also employed on a large-scale in organic farming as a method for maintaining high nutrient levels in soils.

Without the use of pesticides, organic farmers have to be creative in dealing with pests, including insects, rodents, birds, and invasive plants. Common methods at the crop level involve growing resistant species, using oils and soaps that can kill insects without any toxicity, plastic sheeting in early seedling stages, sticky traps that attract pests, and pheromone traps which can attract male pests. In addition to these relatively benign options, organic farms at a higher level plan the spacing, watering, fertilizing, and even crop mix in an integrated way to avoid problems with pests in this first place. This might involve living plant barriers which are meant to attract or repel certain pests sacrificially around borders of crop areas, or even incorporating living predators to control pests (like lady bugs to remedy aphid infestations). There are a number of firms that do brisk business in mating and shipping parasite matched bugs for common crop pests, eliminating threats from beetles, spider mites, aphids, and weevils and other common and not-so common pests. Overall, the organic designation can largely be seen as an attempt to standardize a mode of farming which in many ways predates the explosion of chemical pesticides and genetic engineering, but that also brings modern innovation to the challenge.

Why is Organic a Solution and Conventional Agriculture a Risk?

Some aspects of agriculture, as discussed earlier in this paper, are inherently destructive no matter what type of agriculture is used. Generally in order to grow large, uniform rows of any crop requires the removal of rocks, trees, native plants and potentially whole ecosystems. In heavily wooded or jungle areas, such as the rain forests of Brazil, this a particularly damaging scenario, as much of earth’s biodiversity and biomass resides in trees that are removed through slashing and burning. (This raises the larger question of what should be farmed in which locations, but that is outside the scope of this paper.) There are however some very direct and easily investigated issues with conventional agricultural techniques that bear scrutiny. Using the language of risk, the following are the broad categories for which we recognize the greatest risks of conventional, non-organic agriculture as it exists today, and as a corollary, seek investible solutions.

Pesticides

In the USDA’s comprehensive 2014 report, “Pesticide Use in U.S. Agriculture: 21 Selected Crops, 1960-2008”, the organization found that around 72% of all pesticides applied in the United States were applied to 21 crops, as shown in the following pie chart:

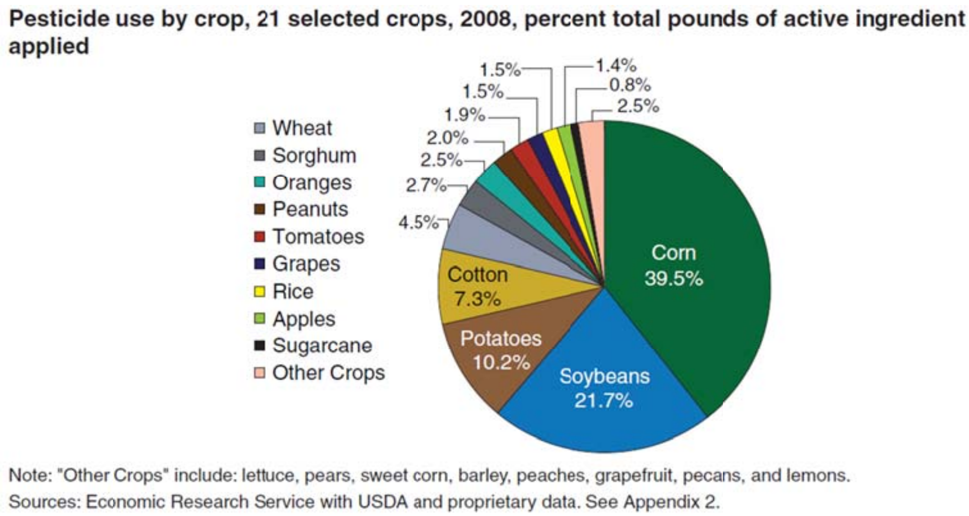


Figure 2: USDA Pesticide Use by Crop[6]

These figures for pesticide application by crop are not relative: the lion's share of pesticides (much of it herbicide) being applied is going on corn and soybean fields because that's what the United States grows the most. The reasons for this are that both corn and soy are used for much more than just food. Corn has grown steadily as a percentage of acreage to feed the world's increasing appetite for meat, as have soybeans. Starting in the 1990's corn began to be planted increasingly for ethanol production. The amount applied per acre also varies widely, and far more pesticide is used on potatoes for instance per acre, than corn (potato producers use about 50 pounds per planted acre, versus 2.4 pounds per corn acre). And finally, increasing levels of food technology and desire for convenience has led to industries which can make hundreds of compounds out of soy beans and corn for use in packaged and processed foods, as well as in food additives and for non-food purposes, some of which have questionable impacts on human health at concentrated levels of consumption. Examples include soy oil, vegetable oils, high fructose corn syrups, and many others. While the rate of increase in the use of pesticides has slowed somewhat in recent decades, it's still on a long-term upward trend.

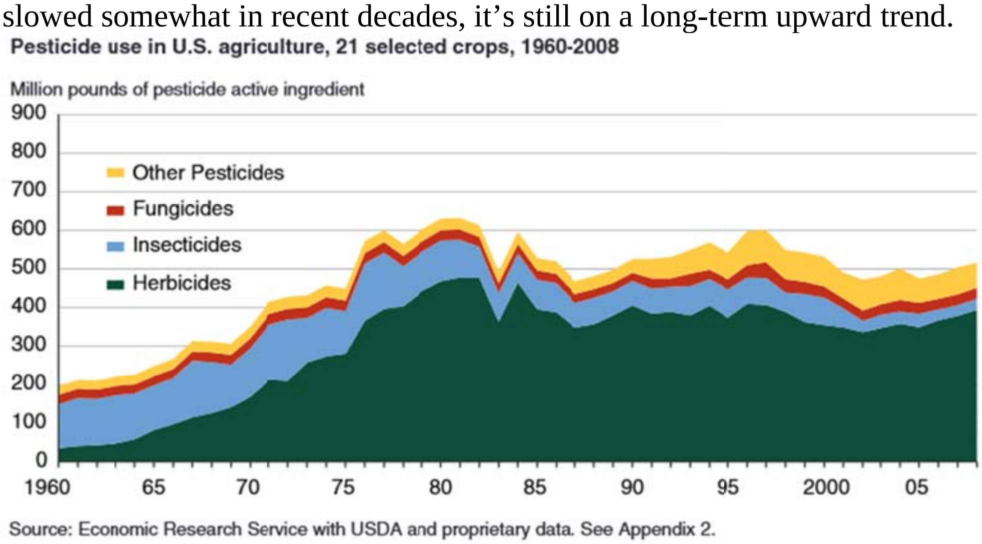


Figure 3: Pesticide Application Volume over Time[7]

Direct Human Health Impacts:

The most serious and acute human health impacts inherent in conventional farming revolve around pesticide residues in humans from consumption of conventionally grown produce, dangers to agricultural workers in the fields, and the somewhat controversial topic of nutritional value of organics versus conventional foods. Humans ingest pesticides largely by eating produce which has been treated with them. Contrary to the beliefs of some, you cannot wash off pesticides. Due to the degree with which they are applied to produce, and at the various points in the lifecycle, many pesticides are taken up completely into the produce itself. They are certainly not limited to the exterior of the items to which they are applied. While it's true that over time the USDA and FDA have eliminated a number of the more obviously toxic and dangerous pesticides from general use, there still remain a number in regular use that are widely known to be toxic. The more common ones like glyphosate and 2,4 D are marketed as safe, but proof is increasingly mounting that they are not as safe as once thought. A massive increase in the use of glyphosate occurred in the 1980's-90's which resulted in highly resistant weeds, which in turn led to greater application amounts, and increased applications of other herbicides like atrazine[8].

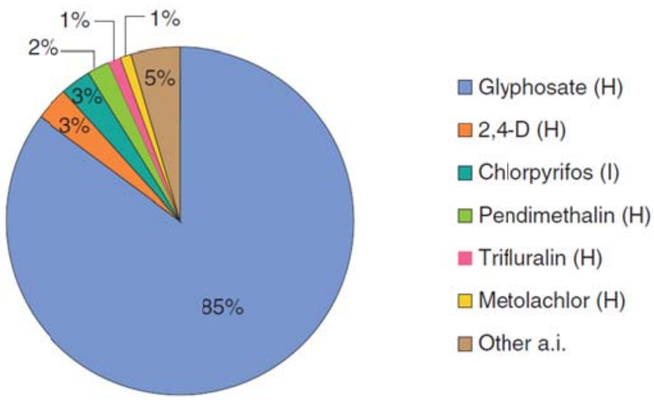


Figure 4: Percentage of Pesticide Applied in soybeans, 2008[9]

According to the CDC[10], atrazine caused pre-term labor in animals, as well as liver, kidney and heart damage. It may be a carcinogen, and it is certainly an endocrine disruptor. It works by being absorbed into the plant and preventing photosynthesis. Glyphosate is currently though to be relatively benign as toxic herbicides go, but some argue there has not been enough research on toxicities in humans over time at the elevated levels with which it appears in food, air and water. Glyphosate occurs in produce at particularly high levels in U.S wheat as it is used not only as an herbicide but is also applied during germination to increase yields[21]. Most pesticides however are not single agents in a bottle, they are mixed together and have other chemicals which are not classed as pesticides as part of their formulation. There are clear and well-known risks involved because many of the additional chemicals are not treated as pesticides, and far less is known about them individually, or in concert with the pesticides themselves.

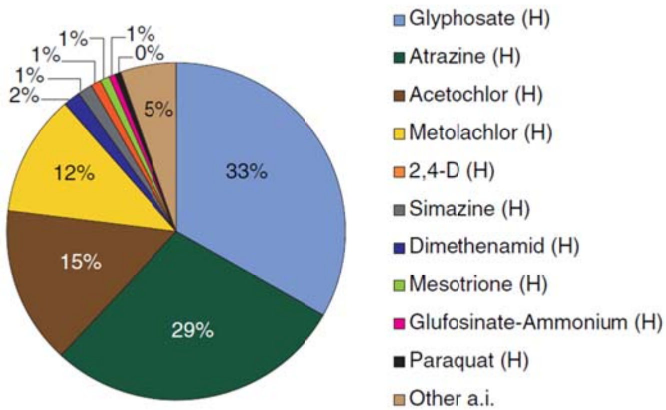


Figure 5: Percentage of Pesticide Applied in soybeans, 2008[11]

Consumer Reports released a comprehensive and well-argued report in March 2015 called "From Crop to Table: Pesticides Use in Produce". It is comprehensive, and written by academic health professionals. This paper won't attempt to repeat all of its findings, but this is an illustrative paragraph (emphasis ours):

> The President's Cancer Panel of the National Institutes of Health writes that exposure to pesticides has been linked to brain/central nervous system, breast, colon, lung, ovarian, pancreatic, kidney, testicular, and stomach cancers, as well as Hodgkin and non-Hodgkin lymphoma, multiple myeloma, and soft tissue sarcoma. Approximately 40 different EPA-registered pesticides that are currently on the market are classified as known, probable, or possible human carcinogens. Although 40 known, probable, or possible human carcinogens may be a disconcerting number in and of itself, it occupies a small percentage of the approximately 900 registered active ingredients in use today. Unfortunately, many of these chemicals have not been proved non-carcinogenic but rather fall into the cancer classifications of "not likely to be carcinogenic to humans" and "not classifiable" (**because of a lack of sufficient information on which to base an assessment**). The Environmental Protection Agency (EPA) acknowledges that the associations between pesticide exposure and certain cancer and non-cancer chronic health effects are well documented in the peer-reviewed literature and sets tolerance levels for residues to try to protect the public and environment from adverse effects[12]

Young children are particularly at risk from pesticide exposure, and residue has been found in the blood of nursing infants, and in the fetuses of exposed mothers. It seems safe to say that eating produce without any pesticide residue is probably safer than not. At Green Alpha Advisors, we would classify that as a risk for conventionally farmed produce. Agricultural workers, both farmers and temporary (largely illegal, undocumented workers from other countries) are also exposed to pesticides at much higher levels. And while the professionals hired to apply pesticides may don adequate protection and take adequate precautions, that is not always an option for workers who come after them in the field to weed, harvest and package the treated produce. There are basically no rules or enforced protections of farmworkers when it comes to pesticides, through OSHA or any other responsible regulatory body[12].

Risks to Clean Water and Aquatic Ecosystem

All of the pesticides that are being applied to these crops do not simply disappear into produce. According to the United States Geological Survey, the National Water-Quality Assessment (NAWQA) Program turned up some pretty scary facts[13]:

- Applications of Fertilizers, manure and pesticides have degraded the quality of streams and shallow ground water in 50% of the United States
- Nitrate concentrations exceeded EPA standards in 20% of sampled wells on agricultural land
- 80% of streams contain excess phosphate which leads to nuisance plant growth which harms fish and other wildlife through lowered oxygen levels
- At least one pesticide was found in 95% of sampled streams, over 60% of samples contained 5 or more pesticides. Pesticides were found in 60% of wells sampled
- Herbicides-especially atrazine and its breakdown product desethylatrazine (DEA), and metolachlor, cyanazine, and alachlor-occur more frequently and usually at higher concentrations in streams and ground water in agricultural areas than in urban areas.
- Insecticides that were used in the past--especially DDT, dieldrin, and chlordane-still persist in streams and sediment. At least one guideline for sediment quality was exceeded at more than 20 percent of sites. This means that concentrations are high enough to be toxic to clams and other aquatic invertebrates and can affect the food supply of fish

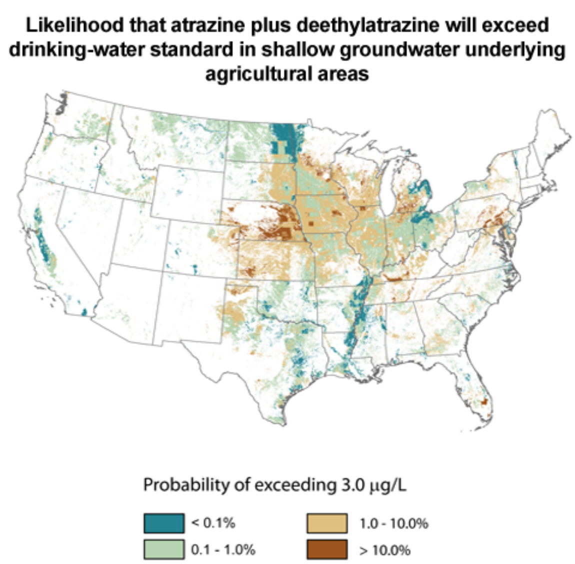


Figure 6: Shallow Water Pesticide Occurrence[14]

Figure 6 illustrates some of the findings in NAWQA overlaid on a map of the United States. Not only does conventional agriculture poison freshwater reserves near agricultural areas, it is the single most water-intensive economic activity in the world. According the United States Geological Survey, the largest withdrawal of freshwater in 2005 (most recently available data) was for thermoelectric uses, which means the cooling of electricity generating equipment like coal and natural gas fired turbines. The majority of this water is returned to the natural water supply, and generally, it is largely unmodified in the process (it does not become polluted or adulterated. However, heated water from power plants does increase evaporation in the warmed return water, and kills fish and other aquatic life that is not accustomed to the hotter water environment.). This use totaled 143,000 million gallons per day. Irrigation in the same period was 128,000 million gallons per day. By comparison with other freshwater use, and excluding thermoelectric uses, irrigation accounted for about 63% of all freshwater use. The next

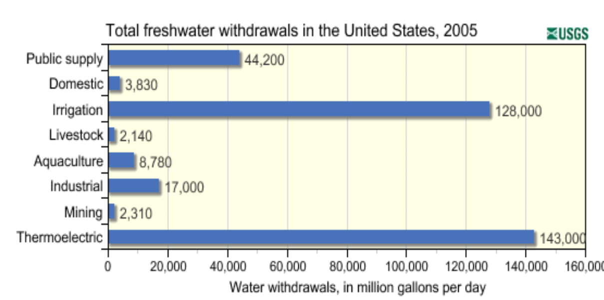


Figure 7: USGS Freshwater Withdrawal

closest category is public supply, at a mere 44,200 million gallons per day. There are other important differences. Thermoelectric power is 99% sourced from "surface water", which is distinct from "groundwater", which is why it is considered mostly non-consumption. Irrigation in 2005 was 42% sourced from groundwater, meaning it is responsible for the lion's share of pumped, aquifer water use. In addition, that water pumped for agriculture is largely redirected to surface water through sewage and waste streams. Very little to none of it makes it back down to an aquifer.

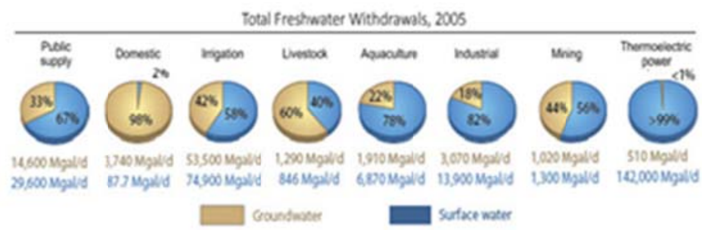


Figure 8: Ground versus Surface water withdrawals

Finally, the soil of artificially and heavily fertilized, non-crop rotated or cover cropped produce has lowered topsoil's ability to hold onto moisture from either irrigation or natural rainfall. This effect is what precipitated the great Dust Bowl of the 1930's in the United States[22]. Deep-rooted plains grasses anchored thin top soil layers in the Great Plains historically. The removal of grass for crops persisted and the top soil began to dry out. Several years of drought caused such drying that the top soil was blown into massive dust storms unlike the country had ever seen. Heavy application of fertilizer and pesticides leads to a loss of organic matter and microbial and insect activity in top soil. This loss creates dry, dead top soils. Over time, these soils require greater and greater amounts of fertilizer and water, and as a result, more herbicide to control rampant weeds that grow in the presence of heavy fertilization. As the soil is unable to contain the water that is applied, the water runs off into surface waterways along with the pesticides and excess fertilizer the soil can no longer hold. Figure 9 shows the results of many years of nitrogen fertilizer application and its diminishing returns on crop yields[16].

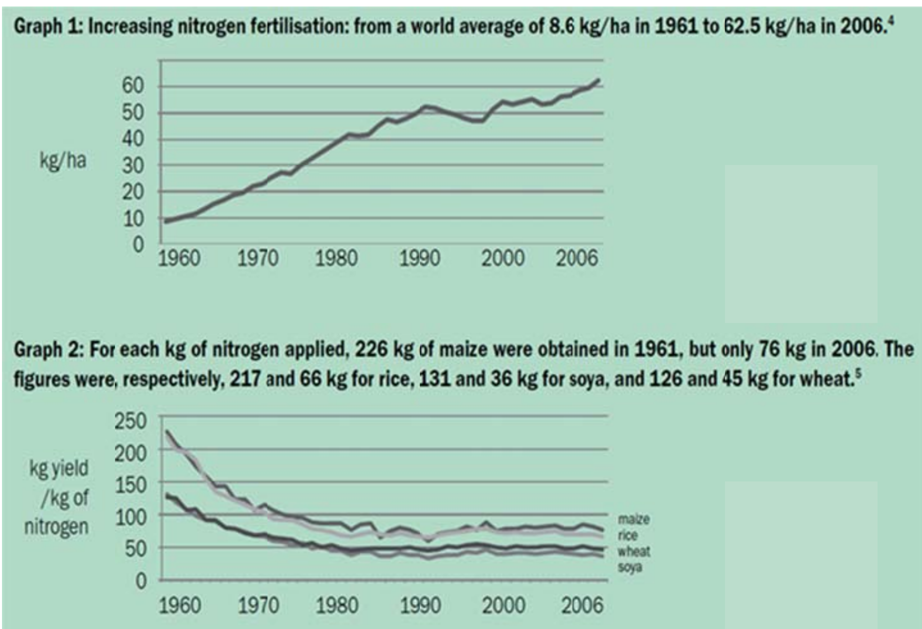


Figure 9: Decreasing Yields from Nitrogen Fertilizer

It is not just freshwater near agricultural land that this type of pollution affects. Oceanic dead zones are areas where oxygen becomes so low that everything living simply dies. One of the largest dead zones appears every spring in the Gulf of Mexico as a result of runoff from the

Mississippi delta after heavy fertilizer application from farmers preparing for summer and fall harvests. As the nitrogen heavy water hits the ocean, algae blooms appear. As the algae dies the decomposition process removes oxygen from the water, contributing to the dead zone[17].

Risks to Climate

All agriculture adds some GHGs to the atmosphere, but conventional farming adds orders of magnitude more. One of the most egregious ways that conventional agriculture acts as a source of GHG emissions is through over fertilization of crops. The two major ways in which in agriculture contributes to GHGs are in the form of soil organic matter (SOM) loss, and nitrogen gas pollution. SOM comes from the decomposition of plant materials that grow above the soil, left over root systems, and the remains of any of the very diverse and large populations of microorganisms that live in healthy soils. The cycle generally follows the pattern of plant materials falling to the soil, and decomposing at the topsoil level. As that plant matter is broken into very small pieces, it percolates into the soil by precipitation, where fungus and microorganisms further break it down enzymatically to its constituent parts. Those same and other microorganisms also transform the basic nutrients and minerals into new forms that are more readily bioavailable for living root systems. In a sense, soil bound fungus and microorganisms are actually farming the above ground plants in order to make more soil organic matter. That organic matter will eventually cycle down and provide nutrients they require to persist in the soil. This is the definition of a symbiotic relationship: one that is mutually beneficial for associated organisms. In conventional agriculture systems today, much of that relationship ceases to exist as SOM is lost, and the symbiotic relationship breaks down. The loss of SOM, sometimes referred to as top soil, is by some estimates equivalent to up one third of the excess carbon dioxide in the atmosphere over pre-industrial levels. This then is one of the clearest examples of risk posed by conventional industrial agriculture.

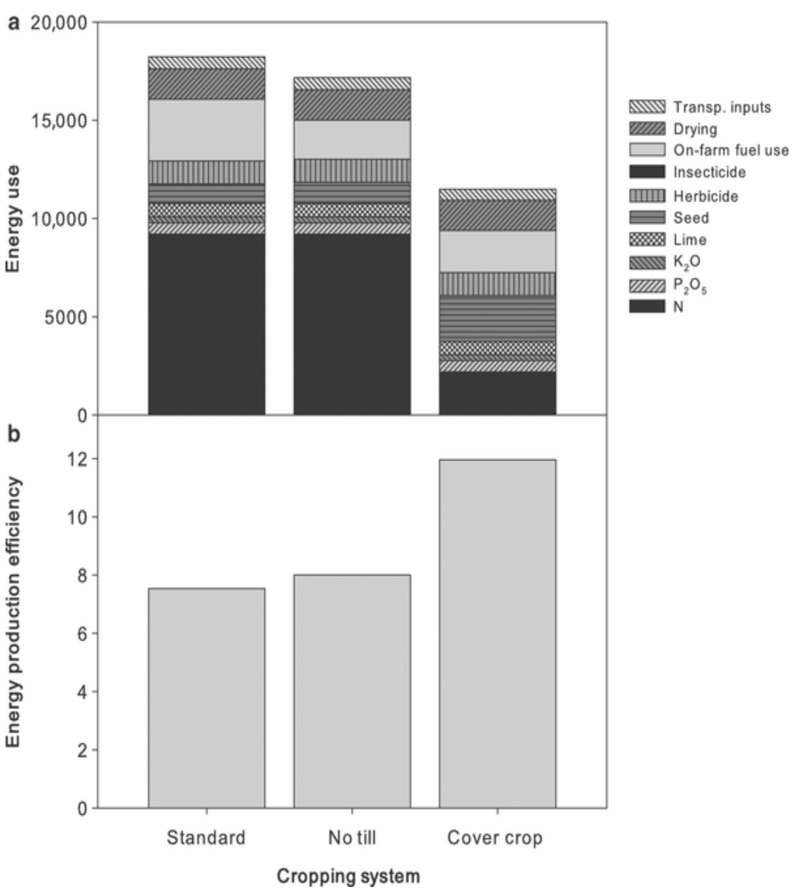


Figure 10: GHG Intensity of Corn

Tilling soil and leaving it bare after harvesting (fallow) results in far less moisture and natural fertilizing soil content (nitrogen, phosphorous, and potassium). As a result, conventionally farmed fields require more exogenous sources of those fertilizers. In figure 10[18], the total GHG intensity (amount of GHG equivalent energy required per hectare per year) associated with corn crops is laid bare. As you can see, the majority of GHGs required to grow corn comes from fossil fuel derived nitrogen fertilizer, and on farm gas and oil use for equipment. In one example of a simple solution, just utilizing cover crops between harvest increases efficiencies by about 50% through reduced tilling and nitrogen application.

Organic, or Something Like It

Organic agriculture represents the possibility of reducing excess atmospheric carbon dioxide over time, substantially, by increasing instead of decreasing carbon sequestered in soils. It's perhaps ironic how much time and money has been spent in the United States arguing about things like clean coal and carbon sequestration when for decades humble farmers have been practicing free, productive carbon sequestration by simply farming organically. By prohibiting pesticides, organic practices massively reduce the GHG intensity of agriculture, and thus the overall economy. Additionally, because all sources of fertilizer for organic agriculture must come from non-synthetic means, there is virtually no GHG intensity contribution from fertilizer in organic agriculture. Organic agriculture as a result has somewhere between 5-15% the GHG intensity of conventional crops[16]. Even when yields for organic agriculture are lower consistently (which actually is dependent on the crop, the farmer's skill, and geographic location), in a future world where carbon budgets exist and are enforceable or financially aligned, organic agriculture represents a vastly more economically efficient method of growing food. Organic agriculture also massively decreases both surface and ground water use by virtue of its increased SOM, and because it does not result over time in water that is unsuitable to drink due to contamination. It does not contribute to NO_x (nitrous oxide) air pollution that decreases blood oxygen in infants and the elderly and reduces air quality. It does not contribute to nitrogen outgassing of fields that have been treated with excessive amounts of decreasingly productive fertilizers, created through inefficient and emissive fossil fuel energy. It does not poison farm workers, food handlers and processors, nor does it leave trace or greater levels of pesticides and their metabolites in blood samples of every human being it contacts. Organic agriculture does not result in unexplained higher rates of reproductive cancers, endocrine disruption, early and low weight births, or decades long contamination of soils and waterways. *Organic agriculture, or something like it, is the solution to the massive and largely unmitigated risks of conventional agriculture and our currently dominant food production systems.*

Growth of Organics

As a result of the human health, GHG and ecological risks mitigated by organic agriculture, organics have become one of the most rapidly growing segments of the food and beverage industry. What are the milestones and trends?

Since legislating for an official and lawful designation for Organics in 1990, the Federal Government has continued to support the standard. Federal support for organic production systems, including financial assistance for farmers completing the certification process and funding for organic research, has increased in each of the last three farm acts. The Agricultural Act of 2014:

- Expands funding to assist organic producers and handlers with the cost of organic certification. Mandatory funding more than doubles from the 2008 Farm Act's mandate to $57.5 million over the lifespan of the 2014 Act.

- Continues mandatory funding to improve economic data on the organic sector at $5 million over the lifespan of the Act; another $5 million is added to upgrade the database and technology systems of USDA's National Organic Program.
- Expands total mandatory organic research funding to $100 million. Authorized funding for the National Organic Program expands to $15 million annually.
- Exempts certified organic producers from having to pay for conventional commodity promotion programs on their organic production, and establishes the option for an organic promotion program.
- Requires improvements in crop insurance for organic producers and strengthens enforcement of organic regulations.

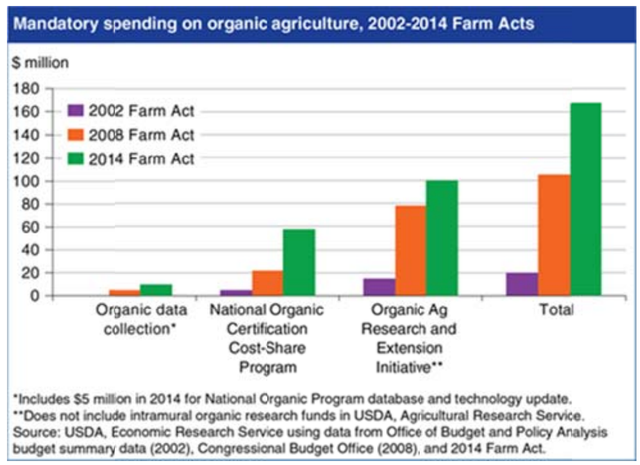


Figure 12: Change in Federal Spending for Organics[19]

These amounts are relatively small given the much larger sums spent on conventional agriculture (crop insurance, subsidies, guarantees, infrastructure, grants, etc.) but they've been influential and they are growing. In terms of potential for growth at the field level, organics have enormous economies of scale to realize. Certified organic cropland and pasture accounted for 0.6 percent of U.S. total farmland in 2011, according to the USDA. Only a small percentage of field crops such as corn (0.3 percent), soybeans (0.2 percent), and wheat (0.6 percent) – were grown under certified organic farming systems as of 2011. This is estimated to be growing 5-10 percent a year in the United States. Non-field crops have experienced much more robust growth earlier, and as a result 14 percent of carrot acreage, 12 percent of lettuce, and 5 percent of apples were grown organically in the United States in 2011. Markets for organic vegetables and produce have been the top selling produce categories in stores for several years running. Moving past plants, approximately 3 percent of dairy cows were certified organic in 2011, as were 2 percent of egg laying hens. Interestingly, the acreage of organic produce planted in the United States is being dwarfed by the rate of growth of actual U.S. retail organic food product sales by revenue. U.S. organic sales reached $26 billion in 2011, with just 1000 certified farm operations, and only 5 million acres of organic farmland, a trend that is getting worse with time (see figure 12).

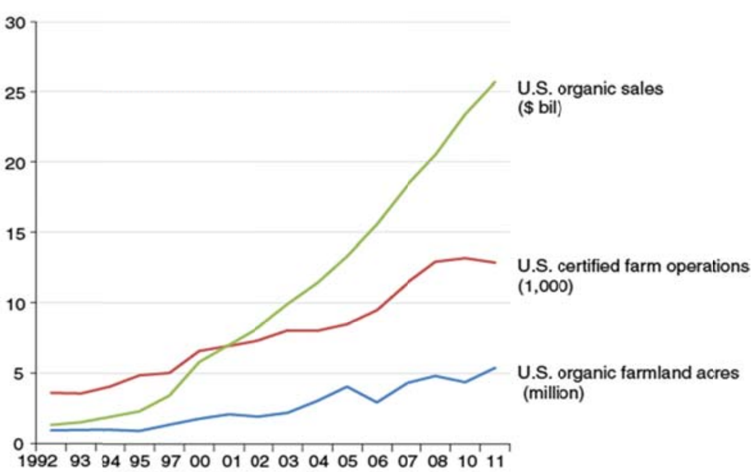


Figure 11: Growth of Organic Sales, Farms, and Acres (U.S.)[19]

The United States imported $1.4 billion worth of organics in 2013[23]. The retail value of those imports are unknown, but conceivably could be 3-5x that number, contributing an estimated 15-25% of total U.S retail organic sales. Moreover, according to the USDA, average organic corn production in the United States yielded around 121 bushels per planted acre, but sold for around $7.20 a bushel (in 2010), which is $871.20 per planted acre. For the same period, conventionally farmed corn yields around 159 bushels per acre, but sold for a paltry $4.50 a bushel, or $715.50 per planted acre. Concerns about reduced yields are vastly overblown for most organic products, and the significant prices for fertilizer, pesticides, and GE/patented seeds from companies like Monsanto add great cost to conventional farming methods.

Retail Sales

In 2012 the USDA estimated that total U.S. organic sales would reach $35 billion by 2014. In 2014, organic sales in the U.S. were actually $39 billion. A recent Bloomberg research report shows that organic food sales growth has massively eclipsed conventional food sales growth over the last 8 years (figure 13), equivalent to a 14% compound annual growth rate over the period.

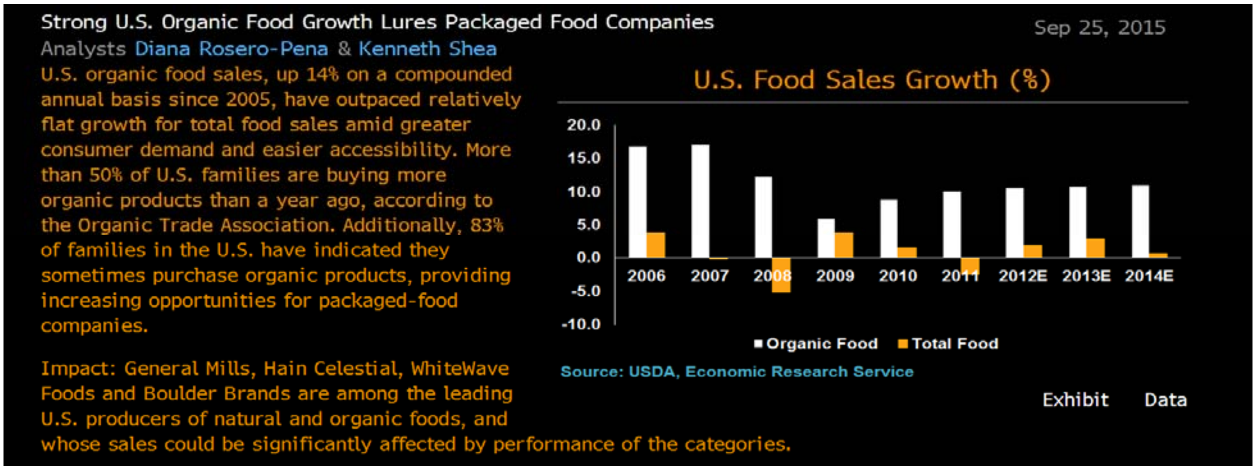


Figure 13: Bloomberg U.S. Food Sales Growth (%)[20]

This phenomenal growth in organic food sales is reflective of the predicted larger transition to the Next Economy. Organic food production is safer for people, safer for the environment, and safer for global climactic health. In the total accounting of costs and benefits, organic is vastly more productive per unit of land. Moreover, produce has lost substantial and in some cases the majority of its minerals over the last 80 years as measured by a program at Kings College, London[16]. The newer data from 2006 shows that this not unique to crops themselves, livestock that eat that produce have suffered similar declines. Despite some industry led efforts to equivocate conventional and organic food products on a nutritional basis, its clear conventional agriculture leads to less nutrient dense products over time.

The net result of all of this is that most of the food we eat is mineral-deficient. In 1927, researchers at the University of London's King's College started to look into the nutrient content of food. Their analyses have been repeated at regular intervals since, giving us a unique picture of how the composition of our food has changed over the last century. The table summarises their alarming results: our food has lost 20–60 per cent of its minerals.

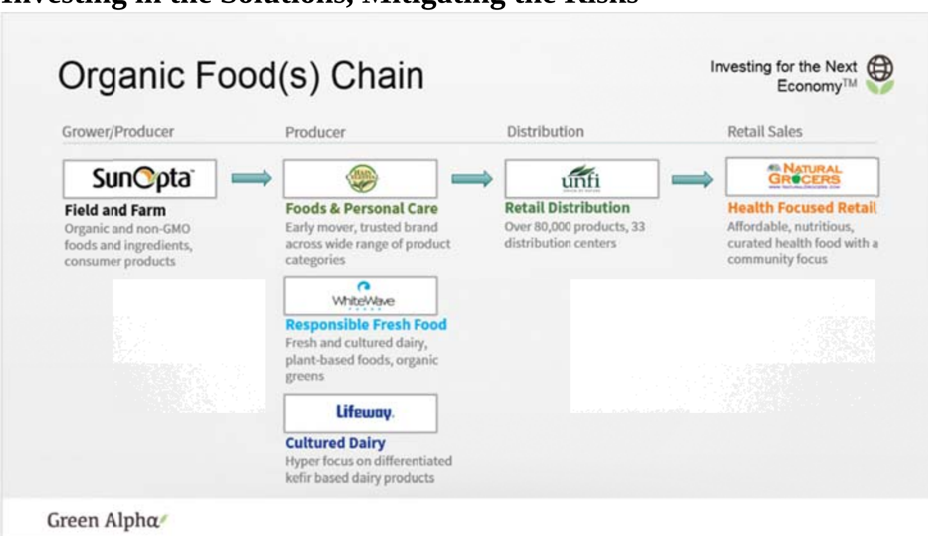
Reduction in average mineral content of fruit and vegetables in the UK between 1940 and 1991

Mineral	Vegetables	Fruit
Sodium	−49%	−29%
Potassium	−16%	−19%
Magnesium	−24%	−16%
Calcium	−46%	−16%
Iron	−27%	−24%
Copper	−76%	−20%
Zinc	−59%	−27%

A new study published in 2006 shows that mineral levels in animal products have suffered a similar decline. Comparing levels measured in 2002 with those present in 1940, the iron content of milk was found to have declined by 62 per cent, while calcium and magnesium in Parmesan cheese had each fallen by 70 per cent, and copper in dairy produce had plummeted by a remarkable 90 per cent.

Figure 14: Loss of Nutritional Content in Food Over Time

Investing in the Solutions, Mitigating the Risks



Whether the future of agriculture is organic as we know it today or some evolved form of agriculture that is even more efficient with reduced impacts on people and planet (large-scale indoor agriculture is one possibility), there is a strong precedent for organic practices in some form being the dominant future method of producing edible calories. Investing in the leaders of organic innovation in food production, handling, distribution, and sales is a clear Next Economy solution to the risks inherent in conventional agriculture. Figure 15 gives a high-level flow chart of how Green Alpha Advisors looks at the publicly traded companies participating in the organic explosion the world is currently experiencing.

We believe, as a matter of principle, across sectors, that investing in the one-two punch of innovation that creates greater economic efficiencies while simultaneously reducing unique and systemic risks is the clearest path toward earning competitive long-term returns. The application of this thesis to topics as elemental as food and water is key to modeling a holistic Next Economy wherein we finally fit the human economy less destructively into the rest of earth's systems, and thereby give ourselves greater chances of enduring and thriving indefinitely.

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